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## News & Views

### Artificial Intelligence in Medical Diagnosis

Increased use of Artificial Intelligence in medicine is changing the face of how diseases are going to be diagnosed in immediate future. First it was Google's AI algorithm which predicted cardiovascular conditions on basis of retinal scans. Just by using the retinal scans in a study in the University of Adelaide, Google's software was able to accurately predict an individual's age, blood pressure, and whether or not they smoke. All this information can be used to forecast the risk of cardiac attack. The interesting part was using retinal scans data to predict an entirely new disease.

Similarly, mammogram analysis is used to detect breast cancer in women. Reading these mammograms is a tough job because cancer tissue is often masked in mammograms by overlapping 'dense' breast tissue. In yet another study by Google, published in Nature on January 01, 2020, use of Artificial Intelligence algorithms outperformed expert radiologists in making accurate interpretations of the mammograms. The major advantage of using AI for medical diagnosis is that it simplifies and speeds up the predictions, and invasive tests are not required.

### The CRISPR/Cas9 Story

CRISPR/Cas9 is a defence system of the bacteria against the viruses. It was unveiled in 2010 as a gene-editing technology and has taken the world by storm. Scientists are using this technology in health care, medical research, animal research, agriculture and chemical processing. A Chinese scientist He Jiankui claimed last year that he had used CRISPR/Cas9 to create the first gene-edited babies. Later, He Jiankui was jailed for three years for illegal medical practice as this technology has not been approved for use on humans by the governments. However, the US Government has now approved clinical trials for CRISPR/Cas9 technology for certain diseases such as cancer, blood disorders, and a certain kind of blindness.

### India's Chandrayaan-2 Mission

Indian Chandrayaan missions have established India as a serious space superpower. The Chandrayaan-2 was launched on July 22, 2019, and on August 20, it entered the orbit of the moon. In a movie like climax on September 7, Chandrayaan-2's lander Vikram was about to land on the moon but lost contact and perished. However, the mission was not a failure as the Orbiter was safe in the moon's orbit and is still performing experiments.

Earlier, Chandrayaan-1 was launched in 2008. Chandrayaan-1 placed an orbiter in moon's orbit in its maiden attempt and crash-landed a probe on moon's surface. The orbiter worked only for ten months in space out of its two years plan. Chandrayaan-1's most significant finding was confirming of presence of water on the moon.

### Quantum Computing Race Heats Up

Quantum computers are different from the computers we know. The memory of a classical computer is made up of bits, and each bit could be either zero or one. On the other hand, the quantum computer memory is made of qubits, which can represent a one, or a zero, or some combination of zero or one. The combination happens by quantum superposition or quantum entanglement. Therefore, millions of combinations are possible, making quantum computers much faster than classical computers. Google's 'Sycamore', the quantum computer, has 53 qubits and using this Google claimed to have achieved quantum supremacy in October 2019. In 200 seconds, Sycamore performed a calculation that would have required 10,000 years for a state-of-the-art supercomputer. IBM has a fleet of 14 quantum computers with the largest having 53 qubits. Other companies in this quantum computing race are Intel, Microsoft, and Chinese companies like Alibaba and Baidu.

## Mini Review



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# Reforms in Agricultural Extension in India and Policy Issues

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The purpose of extension is to disseminate advice to farmers. Currently, government clearly faces the largest challenges in extension. The private sector is enjoying dynamic growth opportunities in agricultural supply chains, and its presence will become more and more pervasive. The required re-think by government prompted by this situation has barely started. Agriculture has moved on. Subsistence farming is history, at least aspirationally. The government needs to adjust by filling the many remaining gaps, in partnership with private for profit and non-profit actors. The "resource-poor" majority, growers of much of India's food, need external, science-based extension to complement local knowledge. Much debate focuses on how best to achieve the desired outcomes that extension can convey. Many countries have neglected extension and indeed agriculture as a whole. But interest appears to be returning globally, and India is no exception. This article builds on that discussion. It looks at extension in relation to both primary production and market links, and acknowledges the contributions of all providers of extension, public and private. Challenges of implementation are widely cited as a bottleneck in Indian agriculture and rural development, begging the question of how government can inject skills, motivation, a sense of mission and renewal where they are needed.

## Agricultural Extension System in India

Reforms in the system of public expansion envisage a more broad-based and comprehensive program of expansion in quality and context beyond the transition of agricultural technology. It will not satisfy its usual function of moving and disseminating appropriate technology and agronomic practices. Extension agencies, services and workers will need to play a more proactive and participatory role, serving as agents of knowledge / information to initiate and facilitate mutually meaningful and equitable knowledge-based transactions among agricultural researchers, trainers and primary producers. All of this must be done efficiently and cost-effectively. The emphasis and application of technology will have to be on the subjects of maximizing resources available to production companies, conservation and software adaptation to cope with diversity more than ever before. In particular, agro-ecological or social circumstances aim at creating a political environment that encourages profitable, competitive and sustainable agriculture (Singh et al., 2013). Field Extension System and Frontline Extension System are the broad typology of the extension systems in India. Whereas the extension system is concerned with the dissemination of large-scale agricultural technology by development departments and agencies to the large number of Indian farmers; the front-line extension system of the Indian Agricultural Research Council (ICAR) and the State Agricultural University Universities (SAUs) focuses on the

adaptation and demonstration of the technologies and capacity building of the related stakeholders. There are five main public extension players *viz.*, the Department of Agriculture and Cooperation (DAC) and the related ministries of rural development through its network of agricultural and related departments at state, district, block and village level; frontline extension systems by KVKs, ICAR institutes and SAUs; Extension services by different commodity boards; Agribusiness houses and input agencies and extension services by the Voluntary Organizations of the country. The Indian extension scheme has evolved over the past 60 years to represent domestic priorities. New technology dissemination frameworks are facing new challenges due to the changing economic conditions in India and the need for effective agricultural and agricultural technologies and agri-management procedures to address food and nutritional protection, poverty alleviation, market diversifications, export opportunities and environmental concerns. Public enlargement alone cannot satisfy the various demands of agriculture systems any longer. The extension of agriculture plays a key role in meeting the holistic needs of sustainable increase in agricultural production. Reforms of the system of public extension were envisaged in the 1990s as a more broad-based and holistic, multi-disciplinary extension system, beyond the transfer of agricultural technology. Reforms of the extension system lead to innovative arrangements for institutions. Agricultural policy reforms include replacing the old single discipline, commodities-based

approach (PT) with the farming system approach and later farmers' involvement approach as stakeholder in technological development and distribution. The policy reforms on agricultural extension include farmers' participation as stakeholders.

The move from a food security policy to a strategy aimed at diversifying agriculture to increase farm incomes and rural jobs involves implicit risks for small-scale farm households that are expected to benefit from this approach (Singh, 2015). To make the extension process more effective at achieving its goals, the above policy and programming strategies will need to be updated. Eventually, states will gradually cut their financial dependence on the central government so that they can take ownership of their revamped extension structures (Babu et al., 2012). The potential of agricultural extension needs to be reassessed to effectively address the needs of the agricultural community both today and in the future. As fundamental changes were being made in the nature and extent of agricultural expansion, India was seeking a whole new policy mix in India to support a pluralist expansion system (Singh et al., 2013).

The Agricultural Technology Management Agency (ATMA) was then formed with the goal of implementing and enhancing public sector agricultural expansion reforms, including the importance, accessibility and efficiency of sharing of information between different actors, actors and stakeholders. ATMA is considered to be the main step to change India's enlargement process. The project was developed to replace T&V with a view to addressing some of its shortcomings and was successful in ensuring that different service providers converged in legal terms. In order to accountabilize the entire extension system demand-driven and farmer-led, the World Bank funded Technology dissemination innovations (ITD) component of the National Agricultural Technology (NATP) Program under which the ATMA was established. It contributed with the participation of all the stakeholders of government and non-Governments at the district level to strengthen research and extension capabilities, restructure public extension system and test new institutional frameworks for technology transfer (Singh 2015). Its innovative approach in providing autonomy and fund flow mechanism made it possible to win back the confidence of all the stakeholders including farmers, towards the public extension system.

There has been a lack of structured support structures below the level of the block, of adequate technical and financial help (support provided during the pilot process which weakens over time) and of a strong organizational structure for implementing public-private partnerships (Kapoo), which include skilful block and village stakeholders. In view of the system's implementation constraints, the government issued new guidelines on ATMA

in June 2010. The Guidelines for Modified Centrally Sponsored Scheme 'Support to State Extension Programmes for Extension Reforms' note that the system does 'not provide the dedicated manpower support at State, District and Block levels' that is required (Government of India, 2010). The new guidelines, therefore, provide for modifications to strengthen specialist and 'functionary' support at different levels; making sure that the 'farmer friend' model (linking farmers and extension agents) works in practice, in particular by filling block-village gaps; revising the 'ATMA Cafeteria' (or list of extension activities to choose from); better enabling Farmers' Advisory Committees to advise administrative bodies at the different jurisdictional levels about extension needs; and delegating powers to State Level Sanctioning Committees for them to approve the state extension work plans (SEWPs). The guidelines include a new organizational chart that articulates sets of activity and fund flow at State, District and Block levels. The guidelines provide for convergence in four areas: manpower and extension-related work under different programs and schemes; public agricultural research and extension at different levels of implementation; convergence with development departments to ensure that the extension activity forms a coherent whole; and convergence with and involvement of the nongovernmental sector (Ferroni and Zhou, 2011).

### **Frontline extension reform: Krishi Vigyan Kendra (KVK)**

Front Line Extension is a general extension mechanism, requiring a higher level of prolonged collaboration between highly skilled research and academic personnel. It is also believed that the scientist who created the technology will teach farmers in their fields the technology more effectively. The field extension program involves the large-scale distribution of agricultural technologies among a large number of Indian farms through development departments and agencies; the Indian Council for Agricultural Research (ICAR) and State Universities of Agriculture (SAUs) frontline extension system focuses on technology adjustment and skill demonstration. There are five main extension players viz. the Department of Agriculture and Cooperation (DAC) and the related ministries of rural development through its network of agricultural and related departments at state, district, block and village level; frontline extension systems by KVKs, ICAR institutes and SAUs; Extension services by different commodity boards; Agribusiness houses and input agencies and extension services by the Voluntary Organizations of the country.

The ICAR started three major front-line extension projects, viz. National Demonstration Project (1965),

Operational Research Project (1972) and Lab-to-Land Project (1979). Another significant development in front-line extension was the establishment of Krishi Vigyan Kendras (KVKs) in 1974. All the three previously launched frontline extension programmes were merged with KVKs. These KVKs were aimed to improve technical literacy of farmers including rural women on the principle of 'learning by doing' and 'teaching by doing'. These KVKs are currently managed by the ICAR institutes, SAUs and nongovernmental organisations (NGOs) with financial support from the ICAR.

The KVKs (Farm Science Centres) have been largely regarded as an institutional innovation that effectively link agricultural research and extension at the district level in India. So far, 660 KVKs have been established across the country with 100% funding support from the Indian Council of Agricultural Research (ICAR). KVKs emerged as critical frontline extension innovation in technology generation and dissemination. The mandate of KVK is technology assessment and demonstration for its application and capacity development

KVK would also produce quality technological products (seeds, seeds, seed plants, bio-agents, cattle) and make them available to farmers, organize expansion activities at an early stage, detect and document selected farms innovations and converge ongoing programs and programs under the KVK mandate. Technologies produced through NARS must be properly evaluated at a given location before they are spread to a wider range via demonstrations. In addition, training programs are essential to transfer the skills related to these technologies to the clientele. In order to be effective, farmers must also produce good quality seeds, planting materials, animal strains, bio-products, etc. The masses are also reached by technology through various extension activities, such as Kisan Mela, publications, field days, seminars, workshops, KVKs visits by farmers, etc. KVKs carry out all of these activities to ensure sustainable growth in farming and its related sectors in their respective areas and with the goal of achieving them.

The KVK system has played a key role in transfer of modern and emerging technologies in agriculture and allied sectors leading to increase in production and productivity, development of high value agriculture like horticulture, livestock and fisheries, introduction of newer varieties for pulses and oilseeds leading to increase in income of farmers and promotion of farm-based enterprises. KVKs have collaborated with State development agencies, NGOs, other agents active in agricultural extension and have trained farmers, farmwomen and youth in modern agricultural practices. Effective linkage between two public extension institutions KVK and ATMA is essential for delivering extension services to the clientele.

## Private extension

In India, the private sector plays an important role in providing extensions. They fill the gap between inadequate input delivery and tailored consulting services. The private sector comprises agriculture research, seed and input firms, distributors and agritourists, various service providers, food processors and retailers, and agri-advisory content providers. To order to extend agriculture, contract farming is an increasingly important method. The term 'embedded services' in this context is used in literature to supply information through the sale of inputs or product marketing (Feder et al., 2011). In India there are approximately 282,000 inputs. They are the cornerstones of their rural and semi-rural communities and are interested in offering their farmer customers quality service. Agricultural inputs and the manufacturers of agricultural inputs sold thereby have an interest in the advice to growers on pre-sales and sometimes on after-sales (Ferroni and Zhou, 2011).

The trend in agricultural investment in India has shown that investment size has increased 2.6 times in the last two decades, but the share of private investment has increased gradually over public investment. Today, more than 80% of total investments in agriculture are kept in the private sector. In particular, by the introduction of biotechnology, information communication technology and intellectual property protection, private-sector contributions to the marketing, extension and research in agricultural products become increasingly important. Financial pressures have, in turn, led to the search for ways of reducing public sector costs by allowing private sectors to take parts in marketing, extension and research, value added services, and cost-sharing arrangements among public, private, NGOs and farmers' organizations (Mukherjee and Maity, 2015).

At present, there are many private companies working as extension agencies like Mahindra & Mahindra, ITC, DCM Shriram Consolidated Ltd., Indian Oil Corporation, TATA, and Rallis etc. Among this TATA has done an innovative job not only in agricultural sector but also developing rural scenario. Tata *Kisan Sansar* (TKS) had started in 2002 by Tata Chemicals Limited with an objective of providing technology information, crop advisory services to empower the farmer as well as providing agricultural inputs to the farmers (<http://www.tatachemicals.com>). In order to support the activities of TKS, which are basically franchisee outlets, the supply chain model is based on 'hub and spoke' model. The hub acts as a resource centre, supports primarily 20-25 TKS franchisee outlets in a radius of 50-60 km, where each TKS caters to 30-40 villages covering approximately 13 million acres overall. The hubs were named as "*Tata Krishi Vikas Kendra*" (T-KVK) the word 'vikas' being synonymous with value added activities conducted like

organisation of farmer meet, repository of related agricultural knowledge, soil, water, plant testing laboratory, demonstration farms and also distribution centre. Presently, there are 32 hubs, which cater to 681 TKS (spoke), covering around 22,000 villages reaching out to approximately 3.5 million farmers. Presently TKS are spread across 68 districts in North Zone and 20 districts in East Zone spanning 4 and 3 states, respectively. Among this more than 300 TATA *Kisan Sansar* centres are running successfully in Uttar Pradesh (Mukherjee, 2011).

Product-driven agriculture and commodity retailers tend to promote their goods without taking into account the needs of the farmers. Some agencies can actually place farmers in a confusing state sometimes with contradictory messages. Because of insufficient information to date, natural resources, which are poorly managed by farmers are still too many. In the supply of vegetable seeds and planting material, fertilizers, and other chemicals to farmers (Rohan, 2005), the private extension system has dominance over public extension systems in technology provision.

### Civil Society and extension

Civil societies in India are very important sources of assistance for small-scale farmers. However, their numbers as service providers in community-based extensions are insufficient to cover all seek advice, as are government organizations. NGOs range in size from small, local to massive, multi-state-based organizations. Their level of professionalism and agricultural knowledge varies, but usually their social commitment is high. Many are committed to forming self-help groups or farming organisations, which could become focal points for agricultural extension driven by demand. Often outside sponsors and donors support self-assistance groups and farmer-based organizations and NGOs, which help bring them alive (Ferroni and Zhou, 2011).

The Non-Profit Sector in India presents an estimate of 1.2 million NGOs in India and most of them are small organisations in rural areas. They are thought to engage about 20 million persons (Pria et al., 2012). NGOs such as Basix, PRADAN and BAIF are at the larger end of the scale in India, and are perhaps better referred to as social entrepreneurs. Basix is a microfinance institution with more than 3.5 million customers, of whom over 90 percent are rural poor households. Basix operates in 17 states, 223 districts and covers over 39,000 villages. It employs over 10,000 staff of which 80 percent work in small towns and villages. (Basix: 2015; Ferroni & Zhou: 2011) Basix provides business development and extension services, and financial products for farmers under one umbrella. It operates across eight crops as well as dairy production (Basix, 2015). BAIF is a development research foundation working in agriculture and livestock development. BAIF employs over 3000 staff,

operates about 750 centres and reaches out to 2.5 million farmers that are mostly organised in cooperatives. PRADAN works across eight states of India through 41 teams of which each comprises ten professionals. PRADAN reaches out to about 200,000 families in over 4000 villages in 2013-14. PRADAN collaborates with a range of institutions such as government agencies, banks, market institutions, panchayats, or research bodies (PRADAN, 2014).

### Empowering farmers through group approach for sharing of strength

Farmer organisations ' interface would lies between the very dispersed members and the technology generation and dissemination bodies that are often overly centralized. The quality of software supply is a crucial concern in a world which is ever more market-oriented and in which there is a propensity to disregard low resource farmers. In reality, this is the field of technology that has been the most productive for farmer organizations. The cost of operating in big, structured farmers ' organisations, however, has proved more than expected. This may be a benefit in certain respects, but also in terms of reproducing existing social hierarchies within organisations. This means neglecting the needs of the weakest people, inadequate leadership (which contributes to members' poor accountability), and challenges in raising and managing money as well.

The Government services will help the establishment and creation of established farmer's associations or cooperatives. The goal must be to help the groups define their goals—for example, specific post-harvest operations, guarantee group coherence and cohesion and enable them to coordinate and establish group structures. Such groups should, over time, monitor the sophistication of their organisations, so that they can participate in their own business activities and gain access to structured credit, likely after reaching certain economies of scale. Extension government and NGO workers should be professionally trained to act as team facilitators. The main input that governments can provide to promote farmers ' inclusion in the agriculture business may be the promotion of farming organizations (Singh et al., 2013).

The exchange of information between farmers is a key role for farmers. For this knowledge sharing, the Farmer Field School (FFS) can be an effective tool. FFS is based on an innovatif, participative and collaborative design approach to farmer education that has become a collective-based learning system. A wide range of crops was used for this approach and topics like crop management, livestock, water retention and land fertility management were further developed. The approach is also used. . It is aimed to build farmers' capacity to analyse their production systems, identify problems, test possible solutions and eventually

adopt the practices most suitable to their farming system. The knowledge acquired during the learning process enables farmers to adapt their existing technologies to be more productive, profitable and responsive to changing conditions or to test and adopt new technologies. FFSs provide the essential relationship between progressive farmers in a village and others. These farmers should be widely selected and follow a transparent selection methodology. These men's and women's farmers will usually be recognised for their performance in adopting new technology and growing the yield and income in agriculture and other related sectors by other farmers (Singh et al., 2013).

### **Priorities in Extension in India**

The role of the extension education and technology delivery system has also changed in the changing agri-rural environment. Making progress at science borders in selected priority areas with greater impact by focussing on basic and strategic research is also important. There was a need for alternatives to the country's public program of agricultural extension. For discipline science, a paradigm shift between single discipline guidance and multidisciplinary approach is essential. The National Farmers' Commission (NCF) has suggested the most important and effective farmer-to-farmer training and technology transfer is most frequent and is found to be reliable. In many farms operated by farmers, farming schools for various agro-climatic zones and in agricultural systems regimes should be created. In farmers led expansion Farm School and Farmer Field School may be effective tools. A shift from production-orientated to market-led enlargement, which results in increased farm revenue by an end-to-end approach, has become an absolute necessity. Market-led extension allows farmers to reduce costs of production, improve the quality of agricultural product, raise commodity price and lead to higher incomes for farmers. The correlation between farmers and markets is a prerequisite for rising agricultural production and farmers' revenues. In this sense, it would be important for creative organizations to take advantage of new opportunities.

### **Framework for technology delivery**

Efforts have been made to institutionalise research-extension linkages at national, regional, state and zonal levels. At the national level, under the ICAR-DAC interface joint meetings of the senior officers from the ICAR and Department of Agriculture and Cooperation (DAC) are organised twice a year to discuss critical research and development issues. At the regional level, eight regional committees were constituted to review research and development status in the ICAR institutes and SAUs located in the region. These committees represented by the senior research and extension officers, farmers representatives and

NGOs meet once in two years. The Zonal Agricultural Research and Extension Advisory Committee meetings and seasonal workshops at the zonal level facilitate close interaction between researchers, extension workers and farmers. The creation and implementation of software must be continuous and interactive. A structure for production and delivery of technology is introduced, while taking into account the necessary change in technology development and delivery systems while using the existing system.

Increased diversity and technology, knowledge orientation and demand driven are now becoming more diversified. It requires extension staff to be the master of so many companies at the cutting-edge rate that is neither feasible nor possible. The role played by the system of expertise and by institutional frameworks for supply, credit, crop and livestock insurance etc. in reducing both risks and unsafe conditions would thus be important in order to achieve the much needed resilience in Indian farming.

### **ICT led extension**

Extension systems and delivery methods in many developing countries have been constantly viewed ineffective in responding to the demands and technological challenges of various types of clients and in reaching the rural poor (Rivera et al., 2001; Davis 2008; Birner et al., 2009). Farm extension is mainly concerned with two pronged services of information empowerment and technology delivery. ICT led extension service attempts to address the information requirements of extension agents to a great extent and emerged as potential delivery medium through which the technology can be delivered to remote farmers with limited extension functionaries. vKVK (voice *Kisan Vigyan Kendra*) and KVK-Net (*Krishi Vigyan Knowledge Network*) platform can play a major role in agricultural knowledge management and its effective delivery.

Voice *Kisan Vigyan Kendra* (vKVK) is a platform that connects KVKs with farmers through internet and mobile technology. It has SMS and Voice messages facility which facilitates effective and efficient functioning of KVKs as an agro-advisory service provider. Agricultural experts convey agriculture extension information to their constituent farmers through physical (face to face) contact—when they meet each other in visits, demonstrations, etc. It primarily has two services; E2F (expert to farmer) and F2E (farmer to expert). In E2F, the agriculture expert can record and send messages to a set of registered farmers using a web based interface (Web to mobile) or a mobile phone (mobile to mobile). In F2E, a farmer can call up and speak to an expert (mobile to mobile). Similar to the voice, the agriculture expert can also send short messages (SMS) to the farmers. vKVK is part of the agropedia suite of services and is integrated with the digital library. This service was started with 24 KVKs in

Uttar Pradesh & Uttarakhand, 5 in Karnataka and 1 in Andhra Pradesh. Presently, all 80 KVKs in Uttar Pradesh & Uttarakhand, along with the 6 KVK from Karnataka and Andhra Pradesh have been given access to use this service. More than 100 Subject Matter Specialists are registered as experts. Total 515593 voice messages and 99020 SMS were sent to the 16290 registered users (Hugar et al., 2012).

KVK-net has been developed with the aim of bringing experts at KVKs on one platform where they can share views on various issues. Such interactions among experts from different regions and expertise will broaden their knowledge base. KVK-Net platform provides Blogs and forum, where user can create blogs & discussion forum, comment on blogs & forums of other people, profile page for sharing content about personal thoughts/ views, updating of voice and text message using a mobile phone, share activity such as farmer fair, any demonstration, training programs, etc. KVK-Net also has Community of subject matter specialists where users can discuss issues in the relevant community page, like in crop science community the users can talk about all the crops, in the animal husbandry community people can discuss on the disease which affect animals and so on.

KVK-Net and vKVK platform have found to be very useful for sharing agricultural information and dissemination of advisory through voice messages. This innovative approach has been found effective as it can reach all sections of the farmers. Two-way interaction (E2F and F2E) is the unique feature which bridged the gap between farmers and experts. This knowledge network among the knowledge users across the nation helped enriching the latest technology developments in agriculture

### ***Production to Marketing***

The National Farmers Commission (NCF) has reported that the most frequent and effective approaches are farmer-to-farmer training and technology transfer. Farm schools in farms operated by farmers in various agro-climate zones and agricultural systems should be established in large number. In farmer-led extension Farm School and Farmer Field School can be effective tools. A shift in focus from development to market-led growth, which has led to increased farmer income by implementing an end-to-end strategy, has become an absolute necessity. Market-driven extension assist farmers in reducing cost of production, improving the quality of farm products, increasing the value of the products and increasing marketability of their incomes.

Farmer and business ties for research-extension are performed in this sense on a routine basis. While there is interplay between extension and farmers, the interaction between research and extension is small and between research and farmers is low. This sector requires greater attention, because technology production must take the needs, context

and opportunities of farmers into account. Incorporating research and development through the participatory mode of technology development, creating the research-extension-farmer and market coordination committee at the state level to undertake necessary political initiatives to enable and create relations, is a matter of concern for the integration of science, extensions and the market. Institutions at the zonal level including zonal research stations and line divisions will establish a zonal farming strategy by advising. At the district and below levels, major institutions such as KVK, ATMA and farmers' organizations need a close connection to each other in order to evaluate and refined their technologies and create a platform between farmer's organisations.

### ***Collegiate participation of farmers***

Given the articulated and increasingly broad literature on participatory research and extension approaches, much of the work performed within a participatory research context for farmers and first and producer focuses mainly on the research aspect of the production of agricultural technology and on the dissemination approach. Concrete examples of the implementation of the underlying participation concepts, indigenous awareness and the view of users (or farmers) on the enlargement mechanism and the consequences for agricultural expansion systems are minimal. More of "Collegiate Participation" is important now-a-days, where different partners work together as colleagues or partners. Ownership and responsibility are equally distributed among the partners, and decisions are made by agreement or consensus among all actors (Singh et al., 2009).

### ***Inclusiveness in extension outreach***

Public extension and provision of knowledge through newspapers, TV and inputs to large-scale farmers is especially tenuous. New approaches exist to improve the integration of the community extension program. A review of the ATMA system foresees an extension of farmers to farmers, aims to increase the number of focus points from three to five each block and provides guidance that will allow small and marginal farmers to participate in learning events by 50 percent (Glendenning et al., 2010). However, it is insisted that the ATMA guidelines require women to receive 30 per cent of ATMA programs (Kaegi 2015). However, the only way to promote real extension of the poor section of the farming community is through effective monitoring and appraisal of these ATMA components (Glendenning et al., 2010).

### ***Evaluation of extension***

There is increasing awareness that many of the necessary reforms are only successful when strong advisory institutions are in place to support the rural people in coping with food security, market growth and climate change. It is

important to track and evaluate the achievements of the extension to rural livelihoods. High quality monitoring and evaluation based on reliable information about the outcomes and impacts of services are a foundation for structured learning from experience. This is also essential to ensure that those supporting and undertaking interventions to improve advisory services are accountable to both the direct clients of these services and also to governments, farmer organisations, and others investing in improving extension.

### ***Integrating gender and nutrition***

The promotion of food as a priority for growth among many stakeholders creates opportunities for action and sustainable nutrition focus. Extension practitioners shall be responsible for assessing and reacting to the needs of both men and women farmers and for the dissemination of sexual and nutritional technologies and for improving the access to inputs for improving women's farm productivity and for improving domestic nutrition. There is a need to identify scale proven mechanisms for delivering improved extension advisory services to women farmers and apply effective, nutrition-sensitive, extension approaches and tools for engaging both men and women in rural areas. Subsistence farmers need technology and tools, and part of this toolbox should include nutrition knowledge and technologies. Conservation and sustainable use of biodiversity and harnessing ecosystem services are also important and should be emphasized as supplementary nutrient-rich food sources to staple and cash crops.

Extension advisory services can be complemented by and consolidated with other delivery channels at the local level. It is important for extension professionals to acquaint themselves with the organizations and knowledge systems available at the local level to determine how they can be improved. This includes extension staff promoting bio-fortified varieties, providing support to social safety net programs, offering education on nutrition-sensitive agriculture, and promoting dietary diversity enhancements (e.g. through home gardens, small-scale livestock, or the promotion of high-nutrient varieties). However, there is a need to better understand which crops are nutritious, and what can be grown and utilized, and where.

### ***Translational research***

With the gradually changing context of technology application in farmers' fields, a number of new concepts and models of participatory research and extension are being evolved. Agro-ecosystem analysis, Farming System Research and Extension and Participatory Technology Development are few of those. In Indian context, the KVKs being the grass root level organizations having direct contact to the farmers and direct reach to the farmers' fields, effectively executing the process of technology application in micro eco situations

to understand the location specificity and applicability of the technologies in field situation by them had been felt quite effective. As the KVKs continued to gain strength, their mandate also changed from vocational training to testing and demonstration of technologies in 1990s to technology assessment and refinement in X<sup>th</sup> Five Year Plan and finally to 'Knowledge and Resource Centre' of agricultural technologies in 2009. The conventional mode of Transfer of Technology (TOT) only through personal contact and skill oriented vocational training is no longer the predominant mode of extension in KVKs. Translating the technologies in the farmer's field itself through conducting small scale trials and thereby assessing location specificity of the technologies for their promotion, therefore aiding to collective adoption has become one of the most important activities of the KVKs. The necessity for translational research-extension in our country is felt higher given the immense proportion of small and marginal farmers and huge diversity in soil and climatic conditions. It is felt very important to address the issue of inadequate manpower and resources in operating the public agricultural extension system. The ever shifting focus from production to profit oriented farm business bears the sign of a quick and timely change of modalities used by this grass root level extension agency. It is imperative to ensure a strong connectivity between the National Agricultural Research System (NARS) with the farmers in a way the technologies are well translated by the KVKs according to the need of localized contexts.

### ***Innovative futuristic extension approaches for effective outreach***

Innovative extension methodologies like Farmer FIRST, Attracting and Retaining Youth in Agriculture (ARYA), *Mera Gaon Mera Gaurav* and *Krishi Dak* need to be validated for further spearheading frontline extension.

### ***Farmer FIRST***

Farmers tend to face problems related to production and natural resource management but they might not have found out solutions to overcome them. In such situations Farmer FIRST is an opportunity for the researchers, extension personnel and farmers to work together and find appropriate ways through assessing different solutions. During the production process, farmers often evolve new ideas to improve their cultivation and natural resources management activities. This creates a space for researchers, extensionists and farmers to design and organize new experiments. Farmer FIRST can be applied not only at household level but also at village and community level as community experimentation. Usually, the experiments are managed at the individual farmer's level who are involved in the project or who are selected by the village as the representatives to conduct experiments. In addition, there are some cases where experiments focus to solve problems

of the whole village.

Farmers are expected to participate in the research process with scientists. Research questions are found out together with selected farmers or the whole village and villagers' participation in monitoring experiments with scientists. The aim is to find out new ways of doing and bringing in synergy of the stakeholders. The experiments need to be adapted to specific conditions of a farming system and to have the participation of farmers as well as scientists. Especially they must acknowledge local knowledge as a vital element for the development of useful innovations. The role of extensionists is to ensure implementation. Farmers FIRST will create linkages between farmers-researchers and extension to support farmers to conduct appropriate experiments selected by them. It will help researchers and extensionists understand and know real needs of villages. In this process, priority does not come from researchers or extensionists but from the end users of results of research and technology development.

#### ***Attracting and Retaining Youth in Agriculture (ARYA)***

This is an innovative initiative of ICAR to develop a comprehensive model for sustainable development of youth in agriculture with the following objectives:

- To attract and empower the youth in rural areas to take up various agriculture, allied and service sector enterprises for sustainable income and gainful employment in selected districts.
- To enable the farm youth to establish net work groups to take up resource and capital intensive activities like processing, value addition and marketing.
- To demonstrate functional linkage with different institutions and stake holders for convergence of opportunities available under various schemes/programmes for sustainable development of youth.

In this programme it is proposed to develop suitable models to encourage youth to practice agriculture like rural/agricultural incubators, "one stop shop" to provide every solution, custom hiring centres, farm youth associations and networking of rural youth.

#### ***Mera Gaon Mera Gaurav (My Village my Pride)***

India lives in villages. If India has to be developed its villages has to be developed. To bring out prosperity in the Indian villages Ministry of Agriculture is planning to start an ambitious programme called as *Mera Gaon Mera Gaurav* (My village, my pride) in which the scientists of Indian Council of Agricultural Research will adopt villages and introduce the technologies developed by ICAR in the villages. Each scientist will adopt a village nearby his institute and make regular visits to the village and extend technical guidance to the farmers and develop the farmers so that they adopt the improved practices. In future it is planned to extend

this programme to the level of students of agricultural universities in India. Through this effort model villages will be developed which will act as a catalyst to develop the neighbouring villages. There are about seven lakh villages in the country. About 6000 scientists of ICAR are serving in ICAR. About 20,000 scientists of national agricultural research system including ICAR and State Agricultural Universities (SAUs) and 50,000 agricultural students of SAUs can cover 70000 villages and transform these villages into model villages.

#### ***Krishi Dak (Agri Post)***

ICAR-Indian Agricultural Research Institute, New Delhi has developed an Innovative Extension Model for dissemination of information & technology among farmers using rural Postman as a Change Agent. In its initial stages, the Institute has provided quality seeds of various crop varieties to the farmers of different remote areas in the country through Post Offices and Postman. Under the Scheme, rural Postman and farmers have been trained on improved agricultural practices by the regional KVKs. These Postmen/farmers demonstrated improved Pusa varieties in their field which became the source of practical training for other farmers. Demonstrated seeds were made available to other farmers through "farmer to farmer seed exchange" by which the coverage and dissemination of the improved varieties increased progressively.

The model was found to be very effective in timely providing improved seeds to farmers in remote areas. The model was found highly effective not only for crops like mustard, millet, vegetables and flower seeds, where the seed is required in less quantity but also for paddy and wheat where the seed is required in bulk quantity. After the successful testing of this innovative model the Indian Council of Agricultural Research has renamed the model as *Krishi Dak* (Agri Post) and planned its expansion in 14 states covering 100 districts.

## **CONCLUSION**

Many institutional developments have provided sufficient evidence of the emergence in India of agricultural innovation system to address deficiencies in the public research and enlargement process. The effect has been a blurred relationship between science, development, farmers, farmers' groups, NGOs and private companies. Extension has an important role to play in promoting access and transfer of information among the various entities within the innovation process. It must also establish competent organizational modes for improving the overall efficacy of the innovation process. If the important role can not be played, it would further marginalize enlargement. For the development of a stakeholder communication process and

structure, a flexible extension strategy is essential for the convergence in a pluralistic environment. The plan should also specify who is going to provide whom with what kind of product or service. Long-term commitments, stakeholder capacity-building and a robust monitoring and assessment process are the key preconditions for effective integration implementation. When every enlargement entity is inspired and empowered to implement better technologies by a structured and converged enlargement strategy, on the basis of their relative profit areas.

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## Mini Review



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# Robotic and Mechatronic Application in Agriculture

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Robotics and mechatronics are playing an important role in agricultural production and its management. The robots have potential for multitasking, sensory acuity, operational consistency as well as suitability to perform odd operating conditions. Electromechanical arrangements have been used in agriculture for decades. Globally the study is going on agricultural robotic system with different precision farming machineries. In the present paper the robots developed across the globe has been discussed with their features and short comings. IARI has also worked on robotic planter. The scope of autonomous vehicle has been discussed. The increasing world population and scarcity of agricultural workers can be compensated by agricultural robots. Machine vision, image processing and mechatronics can be integrated in a single platform "farm robot" which can give most favorable solution for autonomous agricultural operations for precision, economics, reduced human drudgery and environment protection.

## INTRODUCTION

Robotics and mechatronics are needed for autonomous and time saving technologies in agriculture for efficient farm management. Research is going on the agricultural robots which is developed primarily for harvesting, chemical spraying, picking fruits and monitoring of crops whereas mechatronics is applied for precision and control system management.

Electromechanical arrangements have been used in agriculture for decades. With technological advancement, these devices are shifted toward mechatronics and these are the building blocks of modern agricultural machineries. The basic of modern agriculture is the precision agriculture (PA), a concept appeared in the early '80-s. The possibilities in precision farming with mechatronic solutions in the modern agriculture (such as IoT), typically use it for monitoring and control of each sub-process. Many researchers started developing more rational and adaptable vehicles for agricultural operations. Most of the researcher is working for autonomous vehicle design for precision agricultural mobile robots (Burks et al., 2005; Blackmore et al., 2007). Three different verticals namely, Mobile robot navigation implements (Framework & Applications) and Sensor modules are part of the designs to implement. This technique is being adopted by different countries like USA, European Unions, Denmark, Australia, Finland, India and others. Different specialized navigation techniques like an odometer, vision based, sensor based, inertial, active beacon, GPS, map-based, landmark navigation techniques to operate robots under unified control space for farming has been developed and used for seed-bed preparation, seed mapping, seed placement, reseeding, crop scouting, weed mapping, robotic weeding control, micro-spraying, robotics gantry, robotic

irrigation, etc. (Blackmore et al., 2005)

Scientific literature show that to adapt agricultural machinery for agricultural platforms (autonomous vehicles or mobile robots) (Åstrand and Baerveldt 2002; Cembali et al., 2005; Hannan and Burks, 2004; Alexandratos and Bruinsma, 2015) leads to the development of autonomous navigation for agricultural machine with higher safety. Autonomous robot research is carried out in Canada, Japan, Europe, Australia, the USA and initiated in India also (Cembali et al., 2005; Chi and Ling, 2004; Hannan and Burks, 2004; Gollakota and Srinivas, 2011). But most of the studies on agricultural autonomous robotics research had been performed in controlled environments such as robotic picking of cherry tomatoes (Kondo et al., 1996), cucumbers (Norremark and Griepentrog, 2004), mushrooms (Reid et al., 2001) and other fruits (Kondo et al., 1996). Robots have been applied to horticulture field also like citrus (Hannan and Burks, 2004) and apples (Reid et al., 2001). The development of these platforms found two challenges i.e., developing a physical structure suitable for the agricultural environment, and an electronic architecture to integrate various electronic devices. The architecture should be robust and reliable. It also provide quick and easy maintenance with modularity and flexibility for future expansions and integration with new equipment. The present paper discusses the information about the current status of autonomous agricultural robots designed in different countries as well as in India along with scope of new trends in robotic and mechatronics in agricultural sector.

## Agriculture System Status In India

The projected world's population will be more than 9.15 billion by 2050 (Murakami et al., 2008). Tilman (1999) highlighted the challenge for the next decades about

accomplishing the need of food security of the expanding world population by developing a highly productive agriculture management, along with preserving the environment. Most of the developing countries including India are facing agricultural labour shortage. Majority of youths are shifting from village to urban cities for better life. As a result, agriculture operation gets delayed during its peak seasons due to a labour shortage. Human, animal, and Mechanical power source are utilized in agricultural operation in terms of seed bed preparation, tillage, seeding or transplanting, fertilizer and chemical application, intercultural operation and harvesting. Average power availability on Indian farm is about 2.24 kW/ha (Mehta et al., 2019). These power source operated agricultural machinery do not succeed to optimize the operational cost, time and all other inputs. Most of the farm mechanization depends on tractor as a main - power source. Majority of farmers are still utilising traditional animal operated country plough that gives low output and requires a higher number of field operations. A precession applicator is required for placement of seed at optimum depth for better germination rate. Manually operated implements such as wheel hoe and cono-weeder are presently being used for intercultural operation. Currently battery-assisted weeder, seeder and cutter are also developed (Singh et al., 2019 a, b, c). Most of the farmers in developing country apply nutrients manually without much awareness about available nutrient in the field. Application of nutrient is uncontrolled when applied by hand. Some equipment has been designed for delivering fertilizer uniformly.

### Present Status Of Farm Robots

- a. **MF-Scamp robots:** Pedersen et al. (2008) reported about development of MF-Scamp robots. This robot is for scouting, weeding and harvesting. It has either four wheel or six wheel drive. The intelligent hoe tools mounted in the robot uses vision sensor to locate and identify the crops in rows and column. After that it steers itself accurately. This resulted in reducing the usage of herbicides. Colour sensor is also used to identify weeds between the crops. This kind of design reduces the cost of spraying by decreasing the usage of tractor. The negative effects of the system are the higher costs for small farmers (Fig. 1).
- b. **Autonomous Plant Inspection Research Platform:** This Platform was earlier developed by Madsen and Jakobsen in the year 2001. Thereafter, it was developed by Aalborg University in Denmark for precision farming as third generation autonomous research platform. It has four wheel- drive and four-wheel steering with two motors per wheel i.e., one for providing traction and the other for steering to obtain



Fig. 1. View of MF-Scamp Robots



Fig. 2. API Platform

high mobility in the movement of the robot (Bisgaard et al., 2004). The robot has 60cm high clearance, and a track width of one meter (Fig.2 and Fig 3). The platform is equipped with Real Time Kinematic Global Positioning System. A unit over the head of the frame is for operations like spraying devices, sensors or weeding tools. Farm management software is used for navigation system to compute route plan in the field as well providing anti-collision system (Bak and Jakobsen, 2004). It is possible to create weed patches of the entire field based on orientation of weeds and weeds shape and size. Weed maps of fields are prepared using GPS and GIS systems. The capacity of API platform is 4.32ha/h at speed of 3.6km/h when used in autonomous field scouting. This enables weed mapping system and helpful for precise patch spraying with right mixture of herbicides. This way it reduces the usage of herbicides (30% to 75%). However two issues regarding

collection of data about weeds and manually removal of weeds are identified which needs to be addressed. There are different working spaces in farm land which are inter-row area between crops, intra row within plants and the close to crop area within leaf and root envelope. It is easy for machine to operate at inter-row area in the direction of robot movement but intra-row area is very difficult to manage due to delineated space by irregular spacing of crop plants. Area close to crop should not have soil disturbance as this would lead to soil wetting. The system equipped with intelligent sensor is needed to implement micro spraying or laser weeding.



Fig. 3. Crop scouting platform (Blackmore et al., 2005)

c. **Sub canopy robot ISAAC 2:** This prototype is developed to collect timely and accurate information for assessing crop health and its status. This high clearance platform is having sensors which is integrated with GPS and works above the crop canopy. Bak and Jakobsen (2004) reported about the portal robot (Fig 4) which is used to provide automated crop survey, crop nutrient status, multi spectral responses (stress), visible images (pan Chromatic), weed species and weed density. The position and density (biomass) of different weed species are recorded in the form of weed mapping using machine vision. The methods used to identify weeds around the crop are by recording the increased leaf area in rows (Pedersen, 2001) and active shape recognition can be used to identify weed species by their shape (Sogaard and Heisel, 2002). Presently 19 species of weeds could be recognized using color segmentation (Tang et al., 2000). The weed map is final outcome which is created with the help of the machine vision. The robot gets the position of the weeds which is to remove, kill or retard from the area (Norremark and Griepentrog, 2004). Different non-contact methods such as laser treatments and micro-



Fig. 4. Sub canopy robot ISAAC2 (Blackmore et al., 2005)

spraying are being developed but still complete removal of weeds is not yet achieved (Heisel, 2001).

- d. **BoniRob farming robot developed:** A multi-purpose robotic platform ‘BoniRob’ is developed for applications in agriculture. It consists of four independently steerable drive wheels which has the ability to adjust its track width. This independent steering system makes it highly maneuverable (Fig.5). This robot is powered with batteries (Bangert et al., 2010). It can be retrofitted and upgraded with exchangeable application modules (tools) (Billingsley et al., 2008). The robot can navigate autonomously along plant rows (e.g. obstacle) in the field. It has environmental sensors like LIDAR (Light Detection and Ranging), inertial sensors, wheel odometry, satellite and GPS for row detection and navigation. This robot is developed for applications like chemical weed control or uses a rod device to crush the weeds. It is used to combat volunteer potatoes from the previous year, to measure soil compaction and manage plant breeding. Performance of the robot in carrot fields inferred 90% effectiveness in removal of weeds and preserving crop plants. Attempt to develop communication devices for the robot are in process. Further it would make a cohesive fleet of BoniRobs that will be able to communicate with each other as well as farmers (Griepentrog et al., 2010).
- e. **Lettuce Bot:** Lettuce Bot is also known as Rambo of weeds which was designed by Heraud and the Bot’s co-creator Lee Redden at Stanford University (Fig 6). Computer vision and machine learning algorithm is used in the Bot design. This has a database of more than a million images which are used to identify the plants. After identifying the weed, Bot releases a strong spray of fertilizer to disintegrate the weeds around the plant and fertilizing the lettuce plant (Wheeler et al., 1993).



Fig. 5. BoniRob (V2) in a field



Fig. 6. Lettuce Bot in operation

f. **CROPS:** Clever Robots for Crops (CROPS) has been developed to provide a solution for an automated harvesting procedure under a sponsored by the EU Commission. The other partners in development of the CROPS are the Technical University of Munich, Wageningen University, the research institute, CSIC, and the company FORCE-A (Baker, 2005). Modular and intelligent robot platform consistently recognizes the fruit as well as obstacles. This way it can navigate and harvest on its own in plantations and in greenhouses crops. The robot platform is also planned to be able for treating selected areas with pesticides. The researchers are concentrating on the harvesting of apples and peppers with the help of camera and sensors by developing the right gripping and cutting device (Heisel et al., 1999). The CROPS robotic platform is used for harvesting of ripened fruits only. The process of selection by this robot is detection of fruit then determining its ripeness. After that it moves towards the ripe fruit then grasps it and detaches it softly. It is also capable of specific spraying for targets foliage. The challenges which CROPS prototype faces are related to

identification of the fruit hidden under leaves, grabbing and separating from ripen and unripe fruits due to their different shapes and sizes.

g. **HortiBot:** This is a commercially produced robust tool carrier which is developed for high tech plant like organic grown vegetables. Computer vision based guidance system is used for steering of the HortiBot. The main purpose is to control weed and also enabled an automatic execution of one-sided repetitive weeding for outdoor gardening (Claus et al., 2007). Agrocom Vision has developed row detection system with minimal use of GPS. Therefore, it is capable of passing several parcels with visible rows. The major advantage of this prototype is user friendly as it did not take much time for labor training, reducing the labor cost, doing repetitive tasks like cultivating and other form of mechanical weeding, efficient use of herbicides and thus reducing application cost. Drawbacks of HortiBot is towards its high cost for short term use, need professional operator to operate the machines and can only be used in small farms.

h. **AgBot II:** Queensland University of Technology (QUT), Australia developed AgBot II by using sensor networks, drones, weather, satellite and historical data. Mathematical models have been developed with suitable statistical program. This is for helping farmers to take decisions on the use of herbicides, pesticides, fertilizers and watering (Fig.7). A prototype equipped with sensors and software based operation can work individually or in groups where vision sensors allow robots to “see” whether a plant is a weed or a rose and take action accordingly i.e., chemically or mechanically.



Fig. 7. AgBot II, Australia

i. **Agribot:** BIT Hyderabad, India has developed agricultural robot. called Agribot (Gollakota and

Srinivas, 2011). The aim is to increase the productivity, speed, application accuracy of the work and minimizing the labor of farmers in various activities. Harvesting, spraying, seeding and removing the weeds are the major function of this robot. This robot is based on image processing. Relay controls is used in motor of the robot. A vision based row-guidance method guide robot platform along the crops in row. A camera in the robot gives a live vision of the field. A GPS based module can be installed for large farms depending on the specific land map which can be fixed for harvesting. After harvesting, it can pick up crops and place at desired location. The main obstacle to this kind of robot is non-uniformity of farm.

- j. **Vitirover solar Robots:** French Company developed a smart autonomous robot called 'Vitirover' (Fig. 8) by utilising solar power for the electrical motors which could work for hours without any pause. This is used for cutting grass and weeds in vines (2-to-3 cm of vine) at a speed of 500m/h. Sensors and GPS system used in



Fig.8. Vitirover solar Robots, New Zealand.

- k. **Ecorobotix:** Ecorobotix robot works without human control. It covers the ground just by getting its bearings and positioning itself with the help of its camera and GPS (Fig 9). Its vision system enables it to follow crop rows and to detect the presence of weeds in and between the rows (<https://www.ecorobotix.com/en/autonomous-robot-weeder/>). Two robotic arms then apply a micro-dose of herbicide, systematically targeting the weeds that have been detected. In bare fields or meadows the robot positions itself precisely because of GPS RTK. It has very precise arms, the robot uses 90% less herbicide, making it 30% cheaper than traditional treatments.
- l. **Hands Free Hectare Project:** The project, run by Harper Adams University, Shropshire, England and Precision Decisions, York, England, started working from 2016. This is to be the first in the world to plant, tend and harvest crop remotely, using automated machines(<https://www.harper-adams.ac.uk/news/203368>) without operators in the driving seats or agronomists on the ground.
- m. **Blue river technology:** Cutting-edge computer vision and robotics is used by leader in emerging field of precision agriculture to measure accurately and characterize crops and thereby allow farmers to make decisions on plant-by-plant basis. This increases overall yield and promotes more sustainable farming practices. Blue River works on a wide range of applications like precision thinning that uses a real-time robotic platform to kill unwanted plants (<https://www.intel.ai/>). Locating, identifying, and characterizing each crop is critical in each application.
- n. **Dino Weeding robot:** The robot is designed by Naïo Technologies and has been in the market since early 2017 (<https://www.naio-technologies.com>). Now days, more than 20 robots are used by customers' and



1. Photovoltaic panels
2. Camera and artificial vision for guidance and positioning
3. Navigation by GPS and sensors
4. Electrical drive
5. Rapid robotic arms with sprayers
6. Tanks for two different products

Fig.9. Ecorobotix weeding Robots, Switzerland

partners' on vegetable fields in France and Europe. Dino robot is weeding on large-scale vegetable farms, works autonomously with the help of RTK GPS and Camera. It is equipped with cameras and sensors, the robots are oriented on the farm and they adopt their decisions autonomously. The robot perform weeding one bed after another by itself without human intervention and after finishing the work it sends a text message on smart phone (Fig 10). Its dimensions are 250 cm x 130 cm x 200 cm with 800kg weight. Its working speed is up to 4km/h and can cover up to 4ha/ day.



Fig. 10. Dino Weeding robot

**o. Robotic Precision Planter:** An attempt is made to develop Robotic planter based on Cartesian co-ordinate movement for precision planting at ICAR-IARI, New Delhi (Fig 11). The study was carried out for its control and actuation. Simulation of control, actuation and movement was implemented with the help of ATmega2560 AVR based on microcontroller with designed program for the traction and steering. The prototype Cartesian moved in the X and Y-direction in the longitudinal and lateral direction on the frame of the prototype vehicle. The depth of seeding was controlled by movement of seeding unit in Z-direction. To achieve precise actuation capability, different capacity of stepper motors and drivers were used powered by Pure Lead Tin (PLT) 48Volt 70Ah battery located on both the side of the robotic vehicle platform. It provided power to all four traction motors, four steering motors, and three motors used for Cartesian Coordinate X, Y and Z axis. The system was equipped with an emergency switch to stop the operation under emergent situation. A server based control system was developed for handling the system wirelessly through a graphical user interface. The developed robot was tested to evaluate its action, speed and accuracy of movements. A resolution of 0.21 mm was achieved for actuation. The robotic planter achieved the desired crop geometry with accurate depth of seed placement (Rathod et al., 2019).



Fig. 11. Robotic Precision Planter IARI, New Delhi

Above review clearly indicated the need of farm robot in Indian agriculture too for various farm operations to cater the future needs of modern technology. The work on farm robot is multi-disciplinary in nature and workable prototype can be developed. ICAR-IARI New Delhi has initiated work on this technology.

**Generalized Architecture of Agricultural Robots**

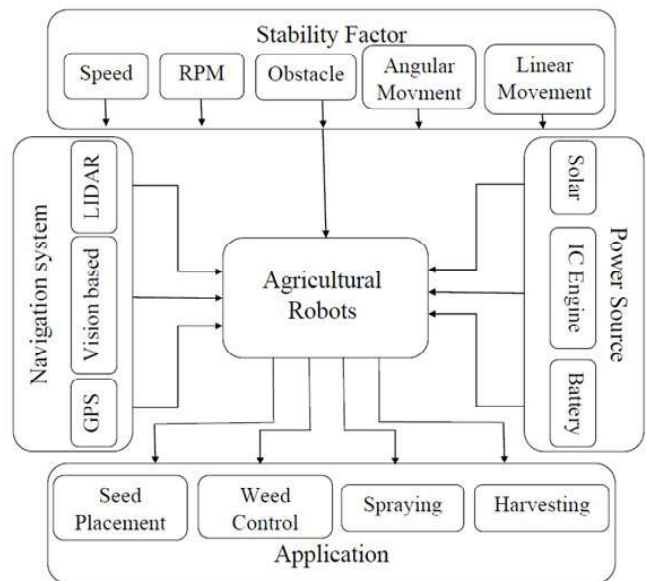


Fig.12. Architecture of Agricultural Robots

A brief idea of the Architecture of Agricultural Robots is shown in Fig12. GPS, Vision processes, LIDAR etc are used in Agricultural (Farm) Robots for navigation in the field. This helps in calculating the waypoints of the field so that robots move accordingly and perform the given operation. The main source of power for agricultural robot may be solar, IC engine and battery. The basic principle for the

agricultural robot is the stability factor while moving in the field as it is controlled by the speed and rpm of the motor. Obstacle detection as well controlling the angular and linear movement of the robot is important factor for its stability. This factors leads to efficient field operation like optimum seed placement, weed control, spraying, harvesting, crop monitoring etc.

### SCOPE OF AUTONOMOUS FARMING

- a. **Data scouting in field:** It is known that crops passes through different stage of growth. Yield in a field may vary depending on a combination of factors (nutrient availability, soil moisture, rooting depth, pest presence, weed density, crop maturity etc). An application of optimum input at appropriate time is required for good agricultural practice. Continuous monitoring and data collection related to crop NDVI, Biomass, Leaf area index, crop growth rate, and water stress are very important parameters for its optimization in different stages of crop growth and crop health. An automated system could be installed within the crop canopy for continuous monitoring as this will be less expensive for crop physical status monitoring and timely data will be available (Gollakota and Srinivas, 2011). Real-time management of inputs could be achieved by sensing different parameters of the crop which can be further processed using microprocessor or micro-controller. The robotic vehicle can continuously monitor the crop canopy by utilizing related data and it will be easy for robot to identify crop diseases and pest attack at an early stage, even in patches. In addition to this, it can monitor weed density and water stress at a different stage of crop growth.
- b. **Intercultural operation:** According to the weed science research, about 33% of the total losses by agricultural pests are caused by weeds only (Aware and Joshi, 2016). Hence, it is important to identify the weeds from the crop and to select spray herbicides for optimizing the chemical application. It is known that the excessive use of herbicides damages the health of people and animals. Agricultural robot with machine vision based technique can accomplish intercultural operation. The advantage of machine vision techniques have already been explained in the paper. A weed maps are generated using these techniques. The robot can appropriately decided weeding technique (mechanical or chemical application) for weeding. Mechanical weeder can be incorporated in removing weeds by partial tillage operation at 2 to 4 cm depth based on actual position of the weeds. Removing weeds between the rows is easier as compared to removing weeds from intra-row. Intra-row weeding requires high-speed sensing device and
- c. **Fertilizer application:** It is a basic and important component as crop nutrient for growth and increasing productivity. The rational use of fertilizers and its technology has a significant effect on the development of agricultural (Yueling et al., 2011). Soil nitrogen is one of the important parts of agricultural production as it has been perceived as a critical nutrient for productivity of crops but it also has important factors of environmental contamination. A major portion of the input fertilizer is lost by leaching which contaminates freshwater, marine ecosystems when high rates of N fertilizers are applied (Tilman, 1999). There are variations of nutrient in quantity within small area of the field and traditional measurements of soil nitrogen with laboratory method are very difficult. Preparation of fertilizer map will guide and assist farmer to vary the rate of application of crop input in a field. This is possible with variable-rate fertilizer application technology. Variable rate fertilize application technology has a potential to apply the input as per need of field which further enhance the economic benefits and maintain soil environmental health. Most of the Variable rate technology is GPS based but some are available on control system based (without GPS) on reckoning up track distance for a variable rate fertilizer applicator. Controlling unit has control over motor rpm at the time of application which is directly responsible for opening area of metering unit or its rpm that is calibrated with the input amount of fertilizer requirement at that particular grid.
- d. **Harvesting:** Bulk harvesting is the common trend of harvesting. But crops like cotton where the maturity of cotton ball achieves at the different time period in a single plant (Robert et al., 2003), therefore in this case selective harvesting of a cotton ball is important. Harvesting of immature crop affects its quality and even production. There is need of threshold parameter to define the range of maturity level for defining crop as mature. In some of crops, selective harvesting is required. This can be assessed using sensing technology. The information obtained with the technology is to be processed through microprocessor or microcontroller. This way, finally defines the status according to which decision support system supply command the mechanical mechanism to harvest of particular crops. Harvesting with the agricultural robot can be done at real-time data sensing. Such kind of precision monitoring and harvesting with the help of farm-robot could help to overcome problem of labor scarcity with quality produce.

## CONCLUSION

The developments of autonomous robot (farm robot) have potential to work on precision agriculture. This will help in continuous monitoring using different sensing technology, that provides different crop status parameter like, micro nutrient availability, bio mass index, status of pest and disease, water stress, thermal stress etc. for better remedial action on crops. The farm robot can compensate the scarcity of agricultural workers with timely performance of various activities. Various technology like machine vision, image processing and mechatronics can be incorporated in a single platform “agricultural robot or farm robot” which can give optimal solution for autonomous agricultural operations for precision, economics, reduced human drudgery and environment protection.

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## Mini Review



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**Key words**  
 Micro plastic Contamination,  
 Fish health, Re-cycle

## Effect of Micro-Plastics (MPs) Contamination on the Fresh Water Fish Health and their Ecosystem

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The production of the plastic throughout the globe is increasing with the accelerating rate due to its durability and multipurpose utility. But due to lack of management practices these plastics are either dumped into the soil profile or thrown into the water bodies. These plastics due to various physio-chemical changes results the MPs of size less than 5  $\mu\text{m}$  which is ultimate hazardous for the soil biota as well as aquatic life. These MPs have potential for the serious health issue which leads up to the mortality as they are the source of the toxins which provides the large surface area to various chemical present in the water bodies. Therefore, comprehensive studies are conducted on the source of the MPs in the fresh water its types and the way they accumulate into the bodies of the fishes. It had been reported that accumulation of these MPs in the fishes causes certain mutagenic changes such as behavioral change, cytotoxicity, neurotoxicity, liver stress etc. From the recent reviewed literature, we concluded that fishes ingest these MPs by assuming their food or accumulate these from consuming from lower tropic organism. Some common studied MPs in the fish's bodies are PE, PVC, PS etc. Our study assures that there is urgent requirement of monitoring the level of contamination of MPs in waterbodies and its environmental concern on aquatic life and thereby its time frame based investigation on the accumulation of micro plastics by fisheries on fresh water rather than unrefresh or muddy water and debate whether this accumulation suggests need of some regulatory legal rules to the bio-dynamics to the eco-system.

### INTRODUCTION

The globe is leading with the plastic production throughout the world with the increasing rate because of the several amenable reasons such as non-corrosive, light weight, easy durable, non-reactive, easy to handle and cheap manufacturing cost. Thus due to its vital role, rate in the developing countries increases acceleratory. The annual plastic production of the globe increases from 15 million tone (1950) to 348 million tone (2017) (Anon., 2019) and every year 20 % of the plastic are recycled every year while rest 80 % of the plastic blurs the ecosystem either by dumping it into the soil or water bodies such as pond, river, lake, ocean etc. It had been found that 55 percent of global plastic waste was discarded, 25 percent was incinerated in the year 2015 (Anon., 2016). These non-recycled plastics due to various physio-chemical and biological changes results to give rise the MPs. Along with these MPs. There are various material such as excreta (raisins and gums) of the plant root, steroids and other. Nano-particles blurs the soil as well as water bodies upto a large extent however, cosmetics which

are the direct source of contamination in the fresh water ranks second in the MPs after the plastics. Most of the studies had been occurred in the muddy, estuarine or marine water systems whereas there is the lack of the data on the abundance and distribution of the of MPs in the fresh water system (Zhao et al., 2015; Su et al., 2016). Most studies impact on the plastic debris biota are their physical effects such as enchantment, ingestion and asphyxia (Barnes et al., 2009; Rayan et al., 2009; Sigler 2014). The MPs are consumed by the fishes via various method and cause adverse effect which leads to the mortality, neurotoxicity, cytotoxicity, liver stress, behavioral changes, oxidative stress, Geno toxicity etc (Luis et al., 2018). The article showed major percentage of the plastics were found in the stomach, gut and intestine of the fishes. To review the current study of the MPs and its impacts on the fresh water is the major objective of this paper along with the objective, types of the micro-plastics, its distribution, method of the ingestion, its impacts several challenges and summary of occurrence are provided for further research work.

### Micro-plastics: Types, overview and sources

Plastics are fragmented on the basis of the size and the type. Size based division of the plastic had been characterized into three parts i.e., large plastic, meso plastic and micro plastic while on the behalf types, these plastics are divided into 5 sub-divisions i.e., fragment, micropilllets, fibers, films and foams (Lee et al., 2013; Anderson et al., 2017; Hidalgo-Ruz et al., 2018). Out of these, micro-plastic is the size based division of the plastic material whose size ranges  $<5\ \mu\text{m}$ . These on the basis of the production is of two types primary and secondary. Primary MPs originates from the textiles, medicine, tooth paste and various personal cosmetics (Cole et al., 2011; Browne et al., 2016). Primary MPs generally fragments into fibers (Rummel et al., 2016), film and foams (Anderson et al., 2017) consisting size  $<5\ \mu\text{m}$  whereas secondary MPs originates from the physio-chemical and biological action or fragmentation of the large MPs degradation. In spite of above processes the debris of the larger particles transforms into MPs by the action of the mechanical forces, thermal degradation, pericyclic reaction, photo-chemical reaction, thermal and optical redox reaction and certain biodegradable process (Zhao et al., 2015) such as synthetic fibers from the washing clothes (Browne et al., 2011). Washing clothes consists of the poly ester, acrylic and polyamide which are the major sources of the secondary micro-plastics whose sizeranges between 100 fibers/lit to 150 fibers/lit (Habib et al., 1998; Browne et al., 2011). There was a myth among the viewers towards size of the plastic material that if the size would be less than  $20\ \mu\text{m}$  it would be referred as micro-plastic in the old view (Thompson et al., 2004). Later on these MPs were considered from ranging  $1\ \text{mm}$  ( $1000\ \mu\text{m}$ ) to  $5\ \mu\text{m}$  (Arthur et al., 2009; Von Couwenberg et al., 2015). The recent research investigates that plastic size less than  $5\ \mu\text{m}$  would be considered as MPs (Betts, 2008; Fendell and Sewell, 2009; Hilalgo-Ruz et al., 2012). The study conspicuous on the types of the MPs and its impacts on the fishes in the fresh water bodies rather than muddy or marine water bodies which is very less in the number (Thompson et al., 2009; House of common 2013; Wagner et al., 2014) The recent survey elicits the information that in the aquatic eco-dynamics, the concentration of MPs is increasing with the increasing rate due to high production i.e. 347 million tons in 2017 (MGarside, Global Plastic Statistics, 2019). According to the viewers the primary source of the plastic which have direct impacts on the fresh water are direct disposal from the public, beach littering and runoff from the factories, cosmetics, shipping sewage and sludge treatments, waste water treatments plants etc. Although the very affecting data come from the runoff factory i.e., it affects upto the large extent. Cosmetics are the specialized form of the MPs which direct influence on the aquatic life in the

fresh water. From a study, the size of the cosmetic size range of four personal care waste were of range  $63\text{--}125\ \mu\text{m}$ ,  $125\text{--}250\ \mu\text{m}$ ,  $250\text{--}500\ \mu\text{m}$  and  $500\text{--}2000\ \mu\text{m}$  (Browne et al., 2015). The basic chemical in MPs are Polyethylene (PE), Polypropene (PE), Polyamine (PA), Polyvinylchloride (PVC), Polystyrene (PS), Polyurethane (PU), Polyethelnyterepthalate (PET) is picturized below which justifies our finding (Hidalgo-Ruz et al., 2012; Van Cauwenbergh et al., 2015; Pitt et al., 2018).

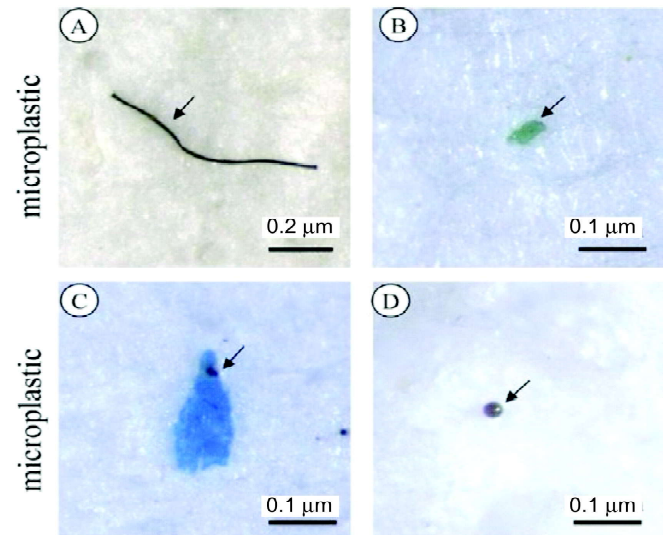


Fig. 1. Photographs of MPs from fish in China (Khaleeda et al., 2016)

### Method of ingestion of Micro-plastics

It had been reported that in more than 270 taxa ingestion of the plastic vitiate its life by several metabolic activities (Laist, 1997). The extent of the vitiation depends upon the type of the taxa, variety and sustaining ecosystem of the tropic level (Cole et al., 2011). Out of these one utmost affected taxa is fish which ingests the plastic or similar material intentionally or unintentionally (Cole et al., 2011; Laist, 1997). Incidental ingestion in search of the natural food item or through the natural tropic transference when fish consumes its pray that already had ingested plastic debris (Peters and Bratton, 2016; Edervall et al., 2012; Mattsson et al., 2015). Plastic materials on the other side are mistaken for the food especially bottom algae or taken as a fragment (Ivar do Sul and Costa, 2007). An experiment was conducted in lab as well pond, in pond a fish and a large plastic debris were broiled which results that fishes frequently attacks and bites on the plastic debris paripassuseveral times in its environment whereas in the lab, fishes were exposed for larvae feeding on the MPs and natural food. Researchers concluded that fish's larva due to incandescent color feed preferentially on the plastic debris rather than natural food (Carson, 2013, Lönnstedt, Eklöv, 2016). The ingested MPs

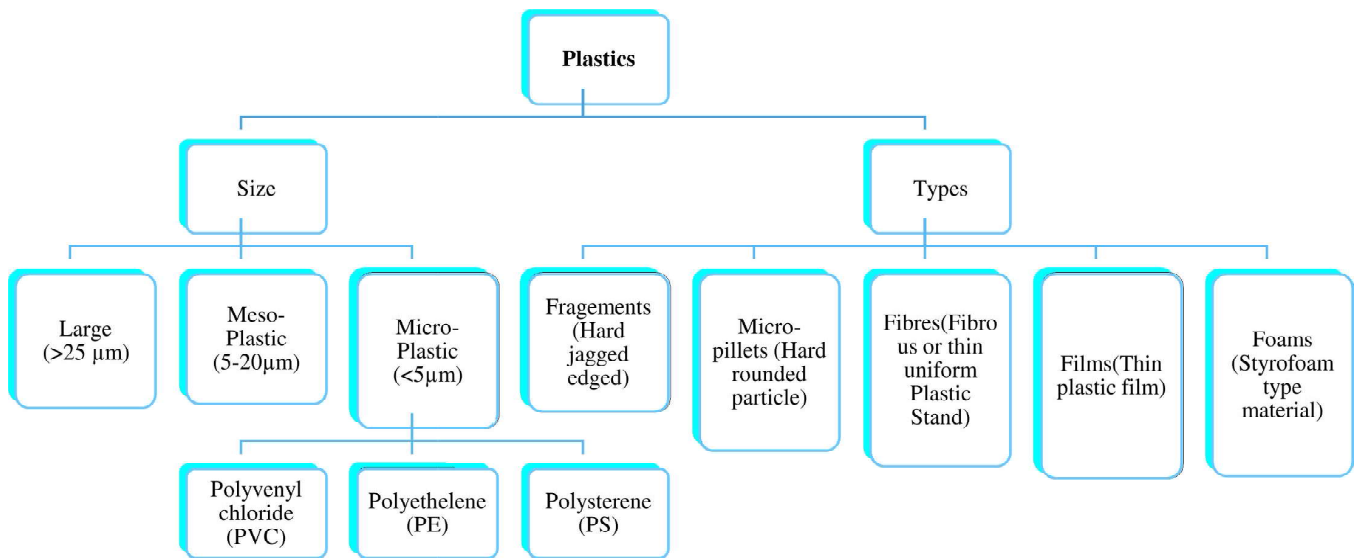


Fig. 2. Flow-diagram of types of plastics information

(Source : Lee et al., 2013; Anderson et al., 2017; Hidalgo-Ruzet al., 2015a; Pitt et al., 2018)

were reported to be deposited inside the stomach, gut, intestinal lining of the fishes which is shown as below:

**Mathematical Inferences**

The impacts of ingestion from the MPs in the fresh water fishes from the different water bodies across the globe were reported by the several researches. The data shows the frequency percentage of the individual uptake of the plastic debris The estuary of the maximum frequency 33% was observed in *Cathorops Agassazzi* which was collected from the Gonia estuary in 2011 whereas *Stellifer brasiliensis* in

2012 Lake Victoria of the African continent among the lake shows the highest frequency of 20%. In this lake *Latesniloticus* and *Oreochromis niloticus* were studied extensively in 2016. A species *Haplosternum littorale* of Pajeu river in the whole assessment have highest statistical frequency of 83% in overall investigation which is predicted to be hazardous of human being via food chain.

The overall results show that species thriving in the river are mostly contaminated with MPs because of the facts that the rivers are most vulnerable to the various sewage discharge with the factory waste.

Table 1. Plastic debris ingestion in fish from freshwater habitats (rivers, estuaries and lakes). The frequency indicates the percentage of individuals observed with the plastic debris inside the gut

| Enviroment | Location                | Species                   | Frequency | Refrence                 |
|------------|-------------------------|---------------------------|-----------|--------------------------|
| Lake       | Lake Victoria (Africa)  | Latesniloticus            | 20        | Biginagwaet al.,(2016)   |
| Lake       | Lake Victoria (Africa)  | Oreochromisniloticus      | 20        | Biginagwaet al.,(2016)   |
| Estuary    | Goina Estuary (Brazil)  | Cathoropsspixi            | 18        | Posattoet al., (2011)    |
| Estuary    | Goina Estuary (Brazil)  | Cathoropsagassizzi        | 33        | Posattoet al., (2011)    |
| Estuary    | Goina Estuary (Brazil)  | Sciadeshertzbergii        | 18        | Posattoet al., (2011)    |
| Estuary    | Goina Estuary (Brazil)  | Stelliferbrasiliensis     | 69        | Dantaset al., (2012)     |
| Estuary    | Goina Estuary (Brazil)  | Stelliferstellifer        | 92        | Dantaset al., (2012)     |
| Estuary    | Goina Estuary (Brazil)  | Eugeressbrasilianus       | 163       | Ramos et al., (2012)     |
| Estuary    | Goina Estuary (Brazil)  | Eucinostomos melanopterus | 92        | Ramos et al., (2012)     |
| Estuary    | Goina Estuary (Brazil)  | Diapterusrhombeus         | 114       | Ramos et al., (2012)     |
| River      | Brazos River Basin (US) | Leponismegalotus          | 44        | Peters and Bratton(2016) |
| River      | Brazos River Basin (US) | Lepomismacrochirus        | 45        | Peters and Bratton(2016) |
| River      | 7 Rivers (France)       | Gobiogobio                | 95-42     | Sanchez et al., 2014     |
| River/lake | Various (USA)           | 26 species                | 5-29      | Philips and Bonner(2015) |
| River      | Pajeu River (Brazil)    | Haplosternumlittorale     | 83        | JS et al., (2016)        |

Source : (Silva-Cavalcanti et al., 2017)

Hence, a hypothesis reflects from the current review is the bio magnifications of the MPs through river water species which is maximum & the consumption of the infected fishes with respect to the MPs can be hazardous for the human also

**Effect of the Micro-Plastic on the Fishes**

Since, the MPs contamination depends upon the extent of the quantity of the uptake, variety and sustaining ecosystem of the tropic level (Cole et al., 2011) with different metabolic disfunctioning therefore the physiology of the contamination towards the fishes due to MPs which is not clearly known MPs ingestion can choke the digestive tract which can cause the starvation and increases the probability of the infection inside the body. Therefore, the dependency revolving the taxa's in the food chain of the infected fish would ultimately cause infection upto the higher tropic levels (Ferrel and Nelson, 2003; Seltenrich, 2015; Sharma and Chatterjee, 2017). MPs ingestion in general may damage the internal digestive enzymes, reproductive systems ( Talvite et al.,

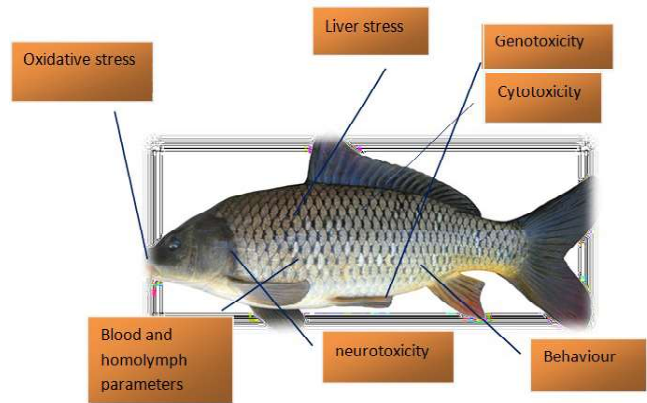


Fig 4. Some of the effects of MPs of freshwater fishes

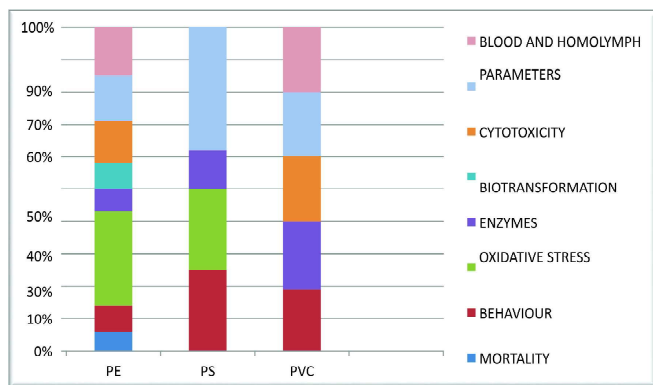


Fig. 3. Eco-toxicological effects of MPs. (data from:Luís Carlos de Sá, Miguel Oliveira, Francisca Ribeiro, Thiago Lopes Rocha, Martyn Norman further, Studies of the effects of MPs on aquatic organisms: What do we know and where should we focus our efforts in the future? Science of The Total Environment, Volume 645,)

2015; Wright et al., 2013). Rochman et al., 2013, shows that tiny particles of low density polyethylene (LDPE) were when exposed to environmental bay condition for three consecutive months then firstly it was fed by the fishes soon after two months the tissue of the fish had greater concentration of persistent bio-accumulative and toxic substances (PBTS) which results to the liver stress, glycogen depletion, fatty vaculation and cell necrosis which shows the negative impacts of these toxins (Rochman et al., 2013). Upto 2014, a total 21 Eco-toxicological effects of MPs was investigated in which ingestion occur either directly or by praying The overall impact on the ingestion of MPs on the fishes include reduction of feeding activity (Besseling et al., 2013, de Sá et al., 2015) oxidative stress (Della Torre et al., 2014) , Geno toxicity (Della Torre et al., 2014) neurotoxicity (Oliveira et al., 2012, Oliveira et al., 2013, Luis et al., 2015, Ribeiro et al., 2017) growth delay ( Della Torre et al., 2014, Au et al., 2015, Redondo-Hasselerharm et al., 2018) reduction in reproductive fitness (Lee et al., 2013, Cole et al., 2015) and ultimately death (Lee et al., 2013, Au et al., 2015, Cole et al., 2015, Mazurais et al., 2015).

Table 2. Summary of MP Effects.

| Effect                                  | Description   | References                                 |
|---|---|--|
| Increased reactive oxygen species (ROS) | Ingested MPs have shown to increase free radicals in which leads to cellular and DNA damage   | Bhattacharya et al., 2010                  |
| Reduced feeding or filtering            | Animals containing MPs in their digestive tracts were found to eat less, resulting in lower energy levels and fat reserves              | Wright et al., 2013<br>Wegner et al., 2012 |
| Immune response                         | MPs in animal tissue can induce an immune response leading to inflammation  | von Moos et al., 2012<br>Köhler, 2010      |
| Hepatic damage                          | Due to metabolic stress caused by MPs, as well as pollutants accumulating on its surface, liver damage has been found in some organisms | Rochman et al., 2013                       |
| Reduced gamete quality                  | Lower gamete quality causes less offspring to be produced and decrease fecundity  | Sussarellu et al., 2014                    |
| Mortality                               | Due to a combination of the physical and physiological effects of MPs particles on certain individuals' fatality is increased           | Lee et al., 2013                           |

Source: Bouwman et al., 2018

## CONCLUSION

The investigation reveals that MPs have an adequate potential to contaminate the fresh water which ultimately affects the environmental dynamics of the aquatic organisms and is increasing day by days, the above represented pictures and graphs are acted as a proof representative of the MPs accumulation and its impact on the fishes.

Based on the above facts the following conclusion can be drawn: -

- 1) Since, most of the studies tend towards the marine or muddy water therefore, there is the lack of study in the fresh water so there need more attention towards the fresh water studies with respect to the fishes.
- 2) The rate of increasing of the MPs increases with the accelerating rate therefore there must be some technical rules which reduces the rate of the plastic dumping in the soil or water bodies.
- 3) Only few personal care must be allowed by the government whose toxic effect and bio-magnification powers with respect to MPs must be evaluated within time bound.
- 4) Cheap and best technical filtering of MPs from the waste water should be adopted at satisfactory level so as there must be the better calculative understanding between the ecological systems.
- 5) Time bounded evaluation should be done towards the prevention, awareness, reduction and counter methods should be developed so as to maintain balance agro-eco-system.

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Mini Review



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# Farm Production and Its Profitability: Farmer Centric Focus

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Study was conducted to develop generic agriculture technology which is need for a change in research system so that area and natural resource specific technologies are developed. The small and marginal farmers are not to be left out of the ambit of modern technologies. Practicability and profitability of the developed technologies will only be adapted by the farmers. In this paper, some examples of farmer and area centric agriculture technologies have been highlighted by introducing a system of “handholding” the farmers in terms of increasing farm production and profitability. The study indicated a need to rejuvenate the extension system to make agriculture production system profitable for the farmers for sustained increase in food production for self-reliance. The policy change will give level playing field to all farmers.

## INTRODUCTION

Some examples of farmer and area centric agriculture technologies have been highlighted in this paper. Even a system of “handholding” the farmers has been explained in terms of increasing farm production and profitability. The decline in contribution of agriculture sector to Indian GDP has largely been due to falling production levels in this sector over the years. The contribution of Agriculture & allied, Industry, and Services sector was 51.81%, 14.16%, and 33.25%, respectively at current prices in 1950-51. Share of Agriculture & allied sector has declined at 18.20% in 2013-14. Share of Services sector has improved to 57.03%. Share of Industry sector has also increased to 24.77% (Figure 1).

natural resources to achieve the unachievable with the current mix of agro-technologies. The other factors for the decline in agriculture production growth have been identified as infrastructure limitations, farm size, farmer capacity and worsening standards of outreach programmes. The agriculture production also remains dependent on adequacy of monsoon rains due to predominant rainfed areas.

Notwithstanding there is debate whether we should focus on enhancing agriculture production per se or farm profitability or perhaps both. While the options for increasing production are dependent on greening of the green revolution, there is tremendous scope for improving farm production profitability and this farmers’ income.

## Agricultural Technology Development

The agriculture technology development has taken place at fast rates. But how much of this technology has been farmer, area or situation specific is a big question mark. Many a times we find that the innovative technologies are not scale neutral. While large or medium farmers are beneficiaries of the innovative technologies, the small are left out of its ambit.

Then there is also mismatch in out stretching technologies developed for assured irrigated to the rainfed or dry land areas. The situation is further confounded by low adoption capability of small and marginal farmers whose numbers are predominant in rainfed and dryland areas. There has been focus on developing rainfed and dryland agriculture technologies but still more has to be done.

Although there are no outer limits to technology advancements but we have observed limitations in their adaptation and adoption by farmers. There are no studies in this regard but the indicators show how the limitations can be overcome by handholding the farmers for breaking the barriers in agriculture production and profitability.

Sectorwise contribution of GDP of India (1950-2014)

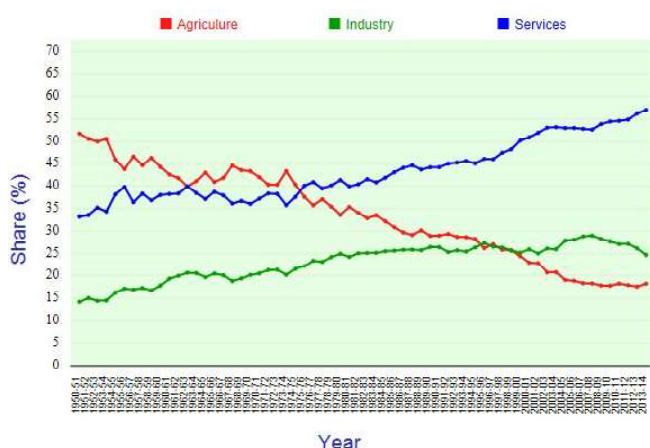


Figure 1. Contribution of Agriculture sector to Indian GDP  
Source: Ministry of Statistics and Programme Implementation

The prospects for achieving an envisaged growth rate viz. 4% or more in agriculture production seems to be bleak. There are ominous signs that we are overstretching our

### Yield Gap Analysis

Several studies have shown that by improving the crop management practices gap in yield realized by farmers' practices and research farm practices can be largely be bridged. And it may be pertinent to point out that even the research farm practices are not able to realise genetic potential of yield of a crop. Jeevalatha et al., (2016) also reported about yield gap analysis of potato under late blight management. Cutworm management technique yielded 29.1 t/ha which was 10.2% higher than local check (26.4 t/ha). Similarly, in case of demonstration plot of, yield was 31.5 t/ha which was 14.5%. According to Dr. BP Singh (CPCRI, Shimla), the potato yield gap in various states can be bridged by improved irrigation and nutrient delivery systems (Table 1).

Table 1. States with high potato yield and reasonable yield gap

|                          | UP   | Bihar | Punjab & Haryana | WB   | Gujarat |
|--------------------------|------|-------|------------------|------|---------|
| Average Potential Yield  | 58.8 | 57.6  | 47.4             | 58.2 | 51.7    |
| Actual Yield             | 23.9 | 20.6  | 24.0             | 30.0 | 30.8    |
| Yield gap attainable (%) | 59.3 | 64.3  | 49.4             | 48.4 | 40.5    |

Trials conducted in western Uttar Pradesh districts showed how sugarcane yield can be increased by use of customised fertiliser even on farmers' field (Table 2). The yield increase registered was considered due to higher nutrient use efficiency realised by their balanced application though fertiliser customised for sugarcane grown in western UP districts. Although the data on cost benefit is not given, enhanced farm income by use of customised fertilisers is imperative.

Table 2. Customised fertiliser use: yield impact

| Crop       | Farmers Practice Yield (t/ha) | Customised Fertiliser Yield (t/ha) | Yield Increase (%) |
|------------|-------------------------------|------------------------------------|--------------------|
| Paddy-Rice | 4.0                           | 4.4                                | 10                 |
| Wheat      | 5.1                           | 5.5                                | 8                  |
| Maize      | 1.6                           | 2.2                                | 38                 |
| Potato     | 29.3                          | 33.8                               | 14                 |
| Sugarcane  | 59.2                          | 65.1                               | 10                 |

Note: Farmer Field Trials in 16 locations in western UP.  
Source: Unpublished report of Tata Chemicals.

### Increasing Farmers Income

The rising cost of production crop production due to escalating farm input prices is hurting the farmers' income. Further the stagnation in crop yields is also discouraging farmers. Suitable actions such as use of location specific

fertilisers can improve farmers' profitability. Researches were conducted under aegis of Tata Chemicals on customised fertilisers specifically developed for wheat, rice, sugarcane and potato. In sugarcane and potato significant yield increase was registered by customised fertilisers over farmer practice or (Figure 2)

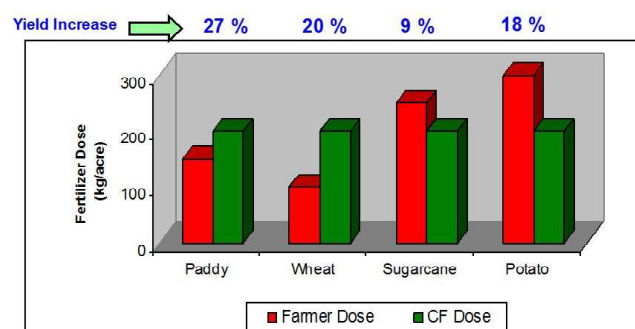


Figure 2. Comparison of performance of farmers' dose vs customised fertiliser dose in farmers' field experiments (>300)  
Source: Unpublished report of Tata Chemical

The yield increases in sugarcane and potato (Figure 3) due to customised fertiliser use together with less nutrient but balanced use through customised fertilisers compared to overdose of fertilisers used by the farmers, helped achieve higher Benefit cost ratio i.e. BCR of 4.7 in case of sugarcane and 100 in case potato. In potato overdosing of fertilisers is rampant. Thus, cost reduction due to optimization of nutrient use by customised fertiliser helped achieve higher BCR.

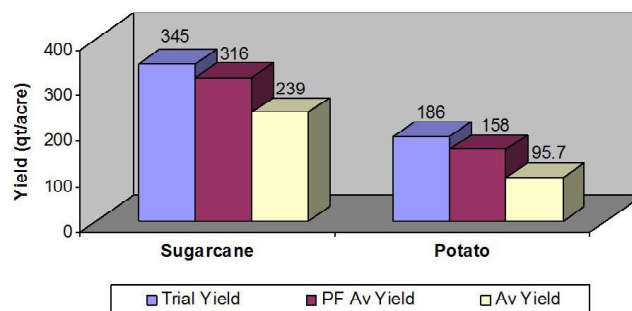


Figure 3. Customised fertiliser experiments on farmers' fields (>300)  
Source: Unpublished report of Tata Chemicals

### Handholding farmer programme

For improving farmers income an example of only one input viz. fertiliser has been sighted above but there are examples of other inputs such as irrigation where optimization has helped reduce its cost without any adverse effect on crop productivity. The "Smart Krishi" programme launched by Tata Chemicals in western districts of UP where rice-wheat cropping system is predominant was basically a

handholding programme with following inputs:

1. Deep ploughing
2. Land levelling by Laser Leveler
3. Customised fertiliser application and sowing by seed cum fertiliser drill
4. Advisory for all other farm operations (package of practices)
5. Harvesting by combines

Each of the above operation is chargeable. The farmers who were registered paid for the operations in advance as they felt secured these services will improve their crop productivity and profitability. Farmers were explained the impact of each of the operations and therefore had confidence to participate in the programme even without any assurances of final yield achievements or the market realisation from the produce.

The smart krishi programme was started in 2010 with rice crop. However, here we have taken example of wheat crop under which 1177 acres or 471 ha were covered with participation of 124 farmers from several villages in western Uttar Pradesh during 2011-12 to 2014-15 (Table 3).

Table 3. Area coverage under wheat in Smart Krishi Programme

| Year  | 2011-12             |                      | 2012-13             |                      | 2013-14             |                      | 2014-15             |                      |
|-------|---------------------|----------------------|---------------------|----------------------|---------------------|----------------------|---------------------|----------------------|
| Crop  | Farmer actual (no.) | Farmer actual (acre) | Farmer actual (no.) | Farmer actual (acre) | Farmer actual (no.) | Farmer actual (acre) | Farmer actual (no.) | Farmer actual (acre) |
| Wheat | 14                  | 138                  | 23                  | 214                  | 30                  | 273                  | 57                  | 552                  |
| Total | 14                  | 138                  | 23                  | 214                  | 30                  | 273                  | 57                  | 552                  |

The average yield level achieved by farmers in the smart krishi programme as compared to their own practices is given in Figure 4.

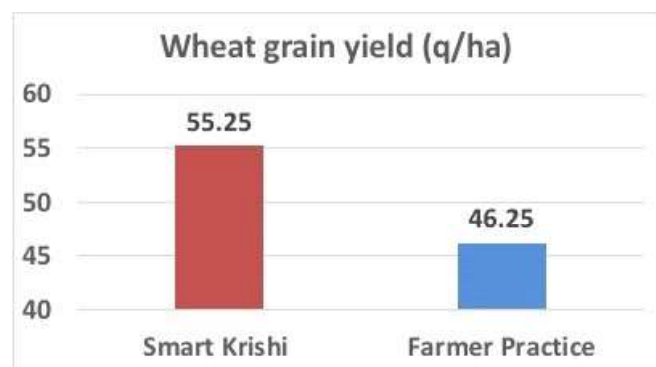


Figure 4. Yield increase due to Smart Krishi Practices

The land treated under smart krishi program had increased wheat production to the tune of 19 per cent (Figure 4). Benefit to cost analysis shows that the farmers for the marginal cost of Rs. 3355 per ha received Rs. 14625 per ha i.e. B:C ratio of 4.4 (Table 4).

Table 4. Benefit accrued by the farmers

|                               |       |
|-------------------------------|-------|
| Marginal Benefit (Rs. per ha) | 14625 |
| Marginal Cost (Rs. per ha)    | 3355  |
| Marginal B:C ratio            | 4.4   |

Higher cost of production in the smart Krishi was mostly due to more investment in inputs to achieve higher production and profitability goals (Table 5).

Table 5. Cost of Production of wheat

| WHEAT  | SK POP (Cost of Cultivation) (Rs/ha) | FP POP (Cost of Cultivation) (Rs/ha) |
|--|--------------------------------------|--------------------------------------|
| <b>Input Expenses</b>  |                                      |                                      |
| Seed   | 3000.00                              | 3125.00                              |
| Crop Nutrition - Basal                                       | 4760.00                              | 2700.00                              |
| Crop Nutrition - Topdressing                                 | 1320.00                              | 1650.00                              |
| Crop Nutrition - Foliar                                      | 1250.00                              | 0.00                                 |
| Pesticide/Weedicide  | 1000.00                              | 1000.00                              |
| Sub Total (Rs/ha)  | 11330.00                             | 8475.00                              |
| <b>Operating Costs</b>                                       |                                      |                                      |
| Deep Ploughing   | 3000                                 | 0.00                                 |
| Land Preparation   | 2500                                 | 2500.00                              |
| Mechanized Sowing  | 750                                  | 750.00                               |
| Harvesting & Straw Reaping                                   | 8750.00                              | 11250.00                             |
| Sub Total (Rs/ha)  | 15000.00                             | 14500.00                             |
| Labor Expenses for Irrigation management & Input Application | 1500.00                              | <b>1500.00</b>                       |
| Gran Total (Rs/ha)   | 27830.00                             | 24475.00                             |

Note: Deep Ploughing is advised once in three to four year  
SK = Smart Krishi; FP = Farmer Practice

Although the cost on weed control and irrigation are similar in SK and FP, but due to laser levelling of fields the irrigation water use efficiency should be more and similarly due to deep ploughing the incidence of weed infestation should be less. So, there could be saving on these inputs by farmers in the long run. And with such realisation farmers should reap more profit with lesser cost of production.

## CONCLUSION

The focus of agriculture sector in India is shifting from production oriented system to farmer income realisation system. It has now been perceived that unless the farmers have the profitable crop production it will difficult to achieve targets of food production or even to sustain it at its current levels. The cost of production of crops has risen in the recent times due to escalation in farm inputs, labour and other prices. The prospects of fiscal interventions seem remote and hence the only way out is the efficient and just use of natural resources and the farm inputs.

More than ever there is need for a paradigm shift in development of agriculture technology. Thus far the focus of agriculture technology development was on how to go on increasing agriculture production. Now there is need that we fine tune the agriculture technology so that the farmers can achieve better crop production together with accruing handsome income. Let us not forget that the question of farm profitability is linked famers' livelihood.

Further it may be pertinent to point out that thus far objective of research was in developing generic agriculture technology. There is need for a change in research system so that area and natural resource specific technologies are developed. So much so that scale neutral agricultural technologies are predominantly dished out to the farmers. The small and marginal farmers are not to be left out of the ambit of these technologies. Needless to emphasize that the adaptation and adoption of agriculture technologies by farmers will rest in their practicability and profitability.

Our current system of agriculture extension is far from satisfactory. There is need to rejuvenate it and this is the call of the time if we have to make agriculture production system profitable for the farmers for sustained increase in food

production for self-reliance.

Finally, the agriculture sector is waiting for policy change which will give level playing field to all farmers. We must go away from input subsidy regime to financial incentives on higher production and productivity as profitable venture. There will not be any need for support prices of farm produce if the farmers have the freedom to sell in an open competitive market.

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## Mini Review



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# Doubling Farmers' Income: Scope and Strategy at Jharkhand

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Food security and doubling of farmer's income by 2022 is one of the top Government's agenda because in past strategy for development of the agriculture sector in India has focused primarily on raising agricultural output while production stagnates and prices were found unstable. The greatest challenge to the agriculture in the years to come is to provide adequate food to burgeoning population in order to combat with hunger and malnutrition. Previously agricultural production has been increased through better technology and varieties and enhanced use of fertilizers, irrigation and agro-chemicals. This strategy paid dividends as the country was able to address massive food shortage during mid-1960s. Since the adoption of green revolution, India's food production multiplied 3.7 times while the population multiplied by 2.55 times. But this strategy did not explicitly recognize the need to raise farmer's income and did not mention any direct measure to promote farmer's welfare. Therefore, it is essential and need of the hour that every state has to mobilize their own strategies and achieve the goal of doubling farmer's income. Although with proper coordination and efforts among centre, state and participation of farmers, the country can achieve the goal of doubling farmer's income. As Jharkhand government is already on the right path of achieving the goal of doubling farmer's income by the year 2022.

## INTRODUCTION

Among all the states Jharkhand's farm household income is 45.3 per cent (Chand Ramesh, 2017). Jharkhand, the 28th State of the Indian Union is best known for its rich mineral resources. However, 78 per cent of the total population of 2.69 crore live in rural areas, largely dependent only on agriculture and allied activities. For doubling the farmer's income it is very much necessary to have the adequate information on farmer's income but it is ironic that estimates of farmer's income are not published by The Central Statistics Office state wise. Though, most recent estimates of farm income were prepared by Chand et al. (2015) for the period 1983-84 to 2011-12. Further, they also reported that the rate of growth was 7.46 per cent a year, which is a great step towards achieving goal of doubling farm income.

In order to this some of the agriculture experts have produced calculations that agriculture will require annual growth of 14.86 per cent per year for five years to get farmer's income doubled (Chand, 2016). It was obvious that the purpose was to double the current income of the farmers or income for the agricultural year 2015-16 by agricultural year 2022-23 which requires annual growth rate of 10.4 per cent.

It is relevant to mention that the latest data on number of cultivators is available only up to the year 2011-12. Therefore, while calculating per cultivator income, it is assumed that farm workers would continue their withdrawal

from agriculture at the rate observed during 2004-05 to 2011-12. Interestingly, even with gradually decreasing number of cultivators in agriculture sector, real income per farmer showed insignificant increase during 2011-12 to 2015-16.

No doubt, it's a difficult call for the Jharkhand government to feed more people with scarce water resources, recurring droughts, undulated lands and difficult access to energy. The agricultural technologies need a shift from production oriented to profit oriented sustainable farming system. For Doubling Farmers' Income (DFI) following measures have been identified as a value led enterprise given below:

### Increase in agricultural productivity

Jharkhand state falls under the agro-climatic zone VII which has been further divided into two subzones. Despite good rainfall, the cropped area and cropping intensity are low.

The cultivable area is estimated around 3.8 million ha but the net sown area is 2.56 million ha and only 12 per cent of cropped area is under irrigation (Jharkhand report, 2012). Thus, agricultural productivity can be increased by two sources *viz.*, area and productivity. Due to rising demand for land for several other uses further expansion in area under cultivation is not feasible. While, there are some reports of decline in agricultural land since the year 2004-05. Therefore, agricultural output can be increased through improvement in productivity of per unit area.

Table 1. Agro-climatic zone VII and their subzones

| S.No. | Sub-zone       | Districts   | Characteristics   |
|-------|----------------|---|---|
| i     | Sun-zone No. 3 | Hazaribagh, Ramgarh, Chatra, Bokaro, Dhanbad, Koderma, Giridih, Deoghar, Godda, Jamtara, Sahebganj, Pakur & Dumka | a. Area of 4.14 million hectares<br>b. Population of 15.32 million<br>c. 6.58% irrigated area<br>d. Coarse textured soils<br>e. Crust formation on the surface of the soil<br>f. Low water retention capacity of the soil<br>g. Erratic and uneven distribution of rainfall<br>h. Lack of safe disposal of runoff and drying of tanks |
| ii    | Sub-zone No. 4 | Palamau, Latehar, Garhwa, Lohardagga, Gumla, Simdega, Ranchi, Khunti, East Singhbhum, West Singhbhum & Saraikela  | a. Area of 2.6 million hectares<br>b. Population of 7.62 million<br>c. Parts of Palamau, Latehar and Garhwa are drought prone areas<br>d. 9.65% irrigated area<br>e. Erratic/uneven distribution of rainfall<br>f. Low water retentive capacity of the soil<br>g. Lack of soil and water conservation practices                       |

**Apart from all these**, there are several additional initiatives required for enhancing the agricultural productivity as elaborated below:

1. Rain water harvesting, conservation and enhancing water use efficiency
2. Adopting water conserving irrigation methods i.e. drip and sprinkler etc.
3. Soil conditioning to increase soil water holding capacity
4. Amelioration of acidic soils
5. Screening, selection and development of acidic soil tolerant varieties.

#### **Diversification towards high value crops**

There is a great scope in Jharkhand to enhance farmer's income through high value horticultural crops such as cultivation of several fruits *viz.*, mango, banana, guava, papaya, tomato and minor forest produce are in abundance in Jharkhand. Scope also exists to raise the income by diversifying towards other allied enterprises like forestry. However there are various legal restrictions on felling of trees and setting of timber industry and transit permit for marketing of timber as a major deterrent to raise trees on private lands due to that farmers are not able to develop forest crops on their private land.

#### **Increase in crop intensity**

Scarcity of irrigation is said to be the main reason for low crop intensity in Jharkhand. However surprisingly, crop intensity on irrigated area, estimated as ratio of gross irrigated area to net irrigated area, is found to be 140 of our country, which is significantly different than crop intensity of this state. Therefore, meets 40 per cent of its non-fuel timber requirement from the import of wood and wood products. Through popularization of intercropping of rice with pulses,

vegetable crops and short duration crops to maintain crop intensity would improve overall productivity of this subsystem.

#### **Promotion of horticultural crops, post harvest and value addition**

In Jharkhand to promote horticultural crops following areas need to be focused on high density orcharding, fruit based multitier cropping system and scaling up of technologies for rejuvenation of old and senile orchards. In non National Horticultural Mission districts, horticulture crops are proposed to be promoted. Fruit crops such as mango, Guava, Citrus fruits, Amla, Jackfruit and other minor fruits, spices such as garlic, ginger, and turmeric are to be promoted.

Apart from this, for promoting vegetable cultivation, quality vegetable seeds, compost and plant protection material should be available for the farmers at government stores. Likewise cultivation of flowers should be encouraged in districts having potential and govt. has set up plant resources centre, mainly for loose flowers, in four districts bulbous flowers. For demonstrative purpose tropical polyhouse for off season vegetable and floriculture can be an alternative and effective source for doubling farmer's income. Subsequently, to promote marketing of horticulture and vegetables and to minimize wastage, pack houses, market yards, grading and packaging centers, refrigerated vans and cold rooms have been proposed by the govt. of Jharkhand.

Secondary agriculture and Entrepreneurship skills

For doubling farmer's income solar energy is a viable option to support secondary agriculture in rural areas in place of electricity. As far as entrepreneurship skills are concerned empowerment of women and youth for sericulture, lac culture, bio-agent production, beekeeping, dairy, goatery,

Piggery and fisheries etc are being implemented at several forums. The task of developing some model village on integrated farming system models like handloom, handicraft, pottery, carpet industry and cottage industry are already being run by KVKs in the state. This can also be a part of their family livelihood and these allied activities could be their secondary source of income.

### Quality seeds

Quality seed is most critical for enhancing agriculture production as setting up of state seed corporation in the primary need. So it should be the primary responsibility of the SAU's to produce required quantity of breeder and foundation seeds of all promising varieties. State government should also ensure procurement of entire seed and timely distribution of seed among farmers. Subsequently, seed reserve at state/district level can also be established. For getting this mammoth target of doubling farmer's income, seed/variety replacement of improved seed varieties should be given priority.

### Fertilizer subsidy, soil fertility and fertilizer use

Without improvement of soil health status, agriculture productivity is tough to improve in Jharkhand. Soil testing is being neglected time and again by the farmer's that is why government is taking keen interest in making soil health card. Based on the need of the soil, it should be treated rationally. For that organic and bio fertilizer, neem coated urea (pelleted urea), vermi-compost and farm yard manure production can be promoted.

### Research and development

State government (Agriculture department), SAUs and KVKs should be supported generously to emerge as key players in rural transformation and wealth creation. The agriculture sector remains among the fastest growing ones in the Jharkhand. This is the need of the hour that SAUs should work in collaboration with government agriculture department and laboratories and farms should be modernized and upgraded by creating state of art facilities.

### Plan and policy making

There are several flagship schemes and policies have been formulated which are very much necessary for doubling farmer's income till 2022. Government of India embraced new economic policies and economy wide reform in 1991. These reforms involved liberalization, deregulation and removal of excessive control and restrictions on private sector which created very favorable macro environment for the private sector participation in economic activities. In order to this government brought several reforms in 2002.

Particularly Jharkhand government have taken several developmental initiatives viz., Jharkhand Opportunities for Harnessing Rural Growth Project (JOHAR), Tribal Sub plan (TSP), Schedule caste sub plan (SCSP), Pradhan Mantri Krishi Sinchai Yojna (PMKSY), Soil health card, National food security mission (NFSM), e-NAM, Pradhan Mantri Fasal Bima Yojna (PMFBY), Mission for Integrated development of Horticulture (MIDH) and Parmaparagat Krishi Vikas Yojna (RKVY-RAFTAAR) to raise output and reduce cost.

### Shift of cultivators to non-farm jobs

The empirical evidence depicted that if same level of progress in various sources of growth, as experienced in the last 10-15 years, is maintained it can achieve 75 per cent increase in per farmer's income by 2022-23 over base year of 2015-16 with better price realization. This falls short of doubling the income (100 per cent increase) by 25 per cent. Thus, to double farmer's income by 2022 the progress in various sources of growth has to be accelerated by 33 per cent (Niti Ayog, 2017). This change could be across the board or more in some area and less in others with overall acceleration of 33 per cent. The details are presented in tabular form as given below.

The low level of farmer's income and year to year fluctuations in it are a major source of agrarian distress and it is spreading and getting severe over time impacting most of the population of Jharkhand that is dependent on farming for livelihood. Therefore, respectable increase in the wages

Table 2: Sources of growth in farm income: Achievements and required growth rate for doubling farmer's income

| S. No. | Source   | Recent achievements           |                           | Required growth rate for DFI |
|--------|--|-------------------------------|---------------------------|------------------------------|
|        |  | Period                        | Growth rate/change        |                              |
| 1      | Crop productivity 70% segment                                | 2001-2013                     | 3.1                       | 4.1                          |
| 2      | Livestock value added 30% segment                            | 2005-2014                     | 4.5                       | 6.0                          |
| 3      | Improvement in resource use efficiency                       | 2005-2012                     | 2.26                      | 3.0                          |
| 4      | Crop intensity (70% segment)                                 | 2001-2012                     | 1 %age                    | 1.3                          |
| 5      | Crop diversification towards fruits and vegetables (70% seg) | 2003-2014                     | 3.89                      | 5.17                         |
| 6      | Better price realisation: Crops                              | Karnataka experience. Reforms | 13% total (in real terms) | 17.0                         |
| 7      | Shift to non - farm occupation                               | 2005-2012                     | 1.81                      | 2.4                          |

in farm sector will also attract youth towards farming profession and ease the pressure on non-farm jobs.

### CONCLUSION

The ambition of the Government of Jharkhand has to be met coherently through productivity enhancement coupled with cost reduction, price realization and policy support. Income from a single crop or commodity will not fulfill the target of doubling farmers' income but it has to emulate from farm and non-farm sources. Diversification of activities which yields better remuneration (area specific) should be the ideal strategy. Most of the developmental initiatives and policies for agriculture are implemented by the state. As progress of various reforms related to market and land lease are also state subjects. Therefore, it is essential to mobilize state to own achieve the goal of doubling farmer's income. With proper coordination and efforts among centre, state and participation of farmers, the country can achieve the goal of doubling farmer's income. If concerted and well coordinated efforts are made by the Jharkhand government with the center the country can achieve the goal of doubling farmer's income by the year 2022.

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Mini Review



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## Guinea Fowl as an Alternative to Chicken

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Guinea fowl is a bird of African origin still semi feral in nature having certain unique advantages over chicken and other poultry species which makes it ideal bird. There are great possibilities for integration with agriculture, horticulture, fisheries and other livestock rearing systems. The present paper is an overview of work done on Guinea fowl to popularize it as an alternative source of chicken. The experiment conducted so far on farm and at on farmer's field on growth, production and reproduction parameter clearly revealed that the guinea fowl can be successfully and beneficially reared by the small and marginal farmers as subsidiary occupation to supplement family income especially when the profit margins from agriculture are shrinking and hence it can serve as alternative source of poultry for India.

### INTRODUCTION

The present worldwide situation of food items calls for a broad range of poultry alternatives to meet increasing demand of quality protein. Besides, complication involved in managing chicken, emergence of new diseases, increase in feed cost and increasing demand of poultry meat bound us to search for alternative species of poultry. In this circumstance rearing of Guinea fowl framed for centuries to meet poultry production requirements of diversified agricultural milieu. The traditionally reared Guinea fowl could become a significant source of food and also a source for substantial supplement income.

### HISTORY

Guinea fowl a bird of West African origin came to India during mediaeval age. Now guinea fowl are being raised in the districts of eastern Uttar Pradesh and in some parts of Tamilnadu. The birds are very popular with marginal farmers and poor classes and are being largely kept as foragers and insectivorous under semi-range and range conditions.

### GUINEA FOWL SPECIALTIES

Guinea fowl are the natural germplasm for the sub-continent and have better resistance against general diseases as compared to chicken. These are hardy birds with a reputation for resistance for most of the poultry diseases. These birds are having gregarious habits which in turn reduce the feed cost. The long neck and legs make them sustainable for grazing. They can eat insect, earth worms, variety of green leaves, vegetables and fruits and variety of feeds in harvested land also. In this way it is helpful in development of low input grain saving aviculture system in Uttarakhand.

It has got better tolerance of aflatoxin in comparison to chicken and hence eat somewhat bad ration to produce good quality of meat. Guinea Fowl eggs have less weight but are hardy and hence have better storage capability. The egg and meat have less cholesterol and hence heart patient can also utilize it. The bird provides variety to existing food basket. Guinea Fowl is the only domesticated bird, which can provide sport quality meat in this era of ban on hunting. It can be raised under a wide range of climatic conditions without any special type of housing etc. Guinea fowl thrive well under adverse climatic conditions, such as poor feeding, poor housing and poor management with variable humidity and temperature. Guinea fowl can eat everything which chickens does not like to consume like grasses, insects, fruits, green leaves and vegetables etc. They don't cause any loss to the field but increase the productivity. Its gregarious habits, flocking instinct, long neck and strong and sufficiently long legs are some of the special advantageous points in favor of the species.

### ADAPTABILITY AND DISEASE RESISTANCE

General disease resistance measures were comparable or higher than that obtained for indigenous fowl (Kadakhnath) and commercial broilers (Saxena 1993). Srivastava and Singh (1988) showed higher resistance of guinea fowl to *Argus persicus* ticks infestation. Similarly, guinea fowl showed lower susceptibility to poultry lice (*Menonpongallinae* and *Lipeurustropicals*). Guinea fowl also seemed to possess high innate tolerance to aflatoxin as compared to chicken and other poultry species. Very few adverse effects were observed among guinea fowl fed 1.0 ppm of aflatoxin (Johri et al., 1988; Bediet et al., 1996).

## Behavior of birds

Survival and performance potential of a poultry species in different conditions is influenced by its inherent behavioral characteristics such as escaped tendencies, broodiness, aggressiveness, social, foraging and feeding behaviors etc. Guinea fowl have gregarious habits and lives in small groups.

## Housing and feeding management

Guinea fowl does not require any special type of housing. The traditional extensive system is most popular in rural areas through out country. It can also be raised in modern intensive system on complete feed, good hygiene and high input. However, its unique status of low input grain saving aviculture can be explored better on extensive system. It has been experimentally proved that there is no significant differences in growth rate between the birds reared on complete feeding and feeding with foraging. This is because of its better digestibility of carbohydrates including pentosan and lignin component of carbohydrate on foraging. Moreover, higher aflatoxin tolerance indicates its potential to utilize lower quality feed ingredient.

In intensive rearing system Guinea fowl keets require 2700 kcal energy/ kg feed and 24 – 26% crude protein to attain optimal body weight up to 12 week of age. However, these birds are not efficient converter of feed as compared to chicken (ratio 3:1) and hence extensive system of rearing Guinea fowl is more popular.

## Reproductive performance of Guinea fowl

Guinea Fowl is a seasonal breeder. Its reproductive performance is affected by environmental causes like temperature, humidity, light, management, feed and diseases etc. Female starts laying from March –April and ended in August –September. The male mature 15 days later than female. The ratio of male to Female should be 1:5 for optimum fertility.

Age at first egg was varied from 250 to 280 days. Egg production was found to be 45-50 eggs in 1st 100 days laying cycle under backyard system and 80 to 110 eggs under intensive system. Guinea fowl eggs are relatively smaller in size than those of the chicken and have an average egg weight about 40g (Singh *et al.*, 1993 and Porval *et al.*, 2002). The shell color is light pink and is due to the porphyrin compounds/ pigments and it is not affected the nutritive value of the egg. The guinea fowl eggs have shape index ranging from 76 to 79 and specific gravity of about 1.20, which was comparatively higher than these parameters in chicken eggs (Singh *et al.*, 1993 and Sajjnar, 1994). The values of fertility and hatchability were observed  $91.52 \pm 0.528$  and  $61.82 \pm 0.921\%$ . Keet weight was recorded  $26.87 \pm 0.12$  g at hatching. The shell of guinea fowl eggs is much thicker

0.42 to 0.45 mm than chicken eggs 0.32 to 0.34 mm (Singh *et al.*, 1993 and Song *et al.*, 2000). Thicker shell with lower porosity makes guinea fowl eggs relatively stronger against shocks, better resistance against contaminations and thus more wholesome (Sajjnar, 1994 and Sachdeva *et al.*, 2006).

## Growth and conformation traits of Guinea fowl

Guinea fowls are reared generally for meat. Growth rate is very important trait for meat production. Body weight was observed  $26.87 \pm 0.12$ ,  $208.02 \pm 1.32$ ,  $619.78 \pm 4.06$ ,  $951.00 \pm 4.87$  and  $1190.14 \pm 5.30$  g. at day old, 4, 8, 12 and 16 weeks of age, respectively. Shank length was observed  $3.22 \pm 0.01$ ,  $4.27 \pm 0.01$ ,  $5.37 \pm 0.02$  and  $6.98 \pm 0.01$  cm at 4, 8, 12 and 16 weeks of age, respectively. The keel bone length was observed  $4.16 \pm 0.01$ ,  $7.41 \pm 0.03$ ,  $8.81 \pm 0.02$  and  $9.96 \pm 0.02$  cm in corresponding age group. The breast angle was recorded  $20.74 \pm 0.10$ ,  $25.17 \pm 0.07$  and  $36.19 \pm 0.06$  ° at 8, 12 and 16 weeks of age, respectively. Growth in guinea fowl is low in comparison to domestic fowl (Sharma and Singh, 2005). The body weight is largely affected by various genetic and non-genetic factors. Among genetic factors, sex and varieties are two important factors (Sharma and Singh, 2005).

## Carcass characteristics and sensory evaluation

For meat production, carcass characteristics are also important. Guinea fowl seem to have about 77% dressing percentage (Mahapatra *et al.*, 1986b; Singh *et al.*, 1999 and Sharma *et al.*, 2000) which is higher than those for commercial broilers. Effect of sex is significant on carcass traits and males have better carcass characteristics (Singh *et al.*, 1999 and Baeza *et al.*, 2000).

Table 1. Reproductive performance of guinea fowl

| S. No. | Character                          | Mean ±S.E.     | Heritability ±S.E.   |
|--------|------------------------------------|----------------|----------------------|
| 1      | Age at sexual maturity (day)       | 250-280        | -                    |
| 2      | Egg production in 100 days Number) | 45-50          | -                    |
| 3      | Egg weight (g)                     | 40.80<br>0.056 | 0.344<br>0.105       |
| 4      | Shape index                        | 77.67<br>0.057 | 0.167<br>0.059       |
| 5      | Fertility                          | 91.52<br>0.528 | 0.135<br>0.048       |
| 6      | Dead germ                          | 12.46<br>0.626 | 0.069<br>0.03        |
| 7      | Dead-in-shell                      | 16.67<br>0.706 | 0.009<br>0.012       |
| 8      | Hatchability                       | 61.82<br>0.921 | 0.144<br>$\pm 0.051$ |
| 9      | Keet weight (g)                    | 26.87<br>0.12  | 0.25<br>0.14         |

Table 2. Growth and conformation traits in guinea fowl

| S. No.                   | Character   | Mean $\pm$ S.E.    | Coefficient of variation | Heritability $\pm$ S.E. |
|--------------------------|-------------|--------------------|--------------------------|-------------------------|
| <b>Body weight (g)</b>   |             |                    |                          |                         |
| 1                        | Day old wt. | 26.87 $\pm$ 0.12   | 8.88                     | 0.25 $\pm$ 0.14         |
| 2                        | 4 week wt.  | 208.02 $\pm$ 1.32  | 12.08                    | 0.21 $\pm$ 0.08         |
| 3                        | 8 week wt.  | 619.78 $\pm$ 4.06  | 15.48                    | 0.17 $\pm$ 0.12         |
| 4                        | 12 week wt. | 951.00 $\pm$ 4.87  | 9.70                     | 1.08 $\pm$ 0.10         |
| 5                        | 16 week wt. | 1190.14 $\pm$ 5.30 | 8.45                     | 0.13 $\pm$ 0.11         |
| <b>Shank length (cm)</b> |             |                    |                          |                         |
| 1                        | 4 week      | 3.22 $\pm$ 0.01    | 6.73                     | 0.23 $\pm$ 0.13         |
| 2                        | 8 week      | 4.27 $\pm$ 0.01    | 8.10                     | 0.42 $\pm$ 0.18         |
| 3                        | 12 week     | 5.37 $\pm$ 0.02    | 8.14                     | 0.07 $\pm$ 0.09         |
| 4                        | 16 week     | 6.98 $\pm$ 0.01    | 4.28                     | 0.13 $\pm$ 0.11         |
| <b>Keel length (cm)</b>  |             |                    |                          |                         |
| 1                        | 4 week      | 4.16 $\pm$ 0.01    | 5.87                     | 0.10 $\pm$ 0.10         |
| 2                        | 8 week      | 7.41 $\pm$ 0.03    | 8.34                     | 0.08 $\pm$ 0.09         |
| 3                        | 12 week     | 8.81 $\pm$ 0.02    | 6.14                     | 0.20 $\pm$ 0.13         |
| 4                        | 16 week     | 9.96 $\pm$ 0.02    | 5.61                     | 0.23 $\pm$ 0.14         |
| <b>Breast angle (°)</b>  |             |                    |                          |                         |
| 1                        | 8 week      | 20.74 $\pm$ 0.10   | 9.44                     | 0.09 $\pm$ 0.10         |
| 2                        | 12 week     | 25.17 $\pm$ 0.07   | 5.84                     | 0.10 $\pm$ 0.10         |
| 3                        | 16 week     | 36.19 $\pm$ 0.06   | 3.20                     | 0.15 $\pm$ 0.12         |

### Socio-economic importance

The land holding is very small in the area and most of them are uneconomic. It has found a special favor with the land less labourers and marginal farmers because of its ability to provide additional income and nutritious food item with out much expenditure on it. There is not exists any type of taboo among poultry farmers regarding the adoption of this newly introduced alternate species of poultry. It reduces the problem of malnutrition to some extent and improved the economic status. It is also a potential source of raising the socio- economic status of poor farmers.

### Marketing and scope of Guinea fowl as an organic food

Guinea fowl rearing is a viable occupation because of the fact that small holder poultry products have already local market of it over in spite of existing religious taboos. Moreover, increasing demand of more and more diversity in poultry products and consumer preference for native free range fed organic poultry products farmer are in favour of Guinea fowl produce. Eggs are used traditionally popular preparations like omelettes, poached egg, scrambled egg, hard boiled egg, egg curry etc. A comparable sensory evaluation study for different egg preparations of Guinea fowl and chicken was conducted and Mohapatra et al., (1986a) reported that significant difference could not be observed for color, texture and chew ability of the preparations from guinea fowl eggs and chicken eggs. However, overall acceptability for most of the preparations was comparatively higher for guinea fowl egg preparations. Low total lipids and

cholesterol in guinea fowl eggs was reported against the chicken eggs (Mohapatra et al., 1986a).

Guinea Fowl production under backyard system finds an important tool to play in the wake of the need of stress free and harmful residue free birds. Uttarakhand has tremendous potential in organic food product because of the existence of traditional backyard system in the area. These birds are mainly kept as foragers and insectivorous under semi-range and range conditions and produce organic products that are fetch high price. Selvam (2004) reported continuous increase in demand of organic meat and eggs due to the introduction of recent concept of organic food.

### Relevance of Guinea fowl as an alternative source of chicken in Uttarakhand and future prospect

Guinea Fowl would be a powerful tool to fight against poverty by creating job opportunities and also increase the production of high biological valued nutritious protein. Guinea Fowl have good adaptation in mountain area and show high resistance against many diseases and stress conditions. Guinea Fowl production seems to be one of the most simple and effective ways to support families to raise their income. Guinea Fowl can be used as organic food along with their eggs and meat under backyard system. If provide a suitable technical inputs, credit facilities, motivation to guinea fowl production and extension facilities, the backyard rearing system of Guinea fowl can be converted to successful organic ventures and as an alternative source of chicken not only in the Uttarakhand but also in the other parts of the country.

## CONCLUSION

Guinea fowl can be successfully and beneficially reared by the small and marginal farmers of Bhabhar and Tarai region as subsidiary occupation to supplement family income especially when the profit margins from agriculture are shrinking and hence it can serve as alternative source of poultry for Uttarakhand.

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## Research Article



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Varieties, nutrient management, grain yield and economics

# Effect of Nutrient Management Practices on Yield, Quality and Nutrient Uptake of Different Soybean Varieties

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A field experiment was conducted during *kharif* season of 2015 on silty clay loam soil at MPKV, Rahuri (MS). The results showed that, the variety KDS-344 recorded significantly the highest grain and stover yield of soybean. The grain yield of soybean was significantly higher by application of fertilizer dose of 125% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS than other treatments, however, it was found at par with 75% GRDF + 0.5 Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS and 100% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS. Similarly, growth and yield attributes viz., plant height (cm), number of branches, number root of nodules, number of pod plant<sup>-1</sup> and weight of seeds plant<sup>-1</sup> (g) were recorded maximum under 125% GRDF + 0.5 Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS. Application of fertilizer dose to soybean 75% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS The total uptake of N, P and K in soybean was recorded significantly the higher by variety KDS-344. The total uptake of nitrogen and phosphorus were recorded significantly higher with application of 125% GRDF (62.5:93.75:00 N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O kg ha<sup>-1</sup> + 6.25 tons FYM ha<sup>-1</sup>) + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS (kg ha<sup>-1</sup>) than the rest of the treatments, however it was found at par with treatment of 75% GRDF + 0.5 Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS and 100% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS. On the basis of experiment, It could be concluded that, the optimum yield, nutrient uptake and higher economic returns of soybean can be achieved by sowing variety KDS-344 fertilized with 75% GRDF (37.5:56.25:00 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 3.75 tons FYM ha<sup>-1</sup>) + 0.5 % Grade II<sup>nd</sup> foliar spray of micronutrient at 30 and 45 DAS.

## INTRODUCTION

Soybean is the premier oilseed crop of India, occupies an area of 116.85 lakh ha and contributes 84.42 lakh tonnes towards oilseed production with 772 kg ha<sup>-1</sup> productivity. Maharashtra occupies 35.85 lakh ha area under soybean and contributes 27.83 lakh tons oilseed production with 776 kg ha<sup>-1</sup> productivity (Anonymous, 2015). Selection of suitable genotype plays a vital role in crop production, particularly in new areas of introduction. The choice of suitable genotype of soybean helps to augment crop productivity by 20-25%. Balanced and timely nutrient management practices applied for soybean contributes to sustainable growth of yield and quality of produce. It also influences plant health and reduces environmental risks. Nutrient management practices involves the use of appropriate combination of organic (FYM) and Inorganic (chemical) fertilizers and foliar spray of II<sup>nd</sup> grade micronutrient at 30 and 45 days after sowing to achieve sustained crop production and for maintaining better soil health. This is best approach for better utilization of resources and to produce crops with less expenditure in soybean (Shinde et al., 2015). It is important to identify the appropriate cultivar and combination of organic, inorganic

and foliar spray of micronutrients which increases yield, improve quality produce and nutrient uptake of soybean. In the present study, an attempt was made to assess the performance of different promising newly released soybean varieties and different nutrient management practices to increase yield potential of *kharif* soybean, for this purpose experiment was conducted on performance of varieties and different nutrient management practices on growth, yield and nutrient uptake of soybean.

## MATERIAL AND METHODS

A field experiment was conducted at Instructional Farm of Post Graduate Institute, MPKV, Rahuri, (19° 48' N latitude and 74° 32' E longitude and 495 meter above mean sea level), in factorial randomized block design with three replications during *kharif* season of 2015. The soil was silty clay loam, having pH 7.72, medium in organic C (0.47%), low in available N (144.57 kg ha<sup>-1</sup>) and medium in available P (17.24 kg ha<sup>-1</sup>) and available K (388.20 kg ha<sup>-1</sup>) and Moderate in organic carbon, pH and EC were 0.47 %, 7.72 and 0.25 dS/m of soil, respectively. Climatologically, this area falls in the semi-arid tract with an annual rainfall varying from 307 to

619 mm. The average annual rainfall at Rahuri is 520 mm. The experiment consists of three varieties viz., V<sub>1</sub>: KDS-344, V<sub>2</sub>: JS-9305 and V<sub>3</sub>: KS-103 and five nutrient management practices viz., N<sub>1</sub>: GRDF (50:75:00 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 5 tons FYM ha<sup>-1</sup>), N<sub>2</sub>: 75% GRDF (37.5:56.25:00 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 3.75 tons FYM ha<sup>-1</sup>) + 0.5% foliar spray of grade II<sup>nd</sup> at 30 and 45 DAS, N<sub>3</sub>: 100% GRDF (50:75:00 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 5 tons FYM ha<sup>-1</sup>) + 0.5% foliar spray of grade II<sup>nd</sup> at 30 and 45 DAS, N<sub>4</sub>: 125% GRDF (62.5:93.75:00 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 6.25 tons FYM ha<sup>-1</sup>) + 0.5% foliar spray of grade II<sup>nd</sup> at 30 and 45 DAS and N<sub>5</sub>: 50:75:30 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 5 tons FYM ha<sup>-1</sup> with 15 treatment combinations. The crop soybean was sown by dibbled at 30 cm x 10 cm in I<sup>st</sup> week of July and harvested at I<sup>st</sup> to III<sup>rd</sup> week of October. The whole dose of fertilizer (N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O kg ha<sup>-1</sup>) were applied at the time of sowing through urea, single super phosphate and muriate of potash. Common treatments of *Rhizobium* and *PSB* were given at the time of sowing and 0.5% foliar spray of grade II<sup>nd</sup> micronutrient (Fe - 2.5%, Zn- 3.0%, Mn-1.0%, Cu-1.0%, Mo-0.1% and Bo-0.5%) was done at 30 DAS and 45 DAS of soybean. The intercultural operations, protective irrigation as per critical growth stages and plant protection measures were carried out as per the recommendations of respective crops. The plant stand and crop conditions were good during the experimental period.

## RESULTS AND DISCUSSION

### Growth and yield

The growth and yield parameters of different varieties and nutrient management practices of soybean were

Table 1. Growth and yield of soybean as influenced by different treatments.

| Treatment                     | Plant height (cm) | Number of branches plant <sup>-1</sup> | Number of nodules at 50% flowering | Number. of pods plant <sup>-1</sup> | Weight of seeds plant <sup>-1</sup> (g) | 100 seed weight (g) | Grain yield (q ha <sup>-1</sup> ) | Stover yield (q ha <sup>-1</sup> ) |
|-------------------------------|-------------------|--|------------------------------------|-------------------------------------|---|---------------------|-----------------------------------|------------------------------------|
| <b>A. Varieties</b>           |                   |  |                                    |                                     |   |                     |                                   |                                    |
| V <sub>1</sub>                | 75.10             | 4.46                                   | 23.11                              | 58.88                               | 11.92                                   | 12.74               | 36.61                             | 46.41                              |
| V <sub>2</sub>                | 63.35             | 4.16                                   | 21.06                              | 46.49                               | 10.23                                   | 11.35               | 32.03                             | 38.22                              |
| V <sub>3</sub>                | 73.94             | 4.12                                   | 22.39                              | 52.85                               | 10.98                                   | 12.39               | 34.07                             | 40.73                              |
| SEm ±                         | 0.54              | 0.07                                   | 0.45                               | 0.55                                | 0.12                                    | 0.10                | 0.47                              | 0.55                               |
| CD at 5%                      | 1.56              | 0.20                                   | 1.29                               | 1.59                                | 0.35                                    | 0.29                | 1.38                              | 1.59                               |
| <b>B. Nutrient management</b> |                   |  |                                    |                                     |   |                     |                                   |                                    |
| N <sub>1</sub>                | 70.34             | 4.3                                    | 21.88                              | 53.02                               | 10.86                                   | 12.22               | 33.51                             | 41.43                              |
| N <sub>2</sub>                | 71.11             | 4.08                                   | 21.63                              | 51.17                               | 10.85                                   | 11.87               | 34.53                             | 42.10                              |
| N <sub>3</sub>                | 70.99             | 4.15                                   | 22.59                              | 53.26                               | 11.12                                   | 12.02               | 34.84                             | 41.92                              |
| N <sub>4</sub>                | 72.46             | 4.74                                   | 23.62                              | 54.30                               | 11.31                                   | 12.35               | 35.79                             | 43.42                              |
| N <sub>5</sub>                | 69.24             | 3.94                                   | 21.20                              | 51.96                               | 11.06                                   | 12.34               | 32.51                             | 40.07                              |
| SEm ±                         | 0.65              | 0.09                                   | 0.58                               | 0.71                                | 0.04                                    | 0.13                | 0.61                              | 0.71                               |
| CD at 5%                      | 1.89              | 0.26                                   | 1.67                               | 2.05                                | 0.15                                    | 0.37                | 1.78                              | 2.06                               |
| <b>C. Interaction (A x B)</b> |                   |  |                                    |                                     |   |                     |                                   |                                    |
| SEm ±                         | 3.28              | 0.15                                   | 2.89                               | 1.23                                | 0.27                                    | 0.36                | 1.07                              | 2.56                               |
| CD at 5%                      | N.S.              | N.S.                                   | N.S.                               | N.S.                                | N.S.                                    | N.S.                | 3.09                              | N.S.                               |

influenced significantly at harvest in Table 1.

The growth and yield parameters viz., plant height (75.10 cm), number of branches (4.46), number of nodules plant<sup>-1</sup> (23.11), number of pod plant<sup>-1</sup> (58.88), weight of seeds plant<sup>-1</sup> (11.92) and 100 seed weight (12.39 g) were recorded significantly higher by soybean variety KDS-344 than variety KS-103 and JS-9305. The variety KDS-344 exhibited superior for grain and stover yield. The higher growth and yield attributes were responsible for achieving higher grain yield (36.61 q ha<sup>-1</sup>) and stover yield (46.41 q ha<sup>-1</sup>) of soybean variety KDS-344 and it was 14.29 and 7.45 per cent higher than JS-9305 and KS-103. It also recorded highest economic indices like gross (Rs.127978), net monetary returns (87355) and B:C ratio (3.17) than variety KS-103 and JS-9305. Similarly, the variety KDS-344 has ability to produce higher photosynthates and dry matter partitioning between roots and shoots. The rate of growth and duration are interrelated into yield, total biomass accumulation and economic returns of crop. These results are in conformity with those reported by Andrade et al. (2005), Kathmale et al. (2013) and Lomte et al. (2006).

The application of fertilizer dose of 125% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS on growth and yield attributes like plant height (72.46 cm), number of branches (4.74), number of root nodules plant<sup>-1</sup> (23.62), number of pod plant<sup>-1</sup> (54.30), weight of seeds plant<sup>-1</sup> (11.31 g) and 100 seed weight (12.35g) were recorded maximum as compared to rest of the treatments. Similarly, these growth and yield attributes were directly reflected on grain yield of soybean and recorded significantly higher grain yield of 35.79 q ha<sup>-1</sup> on application of fertilizer dose @ 125% GRDF

+ 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS than GRDF and 50:75:30 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 5tons FYM ha<sup>-1</sup>, however, it is found at par with 75% GRDF and 100% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS (Table 2). Similarly, application of fertilizer dose @ 125% GRDF (62.5:93.75:00 N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O kg ha<sup>-1</sup> + 6.25 tons FYM ha<sup>-1</sup>) + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 is also recorded maximum gross monetary returns (Rs.124074 ha<sup>-1</sup>) but due to higher cost of cultivation ( Rs.43447 ha<sup>-1</sup>), it decreases B:C ratio (2.85) as compared with 75% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS (2.98) and 100% GRDF + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS ( 3.24). The application of fertilizer dose @ 75% GRDF + 0.5 Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS is beneficial for getting optimum yield (34.53 q ha<sup>-1</sup>) of soybean. Similar results was also obtained by earlier worker (Kathmale et al., 2013; Ramesh and Reddy 2004).

### Quality studies

The difference in varieties showed significant effect on the oil and protein yield of soybean in Table 2.

The soybean variety KDS-344 was also recorded maximum oil and protein content and significantly higher oil yield (7.04 q ha<sup>-1</sup>) as well as protein yield (13.48 q ha<sup>-1</sup>) than rest of varieties KS-103 and JS-9305.

Different nutrient management treatments did not showed any significant differences in oil and protein content as well as oil yield in soybean. While protein yield was significantly affected due to different nutrient management treatments. Application of fertilizer dose @ 125 % GRDF

(62.5:93.75:00 N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O kg ha<sup>-1</sup> + 6.25 tons FYM ha<sup>-1</sup>) + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS recorded significantly maximum protein yield (13.40 q ha<sup>-1</sup>). This might due to soybean grains were accumulated higher concentration of nitrogen which increase the protein and oil synthesis (Table 2). Similar results were also recorded by Ashraf et al. (2013) and Eman Abdel et al. (2014).

### Nutrient uptake

In varietal studies, among the varieties the variety KDS-344 recorded significantly the maximum uptake of N (205.53 kg ha<sup>-1</sup>), P (35.33 kg ha<sup>-1</sup>) and K (79.39 kg ha<sup>-1</sup>) in soybean.

Studies on chemical analysis indicated that the total uptake of nitrogen, phosphorus and potassium were found to be significant due to different nutrient management treatments. The total uptake of nitrogen (199.01 kg ha<sup>-1</sup>) and phosphorus (34.64 kg ha<sup>-1</sup>) were recorded significantly higher with application @ 125% GRDF (62.5:93.75:00 N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O kg ha<sup>-1</sup> + 6.25 tons FYM ha<sup>-1</sup>) + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS than the rest of the treatments but it was at par with treatments of N<sub>3</sub> (195.17 kg ha<sup>-1</sup>) in case of N uptake and in case of P uptake it remains at par with N<sub>2</sub> ( 34.11 kg ha<sup>-1</sup>) and N<sub>3</sub> ( 33.63 kg ha<sup>-1</sup>). While potassium uptake was significantly maximum under treatment of N<sub>5</sub> (83.26 kg ha<sup>-1</sup>). This might be because of balanced application of nutrition with foliar spray in soybean crop, which produces more growth, yield and nutrient uptake. The findings corroborated the results of earlier workers Morshed et al., 2008; Rana and Badliyal, 2014; Sale and Nazirkar 2013.

Table 2. Quality parameters and nutrient uptake by soybean as influenced by different treatments

| Treatments                    | Quality parameters |                  |             |                      | Nutrient Uptake (kg ha <sup>-1</sup> ) |       |       |
|-------------------------------|--------------------|------------------|-------------|----------------------|--|-------|-------|
|                               | Oil (%)            | Oil yield (q/ha) | Protein (%) | Protein yield (q/ha) | N                                      | P     | K     |
| <b>A. Varieties</b>           |                    |                  |             |                      |  |       |       |
| V <sub>1</sub>                | 19.28              | 7.04             | 37.08       | 13.48                | 205.53                                 | 35.33 | 79.39 |
| V <sub>2</sub>                | 19.19              | 6.15             | 37.04       | 12.03                | 170.75                                 | 31.33 | 70.58 |
| V <sub>3</sub>                | 18.91              | 6.44             | 36.97       | 12.91                | 178.56                                 | 32.35 | 71.01 |
| SEm ±                         | 0.24               | 0.13             | 0.15        | 0.22                 | 3.59                                   | 0.62  | 2.04  |
| CD at 5%                      | N.S.               | 0.38             | N.S.        | 0.64                 | 10.39                                  | 1.82  | 5.92  |
| <b>B. Nutrient management</b> |                    |                  |             |                      |  |       |       |
| N <sub>1</sub>                | 18.87              | 6.31             | 36.94       | 12.43                | 178.90                                 | 31.64 | 68.38 |
| N <sub>2</sub>                | 19.07              | 6.58             | 37.16       | 13.29                | 175.81                                 | 34.11 | 71.82 |
| N <sub>3</sub>                | 19.00              | 6.62             | 36.68       | 12.80                | 195.17                                 | 33.63 | 72.70 |
| N <sub>4</sub>                | 19.19              | 6.86             | 37.21       | 13.40                | 199.01                                 | 34.64 | 72.27 |
| N <sub>5</sub>                | 19.53              | 6.34             | 37.17       | 12.11                | 175.84                                 | 31.01 | 83.26 |
| SEm ±                         | 0.31               | 0.17             | 0.19        | 0.29                 | 4.63                                   | 0.81  | 2.63  |
| CD at 5%                      | N.S.               | N.S.             | N.S.        | 0.83                 | 13.42                                  | 2.34  | 7.71  |
| <b>C. Interaction (A x B)</b> |                    |                  |             |                      |  |       |       |
| SEm ±                         | 0.55               | 0.59             | 0.34        | 0.86                 | 18.02                                  | 3.04  | 13.25 |
| CD at 5%                      | N.S.               | N.S.             | N.S.        | N.S.                 | N.S.                                   | N.S.  | N.S.  |

Table 3. Interaction effect between grain yield of soybean by different treatments.

| Treatment   | Varieties | Grain Yield (q ha <sup>-1</sup> ) |                          |                                  |
|---|-----------|-----------------------------------|--------------------------|----------------------------------|
|   |           | V <sub>1</sub> : KDS-344          | V <sub>2</sub> : JS-9305 | V <sub>3</sub> : KS-103          |
| Nutrient management   |           |                                   |                          |                                  |
| N <sub>1</sub> : GRDF (50:75:00 N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O kg ha <sup>-1</sup> + 5tons FYM ha <sup>-1</sup> )  |           | 36.75                             | 31.35                    | 32.45                            |
| N <sub>2</sub> : 75% GRDF (37.5:56.25:00 N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O kg ha <sup>-1</sup> + 3.75 tons FYM ha <sup>-1</sup> ) + 0.5% foliar spray of grade II <sup>nd</sup> at 30 and 45 DAS  |           | 38.51                             | 33.09                    | 32.99                            |
| N <sub>3</sub> : 100% GRDF (50:75:00 N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O kg ha <sup>-1</sup> + 5tons FYM ha <sup>-1</sup> ) + 0.5% foliar spray of grade II <sup>nd</sup> at 30 and 45 DAS          |           | 37.29                             | 31.55                    | 35.70                            |
| N <sub>4</sub> : 125% GRDF (62.5:93.75:00 N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O kg ha <sup>-1</sup> + 6.25 tons FYM ha <sup>-1</sup> ) + 0.5% foliar spray of grade II <sup>nd</sup> at 30 and 45 DAS |           | 39.97                             | 31.91                    | 35.28                            |
| N <sub>5</sub> : 50:75:30 N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O kg ha <sup>-1</sup> + 5tons FYM ha <sup>-1</sup>  |           | 30.36                             | 31.97                    | 35.22                            |
| <b>Source</b><br>(A x B)  |           | <b>SEm +</b><br><b>1.10</b>       |                          | <b>C.D. at 5%</b><br><b>3.18</b> |

### Interaction Effects

Interaction effect between varieties and different nutrient management practices were significant in respect of grain yield of soybean. The data are presented in Table 3. The interaction effects between variety KDS-344 with application of 125 % GRDF + 0.5% II<sup>nd</sup> Grade foliar spray at 30 and 45 DAS recorded significantly highest grain yield (39.97 q ha<sup>-1</sup>) than rest of treatments but however it was at par with variety KDS-344 with application of 75 % GRDF + 0.5% II<sup>nd</sup> Grade foliar spray at 30 and 45 DAS (38.51 q ha<sup>-1</sup>) and KDS-344 with application of 100 % GRDF + 0.5% II<sup>nd</sup> Grade foliar spray at 30 and 45 DAS recorded significantly highest grain yield (37.29 q ha<sup>-1</sup>).

The results showed that, the variety KDS-344 with application @ 125% GRDF (62.5:93.75:00 N:P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> + 6.25 tons FYM ha<sup>-1</sup>) + 0.5% Grade II<sup>nd</sup> foliar spray at 30 and 45 DAS recorded significantly maximum yield of soybean but at par with 75% GRDF (37.5:56.25:00 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 3.75 tons FYM ha<sup>-1</sup>) + 0.5 Grade II<sup>nd</sup> foliar spray of micronutrient at 30 and 45 DAS (Table 2 and 3).

### CONCLUSION

On the basis of the results of experiment, it could be concluded that, the optimum growth, yield and nutrient uptake of soybean can be achieved by sowing of variety KDS-344 fertilized with 75% GRDF (37.5:56.25:00 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + 3.75 tons FYM ha<sup>-1</sup>) + 0.5 % Grade II<sup>nd</sup> foliar spray of micronutrient at 30 and 45 DAS.

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## Research Article



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**Key words**

Broccoli, drip irrigation, black plastic mulch, water use efficiency, yield, economics

# Influence of Different Level of Drip Irrigation and Plastics Mulching on Yield, Quality and Economics of Broccoli Crop under Tarai Region of Uttarakhand

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A field study was carried out at Vegetable Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *rabi* season of the year 2012-2013 to standardize the drip irrigation levels and plastics mulching on growth, maturity, yield, water-use efficiency and economics of broccoli. Seven irrigation levels based on pan evaporation ( $E_{pan}$ ) from a USWB Class-A open pan *i.e.* 100%, 80% and 60 % of PE replenishment daily as well as alternate day along with surface irrigation was tested under two levels of mulching *viz.*, without mulch (open surface) and UV stabilised 50-micron thick black plastic mulch in a two factorial Randomized Block Design replicated thrice. All growth characters, as well as yield and yield attributes, were found significantly higher with 100 % PE replenishment daily under plastic mulch. The highest water use efficiency (WUE) of 13.92 q ha<sup>-1</sup> cm<sup>-1</sup> was observed with 60 % PE replenishment daily through drip under plastics mulch and lowest (6.02 q ha<sup>-1</sup> cm<sup>-1</sup>) with traditional practices *i.e.*, surface irrigation under without mulched (open surface) condition. Highest gross return (Rs.300795ha<sup>-1</sup>), net return (Rs.214969ha<sup>-1</sup>) and benefit-cost: ratio of 1: 3.50 was obtained in 100 % PE replenishment daily with the combination of black plastic mulching.

**INTRODUCTION**

Sprouting broccoli (*Brassica oleracea* var. *italica* L.), a highly nutritious vegetable crop belongs to the family Brassicaceae and is an important member of Cole crops. Due to increasing awareness of its high nutritive values and demand in cities, cultivation of broccoli is gaining popularity in India. In Uttarakhand, broccoli is less known. However, researchers/ farmers experience revealed that this nutritious exotic vegetable could be easily grown in the state. Availability of irrigation water in successful broccoli production is an important aspect and shortage of water is detrimental for head development and drastically reduces the yield. Rapid population growth and need of water for domestic and industrial purpose envisage the needs for the judicious use of water in agriculture. Thus, it is of prime importance to use the right amount and frequency of irrigation water to achieve the maximum production levels. Commonly used irrigation method in India, *i.e.* surface irrigation has considerably low efficiency of 33%, which can be increased to a substantial level by using advanced irrigation methods like a drip irrigation system. The merit of the drip system lies in applying the required quantity of water in the root zone of the crop through a network of tubings. The drip irrigation method is advantageous over traditional methods of irrigation as it provides maximum use of available water, no water being available to weeds,

increase crop yield, decreased tillage, high-quality product, less incidence of insect - pests and diseases, lower operating costs and better use of irrigation water. Research available so far revealed that the use of drip irrigation with black plastic mulching in vegetable cultivation is one of the most efficient management tools for conserving the soil moisture, improves the hydrothermal regime of the soil as per crop need and increase the yield. Mulching also has a positive influence by providing favourable temperature for crop growth and development, improving product quality, water conservation, weed management, and help in getting early and higher yield (Bhatt et al., 2011).

Keeping all the points in view, the importance of judicious use of irrigation water and benefits of drip irrigation and black plastic mulching the present investigation was planned to optimize the irrigation requirement of broccoli using USWB class A open pan under black plastic mulch and without mulched condition *i.e.* open field condition compared to surface irrigation.

**MATERIALS AND METHODS**

The present investigation was carried out at Vegetable Research Centre (VRC) of G. B. Pant University of Agriculture and Technology, Pantnagar U. S. Nagar, Uttarakhand, India. Pantnagar lies in 'tarai' plains of foothills of Shivalik range of Himalayas at 29° N latitude and 79.29°

E longitudes with an altitude of 243.8 m above mean sea level. The pan evaporation and rainfall data during the period of experimentation were recorded at the meteorological observatory located at the Crop Research Centre, Pantnagar, the average pan evaporation was 2.54 mm per day and the average annual rainfall was about 140 cm. The soil of the area was sandy loam in texture and soil pH was 7.1. The available N, P and K content of the experimental field soil were 145.6, 21.67 and 125.13 kg ha<sup>-1</sup>, respectively. The experiment was laid out in Two Factorial Randomized Block Design with three replication. The first factor during the study includes in surface cover by UV stabilized 50 micron black plastic mulch and without mulch (open soil surface) condition. Whereas, seven irrigation leaves *i.e.* 100%, 80% and 60 % PE replenishment daily as well as an alternate along with surface irrigation comprises the second factor. One-month-old broccoli seedlings grown on raised beds were transplanted on 22<sup>nd</sup> November on a raised beds at a spacing of 50 cm x 50 cm on the plastic mulching. The amount of water applied to broccoli *i.e.* daily or alternate day was calculated using mean pan evaporation data obtained from USWB class A open pan separately for each treatment and amount of applied water was controlled with gate valves. Observations for vegetative parameters were recorded by using standard techniques in broccoli. The crop was harvested manually from 31<sup>st</sup> January to 18<sup>th</sup> February, depending upon the maturity of heads. In order to assess the economic viability of different system under variable irrigation, both fixed (interest on initial cost and depreciation on the system) and operating cost including wages of labours incurred since seed sowing in the nursery to final picking along with expenditure on marketing and transportation. The gross and net returns were worked out accordingly by taking cost of cultivation and average sale price broccoli during the growing period. The data recorded were analyzed and were presented in Tables 1 & 2.

## RESULTS AND DISCUSSIONS

### Growth and Development

The data depicted for growth characters (Table 1) revealed that all the growth characters *viz.*, plant height, plant spread, leaf area and stem diameter were significantly influenced by both the factors *i.e.* irrigation levels and plastics mulch used during the study. Among the irrigation levels, irrigating broccoli at 100 % of PE replenishment daily significantly increased the plant height (48.39 cm), plants spread (77.83 cm), leaf area (474.83 cm<sup>2</sup>) and stem diameter (37.74 mm) by the order of 13.6, 10.2, 16.5 and 24.2 % compared to the surface irrigation, respectively. Gradually decreasing the amount of irrigation from 100% to 60% of PE replenishment and to surface irrigation significantly

reduces the vegetative growth. The increase in vegetative growth with an increase in irrigation levels might be due to higher frequency of water managed through drip irrigation, which provides the precise amount of daily requirement of water to the root zone of the plant and maintains proper soil moisture potential in the rhizosphere to reduce plant water stress (Phene and Sanders, 1976). The optimum soil moisture opens the stomatal aperture for gaseous exchange and leads to a higher photosynthesis rate (Turner et al., 1986), which is expressed in terms of more plant growth. In contrast, least plant growth in surface irrigation might be due to alternate excess and moisture stress under surface irrigation temporarily decreased aeration in the root zone and poor aeration causes root injury and reduces the inherent capacity of roots to extract water and mineral nutrient from soil, probably due to the accumulation of excess amount of CO<sub>2</sub>, and adversely affecting the growth and development of plants. A similar observation was also reported in broccoli in 2009 (Kashyap et al., 2009). In case of mulching, significantly higher plant height (47.51 cm), wider plant spread (76.52 cm), maximum leaf area (487.89 cm<sup>2</sup>) and stem diameter (36.70 mm) were recorded under black plastics mulch compared to traditional practice of without mulch condition (44.32 cm, 72.67 cm, 402.84 cm<sup>2</sup> and 30.71 mm, respectively). Increase in growth due to the use of black plastic mulch might be due to the reduced nutrient losses, weed control and improved hydrothermal regimes of soil, which ultimately helps in increasing growth parameters of the plants (Ashworth and Harrison, 1983).

Interaction between mulching and irrigation levels was also found to be significant for plant height and plant spread in this study. As depicted in Table 1, tallest broccoli plants (49.33 cm) with the widest spread of plants 79.50 cm were measured in treatment combination of 100 % PE replenishment daily with black plastic mulch and were both statistically similar with I<sub>2</sub>M<sub>2</sub> (48.64 cm and 78.67 cm, respectively). While the least plant height (40.56 cm) and plant spread (68.89 cm) was measured in surface irrigation with without mulched condition (I<sub>7</sub>M<sub>1</sub>). Increase in plant height and plant spread due to interactive effect of black plastic mulch and higher soil moisture levels might be attributed to the suitable environment conditions *i.e.*, soil moisture status, soil temperature, reduced nutrient losses and weed control in the active root zone, resulted in low soil suction facilitating better water and nutrient uptake by the plant and excellent soil-water and air relationship with higher oxygen concentration in the root zone (Bangal et al., 1987).

### Maturity

Head initiation of broccoli was significantly influenced by both the factors irrigation levels and mulch materials, while their interaction was found to be non-

Table1. Effect of different irrigation levels and plastics mulch on growth, maturity, marketable yield, yield components and WUE of broccoli.

| Treatments                                 | Water applied (cm) | Plant height (cm) | Plant spread (cm) | Leaf area (cm <sup>2</sup> ) | Stem dia. (mm) | Head initiation (days) | Dia. of head (cm) | Net head weight (g) | Yield (q ha <sup>-1</sup> ) | WUE (q ha <sup>-1</sup> cm <sup>-1</sup> ) |
|--|--------------------|-------------------|-------------------|------------------------------|----------------|------------------------|-------------------|---------------------|-----------------------------|--|
| Irrigation levels<br>(PE replenishment, %) |                    |                   |                   |                              |                |                        |                   |                     |                             |  |
| 100 daily (I <sub>1</sub> )                | 20.36              | 48.39             | 77.83             | 474.83                       | 37.74          | 57.25                  | 12.56             | 444.00              | 177.60                      | 8.72                                       |
| 100 at alternate day (I <sub>2</sub> )     | 20.36              | 47.27             | 77.17             | 466.35                       | 36.78          | 56.77                  | 12.14             | 432.00              | 172.80                      | 8.44                                       |
| 80 daily (I <sub>3</sub> )                 | 16.29              | 46.71             | 75.55             | 454.26                       | 34.28          | 56.22                  | 11.97             | 416.00              | 166.40                      | 10.21                                      |
| 80 at alternate day (I <sub>4</sub> )      | 16.29              | 46.27             | 74.08             | 446.19                       | 33.34          | 55.42                  | 11.52             | 399.33              | 159.73                      | 9.80                                       |
| 60 daily (I <sub>5</sub> )                 | 12.22              | 46.06             | 73.97             | 437.63                       | 32.21          | 54.72                  | 10.96             | 377.33              | 150.93                      | 12.35                                      |
| 60 at alternate day (I <sub>6</sub> )      | 12.22              | 44.14             | 72.95             | 430.59                       | 31.19          | 54.23                  | 10.74             | 368.00              | 147.20                      | 12.04                                      |
| Surface irrigation (I <sub>7</sub> )       | 20.36              | 42.57             | 70.61             | 407.70                       | 30.38          | 58.14                  | 10.58             | 343.00              | 139.76                      | 6.86                                       |
| SEM±                                       |                    | 0.28              | 0.31              | 14.18                        | 0.92           | 0.48                   | 0.10              | 4.43                | 1.48                        | 0.16                                       |
| CD (.05)                                   |                    | 0.84              | 0.90              | 41.21                        | 2.66           | 1.40                   | 0.54              | 12.90               | 4.30                        | 0.46                                       |
| Mulching                                   |                    |                   |                   |                              |                |                        |                   |                     |                             |  |
| Without mulch (M <sub>1</sub> )            |                    | 44.32             | 72.67             | 402.84                       | 30.71          | 58.32                  | 10.95             | 348.76              | 139.50                      | 8.57                                       |
| Black polythene mulch (M <sub>2</sub> )    |                    | 47.51             | 76.52             | 487.89                       | 36.70          | 53.89                  | 12.04             | 445.43              | 178.90                      | 10.99                                      |
| SEM±                                       |                    | 0.15              | 0.17              | 7.58                         | 0.49           | 0.26                   | 0.09              | 2.37                | 0.80                        | 0.08                                       |
| CD (.05)                                   |                    | 0.45              | 0.48              | 22.03                        | 1.42           | 0.74                   | 0.29              | 6.90                | 2.30                        | 0.24                                       |
| Interaction                                |                    |                   |                   |                              |                |                        |                   |                     |                             |  |
| I <sub>1</sub> M <sub>1</sub>              | 20.36              | 47.44             | 76.17             | 434.30                       | 34.03          | 59.27                  | 12.09             | 386.67              | 154.67                      | 7.59                                       |
| I <sub>2</sub> M <sub>1</sub>              | 20.36              | 45.89             | 75.67             | 424.22                       | 32.86          | 58.80                  | 11.48             | 374.67              | 149.87                      | 7.36                                       |
| I <sub>3</sub> M <sub>1</sub>              | 16.29              | 45.33             | 74.00             | 412.81                       | 31.20          | 58.37                  | 11.29             | 368.00              | 147.20                      | 9.03                                       |
| I <sub>4</sub> M <sub>1</sub>              | 16.29              | 44.67             | 72.28             | 400.70                       | 30.59          | 57.63                  | 10.73             | 353.33              | 141.33                      | 8.67                                       |
| I <sub>5</sub> M <sub>1</sub>              | 12.22              | 44.56             | 71.61             | 391.30                       | 29.00          | 57.17                  | 10.57             | 329.33              | 131.73                      | 10.78                                      |
| I <sub>6</sub> M <sub>1</sub>              | 12.22              | 41.78             | 70.05             | 384.89                       | 28.89          | 56.83                  | 10.30             | 322.67              | 129.07                      | 10.56                                      |
| I <sub>7</sub> M <sub>1</sub>              | 20.36              | 40.56             | 68.89             | 371.67                       | 28.43          | 60.17                  | 10.17             | 306.67              | 122.67                      | 6.02                                       |
| I <sub>1</sub> M <sub>2</sub>              | 20.36              | 49.33             | 79.50             | 515.37                       | 41.45          | 55.23                  | 13.03             | 501.33              | 200.53                      | 9.84                                       |
| I <sub>2</sub> M <sub>2</sub>              | 20.36              | 48.64             | 78.67             | 508.48                       | 40.70          | 54.73                  | 12.80             | 489.33              | 195.73                      | 9.61                                       |
| I <sub>3</sub> M <sub>2</sub>              | 16.29              | 48.08             | 77.11             | 495.70                       | 37.37          | 54.07                  | 12.65             | 464.00              | 185.60                      | 11.38                                      |
| I <sub>4</sub> M <sub>2</sub>              | 16.29              | 47.87             | 75.89             | 491.67                       | 36.09          | 53.20                  | 12.31             | 445.33              | 178.13                      | 10.92                                      |
| I <sub>5</sub> M <sub>2</sub>              | 12.22              | 47.56             | 76.33             | 483.96                       | 35.43          | 52.27                  | 11.35             | 425.33              | 170.13                      | 13.92                                      |
| I <sub>6</sub> M <sub>2</sub>              | 12.22              | 46.51             | 75.84             | 476.30                       | 33.50          | 51.63                  | 11.18             | 413.33              | 165.33                      | 13.53                                      |
| I <sub>7</sub> M <sub>2</sub>              | 20.36              | 44.58             | 72.33             | 443.73                       | 32.33          | 56.11                  | 10.98             | 379.33              | 156.85                      | 7.70                                       |
| SEM±                                       |                    | 0.40              | 0.44              | 20.05                        | 1.30           | 0.68                   | 0.26              | 6.27                | 2.09                        | 0.22                                       |
| CD (.05)                                   |                    | 1.20              | 1.28              | Ns                           | Ns             | Ns                     | Ns                | 18.24               | 6.09                        | 0.65                                       |

significant. Amongst the different irrigation levels, the earliest head initiation (54.23 days) was observed in I<sub>6</sub> (60 % PE replenishment at alternate day) and was *at par* with I<sub>5</sub> (54.72 days) and I<sub>4</sub> (55.42 days). While the maximum days taken to head initiation was observed in case of surface irrigation (58.14 days) and was *at par* with 100 % PE replenishment both at daily (57.25 days) and alternated day (56.77 days). Increasing the amount of water applied through drip form 60 per cent (54.72 days) to 100 per cent (57.25 days) PE replenishment daily significantly delay the head initiation. Plant that received less or under moisture showed the earliness and began early initiation of head. The delay in head initiation due to higher soil moisture could be attributed to an increase in vegetative growth at higher soil moisture

range and thus thereby delaying the harvesting phase. On the other hand, maximum days taken to head initiation were taken by surface irrigation as uneven supply of irrigation water delays the head initiation. Similar results were also reported by (Ertek et al., 2007) in capsicum. Significantly lesser number of days was taken for head initiation was observed in broccoli by the use of black plastic mulch (53.89 days), which was significantly lesser than without mulch condition (58.32 days). Thus, use of black polyethylene mulch in broccoli advance the head initiation by 4.43 days. Early head initiation of broccoli under black polyethylene was attributed to early growth and development due to higher soil temperature, better soil microclimate (Singh et al., 2005; Bhatt et al., 2011).

Table 2. Economic return of broccoli crop under different irrigation levels and plastics mulch.

| Treatments        | Cost of cultivation ₹ /ha |                |          | Gross return ₹ /ha |                |        | Net return ₹ /ha  |                |        | B: C ratio        |                |      |
|-------------------|---------------------------|----------------|----------|--------------------|----------------|--------|-------------------|----------------|--------|-------------------|----------------|------|
|                   | Mulching material         |                |          | Mulching material  |                |        | Mulching material |                |        | Mulching material |                |      |
| Irrigation levels | M <sub>1</sub>            | M <sub>2</sub> | Mean     | M <sub>1</sub>     | M <sub>2</sub> | Mean   | M <sub>1</sub>    | M <sub>2</sub> | Mean   | M <sub>1</sub>    | M <sub>2</sub> | Mean |
| P <sub>1</sub>    | 74349.89                  | 85825.89       | 80087.89 | 232005             | 300795         | 266400 | 157655            | 214969         | 186312 | 3.12              | 3.50           | 3.31 |
| P <sub>2</sub>    | 74205.89                  | 85681.89       | 79943.89 | 224805             | 293595         | 259200 | 150599            | 207913         | 179256 | 3.03              | 3.43           | 3.23 |
| P <sub>3</sub>    | 73616.64                  | 84868.64       | 79242.64 | 220800             | 278400         | 249600 | 147183            | 193531         | 170357 | 3.00              | 3.28           | 3.14 |
| P <sub>4</sub>    | 73440.64                  | 84644.64       | 79042.64 | 211995             | 267195         | 239595 | 138554            | 182550         | 160552 | 2.89              | 3.16           | 3.02 |
| P <sub>5</sub>    | 72643.39                  | 83895.39       | 78269.39 | 197595             | 255195         | 226395 | 124952            | 171300         | 148126 | 2.72              | 3.04           | 2.88 |
| P <sub>6</sub>    | 72563.39                  | 83751.39       | 78157.39 | 193605             | 247995         | 220800 | 121042            | 164244         | 142643 | 2.67              | 2.96           | 2.81 |
| P <sub>7</sub>    | 72716.25                  | 75201.75       | 73959    | 184005             | 235275         | 209640 | 111289            | 160073         | 135681 | 2.53              | 3.13           | 2.83 |
| Mean              | 73362.3                   | 83409.94       |          | 209259             | 268350         |        | 135896            | 184940         |        | 2.85              | 3.21           |      |

### Yield and yield attributes

As far as the performance of broccoli plants with respect to yield and yield attributes are concerned, it was significantly affected by both the factors studied (Table 1). Diameter of head, net head weight and yield were found significantly higher at higher irrigation level. Amongst the irrigation levels, 18.79 per cent increase in diameter of head, 29.45% increase in average net head weight and 27.11% increase in yield was obtained in 100% PE replenishment daily compared to surface irrigation (10.58cm, 343.00g and 139.76 q ha<sup>-1</sup>, respectively). The total yield of broccoli decreased significantly with a reduction in irrigation levels of the daily and alternate-day irrigation, daily irrigation was found to be significantly better over alternate day except for irrigation at 60% of PE replenishment in which daily and alternate irrigation was statistically similar. The higher yield and yield attributes at higher irrigation levels could be attributed to an adequate supply of moisture which promotes higher uptake of nutrients and ultimately enhancing photosynthesis activity thereby increased the translocation of photosynthesis to storage organ of broccoli. Significantly more diameter of head (12.04 cm), average net head weight (445.43 g), and yield (178.90 q ha<sup>-1</sup>) were recorded under black polyethylene mulch could be attributed to its favourable moisture conserving capacity in soil, as it also improves the microclimate condition that provided a suitable condition in terms of soil temperature and nutrient. These absorbed nutrients might have been utilized by the heads as a result of which there was increase diameter of head, net head weight and yield. Similar finding were also reported in brinjal (Awasthi et al., 2006) and in summer squash (Bhatt et al., 2011). Interaction between irrigation levels and mulch with respect to net head weight and yield was also observed to be significant.

Statistically maximum net head weight (501.33 g) and yield (200.53 q ha<sup>-1</sup>) was observed in black plastic mulch with higher irrigation level daily followed by I<sub>2</sub>M<sub>2</sub> (489.33 g and 195.73 q ha<sup>-1</sup>). While minimum net head weight (306.67 g) and yield (122.67 q ha<sup>-1</sup>) were observed in surface

irrigation under bare field condition. The cumulative effect of black plastics mulch and higher irrigation levels expressed as higher average net head weight and yield due to higher value of moisture level during growth phase under plastic mulching as both the factors favour growth and development in broccoli as described above. A similar finding was also noticed by Yadav and Choudhary (2012) in tomato.

### Water Use Efficiency (WUE)

The water use efficiency was significantly influenced by both the factors and their interactions studied (Table 1). It was measured maximum in 60 % PE replenishment daily (12.35 q ha<sup>-1</sup> cm<sup>-1</sup>) and minimum in surface irrigation (6.86 q ha<sup>-1</sup> cm<sup>-1</sup>) i.e. 80.03 % higher. Increase in irrigation water amount reduces the water use efficiency, while the non-significant influence was observed amongst the daily and alternate-day irrigation. The increased WUE under drip irrigation is because drip system provides a precise and measured quantity of water to every individual plant as per requirement. The saving of water combined with higher yield under drip irrigation are the reasons for increased WUE. Surface irrigated plants showed low WUE because the increased amount of water applied did not result in a corresponding increase in yield. Similar findings were also observed by earlier workers in tomato (Tiwari et al., 1998; Singh et al., 2009). As far as water use efficiency under plastics mulching is considered, it was black polyethylene that gave significantly higher water use efficiency (10.99 q ha<sup>-1</sup> cm<sup>-1</sup>) than the treatment without mulch (8.57 q ha<sup>-1</sup> cm<sup>-1</sup>) as the role of plastics mulch in increasing the yield and water conservation is well known. The cumulative effect of black plastics mulch and lower irrigation levels expressed as higher WUE due to higher saving of water combined with higher yield by both the factors as described above.

### Economic analysis

Use of black plastic mulch during the study proved to be better than that without mulched condition in achieving a higher gross return of Rs. 268350.00 ha<sup>-1</sup> along with the maximum net return of ' Rs.18490.00 ha<sup>-1</sup> and benefit-cost:

ratio 1: 3.21 compared to without mulch in which the benefit-cost ratio is 1: 2.85. Out of irrigation levels, the highest gross return (Rs.266400ha<sup>-1</sup>), net profit (Rs.186312 ha<sup>-1</sup>) and benefit-cost: ratio (1: 3.31) was obtained with 100% PE replenishment daily. However, minimum gross return Rs.209640.00 ha<sup>-1</sup>, the net return of Rs.135681.00 ha<sup>-1</sup> was obtained from surface irrigation. While the minimum benefit-cost ratio of 1: 2.81 was obtained from 60% PE replenishment at alternate day. Among the different treatment combinations, I<sub>1</sub>M<sub>2</sub> (100% PE replenishment daily and black plastic mulch) proved better over all other treatment combinations in terms of achieving higher gross and net return with cost-benefit: ratio *i.e.* Rs.300795.00 ha<sup>-1</sup>, Rs. 214969.00 ha<sup>-1</sup> and 1: 3.50, respectively. Minimum net return and benefit-cost ratio of Rs. 111289.00 ha<sup>-1</sup> and 2.53 respectively, were recorded in traditional practices. The increased net return and higher benefit-cost ratio under black polyethylene mulch were attributed to higher yield, fewer requirements of resources and better management practices resulting in higher economic return to the grower. A similar finding in terms of gross return, net return and benefit-cost: ratio has also been reported by in cabbage (Zaki and Mir, 1992), lettuce (Asaduzzaman et al., 2010), and summer squash (Bhatt et al., 2011).

### CONCLUSION

Based on field study conducted during *rabi* season to standardize the drip irrigation levels and plastics mulching on growth, maturity, yield, water-use efficiency and economics of broccoli, it could be concluded that in order to harvest maximum return from broccoli, it should be grown using 50-micron black plastic mulch and irrigated at 100 % PE replenishment daily through the drip system.

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## Research Article



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## Socio-economic Aspects of the Forage Growers in Rural Subtropics of Jammu Division

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A judicious integration of tree species with agricultural crops and/or animals has been practiced since ancient times across the world in both the tropics and temperate regions. Agro forestry provided both ecological and socio-economic benefits including product for households and national economics like fodder, fruits, and medicines judicious integration of tree species with agricultural crops and/or animals has been practiced since ancient times across the world in both the tropics and temperate regions. The milk yield and care and management of animals depend upon the quality and quantity of feed animals consume. Therefore a Socio-economic aspect of the forage growers in rural subtropics of Jammu Division was taken up in two rain fed districts viz; Samba and Kathua of Jammu region. Nine villages from each district and 6 blocks were selected on purpose. Thus, from 18 villages 144 respondents were selected randomly for study purpose. The data revealed that majority (72.91%) of the farmers were lying in the age group of 43-68 years with a mean of 55(±13). Nearly one half (47.93%) of the responds were having family size of 5-10 members. Regarding educational level 37.51 per cent of the respondents were matriculate with a mean of 8.25± (4.14) .For majority (72.91) of the farmers. Agriculture+labour were main occupation with 116 farmers having marginal land holding of below 1 ha. Agriculture +labour was main source of income for 72.91 per cent of the farmers. Only 4.67 per cent of the farmers were having social participation in the community organizations or other social institutions. Cent percent respondents were aware about the developmental scheme KCC but only a meager percentage (02.77) have availed the loan facility. Majority (95.13%) of the forage growing farmers had not attended the training programme. Cow contributed a major share (61.62) as far as live stock possession is concerned. More than two-third (68.05) of the respondents were having medium level (score 6-9) of information sources with an average score 7.56± (2.25). Among eight independent factors only family size was found to be significant with utilization of agro forestry trees. Z proportion showed significant difference perception regarding utilization of tree species between the two districts. The major constraints uncounted by the respondents were, lack of irrigation facilities, crop damaged by stray animals and lack of training programmes.

### INTRODUCTION

A judicious integration of tree species with agricultural crops and/or animals has been practiced since ancient times across the world in both the tropics and temperate regions. These systems vary from one part of the country to another due its diverse climatic conditions Agro forestry provided both ecological and socio-economic benefits including product for households and national economics like fodder, fruits, and medicines judicious integration of tree species with agricultural crops and/or animals has been practiced since ancient times across the world in both the tropics and temperate regions. Traditionally, people resorted to agro forestry practices for the inter-dependent benefits of the three components, viz. trees, crops and livestock in addition to the 6Fs, i.e. food, fruit, fodder, fuel, fertilizer and fiber. The nutrient cycling exchange and positive spill-off effects of each component brought sustainability to farm production

mechanisms. Most of the agroforestry systems are part of indigenous traditional knowledge of local communities. These systems vary from one part of the country to another due its diverse climatic conditions. Singh (1982) found that agricultural crops are seldom grown specifically for fodder production in India except in certain small areas which account for only less than 2 per cent of the total cultivable area in this country. Cultivation of fodder trees is becoming increasingly important to produce green nutritious fodder for the livestock particularly in the hilly areas where conventional agriculture cannot profitably be practiced and as such extensive plantations of many indigenous and exotic species are raised under social forestry programmes. The trees and shrubs require very little attention in terms of fertilizers, herbicides, fungicides and labour, etc. The leaf fodder of some trees is as nutritious as of leguminous crops. Moreover, more animals feed upon shrubs and trees than on grass or grass-legume pastures which add to their further

importance. Cultivation of fodder crops can greatly contribute towards production of high milk for commercial purposes, besides maintaining ecological balance, uplifting of socio-economic status of the farmers and at the same time diversify the traditional rice-wheat agricultural rotation. Most of the research studies conducted pertaining to analysis of system have dealt with physical & biological aspects, thereby neglecting the systematic analysis of agroforestry fodder trees with respect to its social and economic contributions at farm level. Sood (2003) reviewed that 105 studies on agroforestry adoption (1987-2002) and found that only limited studies were concerned with the tree growing in traditional agroforestry systems. Moreover, these studies were not comprehensive and concentrated on limited number of biophysical and socio-economic factors viz. aspect of the land, altitude, farm size, type of household, distance between house and farm security of land tenure and type of farm of family farms and farm household. It is estimated that out of 500 million heads of livestock, 57 million cattle and 39 million buffaloes fall in the category of milch animals. Among cows, there are about 7.5 million crossbreds with an average milk yield of 6.5 to 7.0 kg/day. The average yield of buffaloes is around 4.0 kg/day, while the indigenous cows yield only about 1.0 kg/day. Because of low productivity, the owners are not keen to feed their low productive animals. As a result, there is no demand for fodder, although the present supply is able to meet only about 40% of the actual requirement (Hegde, 2006). Presently it is estimated that fodder cultivation in subtropical area (Jammu, Samba and Kathua) contributes about 80 percent to the total fodder area of Jammu division. This area has remained almost static since 2-3 decades and there is very little scope for increasing the area under fodder production due to the pressure on land holding to divert the area for other uses. With this view a study entitled "A study on Socio-economic Characteristics of the Forage growers in subtropics of Jammu division" was planned with the objectives (a) to study the personal characteristics of the forage growers, (b) to study the trainings undergone by the forage growers and (c) to study awareness of forage growers about agricultural schemes.

## MATERIALS AND METHODS

The present study entitled "A study on Socio-economic Characteristics of the Forage growers in subtropics of Jammu division" was conducted in Kathua and Samba districts of the Jammu and Kashmir state.

### Kathua:

The district is situated 32° 17' to 32° 55' North Latitude and 75° 70' to 76° 16' East longitude. The District is surrounded by Punjab in the South-East, Himachal Pradesh in North-East, Doda and Udhampur in North and North-

West, Jammu in the West and Pakistan in the South-West with an area of 2651 SqKms having population of 6.15 Lacs with 5 Assembly Constituencies and is also divided into 19 blocks

### Samba

The district is situated between 33° 44' 0" North latitude and 74° 52' 0" East longitudes having 2,651 km<sup>2</sup> area and Samba is situated on the foothills of Shivalik hills along the NH 1-A between 32° 3'. The district has an area of 3,097 km<sup>2</sup>. The climate of the region varies with altitude. In and around the subtropical belt of Jammu region, climate is hot in summers, followed by monsoon and cold.

### Sampling Plan.

**Design:** Descriptive research design was employed for the study

### Selection of districts

There are 10 districts in Jammu region namely: Kathua, Jammu, Samba, Udhampur, Reasi, Rajouri, Poonch, Doda, Ramban, Kishtwar. Out of these districts major areas of Jammu, Kathua, Samba fall in the subtropical zone of the Jammu division, Kathua and Samba districts were selected purposively because these districts have minimum irrigated area (Jammu 102021 ha. Samba 16130ha, Kathua 41493 ha.)

### Selection of blocks

There are 19 blocks in Kathua district and 8 in district Samba. From each selected district 3 Kandi blocks having rainfed conditions were selected purposively. By this way 6 blocks namely Purmandal, Samba, Gaghwal from district Samba and Barnoti, Hiranagar, Dingamb from Kathua districts were selected purposively for the study

### Selection of the villages.

From each block 3 villages having rainfed agricultural conditions were selected purposively. Thus, 18 villages from two districts (9 from each district) were considered for the study.

### Villages selected were:-

- **SAMBA** : Mandal, Nandak, Simblawali, Dhora, Shablote, Naneter, Nonath, Sangwali, Balooni.
- **KATHUA**: Meeruth, Budhi, Nargota, Dingamb, Cheera, Garh, Satoora, Guramehta, Guramundian.

### Selection of the respondents

Eight farmers involved in forage utilization resources were selected randomly from each village. By this way 144 farmers were selected from 6 blocks in two selected district.

An interview schedule was developed for data collection after consulting the specialists from the divisions of Extension Education and Agroforestry. The interview schedule was divided in three parts

### Pretesting of the research schedule

The research instrument was pretested for workability of the instrument. The modifications suggested by the respondents were incorporated in the final questionnaire. The Pre-tested respondents were not considered into the final sample

## RESULTS

### Personal Profile of Forage Growers

**Age:** As is evident from the table 1 over all , majority(72.91%) of the respondents fall in the age group of 43 to 68 years. Only 15.27 per cent of the respondents were in the age group of below 42 years of age. The average age was  $55.91 \pm (12.18)$  in Samba district followed by  $54.83 \pm 12.98$  in case of Kathua district. There was no significant difference in the age groups of the two districts

**Education:** Over all more than one- third (37.51%) of the respondents in the two districts were matriculate followed by middle (27.78%). Illiterate were more (19.44%) in district Kathua than district Samba (9.72%). Only four respondents were graduate and above in Samba and 7 in kathua district.

**Family size:** Over all, more than 101 respondents (70.13%) were having family size of 5 to 10 members. Only 5.55 per cent and 8.33 per cent of the farmers were having above 10 members in their

**Land holding:** Overall more than three fourth(80.55%) of the respondents were marginal farmers ( upto 1 ha). Both district Samba and Kathua were having same number of marginal farmers(15.27%). There was no semi-medium(2 to 4 ha ) and medium (4 to 10 ha) farmers in district Kathua. However small farmers (1 to 2 ha) were more in district Kathua (19.44%) than district Samba (15.27%). Over all land holding average was  $0.75 \pm (0.69)$ .(Table 4.1)

**Occupation** Majority (72.91%) of the respondents were having occupation as agriculture+ labour in district Kathua no respondent was having agriculture +govt. job. However in Samba district 13.19 per cent of the respondents were in govt. job as well as farming. There was significant difference between the two districts (Kathua and Samba) with regard to agricultural +govt. job and agriculture+ labour.)

**Social participation:** Majority(95.83%) of the respondents were members of no organization. In district Kathua only one farmer was member of more than one organization. Kathua district was having 98.61 per cent of farmers who were member of no organization followed by district Samba( 93.05%).

**Annual income** In two districts majority (72.91%) of the farmers were getting income from the agriculture + labour upto Rs.30,000. More than three fourth (83.33%) of the respondents from district Kathua belong to this group. Only 26.38 percent respondents from district Samba and Kathua were affluent and earned above 3 lakh annual income from different sources. Twenty respondents earned their annual income from agriculture + allied+ private job in the range of Rs. 30000 - 3,00000

**Distance:** Overall average distance of the 18 village upto agriculture department was 7 km. while it was 6.50 and 5.27 km upto fodder outlet and input agency respectively.

### Number of Trainings Attended by the Farmers

As is evident from table 4.2 overall 4.80 per cent of the farmers had attended the training from the twin districts of Samba and Kathua respectively. Out of which 6.94 per cent were from district Samba and only 2.77 per cent from district Kathua.

### Areas and duration of the training attended by the farmers:

As is evident from Table no.3 five farmers had attended one month training on Poultry and Mushroom cultivation respectively. One respondent had attended six months training in Poultry in Animal Husbandry Department Samba xFurther the Table depicts that one month duration training was attended by two persons in seed and Vegetable production respectively. Only One respondent had attended horticulture training for 12 days in SKUAST Jammu. No respondent had attended training on Forage crop production. None of the farmers had attended trainings in any areas of agroforestry. Only 4.80 per cent of the respondents had attended training in horticulture seed production, vegetable and mushroom cultivation this may be due to the fact that in Jammu and Kahmir state there is no formal agroforestry system established and farmers follow their traditional practices in different agricultural and allied patterns. Much priority has not been given to organising trainings by the state social forestry department and the departments concerned with it.

### Awareness About Agricultural Schemes

The table 4 reveals that 100 per cent respondents in both districts were having awareness about agricultural scheme Kissan Credit Card (KCC). Overall Only 4.16 per cent of the respondents had availed loan under this scheme. Under Crop Insurance scheme only 24.30 per cent of the respondents were having awareness. Maximum awareness in crop insurance scheme was from Kathua district (27.77%).

Table.1 Descriptive Statistics Regarding Socio-Economic Status of the Farmers

| Particulars   | Samba (n=72)  | Kathua (n=72) | Overall (N=144) | Diff. | Statistic (p-value) |
|---|---------------|---------------|-----------------|-------|---------------------|
| <b>Age</b>  |               |               |                 |       |                     |
| i. Upto 42 years  | 11<br>(15.27) | 11<br>(15.27) | 22<br>(15.27)   | 0     | -                   |
| ii. 43-68 years   | 52(72.22)     | 53(73.61)     | 105(72.91)      | 1     | z=0.18(0.84)        |
| iii. Above 68   | 9(12.50)      | 8(11.11)      | 17(47.22)       | 1     | z=0.25(0.79)        |
| Average Age(in years)                                   | 55.91±12.18   | 54.83±12.98   | 55(±13)         | 1.08  | t=0.51(0.60)        |
| <b>Education:-</b>                                      |               |               |                 |       |                     |
| <b>Level of Education</b>                               |               |               |                 |       |                     |
| i. Illiterate   | 7(9.72)       | 14(19.44)     | 21(14.58)       | 7     | z=1.65(0.09)        |
| ii. Primary   | 2(2.77)       | 6(8.33)       | 08(05.55)       | 4     | z=1.45(0.14)        |
| iii. Middle   | 20(27.77)     | 20(27.77)     | 40(27.78)       | 0     | -                   |
| iv. Marticulate   | 33(45.83)     | 21(29.16)     | 54(37.51)       | 12    | z=2.06(0.03)*       |
| v. 10+2   | 6(8.33)       | 4(5.55)       | 10(06.95)       | 2     | z=0.65(0.50)        |
| vi. Graduate and above                                  | 4(5.55)       | 7(9.72)       | 11(07.63)       | 3     | z=0.94(0.34)        |
| Average formal years of schooling                       | 8.77±3.49     | 7.73±4.66     | 8.25±(4.14)     | 1.04  | t=1.51(0.13)        |
| <b>Family size</b>                                      |               |               |                 |       |                     |
| i. Upto 4 Members                                       | 14(19.44)     | 19(26.38)     | 33(22.91)       | 5     | z=0.99(0.32)        |
| ii. 5-10 Members  | 54(75)        | 47(65.27)     | 101(70.13)      | 7     | z=1.27(0.20)        |
| iii. Above 10 members                                   | 4(5.55)       | 6(8.33)       | 42(29.16)       | 2     | z=0.65(0.50)        |
| Average family size                                     | 6.61±2.38     | 6.44±2.89     | 6.5±(2.64)      | 0.17  | t=0.37(0.70)        |
| <b>Land holding</b>                                     |               |               |                 |       |                     |
| i. Marginal( Upto 1ha)                                  | 58(80.55)     | 58(80.55)     | 116(80.55)      | 0     |                     |
| ii. Small(1-2 ha)                                       | 11(15.27)     | 14(19.44)     | 25(17.36)       | 3     | z=0.66(0.50)        |
| iii. Semi medium(2-4 ha)                                | 1(1.38)       | 0             | 1(0.69)         | 1     | z=1.00(0.31)        |
| iv. Medium(4-10 ha)                                     | 2(2.77)       | 0             | 2(1.38)         | 2     | z=1.42(0.15)        |
| v. Large(above 10ha)                                    | 0             | 0             | 00(00.00)       | 0     |                     |
| Average Land holding                                    | 0.82±0.84     | 0.68±0.50     | 0.75±(0.69)     | 0.14  | t=1.51(0.25)        |
| <b>Occupation</b>                                       |               |               |                 |       |                     |
| i. Agriculture+Govt.job                                 | 19(13.19)     | 00(00.00)     | 19(13.19)       | 19    | z=4.67(0.001)**     |
| ii. Agricultural+Private job                            | 8(5.55)       | 12(8.33)      | 20(13.88)       | 4     | z=0.96(0.33)        |
| iii. Agriculture  | 45(31.25)     | 60(41.66)     | 105(72.91)      | 15    | z=2.81(0.004)*      |
| <b>Social Participation</b>                             |               |               |                 |       |                     |
| Member of no organization                               | 67(93.05)     | 71(98.61)     | 138(95.83)      | 34    | z=1.66(0.09)        |
| Member of one organization                              | 5(6.94)       | 1(1.38)       | 06(4.17)        | 4     | z=1.66(0.094)       |
| <b>Annual income</b>                                    |               |               |                 |       |                     |
| 1. Agricultural+labour (upto 30,000)                    | 45<br>(62.05) | 60<br>(83.33) | 105(72.91)      |       |                     |
| 2. Agricultural+private job +retired (30,000 to 3 lakh) | 08 (11.11)    | 12 (16.66)    | 20 (13.88)      |       |                     |
| 3. Agricultural+Govt.job (above 3 lakh)                 | 19<br>(26.38) | -             | 19<br>(26.38)   |       |                     |
| <b>DISTANCE (average in km)</b>                         |               |               |                 |       |                     |
| Agricultural department(km)                             | 6.77          | 7.22          | 7.00            |       |                     |
| Fodder outlet(km)                                       | 5.77          | 7.22          | 6.50            |       |                     |
| Input agency(km)  | 5.77          | 7.22          | 5.27            |       |                     |

Table 2. Number of trainings attended by the farmers

| Training Attendent | Samba | Frequency | Kathua | Frequency | Overall Frequency |
|--------------------|-------|-----------|--------|-----------|-------------------|
| Yes                | Yes   | 05(06.94) | Yes    | 02(02.77) | 07(04.80)         |
| No                 | No    | 67(46.52) | No     | 70(97.22) | 137(95.13)        |

Figures in parenthesis show percentage

Table 3. Areas and duration of the training attended by the farmers

| S.No. | Name of the Training | Number | Period  | Venue                   |
|-------|----------------------|--------|---------|-------------------------|
| 1     | Horticulture         | 1      | 12 Days | SKUAST-JAMMU            |
| 2     | Seed Production      | 1      | 1 Month | Agri.deptt.             |
| 3     | Vegetable            | 1      | 1Month  | SKUAST-JAMMU            |
| 4     | Poultry              | 1      | 6 Month | Samba, Animal husbandry |
| 5     | Poultry              | 1      | 1 Month | Samba, Aminal husbandry |
| 6     | Mushroom cultivation | 2      | 1Month  | KVK Kathua              |

Table 4. Awareness about agricultural schemes.

| Scheme         | Samba (n=72)  | Loan availed no | Kathua (n=72) | Loan availed no | Overall Awareness(no.) (n=144) | Loan availed (no.) |
|----------------|---------------|-----------------|---------------|-----------------|--------------------------------|--------------------|
| KCC            | 72<br>(100)   | 4<br>(55.55)    | 72<br>(100)   | 02<br>(02.77)   | 144<br>(100.00)                | 06<br>(04.16)      |
| Crop insurance | 15<br>(20.83) | 00<br>(00.00)   | 20<br>(27.77) | 00<br>(00.00)   | 35<br>(24.30)                  | 00<br>(00.00)      |

### Number of Livestock Possessed by the Farmers in the Study Area

Table 5 shows that numbers of livestock possessed by the respondents in the study area. Overall cows were leading with 403 numbers followed by goat 211 and buffalo 40. District Kathua was having highest numbers of cows and goats (208 and 108 numbers) respectively.

However in district Samba 72 respondents were possessed only 29 buffaloes. However, in district Samba 72 respondents were possessed only 29 buffaloes. The overall average number of animals in two districts was 4.54( $\pm 7.3$ ) there was no significant difference in the livestock possession of the two districts.

### Quantity of FYM produced by the animals in the study area

Table 6 shows that cow was having highest percentage (61.62) among the animal possessed by the respondents. The

cows were contributing 5.02 kg of the dung and buffalo 06.87kg to FYM produced by the respondents.

Goat contributed only 700 grams. Cows and buffaloes were contributing 3 to 4 trolleys and 5 to 6 trolleys of FYM per household/animal/year, respectively

### DISCUSSION

The data revealed that majority of the fodder growers were middle to old age group indicating no involvement of youth in fodder cultivation. The involvement of youth in agriculture can solve the problem of unemployment to certain degree. Majority of the fodder growers were literate. Thus majority of farmers can utilise the printed literature as a source of information. Nearly one half (47.93%) of the respondents were having family size of 5-10 members thereby less dependence on hired labour and in turn saving some amount on account of labour charges. For majority (72.91) of the farmers, Agriculture+labour was main occupation with

Table 5. Livestock Possessed By the farmers in study area

| Livestock                 | Samba n=72         | Kathua n=72        | Overall n=144     | Diff. | (t-value)         |
|---------------------------|--------------------|--------------------|-------------------|-------|-------------------|
| i. Cow                    | 195<br>(59.63)     | 208<br>(63.60)     | 403<br>(61.62)    | 13    |                   |
| ii. Goat                  | 103<br>(31.49)     | 108<br>(33.02)     | 211<br>(66.11)    | 5     |                   |
| iii. Buffalo              | 29<br>(8.86)       | 11<br>(3.36)       | 40<br>(32.26)     | 18    |                   |
| Average number of animals | 4.54<br>$\pm 2.19$ | 4.54<br>$\pm 5.86$ | 4.54<br>$\pm 7.3$ | 0     | t=0.247<br>(0.80) |

Figures in parenthesis show percentage

Table 6. Quantity of FYM produced by the animals in the study area

| Animal Type | Share of animal Population (%) | Dung per animal per day (kg) | Quantity of FYM Produced by animal per household per year (per animal in kg/day) |
|-------------|--------------------------------|------------------------------|--|
| Cow         | 61.62                          | 5.02                         | 3-4 trolley  |
| Buffalo     | 06.11                          | 6.87                         | 5-6 trolley  |
| Goat        | 32.26                          | 700 gram                     | -  |

116 farmers having marginal land holding below 1 ha. Agriculture + labour was main source of income for 72.91 per cent of the farmers. Therefore, promotion of scientific fodder cultivation can increase their income and less dependence on the fodder purchased from the market. The farmers should be encouraged to harvest benefits of centrally sponsored schemes. Only 4.67 per cent of the farmers were having social participation in the community organisations or other social institutions. Cent percent respondents were aware about the developmental scheme KCC but only a meagre percentage (02.77) have availed the loan facility. The farmers should be educated about the benefits of different centrally sponsored schemes. Majority (95.13%) of the studied farmers had not attended any formal training therefore, organising short term training programmes can be beneficial for the farmers. Cows contributed a major share (61.62) as far as livestock possession is concerned. Goat being the less expensive in its maintenance and care was most popular animal. Due to scarcity of fodder buffaloes are not preferred livestock. If the irrigation facilities are developed

the fodder production can be increased and more milk can be obtained by rearing buffaloes. Hence a well-defined strategy needs to be developed for popularising fodder production in the area.

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## Research Article



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# Determinants of Agricultural Exports in India: A Commodity Level Analysis

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The export opportunity allows the agricultural sector to expand productive capacity to the full extent. An attempt is made in the present study to specify and estimate the factors affecting agricultural exports of India at the commodity level. The major exportable crops used in the study are rice, wheat, tea, coffee, sugar, cotton lint and tobacco. The literature surveyed clearly shows that Indian exports are influenced by a number of factors. A double log-linear regression analysis has been carried out to understand the role of different factors in affecting agricultural exports across commodities from 1980-2010. The estimated equations for rice shows that lagged export, lagged stock and world income played a predominant role. In the case of wheat, as India does not export much of wheat and there is wide year to year fluctuations, it is mainly influenced by lagged export and lagged stock with the government. Like wheat, sugar export is also influenced mainly by lagged export and production. The estimates of cotton lint reveal that it is influenced by a number of factors like lagged export, production, relative prices, openness and exchange rate. However, world income does not play important role in influencing cotton exports. Factors like, lagged export, production, world income and exchange rate affect tobacco export positively and significantly. Tea export is influenced by lagged export, production, openness and exchange rate. In case of coffee, lagged export, production and world income play the dominant role in affecting coffee exports of India and the coefficients have theoretically consistent signs. The findings of the article validate the hypothesis that the impact of various factors on agricultural exports may not be the same for all commodities.

## INTRODUCTION

Theories on international trade supports that trade plays an important role in the development of a country. Nayyar (1976) has examined that international trade leads to development of a country. Balassa (1982) has revealed that countries applying outward oriented development strategies had a better performance in terms of exports, economic growth and employment whereas countries with continued inward orientation lead to increasing economic difficulties. The importance of international trade deals with the proper allocation and efficient use of resources. World Development Reports have also shown that outward-oriented trade policies have been more successful in promoting economic growth compared to inward oriented trade policies.

The importance of international trade is also explained at the sectoral level in many studies. In the context of agriculture, literature argues that export can be of much potential benefit to the rural sector, as it removes the restriction on productive output imposed by the low domestic demand for food. It also provides the economic incentives to establish and improve the infrastructure in the rural areas (Sachdev, 2000). The export opportunity allows the agricultural sector to expand productive capacity to the full extent.

Exports from any country are influenced by both demand and supply factors. A traditional export demand

function at the aggregate level is expressed as  $X = f(P, Y)$  where  $X$  is export demand,  $P$  is relative export price and  $Y$  is real income of importing countries. The relative export price is measured as the ratio of home country's export unit value index to a weighted average of competing countries unit value indices, the weights being the relative export shares. The income variable  $Y$  is often represented by world demand or world exports to explain export performance. The export demand function is generally specified in a log-linear form and estimated applying the ordinary least squares (OLS) technique. Riedel (1988) emphatically argued that the typical demand function of exports yields biased estimates of the parameters if the supply side variables are not taken into account. Therefore, in the literature, an economic analysis of export performance entails both demand and supply factors to be considered as determining variables in the export function.

Examining determinants of agricultural exports at commodity level would help proper allocation and effective utilisation of resources. The study aims to analyse the factors that explain variations in exports of major agricultural commodities. A double log-linear regression analysis has been carried out to understand the role of different factors. The time period ranges from 1981/82 to 2009/10. The major exportable crops considered for analysis are rice, wheat, tea, coffee, sugar, cotton lint and tobacco. For each commodity,

exports functions are estimated individually. Our objective was to examine the factors that influence exports of major agricultural commodities from 1980-2010, with the hypothesis that the impact of various factors on agricultural exports may not be the same for all commodities.

## MATERIALS AND METHODS

Geographically, the investigations are carried out at the all-India level and separately for seven important tradable commodities, viz., rice, wheat, tea, coffee, cotton lint, sugar, tobacco. The choice of these crops is determined by their increasing share in external trade. The analysis covers a time span of three decades from 1980-2010, broadly representing the pre-WTO period from 1980-1995 and post-WTO period from 1995-2010.

Data is collected from secondary sources and converted at 2004-2005 prices. Data on agricultural exports and production are taken from Food and Agricultural Organisation of the United Nations (FAO) trade database. Data on world income/GDP is taken from World Bank database. Rice and wheat stock data is taken from RBI database on Handbook of Statistics on Indian Economy. The data on domestic and international prices of agricultural commodities are taken from various sources. Domestic wholesale prices have been taken from FAO database. International price data has been taken from World Bank pink sheet database, UNCTAD database and IMF's International Financial Statistics. Real Effective Exchange Rate is calculated from the Report on Currency and Finance, RBI. Wholesale price index for all commodities at 2004-05 prices is extracted from the website of ministry of economic advisor, Govt. of India.

Regarding the methods of estimation of determinants of agricultural exports, double log-linear regression analysis has been carried out for each exportable commodity mentioned in the study.

## RESULTS AND DISCUSSION

In the context of agriculture, literature suggests that export can be of much potential benefit to the rural sector, as it removes the restriction on productive output imposed by the low domestic demand for food. It also provides the economic incentives to establish and improve the infrastructure in the rural areas (Sachdev, 2000).

The empirical literature shows that agricultural exports in India are influenced by multiple factors which vary across the commodities. Kumar and Mittal (1995) examined factors affecting tea exports and found that tea exports are insensitive to price incentives and to changes in the world demand and decrease with increasing share of domestic consumption. Kumar (2004) analysed export performance of Indian

fisheries. World export and exchange rate were found to be positively associated with fishery exports of India. Domestic prices have theoretically consistent sign of coefficient. However, world prices do not play an important role in explaining exports of fisheries products from India. Kumar, et al., (2007) examined the determinants of livestock exports. Ratio of production to consumption, ratio of world export to world output, exchange rate and removal of quantitative restrictions have positively affected livestock exports. However, relative prices did not play important role in influencing overall livestock exports.

Kumar and Rai (2007) analysed determinants of tomato exports of India. World export and relative prices have positive impact on tomato exports. However, domestic production had a negative impact on tomato exports from the country. In this context, the authors put forth the arguments that increase in domestic production had coincided with the increased international production, causing depressed international prices and hence lower exports from India. Gulati and Kelly (2001), Bathla (2011) found exports of agricultural commodities to be determined by a host of factors, varying from commodity to commodity. In the case of wheat and rice, production, stock and government policies matter.

### Specification of the Model

To identify the factors that affect agricultural exports, double log-linear regression analysis was carried. The agricultural export function was specified as follows:

$$\ln Export = \beta_0 + \beta_1 \ln Export (-1) + \beta_2 \ln Production + \beta_3 \ln WP/DP + \beta_4 \ln REER + \beta_5 \ln World Income + \beta_6 \ln Openness + \epsilon_i$$

Where,

$\ln Export$  = Natural logarithm of export of  $i^{th}$  commodity in thousand tonnes

$\ln Export (-1)$  = Natural logarithm of export of  $i^{th}$  commodity in thousand tonnes (one year lagged)

$\ln Production$  = Natural logarithm of production of  $i^{th}$  commodity in thousand tonnes (one year lagged)

$\ln WP/DP$  = Natural logarithm of ratio of world price to domestic price of  $i^{th}$  commodity in rupees per ton at 2004-05 prices

$\ln REER$  = Natural logarithm of real effective exchange rate (REER) at 2004-05 prices

$\ln World Income$  = Natural logarithm of world income in thousand rupees at 2004-05 prices

$\ln Openness$  = Natural logarithm of percentage of domestic agricultural exports to world agricultural exports (values in thousand rupees at 2004-05 prices)

While explaining factors affecting agricultural exports, alternative equations have been tried, mainly to avoid the

problem of multicollinearity. In case of rice and wheat stocks with the government has been taken into consideration.

The empirical literature surveyed on export determination model shows that agricultural exports in India are mainly determined by production, lagged export, relative prices, exchange rate, world export, world income, openness and policy variables like removal of quantitative restrictions. Theoretically, all these variables are expected to have a positive sign. If external price is higher than domestic price i.e., relative price ratio is greater than one and is increasing, it will positively influence the level of exports and hence, bears a positive sign. It also indicates competitiveness of a commodity in the world markets. On the contrary, if external world price is less than the domestic price i.e., the relative price ratio is less than one, then there is no incentive to export and the variable may be insignificant with positive or negative sign (Bathla 2009). Beside relative price movement, production can also explain exports because with an increase in output more marketable surplus can be utilized for export purposes. Exchange rate depreciation is expected to increase exports. Economic literature suggests that an increase in the world income also leads to an increase in exports. In addition, sometimes export also depends on its lagged exports. Further, a greater openness of economy through reduction in export barriers is likely to create a positive environment for export growth. The impact of this variable is captured to the positive openness made to world trade, indirectly captured through India's share of agricultural exports in total world agricultural exports. Dummy variable was used to capture differences in agricultural exports during pre and post-WTO periods. However, it was dropped due to errors in estimation.

**Empirical Results**

The determinants of seven major agricultural exports namely rice, wheat, tea, coffee, sugar, cotton and tobacco are provided as follows:

Table 1 Determinants of Rice Exports

| DEPENDENT VARIABLE: RICE EXPORT |                            |                            |
|---------------------------------|----------------------------|----------------------------|
| Time Period                     | 1981-2009                  |                            |
| Variables                       | Equation 1<br>Coefficients | Equation 2<br>Coefficients |
| Constant                        | -1.33                      | -22.20**                   |
| Export (-1)                     | 0.59***                    | 0.51***                    |
| Govt. Stock (-1)                | 0.75**                     | 0.67**                     |
| WP/DP                           | -.10                       | 0.13                       |
| REER                            | -.58                       | —                          |
| World Income                    | —                          | 0.69*                      |
| R-squared                       | 0.84                       | 0.86                       |
| D-W                             | 2.19                       | 2.20                       |

NOTE: \*\*\*, \*\* and \* denote 1, 5 and 10 percent level of significance respectively.

Table 1 shows that the explanatory variables in the equation 1 and equation 2 could explain 84 percent and 86 percent respectively of the total variation in the exports of rice. The coefficients for most of variables indicate that different factors influence the exports of rice differently. The export function (equation 1) shows rice exports to be positively influenced by lagged export and lagged stock. These variables bear the expected signs and are statistically significant. Ratio of world price to domestic price and real exchange rate have negative signs, however these are statistically insignificant. Therefore, it could be concluded that real exchange rate and ratio of world price to domestic price have not played any significant role in the exports of rice from India during 1980 to 2010. In equation 2, instead of REER world income was added in the model because of the problem of multicollinearity. The coefficient of the world income is statistically significant. It shows 1 percent increase in world income leads to 0.69 percent increase in rice exports. The coefficients of lagged export and lagged stock are also positive and significant. Ratio of world price to domestic price has positive sign, however insignificant.

Table 2. Determinants of Wheat Exports

| DEPENDENT VARIABLE: WHEAT EXPORT |                            |                            |
|----------------------------------|----------------------------|----------------------------|
| Time Period                      | 1981-2009                  |                            |
| Variables                        | Equation 1<br>Coefficients | Equation 2<br>Coefficients |
| Constant                         | -10.53                     | -90.48                     |
| Export (-1)                      | 0.37**                     | .35*                       |
| Govt. Stock (-1)                 | 2.48**                     | 2.63**                     |
| WP/DP                            | 1.70                       | 3.53                       |
| REER                             | -2.21                      | —                          |
| World Income                     | —                          | 2.42                       |
| R-squared                        | 0.27                       | 0.28                       |
| D-W                              | 2.23                       | 2.19                       |

NOTE: \*\* and \* denote 5 and 10 percent level of significance respectively.

In table 2, estimates of equation 1 shows that like rice lagged export and lagged stock are positively and significantly associated with wheat exports. A 1 percent increase in lagged stock leads to 2.48 percent increase in wheat export. Ratio of world price to domestic price does not play any role in affecting wheat export, as the coefficient is insignificant. Because, domestic price of wheat is higher than the world price so increase in world prices do not play important role in increasing wheat export of India. A negative sign of coefficient was expected; however, it is positive but insignificant. Real exchange rate is negative but insignificant. In equation 2 of the model, real exchange rate has been dropped and world income was added, because real exchange rate and world income are highly correlated to each other. The coefficient of world income is positive but insignificant.

Lagged export and lagged stock have major role in affecting wheat export of India.

Table 3. Determinants of Cotton Lint Exports

| DEPENDENT VARIABLE: COTTON LINT EXPORT |              |              |              |
|--|--------------|--------------|--------------|
| Time Period                            | 1981-2009    |              |              |
|  | Equation 1   | Equation 2   | Equation 3   |
| Variables                              | Coefficients | Coefficients | Coefficients |
| Constant                               | -20.49***    | -25.19**     | -24.20***    |
| Export (-1)                            | 0.32*        | 0.33*        | 0.26         |
| Production                             | 3.02***      | 2.17***      | 3.45***      |
| WP/DP                                  | .83*         | —            | —            |
| REER                                   | —            | 2.54*        | —            |
| Openness (share)                       | —            | —            | 1.90**       |
| R-squared                              | 0.51         | 0.51         | 0.56         |
| D-W                                    | 2.15         | 2.02         | 2.09         |

NOTE: \*\*\*, \*\* and \* denote 1, 5 and 10 percent level of significance respectively.

From table 3 of equation 1 it is obvious that cotton lint export is determined by lagged export, production and ratio of world price to domestic price. All the variables have positive and significant signs of coefficients as expected. In equation 2, real exchange rate was added, which is also positive and significant. It shows that 1 percent increase in exchange rate leads to 2.54 percent increase in cotton lint exports of India. Therefore, exchange rate adjustments have major impact on cotton lint export. In equation 3, openness was included in the model to see the integration of domestic economy into the world economy. The value of the coefficient is positive and statistically significant. One percent increase in openness leads to 1.90 percent increase in cotton export. This shows economic liberalization and post-WTO agreements have positively affected cotton exports of India. The included explanatory variables could explain 51 percent to 56 percent of the total variation in cotton lint exports.

Table 4. Determinants of Sugar Exports

| DEPENDENT VARIABLE: SUGAR EXPORT |              |              |              |
|----------------------------------|--------------|--------------|--------------|
| Time Period                      | 1981-2009    |              |              |
|                                  | Equation 1   | Equation 2   | Equation 3   |
| Variables                        | Coefficients | Coefficients | Coefficients |
| Constant                         | -25.28       | -25.39**     | 0.78         |
| Export (-1)                      | 0.64***      | 0.66***      | 0.68***      |
| Production                       | 2.12**       | 2.83**       | 2.37*        |
| WP/DP                            | 0.80         | 0.40         | 0.60         |
| REER                             | 1.70         | —            | —            |
| Openness (share)                 | —            | 1.57         | —            |
| World Income                     | —            | —            | -0.75        |
| R-squared                        | 0.47         | 0.49         | 0.46         |
| D-W                              | 1.71         | 1.70         | 1.72         |

NOTE: \*\*\*, \*\* and \* denote 1, 5 and 10 percent level of significance respectively.

Table 4 shows that sugar export mainly depends on lagged export and production as it is visible in the estimates of the equations. Both the variables are positive and statistically significant. Ratio of world price to domestic price is insignificant in all the three equations. A negative or insignificant value of WP/DP was expected, as is the case, because domestic wholesale prices have been higher than the international prices. Therefore, international prices of sugar do not influence Indian sugar exports. Bathla(2009) analyzed that wholesale price of sugar was higher than the world price from 1980/81 to 1988/89 and then from 1997/98 to 2002-03. Exchange rate and openness also do not seem to affect exports of sugar. World income also does not play any role in influencing sugar export. The value of the coefficient is negative however insignificant. The value of the R-Squared varies between 46 and 49 percent.

Table 5. Determinants of Tobacco Exports

| DEPENDENT VARIABLE: TOBACCO EXPORT |              |              |              |
|------------------------------------|--------------|--------------|--------------|
| Time Period                        | 1981-2009    |              |              |
|                                    | Equation 1   | Equation 2   | Equation 3   |
| Variables                          | Coefficients | Coefficients | Coefficients |
| Constant                           | -2.38        | -0.70        | -31.53***    |
| Export (-1)                        | 0.42***      | 0.45***      | 0.26         |
| Production                         | 0.65*        | 0.64**       | 0.68***      |
| WP/DP                              | -0.39***     | -0.51***     | —            |
| REER                               | 0.36         | —            | 1.79***      |
| Openness (share)                   | —            | 0.28         | —            |
| World Income                       | —            | —            | 0.80***      |
| R-squared                          | 0.72         | 0.74         | 0.75         |
| D-W                                | 2.52         | 2.59         | 2.30         |

NOTE: \*\*\*, \*\* and \* denote 1, 5 and 10 percent level of significance respectively.

Results for tobacco are presented in table 5. Equation 1 of the model shows that export of tobacco is determined primarily by lagged export and production. The values of the coefficients are 0.42 and 0.65 respectively. The coefficient of ratio of world price to domestic price is negative. This shows that prices do not play important role in increasing tobacco exports. The possible reason may be that the products like tobacco are price insensitive and demand for such products are inelastic in nature with respect to price. The coefficient of real exchange rate has positive sign but insignificant. The explanatory variables explain 47 percent of variations in tobacco exports.

In equation 2 also relative prices negatively affect domestic tobacco exports. Openness was included in the model. The sign of the coefficient is positive but insignificant. The dependent variables together could explain 74 percent of variation of total tobacco export. In equation 3, real exchange rate positively and significantly affects tobacco

exports. It shows 1 percent increase in exchange rate leads to 1.79 percent increase in tobacco exports. Production is an important determinant with expected positive sign of coefficient. World income was included in the model. It shows that Indian tobacco export is very much guided by changes in the world income. The value of the coefficient of world income is positive and significant at 1 percent level. 1 percent increase in world income leads to 0.80 percent increase in Indian tobacco export. The explanatory variables together could explain 75 percent of total variations in tobacco exports.

Table 6. Determinants of Tea Exports

| DEPENDENT VARIABLE: TEA EXPORT |                            |                            |
|--------------------------------|----------------------------|----------------------------|
| Time Period                    | 1981-2009                  |                            |
| Variables                      | Equation 1<br>Coefficients | Equation 2<br>Coefficients |
| Constant                       | -.22                       | 0.26                       |
| Export (-1)                    | 0.35**                     | 0.36**                     |
| Production                     | 0.51*                      | —                          |
| Openness (share)               | 0.23**                     | —                          |
| WP/DP                          | —                          | 0.25                       |
| REER                           | —                          | 0.27**                     |
| R-squared                      | 0.39                       | 0.38                       |
| D-W                            | 2.08                       | 1.99                       |

NOTE: \*\* and \* denote 5 and 10 percent level of significance respectively.

From the statistical evidence furnished in table 4.6 of equation 1, it is quite clear that Indian tea exports are influenced by lagged export, production and openness. A 1 percent increase in production leads to 0.51 percent increase in tea exports. Tea export is positively influenced by openness. The value of the coefficient of openness is 0.23. It is positive and significant at 5 percent level. Given a relatively higher world price of tea than the domestic price, one would expect export to positively respond to price incentives. In equation 2, the analysis reveals elasticity estimate of exports to relative price is positive, however insignificant. Tea export also depends on its lag. The value of the coefficient of lagged export is 0.36, which is significant at 5 percent level. Real exchange rate is another determinant of tea exports. Therefore, exchange rate adjustments have important role to play in determining tea exports. A 1 percent increase in exchange rate leads to 0.27 percent increase in tea exports of India. The included explanatory variables could explain around 39 percent of the total variation in the exports tea.

Table 7 shows estimates of coffee exports function. Three equations have been specified and estimated. From the estimates of equation 1 it is clear that coffee exports depend on lagged export, production and exchange rate adjustments. A 1 percent increase in production leads to 0.73 percent increase in coffee exports. The sign of coefficient of

Table 7. Determinants of Coffee Exports

| DEPENDENT VARIABLE: COFFEE EXPORT |                            |                            |                            |
|-----------------------------------|----------------------------|----------------------------|----------------------------|
| Time Period                       | 1981-2009                  |                            |                            |
| Variables                         | Equation 1<br>Coefficients | Equation 2<br>Coefficients | Equation 3<br>Coefficients |
| Constant                          | 1.36                       | 2.12                       | -8.67                      |
| Export (-1)                       | 0.38***                    | 0.30***                    | —                          |
| Production                        | 0.73***                    | 0.65***                    | 0.66***                    |
| WP/DP                             | 0.11                       | —                          | 0.12                       |
| REER                              | -.53***                    | -.50**                     | -.11                       |
| Openness (share)                  | —                          | 0.07                       | —                          |
| World Income                      | —                          | —                          | 0.37**                     |
| R-squared                         | 0.91                       | 0.90                       | 0.88                       |
| D-W                               | 1.97                       | 1.74                       | 1.41                       |

NOTE: \*\*\* and \*\* denote 1 and 5 percent level of significance respectively.

relative price is positive but insignificant. It shows that relative prices have not played important role in influencing coffee exports. The real exchange rate did not have theoretically correct signs. It shows that 1 percent increase in exchange rate leads to 0.53 percent fall in coffee exports. The possible reasons may be that exchange rate anticipation is quite common. Therefore, the export decisions also depend on possibilities of exchange rate changes in near future. Secondly, other countries in the world have also devalued their currencies frequently in the last three decades, thirdly, frequent occurrence of financial and economic crisis in the world over. Fourthly, tea has also emerged as an important substitute to coffee and changes in the prices of substitute products have important implications on export decisions. Fifthly, till 1987, India did not import any coffee, however from 1988 onwards India has been continuously importing coffee and it has gone up tremendously in recent years. In this context, Bhalla(2004) found that exchange rate adjustment does not necessarily lead to higher exports. In equation 2, openness is included which is positive however, it does not play important role in influencing coffee exports. The value of the coefficient of world income is positive and significant in equation 3. It shows that a 1 percent increase in world income leads to 0.37 percent increase in domestic exports of coffee. R-squared is quite robust. The included explanatory variables could explain 88 to 91 percent of the total variation in the exports of coffee.

### CONCLUSION

An attempt was made in the present study to specify and estimate the factors affecting agricultural exports at a disaggregated level from India. The literature surveyed clearly shows that Indian exports are influenced by a number of factors. A double log-linear regression analysis has been

carried out to understand the role of different factors from 1980 to 2010. The major exportable crops used in the model are rice, wheat, tea, coffee, sugar, cotton lint and tobacco. For each commodity, various equations are specified to examine their influence on exports. Alternative equations have been tried in the model mainly to avoid estimation error and multicollinearity.

The estimated equations for rice shows that lagged export lagged stock and world income played a predominant role. In the case of wheat, as India does not export much of wheat and there is wide year to year fluctuations, it is mainly affected by lagged export and lagged stock with the government. Like wheat, sugar export is also influenced mainly by lagged export and production. The estimates of cotton lint reveal that it is affected by a number of factors like lagged export, production, relative prices, openness and exchange rate. However, world income does not play important role in affecting cotton exports. Factors like, lagged export, production, world income and exchange rate affect tobacco export positively and significantly. Tea export is influenced by lagged export, production, openness and exchange rate. In case of coffee, lagged export, production and world income play the dominant role in affecting coffee exports of India and the coefficients have theoretically consistent signs.

Hence, the findings of the study validate the hypotheses that the impact of various factors on agricultural exports may not be the same for all commodities. In a nutshell, the empirical findings reveal the predominance of factors like lagged export, production and world income in determining agricultural exports of India. For rice and wheat rather than production, stock with the government influences export to a large extent. Because of semi government interventions in cereal market, actively for mandatory PDS, exports are not allowed on regular basis for many tradeable commodities like wheat, therefore, much depends on demand and supply.

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## Research Article



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# Effect of Waterlogging Condition on Growth, Physiology and Yield Characteristics of Soybean Genotypes (*Glycine max*(L.) Merrill)

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Waterlogging is one of the environmental stresses that affect the growth, physiology and yield attributes injured due to the anaerobic environment. The objective of above investigation was to study the variation in growth, physiological and yield characteristics in soybean genotypes/varieties. A total of 25 soybean genotypes/varieties were grown in complete randomized block design with three replications having 5 rows 40 cm apart with 3 meter row length of every genotype. Water logging was created at 20 DAS, 40 DAS and 60 DAS in event of no rains after planting by applying water level about 5 cm above the soil surface. The mean data of the all characters viz. plant height, number of branches/plant, number of nodules/plant, dry weight of nodules/plant, ascent of sap in (%), transpiration rate in ( $\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$ ), harvest index (%) and yield (q/ha.) were computed for statistical analysis. The results revealed that soybean could grow and produce grains even under water logging condition. The significant differences were observed among the genotypes for major growth physiological and yield attributes except number of branches, number of nodules and ascent of sap. Further the result revealed that high magnitude of characters like plant height, dry weight of nodules, transpiration rate harvest index and yield per hectare were recorded in genotypes/varieties RVS2007-7, JS2069, RVS2007-1, RVS2001-4 and JS 2059 as compared to control. Hence these genotypes/varieties were found suitable under waterlogged condition.

**INTRODUCTION**

Soybean (*Glycine max* (L.) Merrill.) with its 40-42 percentage protein and 20-22 percentage oil has emerged as one of the major oil seed crop in India it has now been established as one of the most important oil seed crop in the world. Accounting for more than 50 percent of oil seeds production and 30 percent of the total supply of all vegetables oil. Among the various growth stages of soybean, vegetative and flowering period have been found to be most sensitive to excess moisture. The Kharif season of soybean cropping in M.P. is characterized as a monsoon season with gradual increase of soil water content to an excess extent, after a long-term dry season known as Rabi. In the Kharif season, soybean seeds germinate in an optimum soil moisture condition, but suffer in later growth stages from excess moisture conditions due to continuous raining, consequently developing poor root systems by the time of flowering. The end of monsoon corresponds to flowering and maturity stages, thereafter soybean plants further suffer from water deficit due to the poor root system developed in the excess soil moisture. Thus, soybean plants during Kharif season in M.P. face excess moisture stress till flowering as well as water

deficit during the maturity. Identification and use of soybean genotypes that develop good root systems in excess soil moisture conditions during the monsoon to tolerate water deficit during maturity is an important approach to increase or stabilize soybean yields in M.P. The field conditions soybean is very sensitive to excess water compared to other crops. The response to excess water in soybeans is associated with a number of biochemical, morphological and anatomical changes in both the root and the shoot (Richard et al., 1994; Bacanamwo and Harper 1997). Bacanamwo and Purcell (1999) reported that morphological mechanisms of acclimation to flooding stress in soybean appear to involve an avoidance of water loss by transpiration and a facilitated transport of atmospheric  $\text{O}_2$  to the submerged roots through the flood-induced formation of adventitious roots and aerenchyma. The effects of water logging on soybean root development are substantial and generally negative (Sallam and Scott 1987). However, short-term acclimation to flooding through biochemical mechanisms may limit the impacts of injurious factors (Vartapetian and Jackson 1997). Long-term flood tolerance may require morphological adaptations in the plant to sustain adequate aeration and

functioning of the root system (Bacanamwo and Purcell 1999). Extensive adventitious root development has been reported to enhance oxygen transport from the stem to the roots (Visser et al., 1996). Flooding increased adventitious root fresh weight as a percentage of total root weight (Bacanamwo and Purcell 1999). While yield and seed qualities are typically selection criteria (Van Toai et al., 1994). Therefore the present investigation was undertaken to physiological evaluation of soybean cultivars under excess moisture stress.

## MATERIALS AND METHODS

The field experiment was carried at research farm of RAK College of Agriculture, Sehore(M.P.) during 2014 season. Twenty five genotypes/ varieties were grown under three conditions viz. excess moisture condition and recommended cultivation (Control). All the treatments were replicated thrice in a complete randomized block design and each genotypes was grown 5 rows 40cm apart with 5meter row length. The recommended dose of fertilizer for soybean was 20, 60, and 20 kg N, P and kg/ha, respectively. The seeds were treated with thirum and bevestin, PSB and rhizobium culture before sowing. The observations on five competitive plants from every genotype and each replication were recorded as per schedule of the action plan during 2013 and 2014. The root system measure was carried out by cutting of plant from six inches of ground level at blooming stages then wrapped with cotton & immediate tight with rubber bend then removed cotton & recorded weight after 24 hours and finally recorded ascent of sap in mg. Similarly the transpiration rate was measured in  $\text{mmol H}_2\text{O m}^{-2} \text{s}^{-1}$  at flowering stage by using automatic Li-cor 6400 photosynthesis system. The plant growth and yield attributes were recorded at flowering and harvesting stages on five randomly selected plants from every genotypes and replication viz. plant height, number of branches/plant, number of nodules/plant, dry weight of nodules/plant, harvest index (%) and yield (q/ha.) were computed for statistical analysis as per the standard procedure given by (Panse and Sukhatme, 1989).

## RESULTS AND DISCUSSION

### Growth, physiological and yield Characteristics

The interaction between genotypes and environment viz., excess moisture exerted significant impact on plant height per plant, dry weight of nodules, transpiration rate ( $\text{mmol H}_2\text{O m}^{-2} \text{s}^{-1}$ ) at flowering, harvest index (%) and yield (q/ha) at harvesting during 2014 while most of the genotypes did not show significant differences among them (Table -1). Different characters under present investigation revealed that the plant height per plant was found significant

differences among the varieties. However, variety RVS2007-7 recorded maximum plant height per plant (56.00 and 52.40) both the environment at flowering stage and it was at par with all other genotypes under excess moisture and normal condition followed by genotypes JS2069 (54.60, 51.90), RVS2007-3 (53.62, 51.80) and RVS2001-4 (53.58, 51.30) while minimum plant height found was genotype RVS2007-6 (46.80, 37.90), respectively. Waterlogging occurring in early vegetative phase ( $V_2$ ) and early reproductive phase ( $R_1$ ,  $R_2$  and  $R_3$ ) are the major sensitive phases reported by (Linkemer et al., 1998). However variety RVS 2007-7 exhibited the maximum number of branches per plant (5.56, 4.89) both the environment at flowering and it was at par with all other genotypes under excess moisture and normal condition followed by genotypes JS2069 (5.36, 4.80), RVS2007-3 (5.35, 4.76) and RVS2001-4 (5.33, 4.67) while minimum number of branches per plant found was genotype JS20-87 (4.11, 3.44), respectively. It is because waterlogging suppressed branches formation causing less number of branches per plant reported by (Linkemer et al., 1998) also reported a significant decline in branch number after 7 days of flooding at various vegetative and reproductive growth stages. The maximum number of nodules per plant found was genotype RVS 2007-7 (83.70, 69.80) both the environments and it was at par with all other genotypes under excess moisture and normal condition followed by JS20-69 (79.89, 55.92) while minimum number of nodules per plant noticed genotype JS20-79 (47.67, 35.00) However varieties RVS 2007-7 exhibited the maximum dry weight of nodules per plant at flowering (0.64, 0.60) both the environment at flowering and it was at par with all other genotypes under excess moisture and normal condition followed by genotypes JS2069 (0.63, 0.50) and RVS2007-3 (0.62, 0.45) while minimum dry weight of nodules per plant found was genotype JS20-71 (0.30, 0.19) respectively. They conditions lead the plants experiencing water excess stress that occur if the water availability in the soil is more than plant's requirement. In this condition a plant will experience root organ damage and it can be toxic to the plant because of anaerobic condition reported by (Ariffin, 2002). The maximum ascent of sap was obtained higher in varieties RVS 2007-7 (41.62, 36.29) at flowering stages both the environments followed by JS20-69 (38.91, 35.59), and RVS2007-3 (38.02, 35.29). However, minimum ascent of sap was noticed by genotype JS20-71 (27.73, 21.63), respectively. The transpiration rate was obtained higher in varieties RVS 2007-7 (5.45, 3.92) at flowering stages both the environments followed by JS20-69 (4.96, 3.75), RVS2007-3 (4.85, 3.50) and RVS2001-4 (4.59, 3.30). However, minimum transpiration rate was noticed by genotype RVS2007-2 (2.54, 1.58), respectively. The

Table 1. Growth, physiological and yield characteristics of Soybean genotypes/varieties under waterlogging condition

| Genotypes    | Plant height (cm) at flowering |              | No. of Branches/plant at flowering |             | No. of Nodules/plant at flowering |              | Dry weight of Nodules (g) at flowering |              | Ascent of sap (%) at flowering |              | Transpiration rate (mmol H <sub>2</sub> O m <sup>-2</sup> s <sup>-1</sup> ) at flowering |              | Harvest index (%) |              | Yield (q/ha.) |              |
|--------------|--------------------------------|--------------|------------------------------------|-------------|-----------------------------------|--------------|--|--------------|--------------------------------|--------------|--|--------------|-------------------|--------------|---------------|--------------|
|              | Control                        | E. M.        | Control                            | E. M.       | Control                           | E. M.        | Control                                | E. M.        | Control                        | E. M.        | Control  | E. M.        | Control           | E. M.        | Control       | E. M.        |
| RVS 2007-1   | 52.40                          | 51.10        | 5.11                               | 4.44        | 59.00                             | 48.70        | 0.50                                   | 0.31         | 32.80                          | 26.04        | 4.12   | 1.86         | 50.27             | 32.41        | 13.6          | 10.23        |
| RVS 2007-2   | 53.62                          | 47.20        | 5.35                               | 3.67        | 67.56                             | 49.90        | 0.50                                   | 0.37         | 38.02                          | 31.92        | 2.54   | 1.58         | 41.97             | 33.59        | 11.9          | 10.38        |
| RVS 2007-3   | 53.30                          | 51.80        | 5.35                               | 4.76        | 74.70                             | 55.86        | 0.62                                   | 0.45         | 36.56                          | 35.29        | 4.85   | 3.56         | 57.03             | 39.67        | 15.60         | 11.00        |
| RVS 2007-4   | 53.60                          | 46.00        | 4.18                               | 3.89        | 59.80                             | 39.60        | 0.53                                   | 0.44         | 35.34                          | 33.30        | 3.12   | 2.31         | 30.77             | 39.13        | 11.7          | 9.41         |
| RVS 2007-5   | 49.10                          | 44.40        | 4.44                               | 4.67        | 50.60                             | 44.40        | 0.36                                   | 0.28         | 29.64                          | 35.29        | 3.66   | 2.71         | 38.95             | 34.22        | 10.1          | 8.00         |
| RVS 2007-6   | 46.80                          | 37.90        | 4.56                               | 4.33        | 72.20                             | 42.90        | 0.50                                   | 0.20         | 28.43                          | 28.90        | 3.74   | 2.77         | 28.12             | 23.53        | 14.1          | 7.66         |
| RVS 2007-7   | 56.00                          | 52.40        | 5.56                               | 4.89        | 83.70                             | 69.80        | 0.64                                   | 0.60         | 41.62                          | 36.29        | 5.45   | 3.92         | 69.35             | 45.83        | 18.2          | 11.98        |
| JS 95-60     | 51.80                          | 48.70        | 4.40                               | 4.09        | 56.90                             | 43.20        | 0.50                                   | 0.24         | 32.87                          | 28.34        | 2.85   | 3.17         | 38.69             | 37.02        | 14.2          | 8.62         |
| JS 9305      | 54.40                          | 45.30        | 4.56                               | 4.44        | 70.89                             | 53.33        | 0.42                                   | 0.33         | 31.25                          | 27.56        | 4.12   | 2.69         | 45.87             | 37.22        | 13.8          | 8.69         |
| JS 335       | 47.00                          | 49.30        | 4.78                               | 4.65        | 59.40                             | 41.30        | 0.41                                   | 0.27         | 36.56                          | 33.92        | 3.84   | 3.56         | 34.72             | 28.77        | 14.2          | 8.90         |
| JS 97-52     | 55.10                          | 49.30        | 4.22                               | 4.11        | 66.10                             | 51.78        | 0.59                                   | 0.30         | 33.55                          | 30.38        | 4.57   | 2.69         | 37.72             | 31.10        | 12.8          | 10.94        |
| BREGG        | 53.30                          | 41.80        | 4.22                               | 3.83        | 54.70                             | 48.11        | 0.56                                   | 0.38         | 34.02                          | 32.62        | 3.55   | 2.80         | 32.39             | 34.57        | 13.8          | 10.56        |
| NRC 37       | 46.20                          | 48.00        | 4.78                               | 4.46        | 65.90                             | 51.10        | 0.43                                   | 0.36         | 28.97                          | 25.08        | 3.05   | 2.41         | 46.79             | 33.00        | 12.9          | 9.20         |
| NRC 7        | 53.40                          | 40.70        | 4.78                               | 3.78        | 70.00                             | 51.00        | 0.40                                   | 0.32         | 35.66                          | 30.49        | 2.96   | 2.34         | 37.60             | 38.43        | 7.1           | 5.17         |
| RVS 2001-4   | 53.58                          | 51.30        | 5.33                               | 4.69        | 74.33                             | 55.00        | 0.61                                   | 0.45         | 37.34                          | 35.20        | 4.59   | 3.30         | 56.30             | 39.13        | 15.2          | 10.95        |
| JS 20-50     | 52.90                          | 42.80        | 4.33                               | 4.20        | 55.44                             | 39.30        | 0.36                                   | 0.25         | 38.91                          | 30.92        | 3.65   | 2.88         | 52.44             | 38.65        | 16.4          | 10.77        |
| JS 20-53     | 54.60                          | 52.90        | 4.67                               | 4.22        | 58.10                             | 48.00        | 0.40                                   | 0.30         | 36.98                          | 29.43        | 3.41   | 2.39         | 36.30             | 30.91        | 10.9          | 9.76         |
| JS 20-59     | 53.40                          | 51.20        | 5.31                               | 4.67        | 74.68                             | 52.30        | 0.58                                   | 0.42         | 36.70                          | 34.19        | 5.75   | 3.21         | 53.24             | 39.03        | 14.1          | 10.78        |
| JS 20-69     | 54.60                          | 51.90        | 5.36                               | 4.80        | 79.89                             | 55.92        | 0.63                                   | 0.50         | 38.91                          | 35.59        | 4.96   | 3.75         | 65.70             | 40.80        | 16.4          | 11.75        |
| JS 20-71     | 50.30                          | 47.00        | 4.56                               | 3.78        | 70.70                             | 49.40        | 0.30                                   | 0.19         | 27.73                          | 21.63        | 3.01   | 2.11         | 30.75             | 28.72        | 14.1          | 9.44         |
| JS 20-73     | 50.60                          | 45.80        | 4.78                               | 4.22        | 68.78                             | 42.30        | 0.48                                   | 0.30         | 35.64                          | 34.19        | 2.95   | 2.07         | 46.19             | 34.66        | 11.3          | 7.51         |
| JS 20-79     | 48.70                          | 44.70        | 4.67                               | 3.67        | 47.67                             | 35.00        | 0.30                                   | 0.28         | 32.65                          | 28.65        | 2.88   | 2.61         | 53.49             | 33.69        | 14.1          | 10.77        |
| JS 20-80     | 50.20                          | 40.00        | 4.33                               | 3.89        | 63.67                             | 45.70        | 0.40                                   | 0.31         | 36.08                          | 26.60        | 3.47   | 1.91         | 45.59             | 39.03        | 10.6          | 9.81         |
| JS 20-86     | 53.40                          | 49.00        | 4.33                               | 4.17        | 69.40                             | 43.80        | 0.53                                   | 0.35         | 36.70                          | 30.02        | 3.75   | 2.06         | 48.16             | 38.49        | 12.3          | 9.69         |
| JS 20-87     | 52.10                          | 48.00        | 4.11                               | 3.44        | 66.40                             | 42.70        | 0.30                                   | 0.31         | 36.43                          | 35.29        | 3.78   | 2.08         | 42.65             | 29.54        | 13.6          | 9.52         |
| <b>Mean</b>  | <b>49.40</b>                   | <b>47.50</b> | <b>4.28</b>                        | <b>4.27</b> | <b>55.89</b>                      | <b>54.49</b> | <b>0.46</b>                            | <b>0.34</b>  | <b>33.26</b>                   | <b>29.48</b> | <b>3.71</b>  | <b>2.61</b>  | <b>44.84</b>      | <b>34.74</b> | <b>13.17</b>  | <b>9.55</b>  |
| <b>CD 5%</b> | <b>7.40</b>                    | <b>9.41</b>  | <b>NS</b>                          | <b>NS</b>   | <b>NS</b>                         | <b>NS</b>    | <b>NS</b>                              | <b>0.24</b>  | <b>NS</b>                      | <b>NS</b>    | <b>0.60</b>  | <b>0.65</b>  | <b>14.22</b>      | <b>12.99</b> | <b>155.3</b>  | <b>114.8</b> |
| <b>CV</b>    | <b>8.94</b>                    | <b>11.09</b> | <b>25.9</b>                        | <b>20.9</b> | <b>37.39</b>                      | <b>36.75</b> | <b>34.50</b>                           | <b>31.20</b> | <b>31.03</b>                   | <b>30.88</b> | <b>11.4</b>  | <b>10.80</b> | <b>18.90</b>      | <b>22.28</b> | <b>19.3</b>   | <b>19.9</b>  |

maximum harvest index varieties RVS 2007-7 (69.35, 45.83) and seed yield (18.2, 11.98) was found both the environments followed by varieties JS2069 (65.70, 40.80) and seed yield (16.4, 11.75). However, minimum harvest index obtain by varieties RVS2007-6 (28.12, 23.53) and seed yield NRC 7 (7.1, 5.17), respectively. It also reported that yield loss can reach up to more than 60% in soybean applied with periodically waterlogging (Kuswanto, 2011).

### CONCLUSION

Soybean was able to grow and produce grains even in a waterlogging condition almost throughout its life cycle. Genotype RVS2007-7 had the highest seed yield (q/ha) under both the environments followed by JS20-69 and RVS2007-3 varieties. Genotypes had the highest seed yield was supported by a many number of pods per plant. The nutrient content in surface water needs to be analyzed because adventitious roots cannot absorb nutrients from the soil that have rich nutrients.

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## Research Article



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# Gender Perspectives in Rice-based Production System in the Country

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Women are involved in almost every farm operation in agriculture. Rice farming is an area where participation of women is very significant and the majority of farm operations were either carried out by women alone or jointly with men. Understanding the dynamism of roles and responsibilities of men and women in various farm and household activities is very important to address the gender issues in agriculture. A study was undertaken in network mode in five states of the country to assess farm women's role and responsibilities in the rice production system. The study revealed that very less houses were headed by women with variations of 2.4-12.4% in selected regions of the country. The regions having a scarcity of water source have resulted in more pressure of fetching water on farm women. Women membership remained restricted mostly up to self-help group level, whereas men represented up to district level. Joint access over farm resources was also in increasing order. The family women contributed maximum hours in storing of seeds followed by winnowing, harvesting, drying of produce and transplanting. Whereas women labour were involved in transplanting followed by other farm operations/ activities. Among studied states, Uttarakhand recorded the highest mean participation of women across the crops followed by Andhra Pradesh and Madhya Pradesh.

## INTRODUCTION

Women are major participants in farming activities in the rice-growing regions of Asia. In Indonesia, Thailand and the Philippines, women provided up to half the total labour input in rice production. Women's involvement in rice farming, however, varies from region to region and even within regions as well. Rice is typically produced in four ecosystems: irrigated land; rainfed lowland; upland; and deepwater and tidal swamps. Irrigated rice constitutes about half the total harvested area but contributes to more than two-thirds of the total production. All these ecosystems have different requirements and constraints. There is clear cut gender-based segregation in the responsibilities and activities undertaken in various agricultural production systems in India, including the rice farming system. Though, Agriculture Census undertaken at the national level takes care of the basic characteristics of operational holdings such as land use, cropping patterns, irrigation status, etc the disaggregated data on dynamics of gender issues in agriculture remains scanty.

In rural India, the percentage of women who depend on agriculture for their livelihood is as high as 84 per cent. Women make up about 33 per cent of cultivators and about 47 per cent of agricultural labourers. This does not account for the participation in livestock, fisheries and various other ancillary forms of food production. Nearly, 94 per cent of

the female agricultural labour force is engaged in cereal production, whereas 1.4 per cent in vegetable production and 3.72 per cent in fruits, nuts, beverages, and spice crops. As far as women's participation rate in various agricultural sectors is concerned, it is about 47 per cent in tea plantations, 46.84 per cent in cotton cultivation, 45.43 per cent in growing oil seeds and 39.13 per cent in vegetable production. While these crops require labour-intensive work, the work is considered quite unskilled. Women also have a large participation in ancillary agricultural activities. According to the Food and Agriculture Organization (2011), women represented a share of 21 percent and 24 percent of all fishers and fish farmers in two major producing countries i.e., China and India, respectively.

Men and women have different responsibilities in agriculture. Women share goes to as high as 40 percent (Dhaka et al., 1995; Arya et al., 2004; Singh et al., 2007) to overall crop production besides their fixed responsibility of housekeeping. Women are involved in almost every farm operation in agriculture. Rice farming is an area where participation of women is very significant and almost all the activities from seed selection, nursery raising, field preparation, transplanting, fertiliser application, weeding, harvesting, winnowing, parboiling, drying and storage are carried out by women alone or jointly with men. Most of these farm operations involve drudgery, particularly farm

women and hence there is a need to assess and its quantification apart from strategy to increase the work efficiency by reducing workload and operational drudgery. However, to address the gender issues in agriculture, understanding the dynamism of roles and responsibilities of men and women in various farm and household activities is very important. Factors influencing the role and responsibilities of women in agriculture are studies and presented in the paper.

## MATERIALS AND METHODS

Given the significant role of women in rice production system, a project on 'Gender issues in rice-based production system and refinement of selected technologies in women perspective' was conceived by then Directorate of Research for Women in Agriculture (Now ICAR-Central Institute for Women in Agriculture, CIWA) Bhubaneswar, India to undertake in network mode at five Centres namely CIWA Bhubaneswar as Lead Centre with four network centres like Central Rice Research Institute, Cuttack; Project Directorate of Rice Research, Rajendranagar, Hyderabad; G. B. Pant University of Agriculture and Technology, Pantnagar, and Kerala Agricultural University Vellanikkara, Trissur to assess farm women role and responsibilities in rice production system.

In order to undertake a survey, each Centre identified five major rice production systems /zones/districts of the identified state. Further, a rice-growing block was selected in each of the five zones/districts and in each block, eight to twelve rice-growing villages/ panchayats were identified for data collection. Data were collected from one man and one woman of the fifty randomly selected households in each of the villages. This made a study of 1000 respondents of 500 households (500 men and 500 women) at selected state by each participating Centres. Amongst, selected households were randomly taken from large (>10 ha), medium (4- 10 ha), semi medium (2-4 ha), small (1-2ha), marginal (<1 ha) and landless agricultural labour in each village based on proportionately belonging to the above category of farmers. Thus, the total sample size was [5 blocks (one each from five districts) x 2 villages x 50 households x 2 respondents] 1000. The survey schedule was designed in such a way that socio-economic information of selected respondents was taken in in part A and identification of gender issues in the rice production system in part B. The villages selected in respective districts of Madhya Pradesh, Odisha, Andhra Pradesh, Kerala and Uttarakhand are given in Table 1. The sample survey results of 2500 farming families from selected villages of different districts of respective states were analysed in the socio-economic aspect and gender analysis in crop production.

Table 1. Selected respondents from different states.

| States                |                           |                           |                                  |  |
|-----------------------|---------------------------|---------------------------|----------------------------------|--|
| Madhya Pradesh        | Odisha                    | Andhra Pradesh            | Kerala                           | Uttarakhand                              |
| Patehra (Rewa)        | Kimilo (Jagatsingpur)     | Hayathabad (Rangareddy)   | Nedumudi (Kuttanad-Alappuzha)    | Santipuri (Udham Singh Nagar)            |
| Deora (Rewa)          | Chaulia (Jagatsingpur)    | Ankuguda (Rangareddy)     | Champakulam (Kuttanad-Alappuzha) | Dineshpur, Gularbhoj (Udham Singh Nagar) |
| Akaraha (Sidhi)       | Ekagharia (Jagatsingpur)  | Bhupathipur (Karimnagar)  | Edappal (Kole- Malappuram)       | Halduchore (Nainital)                    |
| Dehli (Sidhi)         | Kankana (Jagatsingpur)    | Sambiahpally (Karimnagar) | Vattamkulam (Kole- Malappuram)   | Lalkuan – Bindukhatta (Nainital)         |
| Chikla (Balaghat)     | Purbakachha (Cuttack)     | Gavicherla (Warangal)     | Cheppadu (Onattukara-Alappuzha)  | Bhayu (Bageshwar)                        |
| Newar (Balaghat)      | Madhyakachha (Cuttack)    | Chintalpally (Warangal)   | Pathyoor (Onattukara-Alappuzha)  | Pharshali (Bageshwar)                    |
| Bori-khurd (Seoni)    | Harichandanpur (Balasore) | Chinnatekkuru (Kurnool)   | Thathamengalam (Palakkad)        | Nausar (Almora)                          |
| Pounar Kala (Seoni)   | Sutanati (Balasore)       | Peddatekkuru (Kurnool)    | Chittoor (Palakkad)              | Rawalsera (Almora)                       |
| Orei (Mandla)         | Kudia (Balasore)          | Vatticherukuru (Guntur)   | Noolpuzha (Waynad)               | Dore (Pithoragarh)                       |
| Kanhari Kala (Mandla) | Kujapali (Bargarh)        | Katrapadu (Guntur)        | Nenmeni (Waynad)                 | Bhainskot (Pithoragarh)                  |
|                       | Bhaitikra (Bargarh)       |                           |                                  |  |
|                       | Makarajhola (Ganjam)      |                           |                                  |  |

## RESULTS AND DISCUSSION

The analysis of the data of 2500 farming families of five states is discussed under the following sections.

### Socio-economic profile

Socio-economic conditions and role of women in rice-based production systems were studied in five states viz., Madhya Pradesh, Kerala, Andhra Pradesh, Odisha and Uttarakhand.

Andhra Pradesh had the highest (12.6) percentage of families headed by women followed by Kerala (6.4) and Odisha (3.8). Women found to head only 2.4 per cent families in Uttarakhand mainly in Bageshwar followed by Pithoragarh districts. In Madhya Pradesh women found to head 3.4 per cent families that too mainly in Mendla and Rewa districts. Demise of the male member, divorce or migration of male members far of the place was the main reasons for variation in women-headed households. Region-wise analysis done in Andhra Pradesh revealed that the maximum number of women-headed households were in the Telangana region.

Women had only 5.4 per cent household ownership. Joint ownership was 21.6 per cent; whereas men had 73.0 per cent of house ownership. Kerala recorded highest (10.6%) women ownership; whereas Uttarakhand recorded lowest (2.6%) ownership. Madhya Pradesh recorded only 4 per cent house ownership. Regarding categories of houses, only 3.84 per cent women had Pakka houses as against 42.86 per cent men and 18.52 per cent jointly. Kerala women had the highest (10.6%) Pakka houses whereas Madhya Pradesh women the lowest (0.2%).

Availability of water and electricity are two important facilities that influence lifestyle and efficiency of farm women. There were 92.3 per cent respondents having electricity at their home and 32.1 per cent at their farm. Data recorded at different Centres revealed that electricity was found in all the households (100 per cent) in the states of Kerala and Uttarakhand followed by Madhya Pradesh (97.4%), Odisha (87.8%) and Andhra Pradesh (76.5%). At the farm, Kerala recorded the highest (90%) electricity followed by Andhra Pradesh (58.3%) whereas Odisha recorded the lowest (2.0%).

Table 2. Gender-wise occupation in selected states.

| States         | Gender wise occupation (per cent) |             |             |             |            |            |            |            |             |             |
|----------------|-----------------------------------|-------------|-------------|-------------|------------|------------|------------|------------|-------------|-------------|
|                | Farming                           |             | Farm Labour |             | Service    |            | Business   |            | Others      |             |
|                | Women                             | Men         | Women       | Men         | Women      | Men        | Women      | Men        | Women       | Men         |
| Madhya Pradesh | 36.9                              | 59.4        | 2.1         | 2.2         | 0.5        | 5.6        | 0.0        | 1.7        | 60.5        | 31.2        |
| Kerala         | 4.05                              | 43.9        | 0.4         | 2.1         | 6.32       | 18.3       | 0.1        | 5.4        | 89.1        | 30.3        |
| Andhra Pradesh | 76.8                              | 90.2        | 5.8         | 6.4         | 0.8        | 1.8        | 0.0        | 1.6        | 16.6        | 0.0         |
| Odisha         | 32.6                              | 54.6        | 51.4        | 27.4        | 0.0        | 2.6        | 16.0       | 15.4       | 0.0         | 0.0         |
| Uttarakhand    | 2.6                               | 85.2        | 0.0         | 0.0         | 0.0        | 11.0       | 0.0        | 1.2        | 0.0         | 0.0         |
| <b>Mean</b>    | <b>30.6</b>                       | <b>66.7</b> | <b>11.9</b> | <b>7.62</b> | <b>1.5</b> | <b>7.9</b> | <b>3.2</b> | <b>5.1</b> | <b>33.2</b> | <b>12.3</b> |

N=5000

Low availability of electricity in Odisha, Madhya Pradesh and Uttarakhand clearly indicate the dependency of another source of power for stationary use.

Regarding water sources, 40.7 per cent households were having own water source at their home and 41.0 per cent farm. In Kerala, the water source at the house was available in all the studied households (100%) followed by Andhra Pradesh (69.3%), Odisha and Uttarakhand and Madhya Pradesh. Availability of water source at the farm was highest in Kerala (85.0%) followed by Andhra Pradesh, (53.5%) whereas, Madhya Pradesh recorded the lowest (0.2%). The water source was available with all studied household in Kerala followed by Andhra Pradesh, Odisha and Uttarakhand. In Madhya Pradesh, the water source was not available at any studied household which indicates the pressure of fetching water on farm women.

Highest involvement of women in organisational membership (district/ panchayat/block/SHG level) was found in Andhra Pradesh (73%) followed by Kerala (40%), Odisha (33%). Uttarakhand recorded the lowest membership; whereas the involvement of men in the organizational membership was highest (54.8%) in Kerala followed by Andhra Pradesh (33%) and Odisha (24.2%). Women membership remained restricted mostly up to SHG level; whereas men represented up to district level.

There were 78.3 per cent households with nuclear family structure. Kerala had highest (100%) nuclear families followed by Odisha (76.3%), Andhra Pradesh (76.0%) whereas Uttarakhand recorded the highest number (32.2%) of joint families.

Women are involved in multifarious activities (Table 2). Their participation in other activities was more (33.2%) than farming (30.6%), farming labour (11.9%), services (1.5%) and business (3.2%) professions. Participation in farming was highest in Andhra Pradesh (76.8%) followed by Madhya Pradesh, and Odisha while average men participation was about 2.2 times higher as compared to women. Women as farm labour were highest in Odisha (51.4%) whereas average men participation was 36.2 per cent less as compared to women. Only 1.5 per cent women were in service while

average men participation was about 5.2 times higher as compared to women. On average, women participation in other than farm work was highest in Kerala (89.1%) followed by Madhya Pradesh (60.5%) and Andhra Pradesh (16.6%). Men participation was about 63.0 per cent less as compared to women. Farm women involvement in other sectors than farming was observed to be more which indicates attention.

Literacy particularly technological knowledge in the area of interest is one of the very important factors of gender issues. This is the area that could offer an edge to reduce gender discriminations in social and professional life. Policies and programmes need to be developed to provide equal opportunities for technical knowledge to men and women. Training is an important component of HRD which enhances knowledge, skill and attitude. Data collected revealed that the literacy of women was 74.88 per cent as compared to 89.16 per cent in men in the villages of different states. Illiterate women were found highest in Andhra Pradesh (42.6%) and lowest (13.0-13.62%) in Uttarakhand and Kerala states. The education level of the majority of women were having primary to high school. The data suggest regarding increasing trends in literacy amongst women as compared to past.

Ownership of irrigated, rainfed land, orchards, ponds, fallow/pasture land was mostly with men. However, women were having the highest percentage (5.05 per cent) of ponds followed by rainfed land, irrigated land, fallow/pasture land and orchards. Women in Kerala states were having the

highest percentage of rainfed (10%) and irrigated (3.44%) lands over other states while ponds were highest (20%) in the name of women in the state of Madhya Pradesh.

Jointly access over farm resources was recorded highest (62.3 %). Men stood second (30.5%) whereas women remained far behind (7.1%) as far as access over farm resources is concerned. Whereas control over resources was mainly with men (51.8%) followed by jointly (40.3%) and women had only 5.2 per cent control over the farm resources. Women of Andhra Pradesh were a little bit more comfortable with 11.1 and 10.1 per cent access and control over resources, respectively than the other States and Kerala women had the lowest access and control (1%) over farm resources.

### Gender analysis in crop production

Rice was the main crops in rice-based production system in all the studied areas in Madhya Pradesh, Kerala, Andhra Pradesh, Odisha and Uttarakhand. Rice-wheat was the major cropping pattern in Madhya Pradesh and Uttarakhand states covering 51.2 and 69.0 per cent area, respectively. Rice-Rice cropping system occupied 36.6, 50.6 and 59.4 per cent of the area in Kerala, Andhra Pradesh and Odisha, respectively. In Madhya Pradesh, total thirteen crop rotations were observed of which, two crop rotations were being practiced and twelve other crops namely, field pea, arhar, black gram, finger millet, green gram, khesari, lentil, niger, sesame, vegetable and wheat were being cultivated by the farmers with rice (Table 3). Based on the data, total six

Table 3. Cropping patterns in the rice-based production system in selected states.

| Madhya Pradesh            |              | Andhra Pradesh            |              | Uttarakhand                     |              | Odisha                   |              | Kerala                 |              |
|---------------------------|--------------|---------------------------|--------------|---------------------------------|--------------|--------------------------|--------------|------------------------|--------------|
| Cropping pattern          | Area (%)     | Cropping pattern          | Area (%)     | Cropping pattern                | Area (%)     | Cropping pattern         | Area (%)     | Cropping pattern       | Area (%)     |
| Rice-Field Pea            | 12.3         | Rice-Rice                 | 50.6         | Rice-Wheat                      | 69.0         | Rice-                    | 2.9          | Rice                   | 23.8         |
| Rice-Arhar                | 2.4          | Rice-Pulse                | 18.2         | Rice-Wheat-Sugarcane            | 19.0         | Greengram-Blackgram      |              | Rice-Rice              | 36.6         |
| Rice-Bengal gram          | 1.1          | Rice-Other Crops          | 22.6         | Rice-Wheat-Finger millet        | 5.3          | Rice-Greengram-sunflower | 2.3          | Rice-Cassava           | 4.9          |
| Rice-Black gram           | 13.1         | Rice-Wheat                | 3.5          | Rice-Wheat-Finger millet        | 6.8          | Rice-Black gram          | 1.2          | Rice-Rice-Green manure | 3.6          |
| Rice-Fallow-Finger millet | 0.4          | Rice-Mustard-Jute         | 0.4          | Rice-Wheat-Finger millet-Fallow |              | Rice-Groundnut           | 3.7          | Rice-Rice-Rice         | 8.2          |
| Rice-Green gram           | 0.3          | Rice-Fallow-Finger millet | 4.6          | <b>Total</b>                    | <b>100.0</b> | Rice-Green gram          | 2.1          | Rice-Rice-Sesame       | 6.1          |
| Rice-Khesari              | 3.1          | <b>Total</b>              | <b>100.0</b> |                                 |              | Rice-Mustard             | 4.0          | Rice-Rice-Vegetable    | 16.9         |
| Rice-Lentil               | 3.6          |                           |              |                                 |              | Rice-Groundnut-Mustard   | 1.9          | <b>Total</b>           | <b>100.0</b> |
| Rice-Niger                | 1.9          |                           |              |                                 |              | Rice-Groundnut-Vegetable | 2.0          |                        |              |
| Rice-Rice                 | 9.7          |                           |              |                                 |              | Rice-Rice                | 59.4         |                        |              |
| Rice-Sesame               | 0.7          |                           |              |                                 |              | Rice-Sunflower           | 2.9          |                        |              |
| Rice-Vegetable            | 0.2          |                           |              |                                 |              | Rice-Sweetpotato         | 0.3          |                        |              |
| Rice-Wheat                | 51.2         |                           |              |                                 |              | Rice-Watermelon          | 0.4          |                        |              |
| <b>Total</b>              | <b>100.0</b> |                           |              |                                 |              | Rice                     | 14.4         |                        |              |
|                           |              |                           |              |                                 |              | Rice-Vegetable           | 2.6          |                        |              |
|                           |              |                           |              |                                 |              | <b>Total</b>             | <b>100.0</b> |                        |              |

**Table 4.** Participation (hours/season) of respondents in various activities of rice cultivation in selected states.

| Name of farm activities             | Women        |             |              |             |              | Men         |              |             | Total hours /activity /season |
|-------------------------------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|-------------------------------|
|                                     | Family women |             | Women labour |             | Total        |             | h/season     |             |                               |
|                                     | h/season     | %           | h/season     | %           | h/season     |             |              |             |                               |
| Seed bed preparation                | 2.5          | 11.8        | 0.7          | 3.4         | 3.2          | 15.1        | 18.1         | 84.9        | 21.3                          |
| Nursery manuring                    | 0.4          | 8.9         | 0.4          | 8.9         | 0.9          | 17.7        | 4.1          | 82.3        | 5.0                           |
| Nursery sowing                      | 1.5          | 9.0         | 3.2          | 19.4        | 4.7          | 28.5        | 11.7         | 71.6        | 16.4                          |
| Nursery weeding                     | 2.4          | 12.9        | 7.6          | 40.3        | 10.0         | 53.2        | 8.8          | 46.8        | 18.9                          |
| Nursery watering                    | 2.1          | 23.3        | 1.1          | 12.1        | 3.2          | 35.4        | 5.9          | 64.6        | 9.1                           |
| Seedling uprooting                  | 3.3          | 8.5         | 15.1         | 38.4        | 18.4         | 46.8        | 20.9         | 53.2        | 39.3                          |
| Transporting seedling               | 1.6          | 9.1         | 3.3          | 18.5        | 4.9          | 27.6        | 12.9         | 72.5        | 17.9                          |
| Main field ploughing                | 0.3          | 2.0         | 0.1          | 0.7         | 0.4          | 2.6         | 14.8         | 97.4        | 15.2                          |
| Clod breaking                       | 0.2          | 5.0         | 0.6          | 14.0        | 0.8          | 19.0        | 3.2          | 81.0        | 4.0                           |
| Removal of grasses                  | 1.5          | 17.8        | 3.4          | 41.5        | 4.9          | 59.3        | 3.3          | 40.7        | 8.2                           |
| FYM application                     | 1.4          | 9.1         | 1.1          | 7.3         | 2.5          | 16.4        | 12.6         | 83.6        | 15.0                          |
| Fertilizer application              | 0.16         | 1.3         | 0.4          | 3.3         | 0.6          | 4.7         | 11.5         | 95.4        | 12.0                          |
| Pre transplant irrigation           | 0.0          | 0.0         | 0.2          | 9.1         | 0.2          | 9.1         | 2.0          | 90.9        | 2.2                           |
| Transplanting                       | 6.2          | 8.3         | 32.9         | 44.1        | 39.1         | 52.4        | 35.5         | 47.6        | 74.6                          |
| Ridge making                        | 0.3          | 2.3         | 0.0          | 0.0         | 0.3          | 2.3         | 12.1         | 97.8        | 12.4                          |
| Irrigation                          | 0.3          | 2.7         | 0.0          | 0.0         | 0.3          | 2.7         | 11.4         | 97.3        | 11.8                          |
| Top dressing                        | 0.0          | 0.0         | 0.0          | 0.0         | 0.0          | 0.0         | 5.1          | 100.0       | 5.1                           |
| Weeding                             | 3.8          | 9.6         | 15.2         | 38.6        | 19.0         | 48.2        | 20.4         | 51.8        | 39.4                          |
| Herbicidal application              | 0.0          | 0.0         | 0.0          | 0.0         | 0.0          | 0.0         | 1.8          | 100.0       | 1.8                           |
| Hoeing                              | 0.3          | 12.8        | 0.2          | 8.55        | 0.5          | 21.4        | 1.8          | 78.6        | 2.3                           |
| Sprayer handling                    | 0.0          | 0.0         | 0.0          | 0.0         | 0.0          | 0.0         | 1.3          | 100.0       | 1.3                           |
| Harvesting                          | 7.5          | 10.1        | 22.3         | 30.1        | 29.8         | 40.2        | 44.3         | 59.8        | 74.1                          |
| Carrying harvest to threshing floor | 1.7          | 6.4         | 6.5          | 24.3        | 8.2          | 30.7        | 18.5         | 69.3        | 26.7                          |
| Drying harvest                      | 2.9          | 36.8        | 2.6          | 33.0        | 5.5          | 69.8        | 2.4          | 30.3        | 7.9                           |
| Threshing                           | 4.1          | 10.0        | 10.2         | 25.2        | 14.3         | 35.2        | 26.2         | 64.8        | 40.5                          |
| Winnowing                           | 9.9          | 32.9        | 7.7          | 25.6        | 17.6         | 58.5        | 12.5         | 41.5        | 30.1                          |
| Carrying produce to home            | 4.5          | 23.1        | 2.8          | 14.4        | 7.3          | 37.5        | 12.2         | 62.5        | 19.5                          |
| Drying produce                      | 7.1          | 64.1        | 2.4          | 21.5        | 9.5          | 85.6        | 1.6          | 14.4        | 11.1                          |
| Storing seed                        | 11.7         | 86.8        | 0.4          | 3.0         | 12.1         | 89.8        | 1.4          | 10.2        | 13.5                          |
| Preparing produce for marketing     | 3.3          | 33.1        | 0.8          | 8.1         | 4.1          | 41.2        | 5.8          | 58.8        | 9.9                           |
| Aftercare of seed                   | 9.0          | 98.9        | 0.0          | 0.0         | 9.0          | 98.9        | 0.1          | 1.1         | 9.1                           |
| <b>Total</b>                        | <b>92.8</b>  | <b>15.6</b> | <b>145.7</b> | <b>24.5</b> | <b>238.5</b> | <b>40.2</b> | <b>355.5</b> | <b>59.9</b> | <b>594.0</b>                  |

crop rotations were practised in the state of Andhra Pradesh, of which, rice, pulse, wheat, mustard-jute, finger millet etc were the crops with rice in the rice production system. In Uttarakhand state, four crop rotations were practised in a rice-based production system which was wheat, wheat-sugarcane, wheat-finger millet etc. In Odisha, total fourteen crop rotations were being tried by the farmers of a different selected locale. Other crops after rice were green gram- black gram, green gram- sunflower, black gram, groundnut, mustard, groundnut- mustard, groundnut- vegetable, rice, sunflower, sweet potato, watermelon and vegetable. In the state of Kerala, a total six crop practices were followed by

the farmers after rice in the rice-based production system. The cropping patterns were rice, cassava, rice-green manure, rice-rice, rice-sesame and rice-vegetable.

The data on the participation of women in various activities of rice cultivation were collected from 50 farm families in Khurda and Puri districts (Table 4). The survey data revealed that family women contributed highest hours (11.72h/season) in storing of seeds. This, however, accounted second (86.81h) as far as percent of total hours is concerned. Aftercare of seeds stood first (98.90h) in this regard winnowing was reported second (9.90 h) followed by aftercare of seed (8.90 h), harvesting (7.46 h), drying of

produce (7.14 h) and transplanting (6.16 h). Thus, the role of family women remained mostly with post-harvest operations.

Women labour shared highest/hours in transplanting (32.90h) showing also the highest percentage (44.13h) among all the operations. Harvesting was the second (22.30 h) while uprooting of seedling stood third (15.08 h) as far participation of paid women is concerned. With regards to the participation of total women (family + labour), transplanting shared the highest hours (39.06h) which was 52.39 per cent of total participation in this operation. Similarly, harvesting reported to be the second (29.76 h, 40.16%) while weeding stood third (18.96 h, 48.17%) from the participation of women in rice cultivation is concerned. Harvesting recorded the highest hours (44.34 h) followed by transplanting (35.50 h) and threshing. In fact, these are the three operations, which attributed higher working hours in rice cultivation. Overall the women contribution is different operation recorded 40.15 per cent and that of men 59.85 per cent.

Activities of farmers for different crops in the rice-farming system were observed in Madhya Pradesh, Andhra Pradesh, Uttarakhand, Odisha and Kerala states (Table 5). There were thirteen major crops grown rice-based production system in Madhya Pradesh. Of these, rice recorded the maximum participation of women (44.5 %) followed by finger millet (43.1%) and vegetable (36.9%). In Andhra Pradesh, out of ten major crops grown; rice and maize recorded highest participation of women (44.5% each)

followed by cotton (43.7%) and groundnut (41.1%). In Uttarakhand, the highest participation of women was in finger millet (74.3%) followed by wheat (63.7%) and rice (61.4%). Farmers were raising seven crops in Odisha where in rice recorded the highest women participation (78.2%). There were five major crops grown under rice based production system in Kerala where majority of women participated in vegetable cultivation (42.7%) followed by rice, sesame and cassava. Among different States, Uttarakhand recorded highest mean participation of women across the crops followed by Andhra Pradesh and Madhya Pradesh.

## CONCLUSIONS

The study conducted to assess the socio-economic aspect and gender analysis in crop production revealed that very less house were headed by women with variations of 2.4-12.4% in selected regions of the country. Similarly, the status with regards to ownership of the house was also observed. However, the percentage was increasing in joint-ownership. The regions having a scarcity of water source have resulted in more pressure of fetching water on farm women. Women membership remained restricted mostly up to SHG level; whereas men represented up to district level. Women participation was more in other activities than farming, farming labour, services and business professions. Increasing trends in literacy amongst women were observed as compared to past. Jointly access over farm

Table 5. Participation (%) of respondents of different states in various crops

| Field crops     | Madhya Pradesh |      | Andhra Pradesh |      | Uttarakhand |      | Odisha |      | Kerala |      |
|-----------------|----------------|------|----------------|------|-------------|------|--------|------|--------|------|
|                 | Women          | Men  | Women          | Men  | Women       | Men  | Women  | Men  | Women  | Men  |
| Bengal gram     | 24.8           | 75.2 | -              | -    | -           | -    | -      | -    | -      | -    |
| Black gram      | 28.7           | 71.3 | -              | -    | -           | -    | 2.4    | 4.1  | -      | -    |
| Cotton          | -              | -    | 43.7           | 56.3 | -           | -    | -      | -    | -      | -    |
| Field Pea       | 28.5           | 71.5 | -              | -    | -           | -    | -      | -    | -      | -    |
| Finger millet   | 43.1           | 56.9 | -              | -    | 74.3        | 25.7 | -      | -    | -      | -    |
| Green gram      | 21.1           | 78.9 | 24.4           | 75.6 | -           | -    | 0.1    | 0.2  | -      | -    |
| Groundnut       | -              | -    | 41.1           | 58.9 | -           | -    | 3.3    | 2.7  | -      | -    |
| Khesari         | 24.9           | 75.1 | -              | -    | -           | -    | -      | -    | -      | -    |
| Lentil          | 34.3           | 65.7 | -              | -    | -           | -    | 1.7    | 2.7  | -      | -    |
| Maize           | -              | -    | 44.5           | 55.5 | -           | -    | -      | -    | -      | -    |
| Niger           | 23.3           | 76.7 | -              | -    | -           | -    | -      | -    | -      | -    |
| Red gram        | 29.8           | 70.2 | 31.9           | 68.1 | -           | -    | 2.4    | 2.0  | -      | -    |
| Rice            | 44.5           | 55.5 | 44.5           | 55.5 | 61.4        | 38.6 | 78.2   | 66.5 | 12.6   | 87.4 |
| Sesame          | 28.1           | 71.9 | -              | -    | -           | -    | -      | -    | 8.5    | 91.5 |
| Sorghum (Jowar) | -              | -    | 39.3           | 60.7 | -           | -    | -      | -    | -      | -    |
| Vegetable       | 36.9           | 63.1 | 36.3           | 63.7 | -           | -    | 0.07   | 0.09 | 42.7   | 57.3 |
| Wheat           | 32.4           | 67.6 | -              | -    | 63.7        | 36.3 | -      | -    | -      | -    |
| Flower          | -              | -    | 40.9           | 59.1 | -           | -    | -      | -    | -      | -    |
| Mango           | -              | -    | 37.0           | 63.0 | -           | -    | -      | -    | -      | -    |
| Sugarcane       | -              | -    | -              | -    | 51.6        | 48.3 | -      | -    | 0      | 100  |
| Cassava         | -              | -    | -              | -    | -           | -    | -      | -    | 5.2    | 94.8 |

resources was also recorded in increasing order. The family women contributed highest hours in storing of seeds followed by winnowing, harvesting, drying of produce and transplanting. This indicated role of family women remained mostly with post-harvest operations. Whereas women labour were involved in transplanting followed by other farm operations/ activities. In fact, farm women's involvement was highest for harvesting, transplanting and threshing. Among studied States, Uttarakhand recorded the highest mean participation of women across the crops followed by Andhra Pradesh and Madhya Pradesh.

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## Research Article



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## Key words

Landfill leachate, Municipal solid waste, Groundwater quality, Microbial contamination.

## Physicochemical and Bacteriological Characterization of Water from Wells and Bore Wells nearby Landfill area of the Waste Dumping site of Ahmednagar City

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The impact of solid waste disposal on the groundwater can be judge by monitoring the concentration of potential pollutants in the vicinity of the landfill site. In the present study, groundwater quality within the periphery of the landfill site in Burudgaon at Ahmednagar was investigated. Physico-chemical and bacteriological analysis of water samples from 2 bore wells and 4 dug wells was carried out to determine the extent of pollution. The sampling sites around the landfill area were at a distance of 100m, 400 m, 500 m, 1 km and 2 km. The study revealed that the groundwater quality does not confirm to the water quality standards as given by W.H.O. The effect of dumping of municipal solid waste on groundwater is clearly seen as high concentration of pH, EC, alkalinity, total hardness, total dissolved solids, BOD and COD. The MPN values are not in conformity with the W.H.O. standards. The total viable count and the presence of faecal coliform bacteria point towards the anthropogenic origin of the groundwater contamination. Presence of certain bacteria like *Moraxella* Group, *Enterobacter cloacae*, *Achromobacter dentrificans*, *Aeromonas veronii*, *Escherichia coli*, *Klebsiella pneumonia*, *Acinetobacter haemolyticus* and *Acinetobacter Iwoffii* indicate the degree of water pollution rendering it unpalatable. Thus, the quality of groundwater in vicinity of the landfill site needs to be monitored on a regular basis. Furthermore, proper solid waste management practices should be employed for dumping of solid wastes.

### INTRODUCTION

Ground water provides drinking water to the people and it contains over 90% of the fresh water resources, the quality of ground water is of paramount importance (Kurniawan, 2009). Water is said to be polluted when the water body is adversely affected by both the organic and inorganic contaminants (Oliver et al., 2011). In recent years the risk of groundwater pollution has become one of the most important environmental concerns, particularly in developing countries, where most of the landfills have been built without any sound engineering design such as engineered liners and leachate interception and collection system (Kurniawan, 2009). The usual and most neglected cause of water pollution is uncontrolled dumping of municipal solid waste (Igbal and Gupta, 2009).

In developing countries, several unregulated landfills exist adjacent to large cities, releasing harmful contaminants to the underlying aquifer (Singh et al., 2009). In India, open dumping of solid waste in low lying areas is practiced in most of the centres which are managed by municipal agencies. In urban areas the groundwater is contaminated due to leachate from municipal solid waste disposal site and in rural areas, leachate from fertilizers used for agricultural purposes has contaminated the groundwater (Eldho, 2001).

Municipal solid waste is a growing menace in present times. Population increase has added the problem many fold (Arneeth et al., 1989). Landfilling of municipal solid waste is a common waste management practice and one of the cheapest methods for organized waste management in many parts of the world (Longe and Balogun, 2010). Waste materials or the leachates so formed during the course of time may percolate to the ground water table. This may cause the pollution of ground water and ultimately affects the health of local inhabitants. Leachates are formed by slow decomposition of municipal solid waste (Arneeth et al., 1989). A combination of physical, chemical and microbial processes in the waste, transfers pollutants from the waste material to the percolating water (Christensen and Kjeldsen, 1989). These leachates may run off in the nearby natural water resources such as ponds, lakes and rivers which percolates to ground water causing water pollution (Arneeth et al., 1989).

Supply of adequate fresh water in large quantity to meet the increasing population's demand and maintaining the quality is now a thing of concern (Elinge et al., 2011). Hence, contamination of ground water through the infiltration of leachates via the soil and rocks needs to be avoided. Monitoring of the water quality is very important for environmental safety. In a related study it was suggested that,

constant natural water analysis of physical and chemical properties including trace of element contents are very important for public health studies (Kot et al., 2000). Keeping this in view the present study was undertaken to assess and understand potential contamination of groundwater near municipal solid waste (MSW) dumping site situated at Burudgaon, Ahmednagar.

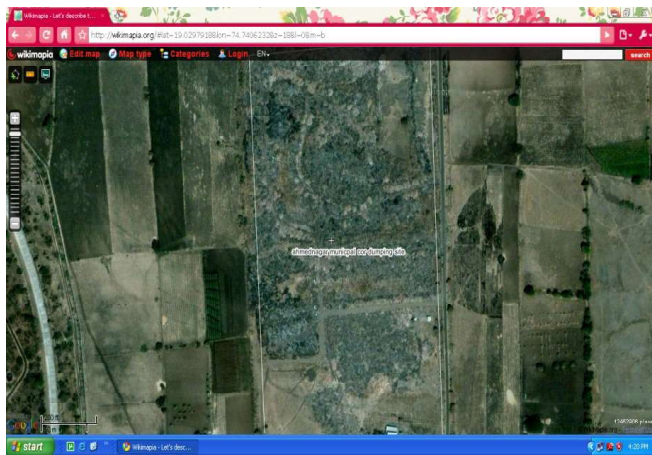
## MATERIAL AND METHODS

### Study Area

The study was conducted in Ahmednagar city in Maharashtra State of India. Ahmednagar city is situated between 19°04' N to 19°08' N latitude and 74°44' E to 74°46' E longitude. It is district headquarter with 85.14 sq. km. area and 3,50,859 populations (2011 Census).

### Dumping site at Ahmednagar

The landfill site at Burudgaon, is 15 km away from Ahmednagar city. The area of the landfill site is 2000 sq. meters and the waste dumped is 76 metric tons. The waste from different parts of the city is collected with the help of automobile vehicles such as trucks, truck tipper, bell vehicles, container placer, tractor trailer and also by manually operated vehicles such as pulling carts, dust bins and brought to the dumping site and is dumped in irregular fashion.



Satellite Image of Landfill Site

### Sample Collection

In an attempt to study the degree of groundwater contamination 6 sampling sites (viz., dug well and bore well) near the landfill site were selected from where the water samples were taken. The samples were collected in one litre capacity sterile polythene bottles. Prior to collection, bottles were thoroughly washed and rinsed with sample to avoid any possible contamination during bottling. The sampling site details including location, distance from landfill site and

type is given in Table 1. After sampling, the samples were marked according to their source and location and immediately transferred to the laboratory and stored at 4°C in the refrigerator until further analysis.

Table 1. Location and Distance of Groundwater Sampling Sites

| Sampling site | Sample Source | Distance from dumping site | Direction  | Depth   |
|---------------|---------------|----------------------------|------------|---------|
| 1.            | Bore well     | 1 km                       | South      | 150 ft. |
| 2.            | Well          | 2 km                       | South      | 48 ft.  |
| 3.            | Well          | 400 m.                     | East       | 54 ft.  |
| 4.            | Well          | 100 m.                     | North      | 48 ft.  |
| 5.            | Bore well     | 500 m.                     | North-west | 250 ft. |
| 6.            | Well          | 500 m.                     | West       | 42 ft.  |

### Physico-chemical Analysis

Various physico-chemical parameters examined and estimated in groundwater samples includes pH, EC, turbidity, alkalinity, TDS, total hardness, calcium, magnesium, chlorides, sulphates, phosphates, nitrates and potassium. All these parameters were estimated according to the standard analytical procedures given by APHA (1998). Along with this BOD, COD and MPN were also estimated. Changes occur in coliform and *E. coli* content of the water on storage. Hence, prolonged storage was avoided and water samples were analysed within 2 hours of sample collection for total viable count and the bacteria were isolated.

Isolation and biochemical characterisation of bacteria

The total viable count (TVC) of the water sample was recorded by serial dilution and pour plate method using nutrient agar. Discrete colonies which developed were counted and the average for duplicate cultures was recorded as total viable count of bacteria in the sample. MacConkeys agar was used for the culture of enteric bacteria. Representative colonies of different morphological types were further sub-cultured on nutrient agar slants. The isolated bacteria were characterized morphologically and biochemically as described in the Bergey's Manual of Systematic Bacteriology, (8<sup>th</sup> Edn.).

## RESULTS AND DISCUSSION

Water quality characteristics may be classified into three broad categories: physical, chemical and biological. Hence, the impact of municipal solid waste landfill site on the ground water quality was investigated in the present study. The physico-chemical and bacteriological analysis of the groundwater samples gave varied results which are given in Table 2.

pH is one of the enlightening attributes of water quality. Since biological activities are pH specific, determination of pH is very important. In the present study, pH of the groundwater samples was in the range of 9.2 (S6) to 9.9 (S3)

Table 2. Physico-chemical and microbial parameters of groundwater samples

| Parameter          | Unit    | S1  | S2   | S3    | S4    | S5    | S6   |
|--------------------|---------|---|------|-------|-------|-------|------|
| EC                 | mScm-1  | 1.58  | 1.82 | 3.69  | 5.16  | 1.80  | 1.6  |
| Turbidity          | NTU     | 0.40  | 0.93 | 0.84  | 2.12  | 3.80  | 0.09 |
| Alkalinity         | mg/l    | 250   | 310  | 300   | 380   | 480   | 370  |
| TDS                | mg/l    | 2445  | 691  | 638   | 4644  | 1032  | 2940 |
| Total Hardness     | mg/l    | 940   | 450  | 460   | 1870  | 590   | 1340 |
| Calcium            | mg/l    | 9.40  | 3.40 | 4.60  | 12.40 | 22.40 | 5.70 |
| Magnesium          | mg/l    | 6.40  | 4.20 | 3.80  | 4.60  | 24.12 | 5.15 |
| Chlorides          | mg/l    | 8.13  | 4.80 | 9.20  | 13.20 | 11.36 | 9.20 |
| Sulphates          | mg/l    | 11.10   | 0.92 | 3.81  | 19.20 | 9.19  | 1.92 |
| Phosphates         | mg/l    | 0.19  | 0.23 | 0.18  | 0.16  | 0.21  | 0.20 |
| Nitrates           | mg/l    | 11.23   | 9.21 | 27.81 | 21.19 | 13.3  | 7.21 |
| Potassium          | mg/l    | 0.10  | 0.11 | 0.09  | 0.18  | 0.13  | 0.09 |
| BOD                | mg/l    | 25  | 24   | 32    | 33    | 35    | 23   |
| COD                | mg/l    | 98  | 96   | 102   | 105   | 94    | 109  |
| MPN                | c/100ml | All samples have coliform count above 16/100 ml |      |       |       |       |      |
| Total Viable Count | TVC/ml  | 90  | 200  | 1365  | 392   | 560   | 6960 |

which is not desirable for drinking purpose. Higher pH suggests alkaline nature of the water samples, which may be due to the availability of nutrients. Maximum pH value of 9.9 exceeds the maximum permissible limit of WHO and Ministry of Work and Housing was from the sampling site nearest to the landfill site. Electrical conductivity (EC) measures the salinity and is indicative of the ability of the sample to carry an electric current. The EC of groundwater samples was in the range of 1.58 mScm<sup>-1</sup> (S1) to 5.16 mScm<sup>-1</sup> (S4). High EC (i.e. > 1mScm<sup>-1</sup>) of water indicates presence of higher soluble salts in the water.

Presence of calcium in water imparts hardness to water. In the present study the calcium content in groundwater samples was found to be in the range of 3.40 mg/l (S2) to 22.40 mg/l (S5). Maximum calcium content was found in a 250 ft. deep bore well which was 500 meters away from the landfill site. Calcium content was found to be well below the highest desirable limit given by WHO Magnesium along with calcium imparts hardness to water. Magnesium content in groundwater samples was found to be in the range of 3.80 mg/l (S3) to 24.12 mg/l (S5), which was within highest desirable limit of 30 mg/l given by WHO Chloride content was found to be in the range of 4.80 mg/l (S2) to 13.20 mg/l (S4), which was below the desirable limit of 200 mg/l given by WHO Sulphates are widely distributed in nature and natural waters. Sulphate content was found to be in the range of 0.92 mg/l (S2) to 19.20 mg/l (S4), which was below the desirable limit of 200 mg/l given by WHO. It was observed that the sulphate content in the groundwater samples increased as the distance of sampling site from the landfill site decreased. Higher phosphate content in water leads to algal blooms. In the present study the phosphate content was found to be in the range of 0.16 mg/l (S4) to 0.23 mg/l (S2). Nitrate in the groundwater samples was found to be in the range of 7.21

mg/l (S6) to 27.81 mg/l (S3). Nitrate content was within the desirable limit of 45 mg/l given by W.H.O. at all the sampling sites. Calcium and magnesium ions in water impart hardness to water. Total hardness was found to be in the range of 450 mg/l (S2) to 1870 mg/l (S4). The total hardness exceeds the permissible limit of 500 mg/l given by WHO at sampling site S1, S4, S5 and S6. According to WHO highest desirable turbidity of water should be 5.0 N.T.U. in the present study turbidity of groundwater was found to be in the range of 0.09 N.T.U. (S6) to 3.80 N.T.U. (S5). It was found to be below the desirable limit given by WHO but was above the acceptable limit of 2.5 N.T.U. given by Ministry of work and housing (1975) at S6 which was 3.80 N.T.U. Total dissolved solids were found to be in the range of 638 mg/l (S3) to 4644 mg/l (S4). They were found to much above the maximum permissible limit of 1500 mg/l given by W.H.O. Mor et al., (2006) has reported the effect of municipal solid waste disposal on groundwater around a Gazipur landfill site at Delhi. The moderately high concentrations of Cl<sup>-</sup>, NO<sup>3-</sup>, SO<sub>4</sub><sup>2-</sup>, NH<sub>4</sub><sup>+</sup>, Phenol, Fe, Zn and COD in groundwater, indicates that its quality is being significantly affected by leachate percolation.

BOD points towards the amount of organic matter present in the water. As per Water Quality Criteria for Freshwater Classification (CPCB, 1979) 2mg/l of BOD is ideal. In the present study the BOD was found to be in the range of 23 mg/l (S6) to 35 mg/l (S4), which was very high indicating presence of organic matter and rendering the water to be not potable. COD is used to measure the amount of organic compounds in water. COD is a measure of total amount of oxygen required to oxidize all organic material into CO<sub>2</sub> and water. It is observed that COD are always greater than BOD, which happens to be true in the present study. The COD was found to be in the range of 94 mg/l (S5) to 109

mg/l at (S6).

Similar observations are made by many researchers (Jeevanrao and Shantaram, 1995) who found that total hardness, alkalinity, BOD and COD were beyond the prescribed limit in the groundwater at both Amber pet and Golkonda solid waste landfill sites at Hyderabad. The effects of dumping activity on groundwater appeared most clearly as high concentrations of total dissolved solids, electrical conductivity, total hardness, chlorides, chemical oxygen demand, nitrates and sulphates. Leachate collected from the site showed presence of heavy metals.

The microbial analysis of the groundwater samples indicates that none of the water samples analysed met the WHO guideline limit. The MPN results showed that the Coliform count of the groundwater samples was found to be > 16/ 100 ml at all the sampling sites, which is above the desirable limit of 1/100 ml as per W.H.O and BIS standards. It is to be noted that the microbial count in the groundwater samples was variable. Fig. 15 shows the total viable count of the groundwater samples, which was found to be in the range of 90/ml (S1) to 6960/ml at (S6). The results imply that the groundwater sites around the municipal landfill site are not safe for drinking purpose in line with the microbial standard.

Depending upon their difference in colony characteristics 8 different bacteria was isolated. Gram staining was performed to observe the cellular morphology and gram nature of the bacteria. It was observed that all the isolated strains were gram negative rod shape bacteria. The results of biochemical test of the isolated bacteria are given in Table 3.

The bacteria isolated and identified were *Moraxella* Group (I1), *Enterobacter cloacae* (I2), *Achromobacter dentrificans* (I3), *Aeromonas veronii* (I4), *Escherichia coli* (I5), *Klebsiella pneumonia* (I6), *Acinetobacter haemolyticus* (I7) and *Acinetobacter lwoffii* (I8). Presence of these bacteria suggests relatively recent faecal, sewage, soil or rotten plants contamination (Grisey et. al., 2010). The leachate may contain microbes some of which may be opportunistic pathogens and that these microbes are capable of producing toxins of public health concern. Microorganisms contaminating water resources via leachate percolation are a potential threat to aquatic ecosystems and public health.

The characterization and identification tests revealed the presence of the diverse organisms in the groundwater samples within the periphery of the landfill site. The frequency of appearance reveals that *Klebsiella pneumonia* was the highest prevalent bacterium which was isolated from all the sites except S4, followed by *E coli* isolated from three sites namely S3, S4 and S5. Increased population of bacteria such as *E. coli*, *Klebsiella pneumonia* have been reported from landfill leachate sites (Donnelly and Scarpino, 1984; Bakare et al., 2003). Other isolates like *Moraxella* spp., which was found

at S3, *Enterobacter cloacae* and *Achromobacter* were found at S4, *Aeromonas veronii* was found at S5 and *Acinetobacter haemolyticus* and *Acinetobacter lwoffii* were found at S6.

The study points towards the possibility contamination of water bodies from the waste dumping site due to leachate percolation. Negative effect of Leachate percolation was seen on water quality parameters of the dug well as well as the bore well samples. pH and alkalinity of the samples were above the desirable limits. Total hardness and total dissolved solids were above the desirable as well as permissible limits at some sites. The BOD and COD of the samples were found to be very high. Presence of microorganism of public health implication was observed in the groundwater samples.

## CONCLUSION

The study reveals the effect of dumping municipal solid waste in the study area due to which the quality of ground water within the periphery of the landfill site is deteriorating. Physical, chemical and bacteriological tests of water quality are inter-related and must be considered together. The groundwater samples from the landfill site were analysed for the physico-chemical properties. Results show that some parameters exceed the desirable as well as permissible limit as prescribed by WHO., which confirm that groundwater samples within the periphery of landfill site is highly polluted and unfit for human consumption.

The MPN results confirmed the presence of faecal coliforms (>16) which indicates the presence of bacteria that can cause illness in human. The total viable count of the groundwater samples point towards the degree of groundwater contamination.

Presence of harmful bacteria like *Escherichia coli*, *Enterobacter cloacae*, *Achromobacter dentrificans*, *Aeromonas veronii*, *Moraxella* spp., *Acinetobacter haemolyticus*, *Klebsiella pneumoniae* indicate the extent of pollution. Certain chemicals provide favourable conditions for the propagation of the above organisms. The biochemical tests confirmed the presence of bacteria found in intestines of humans and mammals which belong to the Enterobacteriaceae family. Leachate is the prime factor for the propagation of these micro-organisms. Leachate generated from municipal solid waste landfill site affects the groundwater quality in the adjacent areas through percolation in the subsoil. Therefore, the quality of the groundwater needs to be regularly monitored and improved with adequate treatment.

Thus the need of the hour is to prevent further contamination of groundwater by proper remedial measures and developing a properly managed landfill site, so as to protect the surrounding environment and prevent health hazards to the people living in close proximity of the landfill site.

Table 3. Biochemical characteristics of bacteria isolated from groundwater sample

| Test                            | Amount /Well (mg) | I1* | I2* | I3* | I4* | I5* | I6* | I7* | I8* |
|---------------------------------|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Ala-Phe-Pro-Arylamidase         | 0.03              | -   | -   | -   | +   | +   | -   | -   | -   |
| ADONITOL                        | 0.18              | -   | -   | -   | -   | -   | -   | -   | -   |
| L-Pyrrolydonyl-ARYLAMIDASE      | 0.01              | -   | -   | +   | -   | -   | +   | -   | -   |
| L-ARABITOL                      | 0.30              | -   | -   | -   | -   | -   | -   | -   | -   |
| D-CELLOBIOSE                    | 0.30              | -   | +   | -   | +   | -   | +   | -   | -   |
| BETA-GALACTOSIDASE              | 0.03              | -   | +   | -   | +   | +   | +   | -   | -   |
| H2S PRODUCTION                  | 0.00              | -   | -   | -   | -   | -   | -   | -   | -   |
| BETA-N-ACETYL-GLUCOSAMINIDASE   | 0.04              | +   | +   | -   | +   | -   | +   | -   | -   |
| GLUTAMYL ArylamidasepNA         | 0.03              | +   | -   | +   | +   | -   | -   | +   | -   |
| D-GLUCOSE                       | 0.30              | -   | +   | -   | +   | +   | +   | -   | -   |
| GAMMA-GLUTAMYL-TRANSFERASE      | 0.02              | -   | +   | -   | +   | -   | +   | -   | -   |
| FERMENTATION \GLUCOSE           | 0.45              | -   | +   | -   | +   | +   | +   | -   | -   |
| BETA-GLUCOSIDASE                | 0.03              | -   | +   | -   | -   | -   | +   | -   | -   |
| D-MALTOSE                       | 0.30              | -   | +   | -   | +   | +   | +   | -   | -   |
| D-MANNITOL                      | 0.18              | -   | +   | -   | +   | +   | +   | -   | -   |
| D-MANNOSE                       | 0.30              | -   | +   | -   | +   | +   | +   | -   | -   |
| BETA-XYLOSIDASE                 | 0.03              | -   | +   | -   | -   | -   | +   | -   | -   |
| BETA-Alanine arylamidasepNA     | 0.01              | -   | -   | -   | -   | -   | -   | -   | -   |
| L-ProlineArylamidase            | 0.02              | -   | +   | +   | +   | -   | +   | -   | +   |
| LIPASE                          | 0.01              | +   | -   | +   | +   | -   | -   | +   | +   |
| PALATINOSE                      | 0.30              | -   | +   | -   | +   | -   | +   | -   | -   |
| Tyrosine ARYLAMIDASE            | 0.02              | +   | +   | +   | +   | +   | +   | +   | +   |
| UREASE                          | 0.15              | -   | +   | -   | -   | -   | +   | -   | -   |
| D-SORBITOL                      | 0.18              | -   | +   | -   | -   | +   | +   | -   | -   |
| SACCHAROSE\SUCROSE              | 0.30              | -   | +   | -   | +   | +   | +   | -   | -   |
| D-TAGATOSE                      | 0.30              | -   | -   | -   | -   | -   | -   | -   | -   |
| D-TREHALOSE                     | 0.30              | -   | +   | -   | +   | +   | +   | -   | -   |
| CITRATE(SODIUM)                 | 0.05              | -   | +   | -   | -   | -   | +   | -   | +   |
| MALONATE                        | 0.15              | -   | +   | -   | -   | -   | +   | -   | -   |
| 5-KETO-D-GLUCONATE              | 0.30              | -   | -   | -   | -   | -   | +   | -   | -   |
| L-LACTATE alkalisation          | 0.15              | -   | +   | +   | -   | +   | +   | -   | +   |
| ALPHA-GLUCOSIDASE               | 0.03              | -   | -   | -   | -   | -   | -   | -   | -   |
| SUCCINATE-alkalinisation        | 0.15              | +   | +   | +   | +   | +   | +   | +   | +   |
| Beta-N-ACETYL-GALACTOSAMINIDASE | 0.03              | -   | +   | -   | -   | -   | -   | -   | -   |
| ALPHA-GALACTOSIDASE             | 0.03              | -   | +   | -   | -   | +   | +   | -   | -   |
| PHOSPHATASE                     | 0.05              | -   | -   | -   | -   | -   | +   | -   | -   |
| Glycine ARYLAMIDASE             | 0.01              | -   | +   | -   | +   | -   | +   | -   | -   |
| ORNITHINE DECARBIXYLASE         | 0.30              | -   | +   | -   | -   | +   | -   | -   | -   |
| LYSINE DECARBOXYLASE            | 0.15              | -   | -   | -   | -   | +   | +   | -   | -   |
| DECARBOXYLASE BASE              | NA                |     |     |     |     |     |     |     |     |
| L-HISTIDINE assimilation        | 0.08              | -   | -   | -   | -   | -   | +   | +   | +   |
| COURMARATE                      | 0.12              | -   | -   | -   | -   | +   | -   | +   | +   |
| BETA-GLUCORONIDASE              | 0.03              | -   | -   | -   | -   | +   | -   | -   | -   |
| O/129RESISTANCE(comp. vibrio)   | 0.01              | -   | +   | -   | +   | +   | +   | -   | -   |
| GLU-GLY-ARG-ARYLAMIDASE         | 0.05              | -   | -   | -   | +   | -   | -   | -   | -   |
| L-MALATE assimilation           | 0.04              | -   | +   | -   | -   | -   | -   | -   | +   |
| ELLMAN                          | 0.03              | -   | -   | -   | +   | -   | -   | -   | -   |
| L-LACTATE assimilation          | 0.18              | -   | -   | -   | -   | -   | -   | -   | +   |

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## Research Article



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# Postural Stress Assessment of Male and Female Dairy Workers of Higher and Lower Age Group Preparing Food for Cattle

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Osteoarthritis of hip and upper limb complaints and hand arm syndrome are the occupational disease and hazards associated with work related risks factors prevalent in dairy farming activities. Age and sex of dairy workers are contributing factors in developing occupational diseases. Further, work force of dairy sector in India is heterogeneous i.e. females and males of various age group are engaged in it. In present study, an attempt has been made to find out postural stress among males and females of lower and higher age groups during preparing food for cattle and to find out impact of age and sex on postural stress caused during preparing food for cattle. Postural stress was measured by assessing time spent in different body postures, frequency of adopting various body postures and angle of body deviations in lumber region of dairy workers preparing food for cattle. Findings of study suggested that bending posture was adopted by dairy workers of all four groups for the longer period along with the highest frequency of adopting various standing positions in preparing food for cattle. Lifting of bundle of fodder is the work posture which requires maximum angular deviation of spine from the normal position. Further, time spent in different posture, frequency of adopting different posture and angle of body deviation in lumber region were maximum in females of the higher age group and minimum in males of lower age group.

## INTRODUCTION

The average size of land holding in India has decreased from 2.28 ha in 1977 to 1.55 ha in 1990-1991 (Chowdhary, 2005). Under these conditions dairy farming has emerged as an important source of income to rural people especially to small and landless farmers. Livestock is the fastest growing source of productive employment as compared to any other sector of Indian economy (Alagh, 2000). Within India the livestock sector supports the livelihood of nearly two hundred million poor (Ahuja et al., 2000). However, unlike developed country, dairy farming requires manual material handling with heavy lifting, pushing and pulling. All these have been recognized as risks factors for occupational health by NIOSH. Manual material handling (MMH) has been recognized as a major cause of industrial accident, acute overexertion injury and chronic repetitive strain injury. Osteoarthritis of hip and upper limb complaints and hand arm syndrome are the occupational disease and hazards associated with work related risks factors prevalent in dairy farming activities. Further, work force of dairy sector in India is heterogeneous i.e. females and males of various age group are engaged in it. As we know that males and females have different body capacity to perform the work and as the age of workers increases, various physiological changes take place in human body which reduce worker's working capacity. Thus, age and sex of dairy workers are contributing factors in developing occupational diseases. Preparing food for cattle

is a very common practice performed by dairy workers. During the activity a worker has to adopt various postures for performing various tasks related to activity. Thus frequent change in postures induces postural stress among dairy workers. In present study, an attempt has been made to find out postural stress among males and females of lower and higher age groups during preparing food for cattle and to find out impact of age and sex on postural stress caused during preparing food for cattle. Findings of the study will be useful in improving the working conditions of the dairy sector and enhancing work and health status of the workers through developing appropriate tools and techniques for the tasks related to food preparation for cattle while keeping age and sex factors of the workers in consideration

## MATERIALS AND METHODS

From the Kalayanpur block of district Kanpur (U.P.), India, thirty male and twenty two female respondents of 30-40 years and ten male and eight female respondents of 40-50 years were selected purposively on the basis of physical fitness. Physical fitness was assessed through body mass index (Garrow, 1981), body temperature (Not above 99°F), blood pressure (120/80<sup>+10</sup>) and heart rate (70-90 beats/min).

Postural stress was measured by assessing time spent in different body postures, frequency of adopting various body postures and angle of body deviation in lumber region of dairy workers during preparing food for cattle. Time spent in

different body postures by dairy workers was recorded with the help of stop watch and frequency of adopting various body postures by dairy workers was observed by simple count and record method from start of work to end of work without splitting up the whole activity into its various parts and without giving rest in between stages of the activity .Angle of body deviation in lumber region of dairy workers was analyzed with the help of flexi curve The shape adopted by flexi curve was immediately drawn on paper and angle of deviation of normal curve and deviated curve were measured with the help of protractor.

$\angle x$  is the required angle

Measure  $\angle y$

$$\angle x = 360^\circ - \angle y.$$

The activity of preparing food for the cattle involves different tasks which are as follows :

**Stage-I:** Onward journey from cattle-shed to grassland

**Stage-II:** Fodder cutting at grassland

**Stage-III:** Preparing and carrying bundle of fodder

**Stage-IV:** Chaffing

The collected data were tabulated and analyzed with the help of tabulation, subjective frequency, arithmetic mean, standard deviation, paired 't' test one way classification, ANOVA, Adjusted ANOVA (Snedecor, G. W. and Cochran, W.G., 1967).

## RESULTS AND DISCUSSION

Time spent in different body postures by female and male dairy workers of lower and higher age groups during milking

In complete cycle of preparing food for cattle, 'F' values

for the group means of time spent by dairy workers in different body postures were highly significant at 0.1 per cent level of significance for all the male and female dairy workers of lower and higher age group ( $A_1B_1$ ,  $A_1B_2$ ,  $A_2B_1$  and  $A_2B_2$ ) i.e. mean value of time spent by dairy workers of each group in different body posture was significantly differ from one another (Table 1).

Table 2 infers that the maximum mean value of time spent by dairy workers in different body postures (squatting, bending, sitting and standing) was recorded among females of higher age group ( $A_2B_1$ ) and minimum among males of lower age group ( $A_1B_2$ ) in complete cycle of preparing food for cattle. It is also elicited from the table that bend posture was the body posture in which dairy workers of all the groups spent maximum time during the work followed by standing posture. Moreover, total time spent in completion of preparing food for cattle was also observed maximum among females of higher age group ( $A_2B_1$ ).

Table 3 indicates that 't' values for the difference of means for time spent in different body postures was significant for each two groups of dairy workers compared at a time.

Main effect of age (A) and sex (B) of the dairy workers on time spent in different body postures during complete cycle of cleaning of cattle shed was significant whereas their interaction effect (A'B) was non-significant in complete cycle of the activity which signifies that effect of sex of dairy worker on the time spent in different postures has not varied from age to age (Table 4).

Table 5 implies that mean value of time spent by dairy

Table 1. ANOVA for the group means of time spent (min) in different body postures by dairy workers during preparing food for cattle (complete cycle).

| Source | d.f. | Body Postures (Preparing food for cattle) |           |                   |           |                  |            |                     |           |
|--------|------|---|-----------|-------------------|-----------|------------------|------------|---------------------|-----------|
|        |      | Sanding ( $S_1$ )                         |           | Sitting ( $S_2$ ) |           | Bending( $B_1$ ) |            | Squatting ( $S_3$ ) |           |
|        |      | M.S.                                      | F         | M.S.              | F         | M.S.             | F          | M.S.                | F         |
| Groups | 3    | 2.644                                     | 97.667*** | 10.378            | 19.892*** | 6.039            | 197.231*** | 7.931               | 15.468*** |
| Error  | 66   | 0.027                                     |           | 0.522             |           | 0.031            |            | 0.513               |           |
| Total  | 69   | 0.141                                     |           | 0.950             |           | 0.292            |            | 0.835               |           |

Table 2. Mean values of time spent (min) in different body postures by dairy workers during preparing food for cattle (complete cycle).

| Body Postures(Preparing food for cattle) | Time spent (min.) in different body posture(Mean values) |                          |                         |                          |              |
|--|--|--------------------------|-------------------------|--------------------------|--------------|
|  | Groups of dairy workers                                  |                          |                         |                          |              |
|  | $A_1B_1 = G_1$<br>(n=22)                                 | $A_1B_2 = G_2$<br>(n=30) | $A_2B_1 = G_3$<br>(n=8) | $A_2B_2 = G_4$<br>(n=10) | F<br>d.f.=66 |
| Standing ( $S_1$ )                       | 6.016(35.70)   | 5.672(22.63)             | 6.843(46.37)            | 5.891(34.25)             | 97.67***     |
| Bending ( $B_1$ )                        | 7.079(50.00)   | 5.865(34.00)             | 7.617(57.00)            | 6.813(45.93)             | 197.89***    |
| Squatting ( $S_3$ )                      | 2.429(5.600)   | 1.472(2.330)             | 3.295(10.37)            | 1.863(3.500)             | 15.47***     |

$A_1B_1$  = Females of lower age group ( $G_1$ )

$A_2B_1$  = Female of higher age group ( $G_3$ )

$A_1B_2$  = Males of lower age group ( $G_2$ )

$A_2B_2$  = Males of higher age group( $G_4$ )

Table 3. Comparison of groups of dairy workers on the basis of time spent (min) in different body postures during preparing food for cattle (complete cycle).

| Groups                           | Time spent (min) in different body postures (Preparing food for cattle) |                   |                           |                   |                           |                   |                             |                   |
|----------------------------------|---|-------------------|---------------------------|-------------------|---------------------------|-------------------|-----------------------------|-------------------|
|                                  | Standing (S <sub>1</sub> )  |                   | Sitting (S <sub>2</sub> ) |                   | Bending (B <sub>1</sub> ) |                   | Squatting (S <sub>3</sub> ) |                   |
|                                  | S.E <sub>D</sub>  | 't' <sub>66</sub> | S.E <sub>D</sub>          | 't' <sub>66</sub> | S.E <sub>D</sub>          | 't' <sub>66</sub> | S.E <sub>D</sub>            | 't' <sub>66</sub> |
| G <sub>1</sub> Vs G <sub>2</sub> | 0.055   | 17.22***          | 0.203                     | 5.595***          | 0.0491                    | 15.13***          | 0.201                       | 2.947**           |
| G <sub>1</sub> Vs G <sub>3</sub> | 0.081   | -9.922***         | 0.298                     | -2.704**          | 0.072                     | -11.45***         | 0.296                       | -4.844***         |
| G <sub>1</sub> Vs G <sub>4</sub> | 0.074   | -3.599***         | 0.275                     | 2.591*            | 0.067                     | 2.873**           | 0.273                       | -2.0720*          |
| G <sub>2</sub> Vs G <sub>3</sub> | 0.078   | -22.44***         | 0.287                     | -6.753***         | 0.696                     | -22.56***         | 0.285                       | -6.400***         |
| G <sub>2</sub> Vs G <sub>4</sub> | 0.071   | -16.944**         | 0.264                     | -2.64*            | 0.064                     | -9.678***         | 0.261                       | -3.661***         |
| G <sub>3</sub> Vs G <sub>4</sub> | 0.093   | 5.7816***         | 0.342                     | 3.633***          | 0.083                     | 11.477***         | 0.340                       | 2.551*            |

Table 4. Adjusted ANOVA for age (A) and sex (B) of dairy workers and their interaction effect (A×B) on adjusted means of time spent (min) in different body postures during preparing food for cattle (complete cycle).

| Groups | d.f. | Time spent (min) in different body postures (preparing food for cattle) |          |                           |          |                           |          |                             |          |
|--------|------|---|----------|---------------------------|----------|---------------------------|----------|-----------------------------|----------|
|        |      | Standing (S <sub>1</sub> )  |          | Sitting (S <sub>2</sub> ) |          | Bending (B <sub>1</sub> ) |          | Squatting (S <sub>3</sub> ) |          |
|        |      | M.S.  | F        | M.S.                      | F        | M.S.                      | F        | M.S.                        | F        |
| A      | 1    | 14.28   | 371.2*** | 7.410                     | 14.26*** | 6.742                     | 220.2*** | 18.16***                    | 35.42*** |
| B      | 1    | 12.14   | 351.6*** | 23.18                     | 44.43*** | 10.90                     | 356.1*** | 4.537                       | 8.85**   |
| A × B  | 1    | 0.554   | 3.39     | 0.040                     | 0.077    | 0.144                     | 3.706    | 0.743                       | 1.449    |
| Error  | 66   | 0.038   |          | 0.522                     |          | 0.031                     |          | 0.513                       |          |

workers in different body postures was maximum in females (B<sub>1</sub>) and minimum in males (B<sub>2</sub>) in complete cycle of preparing food for cattle.

From the findings of Table 6, it is evident that 't' values of time spent in different body postures for difference of means between lower and higher age group of dairy groups (A<sub>1</sub> vs. A<sub>2</sub>) and between male and female dairy workers (B<sub>1</sub> vs B<sub>2</sub>) were significant in complete cycle of preparing food for cattle. Further positive sign ('t' value) indicates that mean value of time spent by dairy workers in different body posture was significantly higher in higher age group than that in lower age group as well as significantly higher in females than in males.

Thus, description of various tables related to time spent in different body postures during preparing food for cattle suggests that age (A) and sex (B) of dairy workers exert significant influence on duration of adopting different body postures during preparing food for cattle. Females dairy workers were taken more time to finish the given work as compared to male dairy workers hence, they spent more time in different body postures during work, furthermore females of the higher age group (A<sub>2</sub>B<sub>1</sub>) spent more time in different

body postures as compared to females of lower age group (A<sub>1</sub>B<sub>1</sub>). Bending posture was adopted dairy workers of all four groups for the longer period than other body posture of preparing food for cattle.

Frequency of adopting various body postures by female and male dairy workers of lower and higher age group during milking

From the Table 7, it is obvious that 'F' values for the group means of frequency of adopting various body postures during complete cycle of preparing food for cattle was highly significant at 0.1 per cent level of significance for all the male (A<sub>1</sub>B<sub>2</sub> and A<sub>2</sub>B<sub>2</sub>) and female dairy workers (A<sub>1</sub>B<sub>1</sub> and A<sub>2</sub>B<sub>1</sub>).

In complete cycle of preparing food for cattle, mean value of frequency of adopting various body postures (S<sub>1</sub>, S<sub>2</sub>, B<sub>1</sub> and S<sub>3</sub>) was maximum in females of the higher age group (A<sub>2</sub>B<sub>1</sub>) and minimum in males of lower age group (A<sub>1</sub>B<sub>2</sub>). Except it, it is also observed from the Table 8 that mean value of frequency of adopting body postures [standing (S<sub>1</sub>), sitting (S<sub>2</sub>), bending (B<sub>1</sub>) and squatting (S<sub>3</sub>)] was maximum for standing postures (S<sub>1</sub>) followed by bending postures (B<sub>1</sub>) and minimum for squatting posture for all the

Table 5. Adjusted means of time spent (min) by groups of dairy workers during preparing food for cattle (complete cycle).

| Body Postures (preparing food for cattle) | Time spent (min.) in different body postures |                |                |                |
|---|--|----------------|----------------|----------------|
|   | Groups of dairy workers (adjusted means)     |                |                |                |
|   | A <sub>1</sub>                               | A <sub>2</sub> | B <sub>1</sub> | B <sub>2</sub> |
| Standing (S <sub>1</sub> )                | 6.331 (39.58)                                | 7.021 (48.86)  | 7.365 (53.74)  | 6.180 (37.69)  |
| Sitting (S <sub>2</sub> )                 | 1.768 (2.626)                                | 2.513 (5.812)  | 2.542 (5.962)  | 1.379 (1.402)  |
| Bending (B <sub>3</sub> )                 | 5.648 (31.40)                                | 6.230 (38.32)  | 6.358 (39.93)  | 5.433 (29.01)  |
| Squatting (S <sub>3</sub> )               | 1.720 (2.458)                                | 2.234 (4.492)  | 2.842 (7.579)  | 1.677 (2.311)  |

A<sub>1</sub> = lower age group(30-40), A<sub>2</sub> = higher age group(40-50), B<sub>1</sub> = females, B<sub>2</sub> = males

Table 6. Comparison of dairy workers on the basis of time spent (min) in different body postures during preparing food for cattle. (Complete cycle).

| Groups                          | Time spent (min.) in different body postures (Preparing food for cattle) |                   |                           |                   |                           |                   |                             |                   |
|---------------------------------|--|-------------------|---------------------------|-------------------|---------------------------|-------------------|-----------------------------|-------------------|
|                                 | Standing (S <sub>1</sub> )   |                   | Sitting (S <sub>2</sub> ) |                   | Bending (B <sub>1</sub> ) |                   | Squatting (S <sub>3</sub> ) |                   |
|                                 | S.E <sub>D</sub>   | 't' <sub>66</sub> | S.E <sub>D</sub>          | 't' <sub>66</sub> | S.E <sub>D</sub>          | 't' <sub>66</sub> | S.E <sub>D</sub>            | 't' <sub>66</sub> |
| A <sub>1</sub> VsA <sub>2</sub> | 0.054  | -19.27***         | 0.198                     | -.3717***         | 0.048                     | -14.84***         | 0.196                       | -5.952***         |
| B <sub>1</sub> VsB <sub>2</sub> | 0.047  | 17.76***          | 0.1745                    | 6.666***          | 0.042                     | 18.87***          | 0.173                       | 2.975**           |

A<sub>1</sub> = Lower age group (30-40), A<sub>2</sub> = Higher age group (40-50), B<sub>1</sub> = Females, B<sub>2</sub> = Males

Table 7. ANOVA for group means of frequency of adopting body postures by dairy workers during preparing food for cattle (complete cycle).

| Source | d.f. | Frequency of adopting body postures (Preparing food for cattle) |            |                           |   |                           |           |                             |          |
|--------|------|---|------------|---------------------------|---|---------------------------|-----------|-----------------------------|----------|
|        |      | Standing (S <sub>1</sub> )                                      |            | Sitting (S <sub>2</sub> ) |   | Bending (B <sub>1</sub> ) |           | Squatting (S <sub>3</sub> ) |          |
|        |      | M.S.  | F          | M.S.                      | F | M.S.                      | F         | M.S.                        | F        |
| Group  | 3    | 6.232   | 214.158*** | 1.816                     |   | 6.039                     | 260.07*** | 0.226                       | 2.082*** |
| Error  | 66   | 0.029   |            | 0.115                     |   | 0.023                     |           | 0.108                       |          |
| Total  | 69   | 0.299   |            | 0.189                     |   | 0.285                     |           | 0.114                       |          |

Table 8. Mean values of frequency of adopting different body posture by dairy workers during preparing food for cattle (complete cycle).

| Body posture (Preparing food for cattle) | Frequency of adopting body postures (Mean values)     |   |  |   | F        |
|--|---|---|--|---|----------|
|  | A <sub>1</sub> B <sub>1</sub> = G <sub>1</sub> (n=22) | A <sub>1</sub> B <sub>2</sub> = G <sub>2</sub> (n=30) | A <sub>2</sub> B <sub>1</sub> = G <sub>3</sub> (n=8) | A <sub>2</sub> B <sub>2</sub> = G <sub>4</sub> (n=10) |          |
| Standing (S <sub>1</sub> )               | 6.280 (38.94)   | 5.485 (29.58)   | 7.044 (49.12)  | 6.007(35.58)  | 214.2*** |
| Sitting (S <sub>2</sub> )                | 1.063(0.630)  | 0.862 (0.244)   | 1.788 (3.696)  | 1.125(0.765)  | 15.77*** |
| Bending (B <sub>1</sub> )                | 6.082 (36.49)   | 5.261 (28.17)   | 6.750 (45.06)  | 6.180(37.69)  | 260.1*** |
| Squatting (S <sub>3</sub> )              | 1.063 (1.630)   | 0.772 (0.096)   | 1.088 (0.684)  | 0.985(0.470)  | 2.082*** |

A<sub>1</sub>B<sub>1</sub> = Females of lower age group (G<sub>1</sub>)      A<sub>1</sub>B<sub>2</sub> = Male of lower age group (G<sub>2</sub>)  
 A<sub>2</sub>B<sub>1</sub> = Female of higher age group (G<sub>3</sub>)      A<sub>2</sub>B<sub>2</sub> = Male of the higher age group (G<sub>4</sub>)

dairy workers of the four groups (A<sub>1</sub>B<sub>1</sub>, A<sub>1</sub>B<sub>2</sub>, A<sub>2</sub>B<sub>1</sub> and A<sub>2</sub>B<sub>2</sub>) in complete cycle of preparing food for cattle .

Table 9 explains that 't' values for difference of means related to frequency of adopting different body postures (S<sub>1</sub>, S<sub>2</sub>, B<sub>1</sub> and S<sub>3</sub>) during complete cycle of preparing food for cattle were significant for each two groups of dairy workers compared at a time.

It is elicited from the Table 10 that the main effect of age (A) and sex (B) of the dairy workers on the frequency of adopting body postures was significant although their interaction effect (A × B) was non-significant in complete cycle of preparing food for cattle. Non-significant interaction effect infers that impact of sex of dairy workers on the frequency of adopting body postures has not changed along with their age.

Table 11 suggests that maximum mean value (adjusted) of frequency of adopting body postures (standing – S<sub>1</sub>, Sitting – S<sub>2</sub>, Bending – B<sub>1</sub> and Squatting – S<sub>3</sub>) during complete cycle of preparing food for cattle was in females (B<sub>1</sub>) and minimum in males (B<sub>2</sub>).

It is clear from Table 12 that mean value (adjusted) of frequency of adopting body postures among dairy workers of higher age group (A<sub>1</sub>) was significantly higher than that of

lower age group (A<sub>2</sub>). Similarly, it was significantly higher in females (B<sub>1</sub>) as compared to males (B<sub>2</sub>) in complete cycle of preparing food for cattle.

Hence, analysis of frequency of adopting various body postures by dairy workers of four groups during preparing food for cattle indicates that frequency of adopting various body posture was maximum for standing posture. It is also revealed that frequency of adopting various body posture or frequency of postural change was maximum in females of higher age group which indicates their lower body capacity to maintain a stable and continuous body posture against the pull of gravity during work. Reason related to it has already been discussed in earlier tables. Thus age and sex of dairy workers have a significant effect on frequency of adopting various body posture during the activity.

### Angle of body deviation in lumber region of female and male dairy workers during selected dairy farming activities

In preparing food for cattle, angle of body deviation in lumber region of dairy workers was measured in different activities which are as follows – cutting of fodder (P<sub>1</sub>), preparing bundle of fodder (P<sub>2</sub>), lifting of bundle (P<sub>3</sub>),

Table 9. Comparison of groups of dairy workers on the basis of frequency of adopting body postures in preparing food for cattle. (Complete cycle).

| Groups                           | Frequency of adopting body postures(Preparing food for cattle) |                  |                           |                  |                           |                  |                             |                  |
|----------------------------------|--|------------------|---------------------------|------------------|---------------------------|------------------|-----------------------------|------------------|
|                                  | Standing (S <sub>1</sub> )                                     |                  | Sitting (S <sub>2</sub> ) |                  | Bending (B <sub>1</sub> ) |                  | Squatting (S <sub>3</sub> ) |                  |
|                                  | S.E <sub>D</sub>   | t' <sub>66</sub> | S.E <sub>D</sub>          | t' <sub>66</sub> | S.E <sub>D</sub>          | t' <sub>66</sub> | S.E <sub>D</sub>            | t' <sub>66</sub> |
| G <sub>1</sub> vs G <sub>1</sub> | 0.048  | 16.60***         | 0.095                     | 2.707**          | 0.042                     | 19.19***         | 0.0924                      | -4.267***        |
| G <sub>1</sub> vs G <sub>3</sub> | 0.070  | -10.84***        | 0.140                     | -5.174***        | 0.062                     | -10.63***        | 0.136                       | 2.543**          |
| G <sub>1</sub> vs G <sub>4</sub> | 0.065  | 2.540*           | 0.129                     | -3.475           | 0.058                     | 3.299**          | 0.125                       | 3.619***         |
| G <sub>2</sub> vs G <sub>3</sub> | 0.068  | -22.96***        | 0.135                     | -6.855***        | 0.068                     | -24.57***        | 0.131                       | 2.412**          |
| G <sub>2</sub> vs G <sub>4</sub> | 0.062  | -11.15***        | 0.124                     | -26.16**         | 0.056                     | -13.40***        | 0.120                       | 2.852**          |
| G <sub>3</sub> vs G <sub>4</sub> | 0.080  | 10.68***         | 0.161                     | 4.121***         | 0.072                     | 10.29***         | 0.156                       | -2.368*          |

Table 10. Adjusted ANOVA for the age(a) and sex (A) of dairy workers and their interaction effect (A×B) on adjusted means of frequency of adopting body postures during preparing food for cattle (complete cycle).

| Groups | d.f. | Frequency of adopting body postures (Preparing food for cattle) |           |                           |          |                           |          |                             |         |
|--------|------|---|-----------|---------------------------|----------|---------------------------|----------|-----------------------------|---------|
|        |      | Standing (S <sub>1</sub> )                                      |           | Sitting (S <sub>2</sub> ) |          | Bending (B <sub>1</sub> ) |          | Squatting (S <sub>3</sub> ) |         |
|        |      | M.S.  | F         | M.S.                      | F        | M.S.                      | F        | M.S.                        | F       |
| A      | 1    | 7.026   | 241.32*** | 2.894                     | 25.13*** | 6.770                     | 291.6*** | 0.459                       | 4.233** |
| B      | 1    | 11.32   | 3888.8*** | 1.763                     | 15.31*** | 11.90                     | 473.5**  | 0.093                       | 8.858** |
| AX B   | 1    | 0.016   | 0.541     | 0.705                     | 2.119    | 0.019                     | 0.838    | 0.117                       | 1.083   |
| Error  | 66   | 0.029   |           | 0.115                     |          | 0.623                     |          | 0.108                       |         |

Table 11. Adjusted means of groups of dairy workers for the frequency of adopting body postures during preparing food for cattle (complete cycle).

| Body postures (Preparing food for cattle) | Frequency of adopting body postures(Adjusted means) |                |                |                |
|---|---|----------------|----------------|----------------|
|   | Groups of dairy workers                             |                |                |                |
|   | A <sub>1</sub>                                      | A <sub>2</sub> | B <sub>1</sub> | B <sub>2</sub> |
| Standing (S <sub>1</sub> )                | 5.884 (34.12)                                       | 6.478 (41.46)  | 6.609 (43.18)  | 5.665 (31.60)  |
| Sitting (S <sub>2</sub> )                 | 0.972 (0.445)                                       | 1.251 (1.065)  | 1.437 (1.566)  | 0.930 (0.366)  |
| Bending (B <sub>1</sub> )                 | 5.670 (31.65)                                       | 6.255 (38.63)  | 6.382 (40.23)  | 5.454 (29.25)  |
| Squatting (S <sub>3</sub> )               | 0.988 (0.475)                                       | 1.062 (0.626)  | 1.0.72 (0.649) | 0.886 (0.286)  |

A<sub>1</sub>= Dairy workers of lower age group, A<sub>2</sub>=Dairy workers of higher age group, B<sub>1</sub>=Female dairy workers, B<sub>2</sub>=Male dairy workers

Table 12. Comparison of groups of dairy workers on the basis of frequency of adopting body postures during preparing food for cattle (complete cycle).

| Groups                           | Frequency of adopting body postures(Preparing food for cattle) |                 |                           |                 |                           |                 |                             |                 |
|----------------------------------|--|-----------------|---------------------------|-----------------|---------------------------|-----------------|-----------------------------|-----------------|
|                                  | Standing (S <sub>1</sub> )                                     |                 | Sitting (S <sub>2</sub> ) |                 | Bending (B <sub>1</sub> ) |                 | Squatting (S <sub>3</sub> ) |                 |
|                                  | S.E <sub>D</sub>   | t <sub>66</sub> | S.E <sub>D</sub>          | t <sub>66</sub> | S.E <sub>D</sub>          | t <sub>66</sub> | S.E <sub>D</sub>            | t <sub>66</sub> |
| A <sub>1</sub> vs A <sub>2</sub> | 0.047  | -15.53***       | 0.093                     | -5.013***       | 0.042                     | -17.08***       | 0.090                       | 2.058***        |
| B <sub>1</sub> vs B <sub>2</sub> | 0.041  | 19.72***        | 0.082                     | 3.912***        | 0.037                     | 21.76***        | 0.80                        | -4.927*         |

A<sub>1</sub>= dairy workers of lower age group, A<sub>2</sub>=dairy workers of higher age group, B<sub>1</sub>=Female dairy workers, B<sub>2</sub>=Male dairy workers.

carrying bundle of fodder (P<sub>4</sub>), and chaffing (P<sub>5</sub>).

'F' values for the group means of angle of body bend in lumber region were highly significant for dairy workers of all the four groups during cutting fodder (P<sub>1</sub>), preparing bundle of fodder (P<sub>2</sub>), lifting bundle of fodder (P<sub>3</sub>), carrying bundle of fodder (P<sub>4</sub>), chaffing (P<sub>5</sub>) (Table 13).

Table 14 indicates that maximum average value for angle of body deviation in lumber region was observed in females of higher age group (A<sub>2</sub>B<sub>1</sub>) and minimum in males of lower age group (A<sub>1</sub>B<sub>2</sub>) during all activities of preparing food for cattle (P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>, P<sub>4</sub> and P<sub>5</sub>). It is also clear that

average value of angle of body deviation was maximum while lifting of bundle (P<sub>3</sub>) during preparing food for cattle.

't' values for the difference of means for angle of body deviation in lumber region among the dairy workers of all the four groups were significantly differ from each other while taken two groups at time in all the activities adopted during preparing food for cattle (Table 15).

Main effect of age (A) and sex (B) of dairy workers on angle of body deviation in lumber region in different activities of preparing food for cattle was significant while their interaction effect (A×B) was non-significant which

indicates that impact of sex of the dairy workers on angle of body deviation in lumber region has not changed from age to age of dairy workers (Table 16).

Mean value (adjusted) of angle of deviation in lumber region in different activities of preparing food for cattle was maximum in females (B<sub>1</sub>) and minimum in males (B<sub>2</sub>) (Table 17).

It is also clear to the Table 18 that mean value (adjusted) of angle of deviation in lumber region in different activities of preparing food for cattle was significantly higher in dairy workers of higher age group (A<sub>2</sub>) than that of lower age group (A<sub>1</sub>). Similarly, it was significantly higher in females (B<sub>1</sub>) than that males (B<sub>2</sub>) in all activities of preparing food for cattle.

Thus, from overall description, it can be summarized

that angle of body deviation in lumber region of dairy workers of all four groups is varied according to age and sex of dairy workers as well as activities of preparing food for cattle. Effect of age on postural deviation may be because of decreased human body capacity to maintain stable body posture during work against to the pull of gravity due to decreased muscle's flexibility, reduced muscles mass and due to increased bone demineralization which reduces bone mass and renders the bone fragile and prone to fractures with the increase of age of dairy workers. Furthermore, on an average upper body strength is 40–75 per cent less in females than in males while lower body strength is 5–30 per cent less in females (Anonymous, 1986). Hence, female's body capacity to maintain stable posture during work is lesser than male's body capacity. It may be a reason behind greater degree of

Table 13. ANOVA for the group means of angle of body deviation in lumber region of dairy workers in different work postures of preparing food for cattle (complete cycle).

| Source | d.f. | Angle of body deviation (Activities of preparing food for cattle) |          |                |           |                |        |                |          |                |          |
|--------|------|---|----------|----------------|-----------|----------------|--------|----------------|----------|----------------|----------|
|        |      | P <sub>1</sub>  |          | P <sub>2</sub> |           | P <sub>3</sub> |        | P <sub>4</sub> |          | P <sub>5</sub> |          |
|        |      | M.S.  | F        | M.S.           | F         | M.S.           | F      | M.S.           | F        | M.S.           | F        |
| Groups | 3    | 2682.4  | 8.300*** | 499.0          | 18.487*** | 169.9          | 3.201* | 5131           | 79.60*** | 756.5          | 103.3*** |
| Error  | 66   | 323.1   |          | 26.99*         |           | 53.09          |        | 64.46          |          | 73.23          |          |
| Total  | 69   | 425.7   |          | 47.52          |           | 58.17          |        | 284.72         |          | 398.9          |          |

P<sub>1</sub> = Cutting of fodder, P<sub>2</sub> = Preparing bundle of Fodder, P<sub>3</sub> = Lifting of bundle  
 P<sub>4</sub> = Carrying of bundle, P<sub>5</sub> = Chaffing

Table 14. Mean values of angle of body deviation in lumber region of dairy workers in different activities of preparing food for cattle (complete cycle).

| Activities<br>(Preparing food for cattle) | Angle of body deviation (Mean values)                 |   |  |   |          |
|---|---|---|--|---|----------|
|   | Groups of dairy workers                               |   |  |   | 'F'      |
|   | A <sub>1</sub> B <sub>1</sub> = G <sub>1</sub> (n=22) | A <sub>1</sub> B <sub>2</sub> = G <sub>2</sub> (n=30) | A <sub>2</sub> B <sub>1</sub> = G <sub>3</sub> (n=8) | A <sub>2</sub> B <sub>2</sub> = G <sub>4</sub> (n=10) |          |
| P <sub>1</sub>                            | 10.09   | 5.933   | 11.25  | 7.900   | 8.300*** |
| P <sub>2</sub>                            | 16.00   | 12.50   | 20.50  | 13.00   | 18.49    |
| P <sub>3</sub>                            | 28.73   | 46.60   | 31.00  | 46.80   | 3.201*   |
| P <sub>4</sub>                            | 8.955   | 5.000   | 12.00  | 6.600   | 79.60*** |
| P <sub>5</sub>                            | 14.00   | 3.900   | 18.37  | 10.30   | 103.3*** |

P<sub>1</sub> = Cutting of fodder, P<sub>2</sub> = Preparing bundle of Fodder, P<sub>3</sub> = Lifting of bundle  
 P<sub>4</sub> = Carrying of bundle, P<sub>5</sub> = Chaffing  
 A<sub>1</sub>B<sub>1</sub> = Females of lower age group (G<sub>1</sub>) A<sub>1</sub>B<sub>2</sub> = Males of lower age group (G<sub>2</sub>)  
 A<sub>2</sub>B<sub>1</sub> = Females of higher age group (G<sub>3</sub>) A<sub>2</sub>B<sub>2</sub> = Males of the higher age group (G<sub>4</sub>)

Table 15. Comparison of groups of dairy workers on the basis of angle of body deviation in lumber region during different activities during preparing food for cattle. (complete cycle).

| Groups                           | Angle of body deviation (Activities of preparing food for cattle) |                   |                  |                   |                  |                   |                  |                   |                  |                   |
|----------------------------------|---|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|
|                                  | P <sub>1</sub>  |                   | P <sub>2</sub>   |                   | P <sub>3</sub>   |                   | P <sub>4</sub>   |                   | P <sub>5</sub>   |                   |
|                                  | S.E <sub>D</sub>  | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> |
| G <sub>1</sub> vs G <sub>2</sub> | 2.045   | 2.176*            | 2.254            | 7.142***          | 5.046            | -4.282***         | 2.458            | 5.774***          | 2.402            | 15.45***          |
| G <sub>1</sub> vs G <sub>3</sub> | 3.008   | -2.974**          | 3.314            | -2.101*           | 7.422            | -3.760***         | 2.145            | -2.536*           | 3.533            | -0.772***         |
| G <sub>1</sub> vs G <sub>4</sub> | 2.779   | 3.518***          | 3.062            | -9.210***         | 6.856            | -3.196***         | 11.982           | 3.913***          | 3.263            | 11.31***          |
| G <sub>2</sub> vs G <sub>3</sub> | 2.899   | -2.546*           | 3.195            | -6.179***         | 7.153            | -2.881*           | 2.067            | -5.667***         | 3.405            | -10.10***         |
| G <sub>2</sub> vs G <sub>4</sub> | 2.661   | -2.087*           | 2.932            | -15.10***         | 6.564            | -3.046**          | 1.897            | -2.352*           | 3.124            | -2.064*           |
| G <sub>3</sub> vs G <sub>4</sub> | 3.456   | 2.069*            | 3.808            | -6.440***         | 8.527            | 2.704**           | 2.464            | 4.484***          | 4.059            | 8.425***          |

Table 16. Adjusted ANOVA for age (A) and sex (B) of dairy workers and their interaction effect (A×B) on adjusted means of angle of body deviation in lumber region during different activities during preparing food for cattle (complete cycle).

| Source | d.f. | Angle of body deviation (Activities of preparing food for cattle) |          |                |          |                |          |                |          |                |          |
|--------|------|---|----------|----------------|----------|----------------|----------|----------------|----------|----------------|----------|
|        |      | P <sub>1</sub>  |          | P <sub>2</sub> |          | P <sub>3</sub> |          | P <sub>4</sub> |          | P <sub>5</sub> |          |
|        |      | M.S.  | F        | M.S.           | F        | M.S.           | F        | M.S.           | F        | M.S.           | F        |
| A      | 1    | 2061  | 6.378*   | 44.30          | 4.641*   | 26.84          | 4.506*   | 9344           | 144.9*** | 15.73          | 8.215**  |
| B      | 1    | 3577  | 11.07*** | 1420.0         | 52.61*** | 454.7          | 8.565*** | 529.6          | 8.217*** | 2267           | 309.5*** |
| AxB    | 1    | 2509  | 0.764    | 22.75          | 0.843    | 23.97          | 0.451    | 5431           | 0.426    | 28.21          | 0.385    |
| Error  | 66   | 323   |          | 26.99          |          | 53.09          |          | 64.46          |          | 73.23          |          |

P<sub>1</sub> = Cutting of fodder, P<sub>2</sub> = Preparing bundle of Fodder, P<sub>3</sub> = Lifting of bundle  
 P<sub>4</sub> = Carrying of bundle, P<sub>5</sub> = Chaffing

Table 17. Adjusted means of groups of dairy workers for angle of body deviation in lumber region during different activities of preparing food for cattle (complete cycle).

| Activities (Preparing food for cattle) | Angle of body deviation (adjusted means) |                |                |                |
|--|--|----------------|----------------|----------------|
|  | Groups of dairy workers                  |                |                |                |
|  | A <sub>1</sub>                           | A <sub>2</sub> | B <sub>1</sub> | B <sub>2</sub> |
| P <sub>1</sub>                         | 73.45                                    | 83.78          | 85.86          | 69.33          |
| P <sub>2</sub>                         | 14.80                                    | 16.62          | 19.81          | 10.71          |
| P <sub>3</sub>                         | 55.64                                    | 57.06          | 58.58          | 53.43          |
| P <sub>4</sub>                         | 37.87                                    | 47.67          | 64.31          | 42.11          |
| P <sub>5</sub>                         | 36.37                                    | 64.02          | 65.11          | 20.67          |

P<sub>1</sub> = Cutting of fodder, P<sub>2</sub> = Preparing bundle of Fodder, P<sub>3</sub> = Lifting of bundle,  
 P<sub>4</sub> = Carrying of bundle, P<sub>5</sub> = Chaffing, A<sub>1</sub> = Lower age group (30-40),  
 A<sub>2</sub> = Higher age group (40-50), B<sub>1</sub> = Females, B<sub>2</sub> = Males

Table 18. Comparison of groups of dairy workers on the basis of angle of body deviation in lumber region during different activities of preparing food for cattle (complete cycle).

| Groups                           | Angle of body deviation (Activities of preparing food for cattle) |                   |                  |                   |                  |                   |                  |                   |                  |                   |
|----------------------------------|---|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|
|                                  | P <sub>1</sub>  |                   | P <sub>2</sub>   |                   | P <sub>3</sub>   |                   | P <sub>4</sub>   |                   | P <sub>5</sub>   |                   |
|                                  | S.E <sub>D</sub>  | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> | S.E <sub>D</sub> | 't' <sub>66</sub> |
| A <sub>1</sub> vs A <sub>2</sub> | 1.993   | -2.711**          | 2.196            | -12.04***         | 4.917            | -2.525*           | 1.421            | -2.281*           | 2.340            | 2.463*            |
| B <sub>1</sub> vs B <sub>2</sub> | 1.760   | 2.927**           | 1.939            | 2.867**           | 4.343            | -3.327**          | 1.255            | 7.253***          | 2.067            | 17.59***          |

P<sub>1</sub> = Cutting of fodder, P<sub>2</sub> = Preparing bundle of Fodder, P<sub>3</sub> = Lifting of bundle  
 P<sub>4</sub> = Carrying of bundle, P<sub>5</sub> = Chaffing, A<sub>1</sub> = Lower age group (30-40),  
 A<sub>2</sub> = Higher age group (40-50), B<sub>1</sub> = Females, B<sub>2</sub> = Males

angle of body deviation among females than males during various activities of milking. Except it, in Punjab, Oberoi *et al.* (1999) also observed greater percentage deviation of angle in female of higher age group as compared to lower age group performing fetching water, collecting and bringing fodder . Furthermore, age of worker in reference to postural deviation has equal effect on the dairy workers of both the sex. Except it, lifting of bundle of fodder is the work posture which requires maximum angular deviation of spine from the normal position.

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# Knowledge and Adoption of Aonla Production Technology by Farmers

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The Aonla (*Emblica officinalis* L.) one of the most important minor fruit and a crop of commercial significance, is quite hardy, prolific bearer and highly remunerative even without much care. It belongs to the family *Euphorbiaceae* and is known as amla, amlaki, amali, ambala, amalakamu and nelli in different parts of India. The fruit is highly nutritive and it is the richest source of vitamin C. The fruits are made into preserves (murabba) souce, candy, dried, chips, tablets, jellies, pickle, tophies, powder etc. The stability of ascorbic acid and presence of astringency in Aonla fruit may be assigned to the presence of Polyphenols or levcoanthocyanins. Aonla can be grown in light as well as heavy soil except very sand one. However, well drained fertile loamy soil is the best. The plant have capacity for adoption to dry regions and can also grown in moderately saline and alkaline soil. It is most popular in Uttar Pradesh where it is largely cultivated in commercial orchard in Azamgarh, Pratapgarh, Varanasi, Bareilly and Raebareli districts. In view of its diverse uses, its cultivation is increasing fast and the tree in becoming popular with the Orchardists. A full grown grafted Aonla tree with good bearing habit yield from 187 to 299 kg fruits per year. In Uttar Pradesh aonla cultivation is concentrated in Raebareli showed a yield of 1.8 qts from the 10 year old tree of Chakaiya and Banarsi varieties. The low yields might be due to lack of technical knowledge about technical know how and non adoption of aonla production technology by farmers. To examine the knowledge and adoption of aonla production technology following two specific objectives were formulated. The study the knowledge possessed by the farmers about Aonla production technology To study the adoption of aonla production technology by the farmers.

The study was conducted in Unchahar block of Raebareli district, U.P. There are 107 villages. Out of these 107 village only 20 villages were selected with the help of lottery method of random method. The data was collected by personal interview method with the help of structural interview sampling. The sample of 150 respondents were drawn with the help of proportionate random sampling schedule.

The data in Table-1 with respect to the practice-wise knowledge possessed by the respondent revealed that 80 per cent respondents were aware about the improved variety and time of harvesting of Aonla. It is further observed that 73.33, 71.33 and 70.00 per cent of respondents had knowledge about the practices like time of plantation, post harvest management and plant protection measures against insect pest & disease control, respectively. However, 56.67 per cent

Table 1. Distribution of respondents according to their knowledge and adoption of recommended Aonla production technology.

| S. No. | Particulars                     | Knowledge | Per cent | Adoption       |               |               |
|--------|---------------------------------|-----------|----------|----------------|---------------|---------------|
|        |                                 | N=150     |          | Full           | Partial       | Nil           |
| 1      | Improved variety                | 120       | 80.00    | 110<br>(91.67) | 10<br>(8.33)  | 30<br>(20.00) |
| 2      | Time of plantation              | 110       | 73.33    | 83<br>(55.33)  | 29<br>(19.33) | 38<br>(25.33) |
| 3      | Spacing                         | 85        | 56.67    | 77<br>(51.33)  | 38<br>(25.33) | 35<br>(23.33) |
| 4      | Dose of fertilizer              | 74        | 49.33    | 42<br>(28.00)  | 34<br>(22.67) | 74<br>(49.33) |
| 5      | Disease& insect pest management | 105       | 70.00    | 37<br>(24.67)  | 58<br>(38.67) | 55<br>(36.67) |
| 6      | Time of harvesting              | 120       | 80.00    | 76<br>(50.67)  | 48<br>(32.00) | 26<br>(17.33) |
| 7      | Post harvest management         | 107       | 71.33    | 44<br>(29.33)  | 63<br>(42.00) | 43<br>(28.67) |

and 49.32 per cent respondents had knowledge about spacing of plants and balanced dose of fertilizer, respectively.

The data of Table-1 shows that, 91.67 per cent respondents had adopted improved variety followed by 55.33 per cent, 51.33 per cent and 50.67 per cent of them adopting the time of plantation, recommended spacing from plant to plant and time of harvesting respectively. Less than half of respondents had complete adopted regarding post harvest management, balanced dose of fertilizer, disease and insect pest management of Aonla crop (29.33%, 28.00% and 24.67% respectively.)

In case of partial adoption majority of respondents 42 per cent, 38.67 per cent and 32.00 per cent adopted post harvest management, disease and insect pest management and time of harvesting followed by spacing, dose of fertilizer, time of plantation and improved variety (25.33 per cent, 22.67 per cent, 19.33 per cent and 8.33 per cent, respectively). However majority of respondents (49.33 per cent) had not adopted balanced dose of fertilizer followed by disease and insect pest management (36.67 per cent).

Table 2. Distribution respondents according to their knowledge and adoption.

| S. No. | Category | Knowledge       |            | Adoption        |            |
|--------|----------|-----------------|------------|-----------------|------------|
|        |          | Frequency N=150 | Percentage | Frequency N=150 | Percentage |
| 1      | Low      | 38              | 25.33      | 35              | 23.33      |
| 2      | Medium   | 85              | 56.67      | 86              | 57.33      |
| 3      | High     | 27              | 18.00      | 29              | 19.33      |
|        |          | 150             | 100        | 150             | 100        |

Table-2 Shows that 56.67 per cent of respondents found to have medium level of knowledge followed by 25.33 per cent low level and 18.00 per cent in high level of knowledge

categories. Majority of the respondents (57.33 per cent) were mediocre in adoption of the Aonla technology. It is therefore, concluded that there is a wide scope to increase the adoption of recommended Aonla production technology.

A critical examination of the data presented in Table-3 reveals that in age established a significant but negative correlation with knowledge possessed by respondents. It meant that with the increase in age, the knowledge, level of respondents decreased significantly. The education level, land holding, annual family income, area under Aonla fruits was found to have positive and significant correlation with the knowledge and adoption of Aonla production technology.

The socio-economic status, source of information and scientific orientation had significant correlation with the knowledge and adoption of the respondents regarding Aonla production technology.

It could be inferred that middle age group farmers with higher education, small size of land holding, higher annual family income, high socio-economic status, high source of information and scientific orientation had higher level of knowledge and adoption of Aonla production technology.

### CONCLUSION

The findings of study indicated that the majority of respondents had knowledge of the recommended practices. This showed that majority of respondents had low knowledge about recommended spacing of plant to plant and balance dose of fertilizer.

The majority of respondents adopted the practices recommended were improved variety, time of plantation and spacing of plant. The non adoption of practices like post harvest management and time of plantation has found to be very high.

Table 3. Relationship between selected characteristics of the respondents with their knowledge and adoption

| S.No.      | Variables                             | Correlation coefficients |          |
|------------|---------------------------------------|--------------------------|----------|
|            |                                       | Knowledge                | Adoption |
| <b>I</b>   | <b>Personnel characteristics</b>      |                          |          |
| 1          | Age                                   | 0.2799**                 | -0.1335  |
| 2          | Education                             | 0.7736**                 | 0.7043** |
| 3          | Land holding                          | 0.6013**                 | 0.7386** |
| 4          | Annual family income                  | 0.6104**                 | 0.7225** |
| 5          | Area under Aonla fruits               | 3.988**                  | 0.6304** |
| <b>II</b>  | <b>Socio-economic characteristics</b> |                          |          |
| 6          | Socio-economic status                 | 0.7663**                 | 0.7988** |
| <b>III</b> | <b>Communication behavior</b>         |                          |          |
| 7          | Source information                    | 0.8322**                 | 0.7322** |
| <b>IV</b>  | <b>Psychological characteristics</b>  |                          |          |
| 8          | Scientific orientation                | 0.7132**                 | 0.5033** |

\*\* Significant at 0.01 level of probability

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It could be, therefore suggested from the above findings that organized technical training programme, method and result demonstrations, farm tours to the University Research Centre as well as farm of progressive Aonla growers.

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Ogunseitan OA (1998). Protein method for investigating mercuric reductase gene expression in aquatic environments. *Appl. Environ. Microbiol.*, 64: 695–702.

Gueye M, Ndoye I, Dianda M, Danso SKA and Dreyfus B (1997). Active N<sub>2</sub> fixation in several *Faidherbia albida* provenances. *Ar. Soil Res. Rehabil.*, 11: 63-70.

Charnley AK (1992). Mechanisms of fungal pathogenesis in insects with particular reference to locusts. In: Lomer CJ, Prior C (eds) *Biological Controls of Locusts*

and Grasshoppers: Proceedings of an international workshop held at Cotonou, Benin. Oxford: CAB International, pp 181-190.

Mundree SG and Farrant JM (2000). Some physiological and molecular insights into the mechanisms of desiccation tolerance in the resurrection plant *Xerophyta viscasa* Baker. In Cherry et al. (eds) Plant tolerance to abiotic stresses in Agriculture: Role of Genetic Engineering, Kluwer Academic Publishers, Netherlands, pp 201-222.

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