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Editorial

With this issue we bring a closure to the year 2020. This was a year that one will never forget because of the COVID-19 pandemic and strict lock downs which affected and changed our social life style and customs. The pandemic made us realize that the world is very small and an invisible virus can bring the world to its knees. Compared to other recent pandemics such as SARS (2003), H1N1 Swine Flu (2009), Ebola (2013) and Zika (2015) which could be contained effectively, COVID-19 spread faster and sooner than the governments could respond leading to worldwide shutdowns and tragedies that we are still to come out from. Mission mode search for drugs and vaccines to stop the spread of this virus has resulted within one year of the start of the pandemic, several vaccines approved and launched for emergency use. This is the earliest in history of vaccine development that has been developed, certified and approved for public use. India had its own unique challenges in dealing with the pandemic because of the size of the country and large population, but the government has led from the front and India became a leader by approving two vaccines for emergency use. With vaccinations start-ups now, we expect an end to the COVID-19 pandemic soon, but the world would never be the same again.

Towards the end of 2020, thousands of farmers gathered at the borders of Delhi to protest against three farm laws - Farmers' Produce Trade and Commerce (Promotion and Facilitation) Act, Farmers (Empowerment and Protection) Agreement on Price Assurance and Farm Services Act, and the Essential Commodities (Amendment) Act. The government formulated these laws to accelerate growth in the agriculture sector through private sector participation and investment in building infrastructure and supply chains for farm produce. The laws would also help small farmers providing them viable options to sell their produce outside APMC 'mandis' to whomsoever gives them a better price. However, the farmers believe that the laws will lead to breakdown of the APMC-MSP system which purchases much of the surplus food grain, and lead to dominance of large corporations that would be detrimental to them in the long term. So far, the government and the farmers have not been able to find a way to end the standoff. We believe that to improve the financial situation of smaller farmers, entry of private players in agriculture will definitely help, but proper legal checks should be in place to prevent exploitation of small and marginal farmers. This is the only way to uplift the Indian farmer and agriculture that is stuck at crossroads since the green revolution. The farmers also should look beyond the protection of minimum support price, and the government should create an environment where even the smallest of the farmers can transform his farming into a profitable venture and not the busines as usual.

With these thoughts we present the third issue of year 2020 for the RASSA Journal of Science for Society. Your suggestions and comments are welcome at our email editor.scienceforsociety@gmail.com.

Editors

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News & Views

Singapore approves consumption of lab-grown meat

In December 2020, Singapore became the first nation to approve lab-grown meat consumption. Proponents of artificial meat cite several advantages for lab-grown meats, such as environment-friendly, free of diseases and antibiotics used in the meat industry. However, the costs are still an issue, and from a massive USD 330,000 for a lab-grown burger in 2013 cost around, it now costs USD 9. However, the industries see a future in it, and a lot of investment has been made into the lab-grown meats over the last few years. Cultured meat is quickly evolving but still in its initial stages.

The sixth mass extinction is underway

In the > 4.5 billion years history of our planet Earth, there has never been a richness of life comparable to that which exists today. It is suggested that in the last 450 million years, five mass extinction episodes caused by catastrophic alterations of the environment, such as massive volcanic eruptions, depletion of oceanic oxygen, or collision with an asteroid have happened, destroying 70 to 95% of the species of plants, animals, and microorganisms that existed at that time. But, life recovered and moved on, and today, the absolute number of species is greater than ever before. However, it has been predicted that life has entered a sixth mass extinction event because of human activities. Millions of species have vanished in the last 100 years, with most people unaware of the loss. These losses are seen in large mammals, insects and other invertebrates, various species of clams, snails, and starfish and plants.

'Tesla' comes to India

The future belongs to electric cars. Several carmakers like Tata, Mercedes, Hyundai, Morris Garage, Mahindra etc., have introduced fully electric car models in India. The billionaire Elon Musk's electric car making company Tesla opened up an office in India. This is good news for Indian car lovers and will push other car manufacturers to evolve faster and might result in better locally made cars. Tesla's cars are different from other electric cars as they are stylish, high performance and Tesla's declared mission is "to accelerate the advent of sustainable transport by bringing compelling mass-market electric cars to market as soon as possible". Tesla is known to bring out innovative and attractive car models. Since rolling out its first car, Tesla Roadster Model S in 2012, Tesla now produces SUV Model X, affordable Model 3 as well as a truck. Tesla has invested in building a network of charging stations, and has combined many of its sales centers with service centers and charging stations.

The age of RNA vaccines

Four main types of vaccines have been historically used for fighting various diseases; live-attenuated vaccines; inactivated vaccines; subunit, recombinant, polysaccharide, and conjugate vaccines, and lastly, the toxoid vaccines. The nucleic acid based vaccines are subunit vaccines employing the pathogen nucleic acid to elicit an immune response in the host. The RNA vaccines are essentially RNA encapsulated into lipid nanoparticles, which are injected into host. Although the technology is old, COVID-19 pandemic ensured a rise in use of RNA vaccines such as the ones used by Pfizer/BioNTech and Moderna vaccines. mRNA vaccines use host cells to make a partial/ full protein which triggers an immune response against the pathogen, leading to production of antibodies and immunity. RNA vaccines are safer, faster and cheaper than traditional vaccines, but some of the vaccines need a low temperature for storage and transport. The technology is promising and would be used against other diseases as well.

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Scientific Correspondence

A Current Perspective on COVID-19

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Acute respiratory syndrome, chest X-rays, COVID-19, CT scan, multiorgan dysfunction

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COVID-19 is a type of coronavirus disease belonging to the family *Coronaviridae*. The disease is thought to originate from bats and spread to people through an unknown medium in Wuhan, China. Ideally, the condition is spread by inhalation or close interaction with infected droplets with an incubation period between two and fourteen days. Today, thousands of infections and deaths have been caused by the disease. The disease symptoms include fever, cough, sneezing, sore throat, difficulty in breathing, and tiredness. The disease diagnosis starts by gathering samples of the upper and lower respiratory tracts of the infected person. Also, chest X-rays and CT scans are used in the diagnosis. There is no precise treatment for the ailment, which calls for the need to prevent the disease from spreading. Notable prevention strategies are isolation of the infected persons, proper ventilation, hand hygiene, and use of personal protective equipment. This paper provides in-depth information on COVID-19 and it discusses the disease epidemiology, transmission, clinical features, diagnosis, treatment and prevention.

INTRODUCTION

COVID-19 epidemic is the foremost global health disaster today and the supreme challenge to the universe. Ideally, COVID-19 is an enclosed RNA virus that is distinctly present in people and animals. The virus belongs to the order *Nidovirales* order consisting of families, namely, *Roniviridae, Arteriviridae*, and *Coronaviridae* (Hassan *et al.*, 2020; Singhal, 2020). At the same time, the *Coronaviridae* family is divided into two, which include *Torovirinae* and *Coronavirinae*. Further, the Coronavirinae subfamily is classified into alpha-, beta-, gamma-, and delta- COVs (Hassan *et al.*, 2020). These viruses have a virus-related RNA genome that measures 26 to 32 kilobases in dimension, making it possible to isolate them from different animal species. Moreover, the coronaviruses can be seen under the electron microscope as it possesses a crown-like appearance (Figure 1).

The extensive spreading and associated health risks of the disease make it an essential pandemic. Primarily, human types of coronavirus are linked to minor clinical symptoms. The World Health Organization (WHO) has conducted studies and lab research to identify the new COV strain, designated as COVID-19 (Anjorin, 2020; Aluga, 2020; Clerkin *et al.*, 2020; Adhikari *et al.*, 2020; Harapan *et al.*, 2020; Prem *et al.*, 2020; Cheng *et al.*, 2020; He *et al.*, 2020; Brand *et al.*, 2020; Altmann *et al.*, 2020; Mehta *et al.*, 2020; Padron-Regalado, 2020; Weiss and Navas-Martin, 2005; di Gennaro *et al.*, 2020; Wang and Enilov, 2020; Harvey, 2020; Seshadri and Geetha, 2020; Alatrany, 2020; Khan and Mian, 2020; Huaman-Saavedra, 2020). On the other hand, the International Committee on Taxonomy of Viruses referred to the disease-causing virus as the SARS-CoV-2 virus. The way the illness spread from person-to-person has made it a public threat (Wang and Enilov, 2020). In this case, COVID-19 is extremely transmissible, and this calls for the need to understand its epidemiology. Epidemiologically all ages are at risk of getting the illness, because the ailment is transmitted through large droplets that result from coughing and sneezing by symptomatic individuals. In some instances, the infection can happen from asymptomatic individuals and before the beginning of symptoms. As of March 2020, the WHO announced that

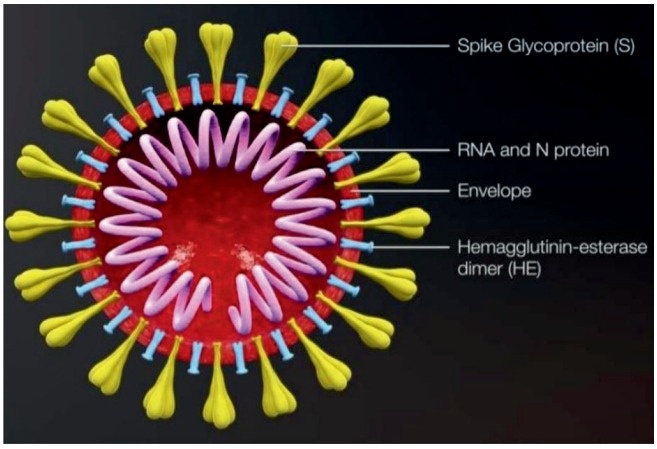

Figure 1. Structure of corona virus particle

there are about 87,317 cases of COVID- 19 globally as well as confirmed cases of deaths is 2977 (Hassan *et al.*, 2020; Shoenfeld, 2020; Escher, 2020; Kumar and Agarwal, 2020; Li and Wang, 2020; Ahmed and Tazneem, 2020; He *et al.*, 2020; George and George, 2020; Patel and Patel, 2020). This implies that the disease symptoms are mild, as only 3.42 percent of patients have died because of the virus. At the same time, the high number of incidences and deaths have been identified in China. It is that 92 per cent of the total number of occurrences have been reported in Asia, mainly China (Patel and Patel, 2020). Notably, the confirmed incidences are clinically identified and laboratory-confirmed. Further, outside Asia, the number of cases and deaths differs due to the ongoing nature of the disease, population density, degree of testing and reporting, and timing of reducing strategies (Harapan *et al.*, 2020). The features of COVID-19 are categorized into the host of the virus, transmission mode and incubation period (Clerkin *et al.*, 2020). In the first place, the Chinese horseshoe bat is the natural hosts and the terminal hosts are humans (He *et al.*, 2020). Also, the transmission is from individual to individual through aerosol droplets. Lastly, the incubation period varies from two to fourteen days. Therefore, COVID-19 cumulative incidence differs depending on the country, and incidences have been confirmed in almost all continents.

Transmission

COVID-19 can be transmitted through direct exposure to infected animals, human-to-human, and environmental contamination. Firstly, the initial cases of COVID-19 are associated with direct contact with infected animals, which was experienced at the seafood marketplace in Wuhan, China (Singhal, 2020). Moreover, the virus can spread from one person to another, which is considered the main form of transmission (Aluga, 2020). The interaction with those with the disease can lead to getting the ailment as spreading happens from the release of respiratory droplets, mainly through coughing. Therefore, close contact with individuals with COVID-19 can result in transmission. In some instances, there is a possible spreading in closed areas because of raised aerosol concentrations (Anjorin, 2020). Several studies support that the COVID-19 virus has a development period of two to fourteen days (Hassan *et al.*, 2020). Equally important, the virus can spread through touching contaminated surfaces. This happens when anyone touches these surfaces and then transfers the virus to mucous membranes in the body's upper parts, especially the mouth, eyes, or nose (Harapan *et al.*, 2020). It implies that the virus remains active in surfaces that individuals are likely to touch daily. Environmental contamination is more likely to be a possible infection source in environments where there is heavy viral contamination, mainly in an infected person's household (Harvey, 2020). As research from Singapore reveals that viral RNA is detected on nearly all surfaces, such as handles, light switches, toilet bowl, and bed and handrails (Singhal, 2020). Necessarily, COVID-19 can persist in surfaces as it has been tested and confirmed that this virus may persist on inorganic surfaces for up to six to nine days without disinfection (Alatrany, 2020). Hence, COVID-19 can be transmitted in different ways, which calls for the need for individuals to be aware of its transmission to keep themselves safe.

Clinical Features

This ailment's clinical features vary, extending from an asymptomatic state to acute respiratory distress syndrome to septic shock and multi-organ dysfunction. Ideally, this ailment is categorized depending on its severity, including mild, moderate, severe, and critical (He *et al.*, 2020). The shared symptoms of individuals with the disease include fever (98.6%), tiredness (69.6%), dry cough, and looseness of the bowels (Singhal, 2020).

Mild Illness

Individuals with minor ailment may present signs of respiratory tract viral contamination. Noticeable symptoms are dry cough, slight fever, nasal infection, sore throat, malaise, muscle pain and headache (Brand *et al.*, 2020). A recent study supports that 81 per cent of the COVID-19 incidences are mild in severity (Pardon-Regalado, 2020). At the same time, individuals with minor illness can rapidly worsen into critical cases.

Moderate Illness

Individuals with moderate disease are likely to present symptoms that are different from those of mild illness. Moderate disease symptoms include cough, breathing difficulty, and tachypnea (He *et al.*, 2020). In this stage, there are no symptoms of a serious ailment.

Severe Illness

Individuals with serious illness are likely to displays symptoms such as pneumonia, acute respiratory distress syndrome, and septic shock (Mehta *et al.*, 2020). In this stage, diagnosis is medical, and health problems can be left

out with radiographic research. Notably, 5 per cent of individuals with the illness can acquire a severe ailment with signs of respiratory failure, anemia, cardiac complications or multiple organ dysfunction (Clerkin *et al.*, 2020). Further, the mortality rate for critical clients is 49 percent. Also, individuals with other health complications have a higher mortality rate. Specifically, these health complications are diabetes (7.3%), respiratory ailments (6.5%), heart disease (10.5%), high blood pressure (6%), and oncological problems (5.6%) (George and George, 2020). This data indicates that individuals without other health complications have a lower mortality rate.

Acute respiratory distress syndrome

The onset of Acute Respiratory Distress Syndrome indicates deteriorating respiratory failure (Weiss and Navas-Martin, 2020). It happens as a difficulty within the first week of clinical confirmation. The degrees of PaO2 / FiO2 is utilized to differentiate Acute Respiratory Distress Syndrome based on changing degrees of hypoxia (Cheng *et al.*, 2020). When the PaO2 /FiO2 value is less than 100 mm Hg, it designates Acute Respiratory Distress Syndrome is severe. Similarly, when the value is between 100 mm Hg and 200 mm Hg, it indicates a reasonable Acute Respiratory Distress Syndrome. Further, the diagnosis of mild Acute Respiratory Distress Syndrome is displayed by values between 200 mm Hg and 300 mm Hg (Cheng *et al.*, 2020). Besides, chest imaging technologies, mainly chest X-ray, CT scan and lung ultrasound, can be utilized to sustain the diagnosis. Occasionally, a CT scan is used because of its accuracy in detecting symptoms (George and George, 2020). Contrariwise, a chest X-ray is not used most of the time because it has a lower sensitivity of 59 percent to detect subtle opacities.

Sepsis and septic shock

Individuals with ailment and sepsis are noted to be severe of them all. The reason is that multi-organ dysfunction increases the severity of the disease. The signs and symptoms of organ dysfunction are severe dyspnea, low oxygen saturation, minimized urine production, high blood pressure and altered mentation (Shoenfield, 2020). Moreover, clients with septic shock are determinedly hypotensive despite volume resuscitation.

Persistent Symptoms or Illnesses after Recovery from Acute COVID-19

There have been an increasing number of reports of patients who experience persistent symptoms after recovering from acute COVID-19. At this time, there is limited information on the prevalence, duration, underlying causes, and effective management strategies for these lingering signs and symptoms. Some of the symptoms overlap with the post-intensive care syndrome that has been described in patients without COVID-19, but prolonged symptoms and disabilities after COVID-19 have also been reported in patients with milder illness, including outpatients.

Some of the persistent symptoms that have been reported include fatigue, joint pain, chest pain, palpitations, shortness of breath, and worsened quality of life. One study from China found that pulmonary function was still impaired 1 month after hospital discharge. A study from the United Kingdom reported that among 100 hospitalized patients (32 received care in the ICU and 68 received care in hospital wards only), 72% of the ICU patients and 60% of the ward patients experienced fatigue and breathlessness at 4 to 8 weeks after hospital discharge. The authors of the study suggest that posthospital rehabilitation may be necessary for some of these patients.

Neurologic and psychiatric symptoms have also been reported among patients who have recovered from acute COVID-19. High rates of anxiety and depression have been reported in some patients using self-report scales for psychiatric distress.

Younger patients have been reported to experience more psychiatric symptoms than patients aged >60 years. Patients may continue to experience headaches, vision changes, hearing loss, loss of taste or smell, impaired mobility, numbness in extremities, tremors, myalgia, memory loss, cognitive impairment, and mood changes for up to 3 months after diagnosis of COVID-19. More research is needed to better understand the pathophysiology and clinical course of these post-infection sequelae and to identify management strategies for patients

Diagnosis

The laboratory methods by which coronavirus gets tested are:

- Swab test: Samples can be taken from the nostril or throat of an infected patient by swiping the special type of swab. Heath professional takes the sample.
- Nasal aspirate: Injection of saline solution into the nasal of infected patients and then collects the sample by removing the solution with suction.
- Tracheal aspirate: In this test the sample gets collected with bronchoscope by inserting it inside mouth of patient or may be to the lungs by health professionals.

- Sputum test: For this test the health professionals collects the sample of coughing in cup or in special type of swab by infected patients.
- Blood test: Blood samples get collected for detection of antigen antibody reactions in body. This test is used worldwide for detection of COVID-19 in approved laboratories. More widely used test of COVID-19 is "Rapid test kit" which is approved by Food and Drug Administration (FDA). This method is fast, accurate and approved in all laboratories throughout the world for detection of novel corona virus (Figure 2).

Preventive measures

People should follow the CDC rule on a regular basis to avoid Infection against the virus (Figure 3). The Government of India has also published many posters or guidelines for prevention against virus as follows:

1. Do not touch your nose, mouth and eyes.
2. Do not come in contact with an infected person.
3. Do not travel unless it is necessary.
4. Stay at home when you are unwell.
5. Cover your mouth and nose while sneezing or coughing with tissue and throw it in the dustbin.
6. Clean and sanitize the gadgets which come in contact with the infected person.
7. Washing hands with soap properly from 10-20 seconds and use sanitizer having 70% alcohol.
8. Avoid sharing dishes, glasses, bedding and other household gadgets when you are ill.
9. Wear a mask and gloves while travelling.
10. Keep social distancing of 6-7 feet with any person.
11. Avoid shaking hands with any person.
12. Drink as much as water to increase immunity.
13. Drink "Ayush kadha" daily to improve your immunity.
14. Do not eat raw or uncooked food or meat.
15. Avoid touching live or street animals.
16. One should wear personal protective care (PPE) kit for better safety while travelling.

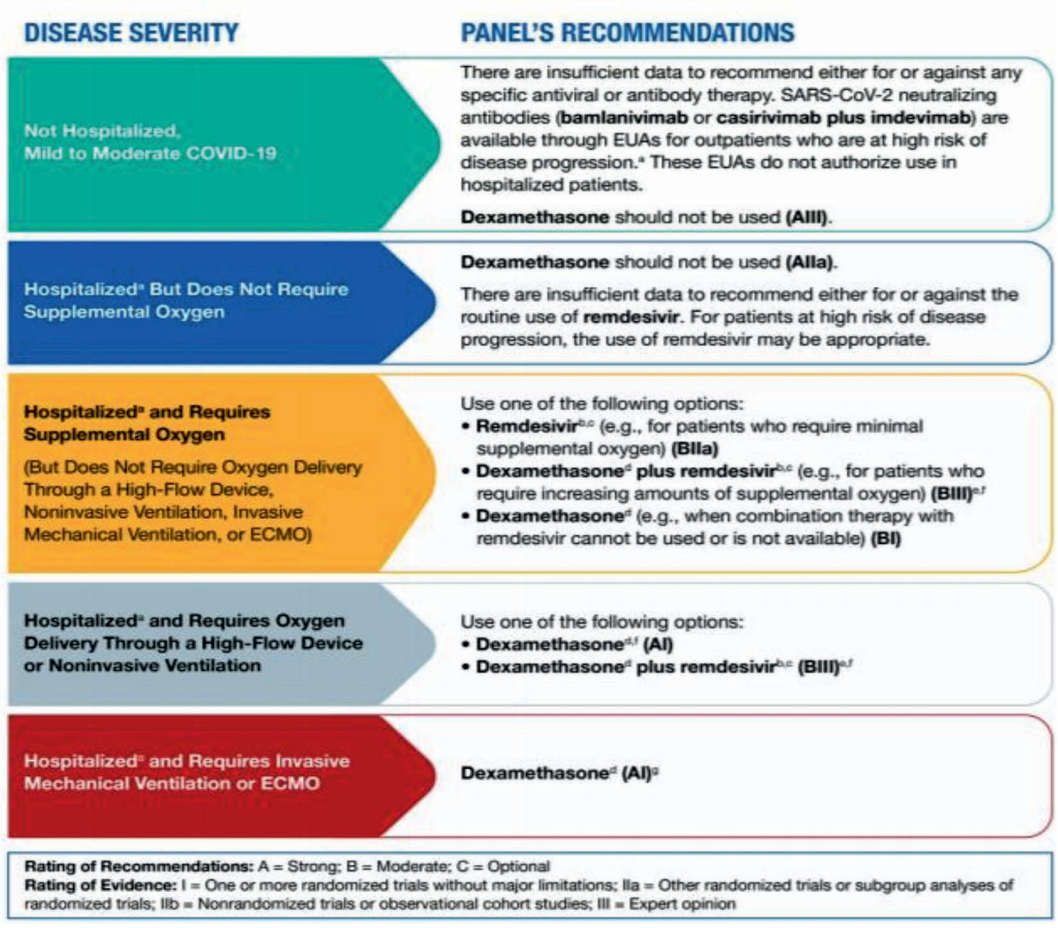

Figure 2. Pharmacological management of patient with COVID 19 based on disease severity

Figure 3. Preventive measures during Covid 19

Treatment Options

There is no specific treatment for treating the outbreak of the coronavirus in patients. Also treatments are under investigation in different countries. People with COVID-19 should receive proper supportive care, which helps to relieve symptoms. To relieve the symptoms, several drugs options are there to relieve the symptoms of this coronavirus as:

1. Anti-malarial drug-like Hydroxychlorquine
2. Antiviral drugs like Remedsivir, Lopinavir, Rotinavir, Ganciclovir, Ivermectin
3. NSAIDS like Ibuprofen, Aceclofenac
4. Neuraminidase inhibitors
5. RNA synthesis inhibitors
6. Combination therapy

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Feature Article

Emerging Issues of Food Security, Agrarian Crisis and Farmers' Distress in India*

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Agro-ecology, farmer's suicide, food contaminations, global economy, green revolution

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The Indian agriculture is facing problems of high input cost, deterioration of agro-ecosystems, poisoning of water, air and food bowls and farmers' distress in spite of huge increase in the productivity of the cereals and other commercial crops due to adoption of the green revolution and successive agricultural technologies. The climate change caused disasters and uncertainty in crop productivity due to varied reasons are increasing day by day. The increasing size of farmer families with decreasing land holdings, poor socio-economic status and deteriorated agro-ecology have made farming as a most problematic profession in comparison with service sector, organized employment and business modules. The young generation of farmers are moving towards cities and metros as daily wage labourers. It appears that the technology transfer and outreach programs for the development of rural economy and agriculture as a profession could not achieve the desired goals. Henceforth, we need to deliberate and investigate the interwoven complexities of the farming, rural development and food security to have a sustainable food security and development of the rural areas, and villages as a green habitat for the large number of rural population, animals, plants and microbes. We can design and develop novel below ground and above ground agro-ecosystems for the emerging economic and nutritional needs of the farmers and entrepreneurs, ecosystem services and to reduce the increasing man-animal conflicts. It will require a new developmental pathway and carbon economy suitable for Indian conditions and novel innovations in agricultural production, storage, processing and marketing with its all possible backward and forward linkages.

INTRODUCTION

A few years ago, when Prime Minister Shri Narendra Modi called for "double the income of farmers" policy there were several discussions and debate of making efforts for its implementation in almost all sectors of the government agriculture system. This slogan triggered a new upheaval on agriculture and farmers, but its culmination was replaced by some serious and academic discourse on new agricultural reforms implemented in a hurry, debate on its opposition and now the vocal controversy of the Delhi-centric long peasant movement. The discourse of agriculture and farmers in India is neither becoming a discourse of economic, social and cultural development of the village, nor ways to industrialize the agriculture and food security. This apathy and confusion is leaving a large population of the country in continuous trouble of uncertain livelihood. In the midst of all this government, non-government, opposition political stir, farmer politics and media noise, farmers are shocked. They do not see any easy way forward for the solutions. A number of technological advancement in agriculture in the Indian context have been initiated by scientists, government departments, and trade groups, ranging from diversification of crops, land reforms, commercial farming and efforts to increase the adoption of new agricultural techniques, but agrarian crisis could not be resolved.

Indian societies have been traditionally rural based agrarian society for thousands of years, where a large number of people have been connected to the ancient traditions of villages predominated with animal husbandry and crop cultivation as back bone of the agrarian economics. The farmers in India lives in villages and are largely having marginal or small scale farm holdings due to high population load and less land resources for the agriculture. Rapid urbanization, social forestry, agro-forestry and increasing industrial and infrastructure cover have further decreased the availability of agricultural fields especially after adoption of the global economy and market dominated developmental pathways.

One of the United Nations Sustainable Development Goals relates to eliminate hunger from the world, achieve

*The views expressed in this feature article are of author's and does not represent the journal's opinion/stand on the issue.

food security, improve nutrition and develop sustainable agriculture. The Green Revolution will not be able to fulfil this requirements of SDG and food security in Indian context. Indian agriculture is largely dependent on the villages. Agriculture in our country is today a means of employment and livelihood for small and marginal farmers who are generally poor, uneducated and culturally different. The historical collectively of the villages and the self-sufficient social structures of the past are almost broken. Despite the slight economic betterment, the contemporary social harmony and cultural structures of the villages are constantly weakening. In such a situation, it is not possible to develop agricultural without developing network of policy makers, scientists, producers, market forces, environmentalists and health managers.

In this phase of global change, villages are unable to establish any remarkable foundation of sustainable development at all three levels of cultural, economic and social securities. Villages outside the cities less affected by Corona crisis and urban air pollution could be a natural and green habitat and hub of the small and medium green industries. This agriculture and farmer discourse started by increasing the income of the farmers got stuck in the whirlpool of farmers' organizations and political groups associated with the poisonous and anti-environment agricultural practices of Punjab, Haryana and Western Uttar Pradesh and questions on the new agricultural reform bills. It is unable to cover the pertinent multidimensional issues of the Indian agrarian crisis. All this debate related to farming, climate change and food security is again turning into taking a political side and opposition at this point.

The notion of keeping national food security connected only to village and farmer is an old concept of rural era which was developed long ago by the evolving societies. We have to change this sooner or later. Majority of the population of the developed countries is re-organized with the principles of development of industrial structures and market. As a result, agriculture and food security will also require industrial and marketing infrastructure principles and skills. The agricultural produce can be exported with variety, quality and non-contamination of toxic substances. Those countries have a better economy, higher per capita income and good indices of the development. Will India be able to change the current situation of agriculture to become a self reliant developed country? Our economical advisors and governments may have started thinking about this only after the adoption open market and economic globalization. The multiplicity of science, technological development and market mechanisms have also changed global agriculture, but our indigenous agrarian politics and agricultural discourse wants to continue to see the village and farmer as the same marginal, small, medium and big farmers.

When the American agronomist Norman Borlaug, who was honoured with the Nobel Peace Prize of global repute and the Padma Vibhushan award of Indian Government, developed dwarf varieties of wheat and subsequently many high yielding hybrids of wheat, rice and maize were developed by the various institutions of Indian Council of Agricultural Research (ICAR), New Delhi the crisis of the staple food of the mounting population of India could be overcome and progressively it was believed that the war against hunger is over. In turn, the technology of the Green Revolution created a huge market for certain highly expensive agricultural inputs in agriculture sector like hybrid and genetically modified seeds, chemicals, pesticides, weedicides, highly mechanized farm equipments and irrigation machinery etc. This agricultural input market was however, highly monopolized by certain huge multinational companies in India like other countries. Indian Council of Agricultural Research, New Delhi spread its country wide research infrastructure in tune to the needs of green revolution which could succeed well in Panjab, Haryana, Western Uttar Pradesh for wheat-rice cropping system and then extended in various other parts of the country for other cereals and commercial crops. The major focus in green revolution was expansion of irrigation facilities, production of hybrid seeds and consumption of agrochemicals to fulfil the need of soil N and to kill pests and pathogens from the croplands. However, such intense inputs could not be extended to storage of agricultural products, development of food processing and marketing chains, expanding nutritional diversity, saving the natural and biological resources from depletion, wastage and poisonous contaminations and henceforth the agrarian crisis in India consistently increased with the burgeoning population.

There was a stagnation and then deviation in the agricultural research and developmental policies to address the agrarian crisis in toto with its socio-economic, cultural and technical bottlenecks. We could not get many success stories like export of Basmati rice. Celebrating these successes, we did not understand the emerging challenges of the future in relation to the Indian agriculture based on rural farmers. In the beginning of 21st century, we entered into a phase of open economy and global market based developmental pathways. This was time when farm holding

declined further due to its division with the progression in generations, and expenditure on cultivation inputs e.g. seeds, agrochemicals, labours charges, wages for farm machines and farmers own living cost increased year by year. The farmers were facing threats of water pollution, depletion of groundwater, damage of cultivated crops due to epidemics, wild animals and climate change induced disasters and stagnation or uncertainties in the prices and markets for the agricultural products. The price of land has been increasing but income of the farmers has been decreasing consistently during these days. Due to urbanization and industrialization land use changes increased (Kukal and Irmak, 2017; Parker *et al.*, 2019 and Hall, 2019; Harwood, 2020; Thakur *et al.,* 2020). Hence, in spite of adoption of open market and global economy the market players could not enter in the crop cultivation, animal husbandry purchase of farm produce and its processing, the way they participated in seed production market and in the production and marketing of agrochemicals and farm machinery. The new generation of the rural agrarian youth shifted to cities and metros as daily wage labourers but in turn the city and metro based or even foreign based industrialists did not entered into the agrarian business as food producer and food processors. The Government supported systems Indian agriculture with its huge investments in research infrastructures and human resources, agricultural universities, multiple federal and government agricultural, horticultural, fisheries, and animal husbandry departments could not evolve the policies, programs and successful network for development of a respectable rural agrarian economy, agro based industrial network and uncontaminated and nutritious food security accessible to all as assigned as a prime target in Sustainable Development Goals (SDGs) of the United Nation. Let us understand the bottlenecks and wrong moves which brought the Indian food system on the cross roads.

The agrarian crisis and implementation gaps of perspectives and policies

Today Indian farmers are in crisis so are the rural agriculture and rural economy. Even after seven decades of the independence, a large population of about six and a half lakh Indian villages is still dependent on farming, which is executed on the small land holdings, with its allied activities and petty trades. Even after seventy years of the being a sovereign nation that large population has not been prepared for any other employment capabilities or skill except for being used as daily wage labourers for heavy jobs in cities and metros. Along with farmers and farmlands the entire agribusiness and sustainable food security are slowly moving towards an all-round crisis. The farmer's agitations and distress are increasing which are turning to their suicide, death by other reasons and economic debits. There are several reasons for this. The destruction of agricultural ecology, which has been continuously occurring since the Green Revolution due to the indiscriminate use of agrochemicals, over use of water in flood irrigate, increasing intensity of climate change-causing natural disasters, huge increase in cultivation cost and increasing uncertainty in crop productivity, prices and availability of consumers etc. (Giraddo and Rosset, 2018; Kukal and Irmak, 2018; Levs and Hall, 2019). Not being able to reach and to protect agricultural produce from animals and thieves in far-flung farms are also increasing due to increasing man animal and man to man conflicts. Under such circumstances, I do not think there is any basis to believe that the new industrialists will take the agriculture hand to hand just because of these most discussed bills and will help or harm the farmers much. These new agricultural bills may not matter much practically in enhancing or reducing the agrarian crisis in India to my understanding and belief. But it can be said that in order to give full opportunity to the democratic judicial rights of the farmers, new laws implemented in the name of agrarian reforms should have been taken a shape after consulting the farmers' organizations in time. Though, such a large peasant movement, limited to not enforcing these new laws, instead of large discussions on the multi-dimensional problems of agriculture and country-wide farmers, is not possible without the participation of political outfits, but it is a matter of regret that insistence on both sides just on these bills and limited newly adopted regulations, instead of addressing the complex challenges of agriculture, farmers and the proper development of the rural economy, it has become entangled in some small quarrels.

The issue is whether this agriculture bill and today's agricultural policies will be able to address the problems of job availability, food security and rural socio-economic and cultural declines? Shall we achieve a sustainable food security and quality life for our huge underprivileged rural population by shaping up the agrarian economy and agro-ecology? Can we cope, adopt and mitigate the increasing climate crisis, and environmental detoriations? Can we remove poison from our air, water and food bowl after this agricultural reform (Mie *et al.,* 2017; Rai *et al.,* 2019; Karunarathne *et al.,* 2020)? Possibly not. On the other hand

it is very unusual to assure that it will transfer agriculture in hand of big business houses.

When the political leadership of the early twenty-first century adopted a large-scale economic reform by adopting an open market based global economy and in this period, there was a huge increase in salary, wages and business profits, the agrarian crisis should have gone away. But the crisis of the agriculture, farmers and farm labourers did not reduce but continued to grow. In spite of a huge enhancement in the daily wages of farm labourers their consistent income could not be secured due to problems of less working days in crop production system. We can understand that under the growth model driven by the economics of multinational companies will not give socio-economic and environmental security to our agriculture sector. The goals to achieve agricultural sustainability and nutritious food security to such a large population of the country can't be achieved this way. The market forces of the global economy see us as buyers, not as builders. The second important aspect to consider is that multinational open economies operating on the principles of the market promoting excessive manufacturing and excessive consumption to increase profits which ultimately leads to consumption of more natural resources and generation of more waste. These practices are fatal for the sustainable development philosophies from the environmental point of view. Rationing of employees in big budget super-tech companies are not suitable for the employment of our large young population. We need to develop our own innovative economic development model, which will make the villages and the country self-reliant, generate more employment and design the agricultural ecology in tune of the emerging consumption needs.

Need for an ecological, economic and Indianized green revolution

The Indian agriculture needs a new philosophy, new methodology and new practices based on science of sustainability, a green self-reliant economy and potentials to engage plenty of unskilled, semi skilled and well skilled human resources as a key domains in our agrarian economy. It can be achieved by adopting the techniques and practices of conservation agriculture, ecological inputs, semi mechanized agronomic practices, designing novel below ground and above ground agroecosystem and aquaculture, hydroponics and multi-tiering. Establishing participatory and networked small to large scale industries and enterprises for the backward and forward linkages of crop cultivation systems can make a significant difference in agrarian economy.

The fragmented land holdings can be avoided by lease farming, contract farming or small farmers' association managed farming. The private operators can manage the input cost and input resources in a better way to reduce the cost of production in comparison to uneducated or semi educated farmer or government institutions. However, they will hardly care for social and ecological management which may require new technologies, innovations and more semi mechanized or manual operations. They can be better managers of storage, and evolving need based market linkages. Therefore, an strictly regulated and transparent policy framework involving the interest of farmers, farm labourers, industrialists, market managers, farmers' associations and consumers will be required to be evolved, implemented and monitored periodically for its impact assessment on agrarian economy, rural development, job creation, restoration and revitalization of agro-ecology and nutritious poison less food stuffs accessible to all.

Many novel scientific and technological outcomes based on agriculturally beneficial soil microbes, semi-mechanized or energy efficient renewable energy based farm machineries, climate resilient planting materials, micro-irrigation devices and non-pesticidal management based pest control measures are getting space in the global agricultural systems to earn uncontaminated food security and to achieve agricultural sustainability in era of the present climate change and global warming in tropical regions.

In the new world driven by Big Data Analysis and computer revolution, the Indian farmer is envisaged as a rural deprivation uneducated or semi-educated middle-aged man. The agricultural scientists, industry operators and agricultural administrators on the other hand, are considered as professional innovator, skilled and competent person in the field of agriculture. At one time, the traditional rural culture was considering farming as a more respectable profession than job and trade. Now this pride of agriculture as a profession has became a history. Now, the farming is considered as a left out profession and executed by those who are unable to do jobs or business. For the sake of public discussions the farmers are given the name of 'Annadata' but all the gentle people at heart consider agriculture as the last choice and the farmer as a rural illiterate and poor villager. Should not a sovereign nation, independent for seven decades, regret the social, cultural and economic insecurity provided to such a vast

population involved in farming? This should be considered with honestly and due seriousness.

The fatigue of green revolution

It is believed that the farmers in some areas of Punjab, Haryana and Uttar Pradesh, where mainly wheat and paddy are cultivated are richer than the others and the Green Revolution farming reached one day in India from America, has done wonders. Dwarf breeds of wheat and rice brought an unprecedented increase in the yield of these cereals and a significant increase in the economic status of the farmers who were already having relatively better social status with larger land holdings. But even then these rural farming communities could not get economic and social security like entrepreneurs, businessmen and well paid employees. The expensive inputs of the Green Revolution, filled with a multiplicity of hybrid seeds, chemical fertilizers, poisonous pesticides and farm equipments, suddenly increased the production of wheat and paddy, but the farmers are not happy, the fields are not fertile and the nutritional quality of the food items could not be maintained. Water, land, air, food plate all became poisonous. The ground water went down. Poison was poured in the rivers. The diseases like cancers, organ failure, nervous disorders have increased. The achievements of Green revolution which were an immediate solution to hunger could not be evaluated and reorganised with the emerging requirements the agrarian society in India later. Though the green revolution helped to strengthen the Public distribution system for the rural India and the country earned status of self-sufficiency in food production, which strengthened our national honour, we forgot that this achievement was not enough to meet the challenges of the open economy and socio-economic security of a large unskilled and semi-skilled young generation. The scientists, policy makers and the government departments, seeking their own benefits in commemorating the success of the Green Revolution, consistently ignored the real problems of farming and farmers living in distant rural India. Like the Scheduled Castes, Scheduled Tribes, Backward Castes, women, no permanent commission was formed to protect the rights of farmers, agricultural labourers and villages despite a clear situation that they are also not being included in the mainstream of the development. The suggestions of short-term committees of agricultural scientists and administrators like the Swaminathan Commission were also put in cold storage. It would not be right to assume that all the problems of today's agriculture would have been corrected by adopting suggestions of these committees and commissions but adopting the recommendations might have given same way out on certain issues.

Most of the villages and farmers are still struggling with poverty, illiteracy and plight. Several stories of farmers' suicides beset by debt and discord are usually in the news. Rural youth are socially, culturally and economically insecure, despite working hard in the industrial areas of the cities and metros living humiliating lives in the urban slums. It was evident by their walk for thousands miles to reach their villages by foot within the Corona crisis. The income of farmers and agricultural labourers which was already uncertain and insufficient has gone down due to the emerging threats of climate change and increasing disasters which have made the agricultural productivity more vulnerable.

We have to understand that food security is not just about the production of grains like wheat and paddy. According to age and work, every person has to be provided with the nutritious food on time. How far have we reached to this scale? How strong has our position been in the Global Development Indices? Its figures are no secret in the public domain. In the discussions of the present farmers' movement and agrarian reforms, there is a need to consider and debate, where did we really missed out the catch which resulted not be achieve the desired results.

Today's peasant movement is focused largely on the farmers who are having better land holding and practicing Green Revolution based wheat-rice cropping system. They are consuming more natural resources and poisoning the agro-ecosystems during the farming practices. They are afraid that the new agriculture bill and the new policies of the central government will endanger their prosperity, their independence, government support of the minimum support price and continuity of their profession as farmer. They doubt that the farming will go into the hands of commercially large industrial houses. Many believe that will not happen due to this reform bill. In the future due to the dwindling holdings and pressure of huge population, farming will have to be commercialized or it will have to be operated in groups. But it is not easy. We have to understand that this crisis, distrust and superficial politics is not going to solve the crisis of agriculture, farmers and food security in the context of the present agrarian problems. This crisis has the deep roots and is multidimensional facets. So far, apart from the Green Revolution, all the efforts made for land reforms in several

states, fish farming and animal husbandry promoted in the name of white and blue revolutions, and all the efforts of the budget of rural development in the name of Panchayati Raj failed to rescue the country from this crisis. It could be seen otherwise too. The people would have created a network of the green small scale industries in the villages as the backward and forward linkages of Food Production System and this would have created respectable employment for a large number of rural youth. Many urban people may like to move out of the crowded, catastrophic and polluting conditions of the cities at one stage of age and choose villages for a peaceful, simple more natural habitat similar to many developed countries. Youths and young people with educated and innovative tendencies would have created a business model for the network of small scale industries, innovations and to adopt scientific techniques in the agriculture, to produce the organic and environmental farming inputs and marketing of the agricultural products.

Organic agriculture can become a good and interesting business, laying the foundation of self-reliant India, many farmers still do not know. It is possible that if big businessmen come in agriculture, then they will not allow these agro-based small scale industries to grow. Big businessmen will be more interested in big capital, expensive and centralized technologies and products which are basically anti-environmental conservation, anti-health concerns and anti-employment potential. That is why the government should not hand over agriculture to the market forces right now. Indian agriculture has to be developed with the principles of social business with full responsibility and honesty for rural employment, diversification of agro-ecology and non-contaminated food security, gradually adopting professional and scientific approach along with the green industries.

It can be said that before passing this bill, the government did not have wide consultation with farmers and farmer organizations. Due to the weak opposition of the Opposition in the Lok Sabha and Rajya Sabha, it could not be debated adequately even in the Parliament. But the question is also vibrant, whether a debate could have really addressed the multifacial agrarian crisis in India? Are political parties and farmers' organizations really so honest and serious about agriculture, farmers, villages and food security that they can talk even outside their political interests? Probably not. Even today, Indian agriculture is as much dependent on rural farmers as the farmers and the people of the village are dependent on farming and allied activities. The farm labour and small industries related to farming and small business are the major component of the agrarian rural economy. If other underprivileged groups have reservations in government jobs and business activities, then why not the rural youth who are deprived with economic and educational opportunities can be given reservation in the more lucrative professions? Are not the rural poor youth disadvantaged groups? Many small developing countries have also created rural development universities, research institutes and similar departments apart from agriculture for the development of villages which have direct accountability for the development of rural areas as an unit. We did not set up an independent, transparent and accountable system to assess the success of government schemes for rural and agricultural development even after seventy years. As a result, we are neither able to develop agriculture nor villages. Does this not put our intentions in the circle of questions?

CONCLUSION

The Indian agrarian crisis is a rural challenge for rural development, food security and ecological rejuvenation. The green revolution though has increased productivity of cereals and same commercial crops, has caused severe problems of agro-ecological damage, increased input cost, poisoning of food system and farmers' distress, hence no more sustainable. We need to develop ecological agriculture with low external input, food diversity, resource conservation and market management. We need to evolve some mechanism for large scale cultivation with scientific and technological adoptions and acclimatization evolving a strong network of small scale decentralized input production and cottage industries and marketing strategies for self relient food security and green developmental pathways. The agrarian discourse should not limit to being pro and against the current agricultural reform bill only.

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Review Article

Integrating Vermicomposting and Aquaculture: An Ecofriendly Approach for Sustainable Rural Livelihood

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The economy of the Indian subcontinent is predominantly rural and agricultural in nature. Agriculture and its allied sector have major responsibility of providing nation with food and nutritional safety to its expanding population. However, deterioration in agricultural production due to decreasing land area threatens the concept of agricultural farming practices. Integrated approaches are required to deal with the rising issues in this context. Therefore, it is extremely crucial to establish adequate policy that facilitates appropriate employment and earnings, especially for small and peripheral farmers who contribute significantly in economical growth of developing countries. Farming systems approach is a valuable approach to tackle the problems of sustainable financial expansion for farming communities in developing economies like India. Hence, integrated development and economical approach in rural system is considered to be a sustainable substitute of commercial agricultural organizations basically on marginal lands. This will help in attaining sustainable rural livelihood goals. The current article overviews the prospects of integrating vermicomposting and aquaculture with an intention to generate sustainable rural livelihoods.

INTRODUCTION

Intensive agricultural practices in spite of scientific principles and ecological concerns has worsened soil dynamics and freshwater resources that simultaneously affects agrobiodiversity. With rapid diversion of cultivable land for non-agricultural uses, the challenge to nourish the mounting population without clearing more forest land and depleting other resources is certainly enormous (Blythe *et al.*, 2017). In order to survive and prosper, rural household's livelihood strategy involves number of different activities such as farming, herding, fishing, hunting and gathering. Regions where land becomes infertile, rural evacuation occurs, that further degenerate productivity and eventually modify communities (Kesavan and Swaminathan, 2008). However, as food production is critical, the pressure on existing marginal lands led to soil deterioration through use of inorganic manures and fertilizers (Béné *et al.*, 2016). In rural areas of the developing countries, there is dependency on agriculture to a great extent as it plays an important role in its progress. The factors that especially contribute to agricultural development are growth in farming technology, supply of inputs, access to markets, policies and programs. Sustainable agriculture provides a lot of simultaneous benefits that could be attained with rural livelihoods (Tilman *et al.*, 2002). Sustainable rural livelihood is a multifaceted approach representing a process to stimulate the demands for food and resources. It also comprises of secured possession and resource utilization, along with income-generating activities to balance the risks, relieve shocks and organize exigencies (Allison and Horemans, 2006). Keeping this perspective in mind, the idea of sustainable agriculture should be viewed as a pre-requisite for improvement of efficiency and productivity of farming and particularly, the enhancement in the farmer's economic status. As described by Chambers (1988), sustainable rural livelihood is a secure access to meet their adequate basic requirement of food and money, where security is expressed with reference to possession of (or access to) reserves and income-generating activities, embracing the availability of resources and capitals to offset risks. Sustainable rural development is vital for the economic, social and environmental viability of nation. It is essential for poverty eradication since global poverty is overwhelmingly rural. Agriculture is crucial for economic welfare of rural people and is one of the most powerful tools to end extreme poverty and augment shared prosperity. Growth in the agriculture sector is two to four

times more effective in raising incomes among the poorest compared to other sectors. Also, if prompt agricultural expansion is achieved in countries with rural arable farm and non-farm profits can increase satisfactorily to allow it to become more secure for food (Prein and Ahmed, 2000). A variety of aquaculture form is a fundamental element within agricultural and farming systems development. The world aquaculture production and their utilization is listed in Table 1.

Although the *range* of options for *aquaculture development* are complex but its practice can assist in mitigation of food uncertainty, undernourishment and scarcity during the provision of high nutritional value food and improved the nutrition revenue. It will generate employment, and decrease the threat of failure of monoculture production, along with, improved aquatic resource management and also better farm sustainability (Ahmed *et al.* 2019; Bashir *et al.* 2020). This article inspects the prospective of integrating vermicomposting and aquaculture with an intention to create sustainable rural livelihoods. It encompasses both inland areas and coastal realms with no distinct geographical focus. However, general emphasis is on low-income, food-deficit countries where almost 75% of the population reside in rural regions and agriculture plays a significant aspect on rural economy.

Vermicomposting and its significance

Vermicomposting is a composting or natural alteration of biodegradable waste into superior quality manure, which is a disintegration procedure involving the collective accomplishment of microorganisms together with earthworms (Srivastava *et al.*, 2015). It is an environmental friendly bio-oxidative process which converts organic fraction of solid waste into valuable byproduct commonly referred to as vermicompost (Srivastava *et al.*, 2020). Earthworms serves as a critical operators of degradation procedure, since they fragment the substrate and increase available surface area for microorganisms, in that way improving enzymatic actions and are liable for variation in physical conditions of putrescible fraction of waste (Malley *et al.*, 2006; Fornes *et al.*, 2012). Scientists have tried the option of utilizing the earthworms for breaking down putrescible fraction of wastes such as animal wastes (Sinha *et al.*, 2002), vegetable wastes (Suthar, 2009), sewage sludge (Benitez *et al.*, 1999), municipal solid waste (Kumar, 2011) and textile factories' sludge (Kaushik and Garg, 2004). The selection and preference of appropriate species of earthworm for progression of vermicomposting is the crucial step since it affects the pace of substrate stabilization, for that reason their proper selection is vital. Mineral constituent of vermicompost greatly depend on the quality of earthworm feed materials. According to Govindan (1998), earthworm body comprises of 65% (sixty-five) protein, 14% (fourteen) fats, 14% (fourteen) carbohydrates and 3% (three) ash. Similarly, Ronald and Donald (1977) determined that, 72% (seventy-two) of an earthworm's dry weight comprises of protein and around 0.01 g of nitrate is released into soil on decease of an earthworm. Furthermore, earthworms utilize huge sum of plant organic matter comprising of considerable sum of N, and much of this is reverted in form of their excretions to the soil. It has been accounted that N mineralization would be enhanced in the company of earthworms and mineral N is maintained into the soil biota in form of nitrate (Hand *et al.*, 1988).

Table 1. World aquaculture production and utilization (Adapted from FAO 2014)

	2007	2008	2009	2010	2011	2012	2013	2014
				(In Million tonnes)				
Production								
Aquaculture								
Inland	29.9	32.4	34.3	36.8	38.7	41.9	11.2	11.3
Marine	20.0	20.5	21.4	22.3	23.3	24.7	79.4	79.9
Total aquaculture	49.9	52.9	55.7	59.0	62.0	66.6	90.6	91.2
Utilization[1]								
Human consumption	117.3	120.9	123.7	128.2	131.2	136.2	140.1	144.8
Non-food uses	23.4	22.2	22.1	19.9	24.5	21.7	20.6	20.0
Population (billions)	6.7	6.8	6.8	6.9	7.0	7.1	7.2	7.3
Per capita food fish supply (kg)	17.6	17.9	18.1	18.5	18.7	19.2	19.5	19.9

[1]*Note:* Data in this section for 2014 are provisional figures.

The species of earthworm that have innate capability to inhabit putrescible discard, high rate of putrescible waste intake, absorption and assimilation, ability to bear a varied range of environmental stress, high reproductive rates, accelerated growth rate and development rate from offspring to adults (Dominguez and Edwards, 2004; Ansari and Ismail, 2008). There are various earthworm's species that bears the probability to be employed in sludge stabilization and waste management processes. Some epigeic earthworms *Eisenia fetida*, *Perionyx excavates, Perionyx sansibaricus* and *Eudrilus eugeniae* – are commonly used for vermicomposting (Dominguez *et al.*, 2001; Garg and Kaushik, 2005). As accounted by Ismail (1993) in tropical and sub-tropical condition, the most competent earthworm species for vermistabilization of putrescible fraction of wastes are *Perionyx excavates* and *Eudrilus eugeniae* (Kale, 1998).

Both the composting together with vermicomposting are very much effective in recovering soil quality, but vermicomposting is the best process to produce greater bacterial diversity, and greater functional diversity (Vivas *et al.*, 2009). According to Morgado *et al.* (2018), earthworms are the natural markers of soil wellbeing, and can participate in solid waste management along with soil management. Numerous researchers had already reported higher quantity of ammonia (NH_4), nitrates (NO_3), magnesium (Mg), potassium (K) and phosphorus (P) in castings of earthworm as when evaluated against soil (Gupta and Sakal, 1967; Tiwari *et al.*, 1989). Fecal matter (vermicasting) produced by earthworms offers appropriate organic substrates (e.g. carbon, nitrogen, potassium, phosphorous, enzymes) to inhabit adjoining microbes supporting microbial growth and also prevent plant pathogens (Bhattacharya *et al.*, 2012; Yasir *et al.*, 2009; Pramanik *et al.*, 2007).

According to Parthasarathi and Ranganathan (2000), greater N, P and K contents in vermicompost could be due to enzyme actions during passage through the earthworm's gut. An earthworm helps in cutting down the C/N ratio of naturally occurring organic material through respiration (Talashilkar *et al.*, 1999; Edwards 2015). According to Dominguez (2004), in vermicomposting process earthworm's serves as a mechanical blender by pulverizing organic matter, then modifying its physico-chemical and biological status, steadily lowering its C: N ratio, which augments the surface area that is exposed to make it favorable for microbial action and its further degradation. The earthworm retains aerobic state in the organic wastes, ingests solids, converts a portion of the natural component into body mass and respiration products, and ejects the remaining partly stabilized product well-known as vermicompost (Benitez *et al.*, 1999). It has been accounted by several researchers that precomposting is critical for preventing earthworm mortality in vermicomposting process (Kaushik and Garg, 2003). The vermicompost mineralization and maturation is represented by significant reduction in C/N ratio, volatile solids (VS), aliphatic, protein, carbohydrate and lignocellulosic contents, however rise in aromaticity, humic acid and acid phosphatase activity is noticed (Eckhardt *et al.*, 2016; Sen and Chandra, 2007). Suthar and Singh (2008) found that earthworm's metabolic waste products, mucus, body fluid, enzymes, etc. play a major part in boosting nitrogen level of vermicompost. Many workers have also laid emphasis on earthworm's capability to accumulate heavy metals and confirmed that earthworms bioaccumulate considerable quantity of heavy metals like, iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) in their tissues (Suthar and Singh, 2008; Suthar and Singh, 2009; Hait and Tare, 2012).

The heavy metals absorption by earthworm is attained by epithelial (outer) layer of gut from contaminated putrescible fraction of waste; hence heavy metals bioavailability declines during vermicomposting process (Dominguez and Edwards, 2004). Earthworms consume enormous sum of substrates and therefore come in contact with heavy metals via their skin and intestine. Earthworms bioaccumulate heavy metals in their tissues extracted from the substance on which it acts (Oste *et al.*, 2001). Owing to this reason, vermicomposting could be utilized for toxic metals elimination and breakdown of complex chemicals to simpler and non-toxic forms (Jain *et al.*, 2004). Vermicompost can be employed efficiently as natural accumulator for heavy metal (Matos and Arruda, 2003). As stated by Saxena and Chauhan (1998), earthworms (*E. foetida*) bioaccumulate high concentration of metals during vermicomposting of sewage sludge. Similarly, vermicomposting might be very much helpful in bioremediation of heavy metal contaminated organic waste despite solid waste management.

Vermiculture technology has numerous benefits, as it is odorless, cost efficient, devoid of toxic waste and its outcome is a valuable end product. According to Ghosh (2004) vermicomposting could be one of an effective technology which could provide improved P nutrition extracted from diverse organic wastes. The biomass generated as a byproduct of vermicomposting has also been

proved to be excellent source of protein for fish. The application of vermicasting, an extraordinary organic fertilizer applied to aquaculture ponds decreases the input cost by making the aquaculture initial production process more cost-effective and it also aids in regulating the harmful effects of inorganic fertilizer application. Deolalikar and Mitra (1997) reported that utilization of vermicompost from paper and pulp waste showed enhanced production of fish called Rohu (*Labeo rohita*, Hamilton) as when compared with other commercially existing organic manures. They also reported, boost in net primary productivity from 32.08 - 220.83 mgC/m/h.

Nutritional requirement, plays as an important factor for growth and reproduction potential of fish. Fish meal is best source of protein for aqua feeds, however, the escalating price of fish meal has compelled the commercial production of vermimeal (processed earthworm) as a potential substitute for fish food in fish supplies. Fishes are incapable to synthesize essential and indispensible amino acids (EAAs) and they often remain inadequate, still they are desired for growth and tissue development in fish (Abowei and Ekubo, 2011). Comparison of proximate, mineral compostion and essential amino acid constituents (g/16ng) and indices of earthworm and fish meal are listed in Table 2. Numerous byproducts from agriculture, animal husbandry and industries have an exceptional food value having low price that can be effortlessly processed and recycled in the form of fish food. This comprises of all sort of animal feed stuff i.e silkworm, earthworm, termite, tadpoles, maggot, grub etc., and plant wastes like jack bean, cotton seed meal, soybean, palm kernel cake, rice and maize bran, groundnut cake etc, along with variety of wastes from animal source, feathers, blood, bone, fish silage, etc. (Devendra, 1988). Fish diets are likely to be high in protein generally, however, foodstuffs for fry and fingerlings regularly exceed 50% crude protein. The information on the approximation of dietary protein requisite for maximal growth of various species of juvenile fish (as fed basis) is provided in Table 3. When the growth rate declines, protein levels in diets declines consequently (Abowei and Ekubo, 2011). Several researches have accounted that earthworm not only provide rich protein source, but also supplies essential amino acids, mainly lysine which is inadequate in several essential foodstuffs and also the amino acid content of earthworm is analogous to that of fish feed and possibly better to meat meal (Dynes, 2003 and Vielma-Rondon *et al.*, 2003).

Table 2. Proximate, mineral compostion and essential amino acid composition (G/16Ng) and indices of earthworm and fish meal

Proximate and Mineral Composition	Earthworm Meal	Fish Meal (Clupeid)
Crude Protein (%)	63.04[b]	71.46[a]
Ether Extract (%)	5.90[d]	7.96[c]
Crude fibre (%)	1.90[d]	1.18[d]
Ash (%)	8.90[c]	18.22[b]
Nitrogen free extract (%)	13.76[b]	3.17[c]
Moisture (%)	8.60	8.89
Dry Matter (%)	91.40	90.21
Gross Energy (kJ/100g)	19.68[c]	2074.79[b]
Sodium (g/100g)	0.43[d]	0.91[b]
Calcium (g/100g)	0.53[d]	3.53[a]
Potassium (g/100g)	0.62[a]	0.96[b]
Phosphorus (g/100g)	0.94[b]	2.40[a]
Magnesium (g/100g)	NA	0.08
Essential Amino Acids Composition/Animal Protein Source		
Arginine	2.83[a]	5.34[b]
Histidine	1.47[a]	4.19[b]
Isoleucine	2.04[a]	2.62[a]
Leucine	4.11[a]	8.31[b]
Lycine	6.35[a]	10.96[b]
Methionine	5.30[a]	2.26[b]
Pheylalanine	6.26[a]	5.52[a]
Threonine	4.43[a]	5.28[a]
Valine	4.43[a]	5.88[b]
Tryptophan	0.88[a]	0.97[a]
Total Essential Amino Acid	37.99[a]	5.33[b]
Crude protein (%)	63.09a	71.64[a]
EAAI (%)	71.50[b]	96.70[v]
Cs/Ps (%)	36.10[a]	48.80[a]
E:P	0.60[a]	0.72

All values on the same row with different superscripts are significantly difference $p<0.05$
Source: Clausen (1967)

Vermimeal or earthworm meal, a feed preparation comprising of processed earthworm biomass, supplies animal protein along with essential amino acids, fats, vitamins, and minerals for livestock, birds and fish. About 5.5 kg of fresh African night crawler (ANC), scientifically known as *Eudrilus eugeniae*, biomass (18% dry matter) is desirable to produce 1 kg of earthworm feed (Guerrero, 2009). Vermimeal is supposed to be reserved in cool and desiccated place in a plastic bag away from sunlight. Several

Table 3. Estimated dietary protein requirement for maximal growth of some species of juvenile fish (as fed basis)

Species	Protein Source	Estimated protein requirement (% as fed basis)	Reference
Snakehead	Fishmeal	52	Wee and Tacon (1982)
Estuary grouper	Tuna muscle meal	40–50	Teng *et al.* (1978)
Channel catfish	Whole egg protein	32–36	Garling and Wilson (1976)
Grass carp	Casein	41–43	Dabrowski (1977)
Rainbow trout	Fishmeal, casein, gelatin, and amino acids	40	Satia (1974)
Common carp	Casein	31–38	Ogino and Saito (1970); Takeuchi *et al.* (1979)
Blue tilapia	Casein and egg albumin	34	Winfree and Stickney (1981)
Mossambique tilapia	White fishmeal	40	Jauncey (1982)
Nile tilapia	Casein	30	Wang *et al.* (1985)
Yellowtail	Sand eel and fishmeal	55	Takeda *et al.* (1975)

Source: NRC (1993)

studies on diverse livestock animals, birds and fishes have presented outstanding outcome of nourishing the animals with vermimeal or earthworm meal (Guerrero, 2005). Proximate analysis of an African night crawler vermimeal dried with pulverized state showed the subsequent composition: 9.57% fat, 68% crude protein, 11.05% nitrogen-free extract, and 9.07% ash (Guerrero, 2009). Ghosh (2004) employed earthworm as fish meal and witnessed the boost in weight of fish as evaluated with synthetic fertilizer, commonly utilized to improve the fish biomass. The chemical compositions of earthworm, *Eisenia fetida* and two other protein sources are compared in Table 4.

Mature worms could be parted and oven dried to make "worm meal" that is rich in protein (70%), oftenly used as animal, poultry and fish feed. Earthworms can be

Table 4. Nutritional profile of *Eisenia foetida*

Nutrient Composition	Freeze dried	Oven Dried
Crude Protein (%)	66.2^{b}±0.63	59.7^{a}±0.63
Calcium (%)	0.82^{a}±0.02	0.82^{a}±0.02
Magnesium (%)	0.3^{b}±0.01	0.1^{a}±0.01
Potassium (%)	2.2^{b}±0.03	0.9^{a}±0.03
Phosphorus (%)	1.2^{b}±0.02	0.9^{a}±0.02
Zinc (mg/kg)	317.0^{b}±5.02	150.7^{a}±5.02
Copper (mg/kg)	812.1^{b}±11.23	22.3^{a}±11.3
Manganese (mg/kg)	16.6^{b} ±2.21	26.3^{a}±2.21
Iron (mg/kg)	1498^{b}±23.35	495.3^{a}±23.3
Aluminum (mg/kg)	1117.7^{b}±31.51	86.0^{a}±31.51

Source: Gunya *et al.* (2016)

cultivated and put to several utilization i.e. for ameliorating and sustaining soil fertility, by converting putrescible portion of discard into manure along with producing earthworm-based protein rich diet also called as earthworm meal for livestock, drugs and other vitamin source. It can also act as natural detoxicant besides being baits for fish marketplace (Ghosh, 2004).

Artificial feeds are generally used during fish farming so as to increase yield. *Eudrilus eugeniae*, an earthworm species native to Africa, is widely cultivated in the USA, Europe, Canada and Asia meant to be used as bait for fish market (Dominguez *et al.*, 2001). Langer *et al.* (2011), in his study on local prawn species *Macrobrachium dayanum* investigated the consequence of availability of cheap components such as soyabean meal (SBM), silk worm pupae (SWP) and earthworm meal (EWM) as an alternative to fish meal (FM) on growth, production, survival and biochemical composition. He found a considerably higher rate of production, survival and food conversion ratio (FCR) for prawns nourished by earthworm meal (EWM), as when compared to silkworm pupae (SWP), soyabean meal (SBM), and fishmeal (FM). The prawn flesh fed with EWM, further revealed a higher concentration of protein along with lipids, thus indicating EWM a promising substitute of fishmeal (FM) (Langer *et al.*, 2011).

Dissimilar to the manufacturing of traditional fish meal which mostly depend on the application of wild fish, vermimeal is produced from worm cultures which are based on the recycling and reusing of wastes. Monebi and Ugwumba (2013) carried out an experiment to investigate the appropriateness of various media for cultivating

earthworm *E. eugeniae*, and also to resolve the outcome of alternative earthworm feed to fish feed after the evolution of the hybrid mud catfish Heteroclarias, (♂*Heterobranchus longifilis* ×♀*Clarias gariepinus*) that is generally cultured in Nigeria. *E. eugeniae* were cultured about twelve weeks and the meal was utilized as an alternative to fish feed in the food consumed by fingerlings of the Heteroclarias. Fish fed with 75% EWM gained highest mean weight, whereas relative plus specific growth rates were maximum in fish supplied with 25% EWM and lowest in fish supplied with the control diet. Food conversion ratio was accounted to be minimum in fish supplied with 50% EWM and maximum in fish supplied with 100% EWM. Substitution of fish feed to earthworm feed at 50-75% additional level is appropriate for optimal growth attainment and nutrient consumption in *Heteroclarias* fingerlings.

Aquaculture and its Importance

Japanese Resource Council, Science and Technology Agency has defined aquaculture as "an industrial process of raising marine organisms upto final marketable production within suitably separated aquatic areas, that controls the environmental dynamics and governs the life history of the organism completely". Aquaculture is also called as aquafarming, that is *farming* of fish, crustaceans, molluscs, algae and *aquatic* plants. Aquaculture was initiated as an Asian freshwater food production system that involves cultivating freshwater and all marine environments under controlled conditions, is now widespread to all the continents (Martínez-Novo *et al.*, 2017). Aquaculture, that was primarily small scale, non-marketable and family based, now comprises large-scale commercial and industrial manufacturing of high-value species that are merchandized at regional, national and international levels. Aquaculture is employed for an array of marine products that may be cultivated to supply water for sport fishing or for commercial fishing; or might be to save endangered species (Kobayashi *et al.*, 2015).

Fish not only serves as primary source of protein, but also provides several essential amino-acids and minerals, particularly in low-income and food-deficit countries (FAO, 2009, 2010; Rice and Garcia, 2011). Major portion of the world's population depends on fish as a major source of animal protein. World's mounting requirement for protein is one of the reasons for the current and projected speedy growth of aquaculture. About two-third of fisheries generation is directly consumed by human beings and rest is prepared to make fish feed along with fish oils as nourishment for aquatic organisms in addition to livestock industries globally (Naylor *et al.*, 2000, 2009; Smith *et al.*, 2011). The natural advantages of marine organisms as a food source indicate the worth of the increased use of that product in diet-deficient regions of the world.

Fish cultivation and other living aquatic resources show great biological productivity in varied conditions. Fish are considered nutrient-dense food as apart from protein and fatty acids, they provide highly bioavailable minerals and vitamins. Aquaculture has been successfully put into practice by small farmers on land inappropriate for agriculture. Considerable increase in aquaculture production and value could be easily controlled depending on prevailing biophysical conditions and cultural traditions. However, it is supposed to remember that 'neither aquaculture, nor any other method of food production will be a remedy for human nutritional problems, but all are capable of, and should be obliged to contribute so as to ban the specter of hunger' (Bardach *et al.*, 1972). Coupled with the demand for high-quality protein and micronutrients in developing countries there is also mounting interest in sport fishing. Many public fisheries have had to trim down creel limits (quantity of fish legally allowed to be caught per day) or have imposed seasons for catching particular species of fish. For centuries aquaculture is adopted in many Asian countries. However, its new type of farming in many African and Latin American countries. Aquaculturist control few parameters of environment so as to achieve control over the generation of aquatic fishes and other marine organisms which is normally not possible in natural environment (Fisher *et al.*, 2017; Spiliotopoulou *et al.*, 2016). The benefits associated to aquaculture practices can be summarized in following subheads described below:

(a) Efficient use of poor agricultural lands

Ponds constructed on excellent agricultural terrain have maximum natural productivity. High production from aquaculture practices is also likely in ponds built on land which is inappropriate for other forms of agriculture (Da *et al.*, 2015). Hilly terrain, that is hard for farming or eroded by external factors, can be employed for aquatic ponds. Likewise, soils with high soil content or other swampy areas might also be employed for aquaculture practices (Namdev, 2015).

(b) Natural resource conservation

Aquaculture or other water harvesting practices can contribute significantly in the preservation of natural

reserves, especially water and soil (Little *et al.*, 2016). The requirement of plentiful water for aquaculture process provides opportunity and justification to build ponds for harvesting and storing water. This practice makes water available for domestic purposes, stock watering or for supplemental irrigation. Ponds are also very useful in lessening the threat of downstream flooding by increasing water holding capacity in watershed and also put the check on force of erosion during sudden runoff. Ponds retain soil moisture in their nearby areas and thus support vegetation and wildlife. Gómez-Tenorio (2015 analyzed the output of the established farms in mangroves and nearby coastal plateaus and considered that the yield of shrimp in coastal highland is less injurious to long-term preservation of mangrove forests. Ponds constructed on unimproved and vulnerable watersheds trap topsoil which may be recuperated and reallocated to gardens and fields. Problems of water and soil preservation are often extreme in hilly areas. Landscape in these areas offers itself for the advancement of watershed ponds.

(c) Fiscal value of aquaculture products

Aquaculture may result as a cash crop in a subsistence level economy. Farmer's oftenly receive better net returns for fish when related to other traditional crops. Even undersized ponds could share their contribution considerably in farm earnings or lessen family costs as aquatic organisms are sold, traded or eaten. Preliminary construction price for nurturing of fish are very high, but once aquatic ponds are constructed aquatic organism are generally the most cost-effective to produce. By utilizing waste materials from integration of livestock and crop ventures may also lessen preliminary costs while cultivating fish. Fish transform food into flesh very competently. Protein in food gets transformed to muscle protein with absolutely matching effectiveness of chickens or swine, other than this they involve much lesser amount of starch for energy (Chaijan and Undeland, 2015; Balti *et al.*, 2015).

Byron *et al.* (2015) demonstrated ecological and economic systems in Rhode Island and found that in the year 2012, there is an augmentation in employment in aquaculture industry from 121 to 16,806 employment with total impact mounting from 129 to 17,945 employment in economy sector. Likewise, Nebeský *et al.* (2016) assessed the trends in export and import of aquatic products in Czech Republic and established that the monetary rise in import was enhanced by 81% in the year 2010 as of 90.2 million EUR to 169.9 million EUR in the year 2015. Similarly, Dickson *et al.* (2016) in an impact assessment investigation reported that average net profit was considerably higher in farms that practiced best management practices (BMP) as when correlated with control farms. In the year 2014, the additional profit was around $15, 000 from a farm size of about 7.5 hectares in Africa.

(d) High nutritional value

Fish represent superior quality protein source and is better from red meats in any respect. The edible section of fish is analogous to other animals (49-52% of the whole animal), excluding that fish flesh consists of superior quality and more digestible protein when compared to red meats (Béné *et al.*, 2016). Proofs that fish consumption decreases blood cholesterol level is increasing. Fish flesh bears more unsaturated fat than that in red meats (Torrissen and Onozaka, 2017).

(e) Integrated aquaculture: a truly sustainable agriculture

Aquaculture is sustainable since it relies and oftenly makes use of locally accessible resources. Integrating aquaculture with other types of agricultural practices diversifies the farm productivity (Pahlow *et al.*, 2015; Edwards, 2015), which is described and illustrated in Figure 1. This integration sequentially provides opportunities for increased production with more well-organized distribution of land, water, labor, equipment and any other limited capital. Stored water in pond act like catalyst for rural development since wide range of diverse activities may be concurrently undertaken (Chakraborty *et al.*, 2014). Polyculture is raising of many different aquatic species with complimentary distinct feeding habits collectively in the similar pond, is more complex, but utilizes much of the existing natural food organisms (Cruz-Velásquez *et al.*, 2014). Shoko *et al.* (2016) conducted an experiment to investigate the consequence of monoculture and polyculture in mixed Nile tilapia (*Oreochromis niloticus*) and African sharptooth catfish (*Clarias gariepinus*). Higher yields are thus attainable with polyculture which is not possible by cultivating a single fish species (Shoko *et al.*, 2016). Polyculture also promotes several diverse aquatic species that demands dissimilar market prices when grown. A wide range of consumer tastes and demand can be fulfilled from single pond.

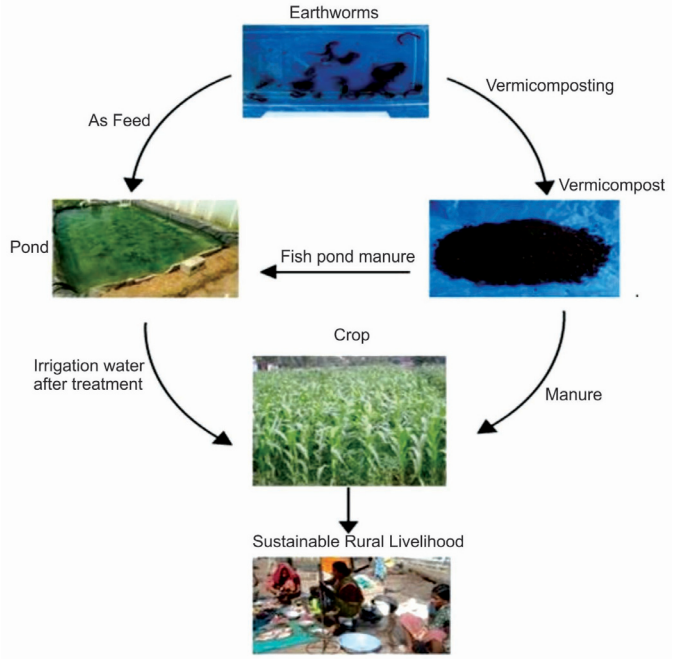

Figure 1. Integrated vermitechnology and aquaculture approach

(f) Self-support system for survival of farmers

Aquaculture process makes available fresh fish in rural and sub-urban areas. There are no areas around the developing world where fishes are not an accepted as excellent protein source (Obayelu *et al.*, 2016), however, fish captured off from the coasts of these countries are exported regularly and are very costly for the poor. Large populations of rural poor reside in remote regions where conveyance and market facilities are insufficient to offer them with enough fish or other fish products (Garrido and Moreira, 2017). Inland ponds permit subsistence farmers to rear aquatic organisms for raising their families. Aquaculture helps them to expand food production, furthermore encourages self-sufficiency by diffusing crop failure risk. Fish also being a tiny package of protein, can be independently harvested and used as desirable, without involving refrigeration to retain huge quantities from spoiling. This is an added advantage for an area without electricity or ice (Beveridge *et al.*, 2013).

Aquaculture yielding techniques can be evaluated by interacting five factors that can be manipulated to some extent when needed. These are the physical atmosphere, fish culture facilities, species cultured, twelve available nutrient and the producer's capability to balance all the aspects in a valuable package (Kumar *et al.,* 2018). The natural atmosphere is principally fixed, nevertheless subject to slight modifications. It comprises all such climatic events like temperature, rainfall, land elevation, topography, storm patterns, soil characteristics (in particular water holding capacity), accessibility of water along with other geographical obstacles to supplies and/or markets. In case, these situations are unsuitable for aquaculture development, very less can be done to transform them (Hasan and Bhowmik, 2016). This demand for aquatic fishes are determined by consumer income, price of substitute foods and combination of dietary and taste preferences. The capability to create lucrative aquaculture practices is as well affected by traditions with consideration to land use pattern, time management and division of other resources. Seasonal variations in demand and supply, coupled with social and political factors also affect the viability of aquaculture (Dang *et al.*, 2017).

World Status of Aquaculture

By the year 2050, it is expected that global population would reach 9.6 billion by adding another 2 billion mostly in coastal areas (Malindretos *et al.*, 2016). So, to feed this enormous population and protecting the natural resources, integrating aquaculture with vermicomposting could be a better option. Direct human consumption for fisheries increased around 70% in 1980 to 85% i.e. about 136 MT in the year 2012 (FAO, 2016). Globally, aquaculture is fastest rising division that provides job and livelihoods to millions of people (Villasante *et al.*, 2015). Aquaculture provides economic benefits in developing economies like Bangladesh, India, and Vietnam etc. both as cash and subsistence crop.

As stated in FAO reports (2012), about 58.3 million citizens were earning their livelihood through fisheries and aquaculture in the year 2012. Among them about 84% people employed were from Asia; besides more than 10% from Africa. Similarly, in 2012 about 200 countries were reported to export fish and other aquatic products. 2012 was the year of all-time high yield and this is expected to rise by 62% by the year 2030 (FAO, 2014). 90.4 MT (live weight equivalent) was attained by global aquaculture production in the year 2012 worth US$ 144.4 billion that includes 66.6 MT of food fish and 23.8 MT of algae. Country like China alone produces 43.5 MT of food fish with 13.5 MT of aquatic algae. Globally, the aquaculture expanded at an annual rate of 6.2% in the period of 2000-2012 i.e. from 32.4 to 66.6 MT. This growth was comparatively more rapid in Africa with 11.7%, Latin America and Caribbean with 10%. Apart from China whose annual growth rate is 5.5%, the other part of Asia grew by

8.2% per year. By this, since 2011 China has turn out to be the third largest importing country followed by the USA and Japan. This is the useful indicator of new perspectives in aquaculture. The other country of importance in this reverence was Vietnam that contributed about 16.7% of aquaculture yield with growth rate of 30.1% (Bostock *et al.*, 2010). In the year 2012 alone, about 92.7% of farmed fish were accounted by fifteen main producer countries.

Similarly, the per capita fish consumption boosted from about 9.9 kg in 1960 to 19.2 kg in 2012 and in developing areas from 5.2 kg in 1961 to 17.8 kg in 2010 while in low-income food-deficit countries (LIFDCs) increased from 4.9 to 10.9 kg. There is a drop in the aquatic stocks fished surrounded by biologically sustainable levels since 90% in 1974 to 71.2% in 2011, 28.8 percent of fish stocks were assessed as overfished at unsustainable level (FAO 2014). Of the stocks assessed in 2011, 61.3% were completely fished and 9.9 percent were under fished stocks. In the marine ecosystems illegal, unreported and unregulated (IUU) fishing act as main threat. In order to avoid, prevent and eliminate illegal, unreported and unregulated fishing (IPOA–IUU), there is implementation of International Plan of action adopted by the many States (De Bruyn *et al.*, 2013). For achieving sustainable aquaculture, The Code of Conduct for responsible Fisheries (the Code) must be followed (Gullestad *et al.*, 2014; Kirby and Ward, 2014; Alabsi and Komatsu, 2014) and implementation of the Code of Conduct is crucial for the consideration of relevant biological, technical, economic, social, environmental and commercial aspects. FAO (2016) has defined the international guiding principle on bycatch management and discard reduction and has been insisted to implement within the ecosystem approach to provide support in capacity building.

In the last decades aquaculture is growing continuously that led to considerable socio-economic profits such as increased nutritional levels, income, employment and foreign exchange, coupled with vast un-utilized and under-utilized land and water reserves underneath cultivation (Kathijotes *et al.*, 2015). It is need of the hour to move ahead of the simple objectives in future policy development regarding areas covering economic development, employment generation, environmental protection and conservation. The integration of vermicomposting and aquaculture has many opportunities in the seafood and agriculture market to attain sustainable rural livelihood with new policy support (Garibaldi *et al.*, 2017).

Challenges in vermicomposting and aquaculture

Globally, the scientific society is investigating for a technology that is economically feasible, environmentally sustainable and also socially acceptable. Integrating vermicomposting with aquaculture joins all these features together. Scientists know the importance of earthworms as "farmer's friend", helps in waste management, soil remediation and fertility improvement. Vermicomposting has been considered a very efficient proven waste management technology globally (Ali *et al.*, 2015). Similarly, aquaculture has spread out all around the globe. It has altered not only the financial condition of the humanity but also boosted the rural economy of the region. Aquaculture provides considerable protein food source and micronutrients appeals as profitable business globally (Kassam and Dorward, 2017). Increasing population coupled with increasing food demand with limited natural reserves has accelerated the demand for seafood, which must be met by aquaculture (Hilborn *et al.*, 2003). Nevertheless, both the technologies are facing an array of challenges globally that are discussed further in this review.

Challenges in Vermicomposting

The employment of vermicompost in agricultural practices is gaining importance worldwide. No doubt vermicomposting is a novel, scientific and the simplest technology available for disposal of putrescible fraction of urban solid waste. But, at the same time, the starting of the procedure is a very complicated as when compared to other traditional composting. Vermicomposting can be quicker but in general it entails more labor and space as earthworms are mostly surface feeders (Chandrappa and Das, 2012). Earthworms are most prone to environmental pressures like temperature, pH, drought etc. It is well cited that the process requires more resources to start which may be in cash, time or labor (Edwards *et al.*, 2010; Ansari, 2013).

Challenges in Aquaculture

Aquaculture covers nearly all component of the earth. Aquaculture aims at increasing growth rate of the seafood and lowering the production cost (Asche *et al.*, 2016). To achieve this, there should be constant supply of feed for the organisms so as to achieve maximum growth rate and water (both quantity and quality) which are vital part of the aquaculture system (Troell *et al.*, 2014). There are number of challenges linked with aquaculture that includes: maximizing conversion of feed, water quality, processing, power and storage cost of the species and

optimization (FAO 2010; Ross *et al.*, 2013). Feed provided to the organisms generally comprises around 50% of the production cost and is critical to the growth, quality, safety and nutritional value of the farmed fish (Allen *et al.*, 2011). Absence of proper feed results in low quality sea food with poor nutritional value.

In Ghana, one of the major challenges currently for fish farmers especially pond farmers is high cost of fish feed and its constant supply (Hiheglo, 2008). Currently, many pond farmers nourish fish by imported formulated meals in the initial month of development period and then utilize local agricultural byproducts such as maize and rice bran mixed together with groundnut peels for rest of the culture period. As the imported feeds are very costly and common pond farmer cannot support its use throughout a production cycle. Sometimes there are feed scarcity in the commercial market owing to delays in delivery and clearing of the feedstock from the harbor. This obliges aquaculturist to rely on the local agricultural products whose accessibility is sure and are relatively cheaper (Amoah, 2012).

Another concern for survival of the species is water quality parameters for instance dissolved oxygen, pH, hardness, temperature, etc. Proper nutrient input stimulates plants, microbes and other phytoplankton to grow and this results in bad water quality that directs to poor nutritional value of aquatic species or ultimately the casualty of the species. The quantity of nutrients in water is directly related to hydraulic turnover rate and water retention time (Tucker *et al.*, 2005). Xiong *et al.* (2015) assessed the concentration of antibiotics and antibiotics resistant genes in aquaculture atmosphere of Guangdong, China and found that fish ponds are pool of antibiotics resistant genes. Another key concern about aquaculture is addition of non-native species in the wild (Gozlan, 2008; Vitule *et al.*, 2009; Peeler *et al.*, 2011). For instance, due to escaped aquaculture species there is introduction of seaweeds in Hawaii and carp in the Mississippi River that compete with the local wilds of the region (Dalton, 2004). In absence of strong policies in many developing economies may cause "biological pollution" by introducing non-native species into the wild (Naylor *et al.*, 2001). In spite of all the challenges, aquaculture remains a sustainable option that utilizes fewer fossil fuels, packaging cost and storage services.

Opportunities and Challenges in Integrating Aquaculture and Vermicomposting (IAV)

The target of sustainable aquaculture is permanent, which is achieved by optimal utilization of renewable resources. As stated in FAO (2006), 50% of the worldwide fish is accounted by aquaculture. Although aquaculture is a major source of fish supply, employment and profit generation, it also faces environmental, ecological, and socio-economic challenges. Integrated approach of aquaculture and vermicomposting provides utilization of holistic farming system, that is an autonomous organic agro-ecosystem. A composite aquaculture-vermiculture farm may be completely synergistic. The low-cost aquaculture system primarily employs vermicompost and other vermi-products such as vermiwash, earthworm, cocoon, etc. The biomass generated as an outcome of vermicomposting process is constituted to be a better protein source for fish (Stafford and Tacon, 1984a, 1984b, 1985; Nandeesha *et al.*, 1988; Cruz, 2006; Khwairakpam and Bhargava, 2007; Tacon *et al.*, 2008). Organic aquaculture is an enterprise that avoids the use of inorganic fertilizers and pesticides, growth regulators and other feed additives (Joshi and Aga, 2009). In last decades, the world's aquaculture markets have revolutionized intensely. Because of lower transportation cost and better logistics and distribution, global markets are been created for a number of species that formerly had only regional or local markets. Since seafood is considered as a commercial product, hence, trade barriers are not a major obstacle. This has made seafood one of the most traded groups of products (Dahl and Oglend, 2014; Asche *et al.*, 2015). Thus, increased demand intended for sea food, has created an opportunity for aquaculture that had allowed fish farmers to exploit and enhanced aquaculture production from approximately 4 MT in 1970 to 66.6 MT in 2012 (FAO, 2012). Therefore, taking all these point into consideration, researches on utilization of the vermicomposting product and earthworm in aquaculture are of great importance.

Aquaculture is an innovative way of interacting with the atmosphere, which has a potential to cause considerable environmental destruction and social conflicts as it replaces other activities, directly or indirectly. Earthworms have tremendous tendency to bioaccumulate noxious organic residues (like pesticides, herbicides and antibiotics) and heavy metals like nickel, zinc, cadmium, and lead into their tissue. Table 5 illustrates nutritional profile of earthworm powder of *Lampito mauritii.* These toxicants can biomagnify their effects through use of vermicompost. To avoid the bioaccumulation hazard, proper feedstock should be used in vermiculture. A number of studies, such as Naylor *et al.* (2000), investigated its potentially harmful environmental effects. These include (a) land or water

Table 5. Nutritional profile of Earthworm powder of *Lampito mauritii*

Nutrients	Mean±SD
Carbohydrate (%)	4.1±0.007
Protein (%)	31.7±0.011
Nitrogen (%)	1.832±0.074
Phosphorus (%)	0.385±0.001
Potassium (%)	0.533±0.003
Iron (ppm)	241.1±0.088
Magnesium (ppm)	0.213±0.018
Manganese (ppm)	17.2±0.014
Zinc (ppm)	32.34±0.068
Copper (ppm)	4.504±0.008
Calcium (ppm)	0.280±0.001

Source: Nhi (2010)

column converted to aquaculture use, of which devastation of mangrove forests is the most well-known; (b) local environmental deterioration due to pollution and enhanced nutrient loading; (c) destruction of surrounding ecosystems due to diseases; and (d) increase in species with production cycles that are not closed. Besides, it is held that aquaculture constitutes a universal environmental problem through its requirement for feed, as improved aquaculture production leads to an increase in demand for fish meal and thereby increased fishing effort in such fisheries. As a substantial fraction of the aquaculture production is exported, this means that there are potential trade matters related to aquaculture, both in its demand for inputs and its supply of outputs.

Naturally, the organically produced fish will have high demand among all sections of consumers (de Haen and Réquillart, 2014). Much importance has been given to intensive agriculture and sustainable agricultural practices; however, less emphasis had been given to intensive aquaculture and its sustainable practices. Consequently, this creates an alarming problem at a global level. Therefore, attention has to be given to organically managed systems of aquaculture for the achievement of harmful chemicals-free and safe food for human consumption.

Impact of integrated vermicomposting and aquaculture on rural economy

Integrated vermicomposting and aquaculture are an approach to manage resource flows from farm to fish production with the purpose of improving productivity as well as in reaching the claim for sustainable development (Janssen, 2001). This diversification, in the form of integrated vermitech-aquaculture can only be successful when requirements for investments (e.g., pond construction, feeds, and fertilizer) are minimal and the use of existing on-farm and near-farm resources can be optimized. Technologies for aquaculture that require low levels of investment, labor, and material inputs have been developed and adopted by small and marginal farmers thus, its association with vermicomposting would surely lead to sustainable farm production along with food security (Joffre *et al.*, 2017). Integrated vermicomposting and aquaculture in agro-ecosystem provides a synergistic approach in which waste produced from one becomes the input for other process.

Integration of vermicomposting with management of existing seasonal or perennial water bodies often by households and communities, can be the easiest doorway of vermicompost into aquaculture. Aquaculture increases total production and eventually profits in rural economy by minimizing the external inputs through reutilizing the organic waste and other residue generated in one system into another. In this respect, integration of vermicomposting as fish pond manure and earthworms as bait to fish and in return the residue (by-product) generated from pond could be vermicomposted in to manure. Integration of vermicomposting with aquaculture interact eco-biologically, mutually supportive and dependent on each other. It enhances productivity, profitability, sharing of inputs, proficient use of labors, security for the farmers and sustains soil productivity, effective utilization of waste, income and employment generation for poor and marginal farmers that increases economic resources of that region (Jayanthi *et al.*, 2009; Dadabhau and Kisan, 2013). Therefore, integrated vermicomposting and aquaculture is an approach to make sustainable consumption of the natural reserves for the profit of present and future generations (Preston, 2000).

CONCLUSION

This review provides information on the potential assimilation of vermicomposting and fish aquaculture with the goal of achieving more sustainable and cost-effective byproducts. Aquaculture can contribute to meeting the demand through culture of species accepted by consumers, either introduced or indigenous species. One of the indirect supplementary benefit of integrating both of them is that vermicomposting provides organic fertilizer for crop fields, and earthworms can be useful in aquaculture; however, aquaculture can provide substrate to be vermicomposted

i.e. contribute food for earthworm. Therefore, fish produced organically would have high demand amongst its consumers which could be possible through some ways of proper marketing. In several developing economies, majority of population is rural therefore natural resource conservation intervention would encourage the establishment of low-input enterprises based on the sustainable practice. In developing countries similar to India farmers are hugely dependent on monsoon for irrigation and loss in agricultural output due to abrupt rains are quite frequent. Besides water, soil fertility is also the prime factor governing agricultural productivity. Sustainable rural livelihood, is an outstanding model referring to protection and improvement in accessibility to food and revenue-generating actions on a long duration basis which could be very helpful for agrarian economy. As declining agricultural land raises an alarming concern for food security to the population at global level. therefore, emphasis should be givenfor organically managed system of aquaculture for the possibility of harmful chemicals free and safe food. For food security, the concept of sustainable agriculture should be seen in the context of integrating vermicomposting and aquaculture for enhancing agricultural efficiency and generate revenue. finally, it is imperative to develop strategies that enable adequate employment and generate income, especially for small and marginal farmers who constitute more than 80 percent of the farming community.

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Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Review Article

Challenges and Prospects of Value Addition in Vegetable Crops

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Vegetables play a major role in our diet towards providing nutritional and food security as vegetables are rich sources of vitamins, minerals, dietary fibre and phytochemicals. Increased vegetable consumption in our diet reduces many modern life style diseases such as coronary heart diseases, hypertension, type-2 diabetes, renal diseases etc. Vegetable production is seasonal in nature and in certain period of life cycle, the vegetable production exceeds the demand. As a result, the producer is unable to get the remunerative price of its produce and vegetable growers are forced to sale their produce at very low price in view of poor post-harvest management practices and lack of suitable low cost processing facilities available in our country. Presently the value addition in our country is only 2.2% and large quantities of vegetables around 4.58-12.44% perish and accounting the losses of around of Rs. 15000 crore per annum. Furthermore, vegetable growers face many problems such as lack of cold chain management practices in our country, lack of mechanized sorting/grading facilities, non-availability of genotypes suitable for processing, optimum harvesting time of vegetables and lack of complete value chain in vegetable market. Many public and private sectors in our country is focusing low cost drying technology, hurdle technology, minimal processing, steeping preservation, and technologies towards ready-to-eat and easy-to-cook vegetables to increase the processing facilities for increasing the farmer's income. The present Central and State Government in our country is further promoting processing facilities of perishable crops especially vegetables by providing loans at nominal interest, giving subsidiaries to boost the processing facilities in vegetables for reducing the post-harvest losses and increasing the value addition in vegetables.

INTRODUCTION

Horticultural crops, mostly fruits and vegetables, play an essential role in nutritional and food security. Given the increasing of population in our country, the availability of water and land is diminishing from for our country's livelihood. Our population has touched 1.36 billion, and it is increasing at the growth rate of 1.8 percent annually. In the recent scenario, the importance and demand of horticulture is growing towards in conserving the moisture, maintaining soil nutrition as well as contribution towards creation of more employment. Our Government, both at Central and State level, is focusing more attention on this sector as this sector will increase more job opportunities at rural sector so that migration of rural people to cities can be checked. India has taken big lead in producing large quantities of quality vegetables to increase the nutrition of large masses of population. The growing awareness of nutritional health benefits has created the big demand of vegetables in the market as a result, more high-yielding vegetable genotypes are developed both at public and private sectors. India has become the second largest producer of vegetables in the world after China. It is estimated that around 175 types of vegetables are produced in our country. Leafy vegetables contribute around 82 types followed by 42 types of tuber and bulb crops. There has also been the cultivation of 60 types of commercial vegetables. India has diverse climate as a result all types of vegetables are not available in one season. These vegetables are available in large parts of country irrespective of diverse climate. Five states especially West Bengal. Bihar, Uttar Pradesh, Madhya Pradesh and Andhra Pradesh contribute 50% of total vegetable production.

Food consumption is directly linked with health and food consumption pattern varies from one region to another. Balanced diet consumption has direct link in reducing many chronic diseases. The habit of consuming the balanced diet should be started in children at the age of two years which is similar to the dietary pattern of adult diets. The balanced diet is particularly low in sugar, salt, fat and rich in carbohydrates, fruits and vegetables. The consumption of balanced diet is reflected to various factors such as religion, region, economic condition, technological

advancement, etc. Several epidemiological studies in last many decades have clearly reflected that increase consumption of fruits and vegetables in diet control the risk of many chronic and life style diseases and improves the gut morphology which helps in better utilization of nutrients in the body. The regular consumption of fruits in our daily diet of the majority of the Indian population is not possible because of cost factor of fruits as large section of population lives below poverty line. Vegetables being cheaper in cost can play very important role in decreasing the incidence of many types of cancer, including stomach, breast, colon, lung and prostate cancers.

Vegetables contribute major portion of the diet of humans in many parts of the world and play a significant role in human nutrition especially in supplying vitamins, minerals, dietary fiber and phytochemicals. Furthermore, the increased consumption of vegetables in diet has been associated with lower risk of cardiovascular disease in large section of human population. The mechanism by which vegetables decrease the risk of disease is complex and not fully documented. The presence of phytochemicals and antioxidants may work directly in quenching free radicals or indirectly by participating in cell signaling pathways in human body. The presence of significantly higher amounts of dietary fiber in vegetables contribute to overall health benefit such as improving bowel transit, lowering cholesterol level, managing blood glucose concentration, and by transporting a significant amounts of minerals and phytochemicals linked to the fibre matrix through the human gut. Regular vegetable consumption in diet may reduce the intake of saturated fats especially trans fats, foods with higher caloric density. These are all related to healthier overall diet.

India is second largest producer of vegetables after China with annual production of 192.5 million tons on cultivable area of 10.47 million hectare with the productivity of 18.2 t/ha. The importance of fruits and vegetables can be realized with the fact that the requirement of around 50% vitamin A and 90% vitamin C in human can only be fulfilled by consumption of fruits and vegetables.

Vegetable production is seasonal in nature and vegetable production cycle in majority of vegetables completes in 4-5 months and in certain periods of life cycle vegetable production causes glut in the market as a result producers are forced to sale their produce at very low price. In view of poor post-harvest management practices and non-availability of processing facilities in India, large quantities of vegetables perish. These results in huge economic losses to the producers as well as large section of consumers are deprived of quality vegetables in their diet. Presently the value addition in vegetable sector is 2.2% and large quantities of vegetables around 4.58-12.44% perish thus amounting to the losses of Rs. 15000 crore. There is an urgent need of effective post-harvest management practices and low cost processing technologies for handling of large quantities of vegetables to produce cost effective value added processed products.

Challenges and Prospects of vegetable processing in India

Urban population in cities is demanding newer processed ready-to-eat and easy-to-cook form of vegetables to rapid change in the eating habit of the urban population as well as more income of the majority of population in cities. There are 350 million strong urban middle class population which demand large quantities of processed vegetable products depending upon the taste. Our Ministry of Food Processing Industries has introduced number of schemes for providing financial assistance for setting up modern vegetable processing units, building infrastructure, supporting R & D and skill development to encourage the growth of vegetable processing sector. Our national policy also aims at increasing the present level of value addition in vegetables from 2.2% to 25% by 2025. Vegetable processing level is alarmingly very low as compared to 35% level of processing in milk, 20% of buffalo meat, 26% of fish and 6% of poultry meat.

Vegetable Processing Challenges

- **Cold chain management**: Presently there are 7645 cold storages in India with the capacity of 34.5 million tones as against the required capacity of 61.13 millions. Majority of cold storages are meant for storage of potato having optimum storage temperature of 2-4^{o}C and 90-95% RH. However, vegetables on a whole require varied temperature from 2-10^{o}C for maximum shelf life. Broccoli and all leafy vegetables require 10^{o}C and 90-95% RH and similarly other vegetables such as tomato, eggplant, cucumber, okra and pointed gourds require optimum temperature of 7-8^{o}C with more than 80% RH for maximum shelf life. Other cucurbit vegetables need the optimum storage temperature of 12-14^{o}C for enhanced shelf life. Moreover, vegetable production is confined in villages and cold storages facilities are located in cities

especially for potatoes only. However, potato storage conditions would lead to chilling injuries in majority of vegetables during storage and spoilage of vegetables to the greater extent.

- **Lack of mechanized sorting/grading facility**: There have been no mechanized grading/sorting facilities for vegetables in many vegetable markets in India. Only hand grading/sorting facilities exist in vegetable markets which is cumbersome and time consuming. Furthermore, it is inefficient for the grading of large volumes of vegetables. Similar to fruits, sorting mechanism and machineries should be developed for vegetables towards efficient grading and sorting facilities.
- **Non availability of varieties suitable for processing**: Vegetable breeding programme in public and private sector is confined mainly to develop genotypes for higher yield only. There have been no serious thinking towards breeding programme for improvement in quality and more precisely for genotypes suitable for processing. Furthermore, except for few vegetables, the quality traits are also not well defined. This clearly indicates the primitive level of vegetable processing in India. There have been no linkages among farmers, public institutions and processing industries. Many leading processing industries such as ITC, Heinz and Kisan are still importing tomato paste and tomato puree from China and European countries. There have also been no commercial scale lycopene processing industries in India which can cater the requirement of lycopene in India. Apart from food industries, lycopene has also major role in pharmaceutical industries. Many public and private institutions can play a big role in promoting their varieties suitable for processing.
- **Optimum harvesting stage of vegetables:** Vegetables attain maximum sensory perception during certain stage of their growth in terms of sensory qualities such as flavour, colour and appearance and overall acceptability. Processing also requires the harvest of vegetables at proper maturity stage. Harvesting of vegetables should be monitored from first day of anthesis, as a result processed vegetables would be of uniform quality in terms of sensory perception to consumers.
- **Complete value chain of vegetables**: There should be complete package of practices for product and bye product utilization for sustainability as well as for better return to processing industries. Every part of vegetable is important for nutrition to human as well as good source of feed to animals. The leading tomato processing industries are interested in tomato pulp and discard peel and seeds. Tomato peel can be good source of lycopene extraction and seeds can produce good quality of protein and oil. Similar types of thrust should be given to all types of vegetables suitable for processing. Every part of vegetables should be effectively utilized one or other usage at the time of processing to avoid wastage.

Post-harvest management practices

Effective post-harvest management practices after harvest improves the sensory perception and shelf life of processed vegetables. Post-harvest management practices in vegetables include sorting, grading, washing, drying in air and packaging of vegetables for increasing the shelf life and retaining the quality of vegetables for longer time. Harvesting of vegetables should always be preferred before sun rise or after sun set due to low atmospheric temperature. Vegetables should also be washed immediately to remove the dust and trashes from the vegetables as well as to reduce the temperature of harvested vegetables. Respiration and transpiration process also adversely affects the quality of vegetables. It is well established fact that with increase in the respiration process, the quality in terms of flavour, colour and nutritive value of vegetables is adversely affected. Further weight loss of vegetables is also big concern to producers and consumers during ambient storage of vegetables for 3-4 days.

Potential vegetable processing technologies for commercial usage

The use of appropriate post-harvest technologies reduces the post-harvest losses during storage, add value to the product, generate employment in village and promote establishment of agro-processing industries at rural sector. Presently, the farmers sell their vegetables without processing. Primary processing in vegetables is very important in the village market and peri-urban market. It would fetch more money to the producers and provide good quality vegetables to the consumers. Primary processing involves sorting, grading and packaging of vegetables. Primary processing concept should be promoted at every village level as a result more employment can be generated and farmers will get more money of their produce.

i) **Dehydration**: Drying or dehydration is practiced since ancient times and with time many improvements have been taken place. The process involves complete removal of water from foods under controlled condition. Vegetables are commonly dried to reduce the final moisture in the range of 1-2%. The major criteria of the quality of dried vegetables are that when reconstituted in boiled water, vegetables should attain the same sensory qualities in terms of colour, texture and flavor. Air convection type of dryers has insulated enclosures for circulating hot air across the trays. The greater the temperature difference between the heating medium and the vegetable, the greater would be the rate of heat transfer into the vegetables. This gives the driving force for the removal of water from the vegetables. The moist air from the vegetables should be driven out regularly otherwise the moist air would be saturated on the surface of vegetables which in return slows down the rate of subsequent removal of water from the vegetables. The attachment of dehumidifier with air convention dryer helps in the removal of moist air at regular interval and supply of fresh air for heating purposes.

Drying processes can be effectively carried out to improve the sensory perception of vegetables as well as handling of large quantities of vegetables during peak season of production. This would prevent the enormous post-harvest losses of perishable vegetables and would help in preserving the nutritional and food security along with preventing the high prices of offseason vegetables (Sagar and Kumar, 2010).

Osmo air-drying has greater potential for drying of large quantities of vegetables with retaining sensory and nutritional quality to the greater extent. The process involves blanching of vegetables with permitted additives to retain the green colour as well as inactivation of enzymes. The blanched vegetables are osmotically diffused in 2-3% brine solution at 40-50°C for 60-90 min. The osmotically diffused vegetable pieces are dried in cabinet dryer at 50-55°C to reduce the final moisture in the range of 1-2%. Indian Institute of Vegetable Research, Varanasi has standardized osmo-air drying of bitter gourd slices, cauliflower, carrot, okra, broccoli, cabbage, cow pea and ivy gourd slices during osmotic diffusion treatment in 2-3% brine solution at 50–55°C osmotic diffusion treatment for 60-90 min followed by drying at 55-60°C for 6-8 hrs to reduce the final moisture to 1-2% in dried vegetable pieces. The effectiveness of drying technology requires the treatment of vegetables with permissible additives to ensure good rheological, sensory and rehydration properties (Singh and Singh, 2015). This drying process can be easily adopted as a rural based low cost simple technology by small entrepreneurs, home-scale industries and also by self-help groups in close association with NGOs. Small entrepreneurs can adopt osmo-air drying process during glut production of vegetables. Under Indian scenario, osmo-air drying can be promoted to increase the processing level beyond 2.2% level to reduce the post-harvest losses and increase the farmer's income to the greater extent.

Consumers today are demanding the quality and safety of dried vegetables. The growing awareness about the health benefits of vegetables and increasing demand of processed vegetables in cities have given the opportunity to improve the quality and retaining the nutrients to the greater extent in the processed vegetables. Therefore, alternate technologies which offer convenience of traditional drying without compromising on quality are of much demand. The most applicable method of drying includes freeze, vacuum, osmotic, cabinet or tray, fluidized bed, spouted bed, ohmic, microwave and combination thereof (George *et al.*, 2004). The choice of drying method depends on various factors such as the type of product, availability of dryer, cost of dehydration and final quality of dried product. Energy consumption and quality of the dried vegetables are the critical areas in the selection of a drying process.

ii) **Hurdle technology:** The concept of hurdle technology has gained importance to preserve meat based products in western countries as shelf stable foods with extended shelf life without refrigeration. The spoilage in vegetables is multifaceted because of chemical and microbiological spoilage. Heat treatment or sterilization is best preferred process to preserve the vegetables for longer time. Canning or sterilization has gained popularity to supply the processed vegetables to the soldiers during World War I, II and Kargil wars. Severe heat treatment has adversely affected the sensory properties of vegetables. Consumers demanded safe and tasty vegetables with respect to sensory qualities. In this process, hurdle technology has gained popularity to satisfy the consumer's need. Hurdle technology based

vegetables are preserved by a combination of at least three or more preservative factors as none of alone one factor is sufficient to prevent microbial spoilage. Methods have been standardized to preserve high moisture (>90% moisture) vegetable slices by lowering the water activity, lowering down the alkaline pH of vegetables to acidic range and mild heat treatment to effectively control the chemical and microbial spoilage without altering the sensory properties of vegetables during ambient storage. The process can be applied to tropical and temperate vegetables. The preserved vegetables can be eaten as such or can be used for vegetable based curry or preparation of fermented pickle. The preservation of onion bulb and paste is standardized at Indian Institute of Vegetable Research, Varanasi using hurdle technology concept of 1-2% brine, acetic acid steeping at pH 2.5-2.75 for 1-7 days along with addition of 100 – 500 ppm of potassium metabisulphite and heat treatment at 100°C for 2-5 min for reduction of 90% microbial load. The good sensory quality of onion bulb and paste is maintained with hurdle technology during 6 months of ambient storage.

iii) **Minimal processing**: Minimal processing has gained popularity in metropolitan cities where consumers have no time to peel, cut, core or slice the vegetables. It is estimated that these primitive stage of curry preparation requires around 20-30% time for whole curry preparation. The fresh-cut vegetable industry especially Mother Dairy is bringing many sliced vegetables such as sliced bitter gourd, mix cut vegetables of carrot, cowpea and french beans to cater the growing demands of consumers. There have been strict monitoring of quality standards towards inhibiting undesirable microbial growth in all the steps from production to distribution chain.

Minimal processing has gained popularity in recent past. The technique enables marketing of pre-cut vegetables in packaged form and the products are meant for specific end uses viz., curry, salads, pies, stuffing's, toppings and garnishing. It further offers removal of uneven cut, sliced or cored vegetables with uniform cuttings with sufficient convenience, minimum investment in packaging and transportation. A number of preservative methods have been used for minimally processed fruits and vegetables such as addition of texture improvers, antibrowning agents, acidulants, antimicrobial agents, reduction in a_w coupled with modified atmospheric storage.

iv) **Steeping preservation**: Vegetable production in India is seasonal. The production of vegetables exceeds the demand during the peak production as a result producer is bound to dispose the perishable vegetable crops in no time of storage. Large quantities of vegetables during peak season of production can be preserved in steeping solution consisting of permissible chemical preservatives and other food additives which is non- thermal and alternate to processing technology with considerable scope for adoption at rural sector by women. Consumers are more conscious on health benefits and are demanding additive free processed food products.

Food Safety Standards Authority of India (FSSAI) is regularly monitoring the level of the permitted food additives and some of the permitted additives are either deleted or the level is reduced depending upon nature of health hazards associated with additives. However, the steeping treatment involves the use of permitted additives at a low level of maximum permissible limit and at the same time it should not affect the sensory and nutritional properties of the product and should also be convenient and economical to use. The steeping preservation technology has been standardized at pilot scale at our institute for steeping preservation of cauliflower and carrot. Blanched cauliflower at 100°C for 1 min and steeped in the chemicals consisting of 2-4% sodium chloride, 1-1.5% acetic acid and 350 ppm sulfur di oxide remained acceptable upto 75 days of storage at room temperature. Similarly, carrot slices steeped in 25% sugar syrup, 0.4% citric acid, 400 ppm benzoic acid and 350 ppm sulfur di oxide remained acceptable organoleptically for flavour, texture, colour and appearance and overall acceptability (Singh *et al.*, 2015). Similarly the availability of red carrot is confined in the market for 4-5 months and these red carrots are good sources of β-carotene and are frequently used in dessert, salad and curry preparation. Sliced red carrots during peak production can be preserved in steeping solution consisting of 25-30% sugar syrup, 0.4-0.6% citric acid and 350-400 ppm sodium benzoate, Red carrot slices can be effectively preserved for 8-10 months at ambient storage temperature (Singh and Singh, 2015).

v) **Ready-to-eat convenience vegetables**: Convenience foods refer to the category in which foods have undergone major processing by the manufacturers such that these types of products require no further processing / cooking before

consumption. Convenience foods are good choice of the day can be designed to suit all segments of population including armies, airways, railways and even patients with suitable supplements. Convenience category vegetables are gaining popularity to large section of population in cities as the consumers in cities have choice to consume vegetables for taste and overall health benefits. The demand for convenience food is growing at a faster pace due to changes in social and economic patterns, as well as increase in urbanization, buying power and awareness about health foods, changes in meal pattern and existing food habit, desire to taste new products, etc. The consumer preference is focused towards convenience form of food products which are easy to procure and consume instantly.

Many convenience moringa based products can be popularized in cities. Moringa is a plant where every plant part is store house of nutrients. Moringa leaves contains 7 times more vitamin C than oranges, 10 times more vitamin A than carrot, 17 times more calcium than milk, 9 times more protein than yoghurt, 15 times more potassium than banana and 25 times more iron than spinach. Further, moringa leaves and pods have controlling ability of many life style diseases such as Type 2 diabetes, stomach disorders, anticancer property due to the presence of glucosinolates, isothiocynates and glycoside compounds. The utilization of dried moringa leaves powder, pod powder along with corn flour, whey protein concentrate can result in the development of protein rich (24-26% protein) instant moronga soup mix, protein rich instant morirnga-jaljeera drink (18-20% protein), mix powder and instant low calorie protein rich moringa drink (35-38% protein) mix powder with good consumer acceptability and extended shelf life of 6-8 months at ambient storage temperature.

vi) **Easy-to-cook leafy vegetables:** Leafy vegetables are store house of nutrients of vitamins, minerals and bioactive components contributing health benefits. Many leafy vegetables are seasonal in nature and availability is confined to 3-4 months in the season. Leafy vegetables started drying very fast after harvest due to rapid loss of moisture as a result, the retention of quality attributes in bulk leafy vegetables is challenging in India because of limited cold storage facility. As per the guidelines of National Institute of Nutrition, Hyderabad, an adult should consume 100 g of leafy vegetables in daily diet. Seasonal variability as well as low processing base also affects the availability of leafy vegetables throughout the year. Leafy vegetables such as amaranth, spinach, fenugreek, *bathua* and *basela* can be developed in the form of easy-cook-leafy vegetables. Our Institute has standardized the process of easy-to-cook amaranth, fenugreek, spinach, bathua and cabbage leafy vegetables. The process involves sorting, cleaning and washing, blanching with permitted additives followed by osmotic diffusion treatment and subsequently drying at 50-55^{o}C for 3-4 hrs to reduce the final moisture to less than 1%. These dried leafy vegetables can be effectively preserved in polyethylene pouches for 7-8 months at ambient storage temperature.

vii) **Instant bottle gourd *kheer* mix**: Sweets are very popular in our Indian diets. Sweets are of great demand in every functions and festivals. It is liked by all sections of society such as children, adult and old people. It is a symbol to welcome guests by offering sweets in our culture. The demand of vegetable based sweets is increasing because of presence of many nutritional and functional attributes present in vegetables. Further, very few vegetable based sweets are available in the market. Traditionally bottle gourd based *kheer* is popular and is relished during festival seasons. However, the process for the manufacture of bottle gourd *kheer* mix is cumbersome and time consuming and shelf life is also limiting factor. Instant bottle gourd *kheer* mix can be developed by mixing dried bottle gourd pieces with sugar, thickener and milk powder. Bottle gourd kheer can be prepared by reconstitution of mix in known quantity of water followed by boiling the reconstituted mix for 2-3 min. Furthermore, convenience bottle gourd *kheer* mix can be preserved in laminated pouches during 6-8 months of ambient storage.

Prospects of vegetable processing

India has very strong supply base of vegetables not only in Indian markets but also good demand in International markets. Recently large quantities of green chilli and pea are exported by air to many European and Middle East countries. The growing international demand of vegetables in global market has placed big challenges and opportunities to large section of vegetable growers. Further, growing demand of organic production of

vegetables in global markets also compelled the farmers to produce organic vegetables on larger scale to get more money for their vegetables. The availability of good quality vegetables will increase in coming years due to growing awareness about the health benefits in large section of consumers. The prospect of vegetable processing will definitely be at increased level because of more availability and desire of thrust to conserve the valuable nutrients present in the vegetables. Further increased level of processing will generate more employment at rural sector and migration of labourers from one state to another can be checked.

Challenges and opportunities in vegetable sector

In view of huge post-harvest losses in vegetables and the presence of valuable bio active phytochemicals, there have been huge potential and opportunities for increased post-harvest management practices and low cost processing. There will be growing demand of processed vegetables due to rapid change in life style, rapid urbanization and growing awareness of increased consumption of vegetables in our daily diet. The advent of many low cost processing technologies can make the processed products affordable to the large section of population. Natural edible coating in the form of carnauba wax and shellac based coating can make vegetables more attractive in the form of glossy appearance with much reduced rate of respiration and transpiration thereby increasing the shelf life of vegetables to a greater extent. Carnauba wax and shellac based coating are very cheap and be adopted for bulk quantities of vegetables.

Minimally processed vegetables have greater opportunities for gaining its popularity in cities as it is very convenient and leaves no wastage at the end of consumers. Further it requires less time for cooking and suits the need of urban consumers. Processed vegetable industries in India have big challenge towards microbial safety of minimal processed vegetables during refrigerated storage.

Marketing problems and opportunities

Marketing of vegetables is the major bottleneck to its growth. Vegetables are highly perishable in nature. Proper cold chain management is required to handle bulk quantities of harvested vegetables, In India, there have been complete lack of cold chain management facilities. Large quantities of vegetables perish due to non-existence of cold chain facilities. These results in big losses to producers as well as quality vegetables do not reach at the door steps of consumers. The perishable nature of the vegetable requires careful handling to minimize the losses. Our Central Government has planned for setting up 42 Mega food parks and 236 integrated cold chain management facilities with the investment of 750 USD and 936 USD, respectively.

Unlike cereal based products, many vegetable based products could not be popularized in India. Public sectors and private sectors have developed many viable vegetable processing technologies to suit the demand of consumers. Majority of entrepreneurs are hesitant to start new venture with the fear the processed vegetable products would not get proper market. Entrepreneurs should take the challenge for maintenance of the quality during processing of vegetables. Further vegetable processing industries should build up faith with consumers about maintaining quality in every subsequent batch. Industries should hire skilled and trained labours. Skilled labours can easily understand the quality norms of processed products developed in the industry. This would result in maintaining the quality and building faith to the consumers.

In the west, the bulk of fruits and vegetables are processed and the scale of the processed food industry is so large that it can sell processed foods much cheaper than fresh fruits and vegetables. In the western markets, the fresh fruits and vegetables are relatively expensive due to large demand and preference towards consumption of fresh raw vegetables due to more health benefits. Indian co-operative form of dairy set up has made the dairy business more lucrative. In dairy sector, farmers get 66% of the price which consumer's pay for milk whereas in vegetable sector, farmers get less than 20% of what the consumers pay. This is quite clear that the price elasticity in dairy sector is more as compared to fruits and vegetable sector (Mangaraj and Singh, 2008). Many big private players are joining regularly and posing challenges to public sector in dairy sector. However, the time has come for replicating the business of dairy sector into vegetable processing sector.

Newer processed vegetable products should be launched in the market at regular interval as a result the chances of saturation of one processed product can be minimized. There should also be good linkages and co-ordination between the private industries and public institutions, Food laws prescribed by FSSAI should be strictly followed in processed products. This would help in building good faith between the industry and consumers. Self-help groups should be promoted so that they can compete the established processed industries. Self-help group should be encouraged to establish startup companies

and it would be helpful in building the image of **BRAND INDIA** in larger perspective.

CONCLUSION

The processed fruit and vegetable industry has great potential to realize the agricultural resources. There have been huge challenge to vegetable industry to increase the processing of the perishables to provide sufficient growth to the global trade by adding increased value to the end products. The Ministry of Food Processing, Govt. of India, also intends to increase the processing of horticultural crops from 2% to 20%, value addition from 7% to 35% and share of global trade from 1 to 3%. Farmers particularly women in rural sector can play a crucial role to give a boost in the processing of perishable products at small sector. There is an urgent need to support farmer-managed rural production and marketing ventures in horticulture, and post-harvest processing and to provide technology training and input support to farmers to take advantage of emerging high-value agribusiness sector. Agro-processing particularly vegetable processing can generate employment to whole family of farmer so that farmer's income can be increased. Harvesting of fruits and vegetables at proper stage of maturity, storage under cold chain management and suitable processing with assured marketing of processed products can increase the income of the farmers and it would be a step towards fulfilling the mission of our Honourable Prime Minister by doubling the farmer's income by 2022.

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Review Article

Phytochemical and Pharmacological Importance of Stevia: A Calorie Free Natural Sweetener

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Stevia, a natural sweetener, comprises of 200 species of herbs and shrubs from the family Asteraceae (Composite). Among the different species of *Stevia*, *S. rebaudiana* exhibits the highest level of sweetness. Stevia contains entkaurene, a diterpene glycoside commonly known as stevioside which is 150-300 times more sweeter than sugar. In addition to its interesting sweetening property, *Stevia* plant shows many other pharmacological properties. Its' leaves also contains good amount of protein, amino acid, lipids, vitamins and minerals. Phyto-chemical screening showed that tannins are also present in higher concentrations followed by alkaloids, glycosides, saponins, sterols, and triterpenes, anthraquinones, and other reducing compounds. Stevia glycosides possess many pharmaceutical properties viz; anti-hyperglycaemic, antihypertensive, antioxidant, antimicrobial activity, anticancer effect, anti-inflammatory and immune-modulatory effect etc. Stevia has potential qualities of a sweetener and also constituting a source of many substances with a nutritional effect on the human beings. Among different chemical constituents, stevioside has a potential mode of actions in controlling type 2 diabetes. Stevia enriched food products brings several benefits to human society. Commercial marketing of products stevia in different form such as leaf powder, liquid and fresh leaves has become a potential adventure for many biotechnological companies because of its large demand.

INTRODUCTION

Stevia genus comprises about 200 species of herbs and shrubs from the family Asteraceae (Composite). The most common species of this genus and family with sweetening potential are *Stevia dianthoidea*, *S. phlebophylla*, *S. anisostemma*, *S. bertholdii*, *S. crenata*, *S. enigmatica*, *S. eupatoria*, *S. lemmonii*, *S. micrantha*, *S. plummerae, S. rebaudiana*, *S. salicifolia*, *S. serrata* and *S. viscida* but among these only *Stevia rebaudiana* exhibits the highest level of sweetness (Carakostas *et al.,* 2008). Stevia is a natural sweetener with high medicinal value and commercials importance due to its great demand all over the world. This is commonly known as sweet leaf, honey yerba, honey leaf, meethi tulsi, sweet chrysanthemum, candy leaf and by some other variations of these names (Carakostas *et al.*, 2008). It is also referred as 'the sweet herb of Paraguay' due to its origin in Paraguay and Brazil. Stevia is a perennial shrub and mature plant grows up to height of 65 – 100 cm in naturally fertile soil (Chan *et al.*, 2000). Stem is weak and semi-woody while leaves are sessile, oppositely arranged, lanceolate and serrated above the middle. It is classified as short-day plant and flowers during January to March in the southern hemisphere. The flowers are small, white and arranged in indeterminate heads. Botanically fruit is an achene with a feathery pappus. It grows well in sandy soil with the soil pH of 6.5 to 7.5, in the area of warm sunny situation (Singh *et al.*, 2005). The semi humid, subtropical climate with temperature range of 21 to 43°C and with an average of 24°C are most suitable for its cultivation (Huxley, 1992). A temperature of 15-30°C with abundant rainfall is most suitable for its optimum development but when temperature drop below 0°C, it behaves as annual plant. It is grown in China, Taiwan, Thailand, Korea, Brazil, Malaysia, Canada, Hawaii and California. Rajasthan, Maharashtra, Kerala and Haryana are the main Stevia growing states in India.

A zero calories sweetening agent, ent kaurene diterpene glycosides commonly known as steviol glycosides which are many folds sweeter (150-300 times) than sugar is present in the leaves of *S. rebaudiana* (Kinghorn *et al.*, 1982; 1984; Kasai *et al.*, 1987; Liu *et al.*, 1997; Raut, 2017). In addition to its interesting sweetening property,

Stevia extract shows many pharmacological properties. Several studies showed that a diterpenoid glycoside stevioside is the main component of stevia. This stevioside contains steviol, an aglycon glycoside (Geuns, 2003) which is thermostatic, pH stable, and non-fermented hence it can be used easily in cooked food and drinks without any quality loss (Abdullateef and Osman, 2012). Toxicological studies based on stevioside suggested that it does not show tumor inducing or mutagenic effect. Stevia has attracted economic and research interests mainly due to sweet and therapeutic properties of leaves. If we look upon the economy of stevia cultivation, the plant needs very little water (5% of the sugarcane) which is the major issue at present days. Even many farmers are interested to take up the stevia cultivation in various part of world but still its acerage is not up to the mark due to high input costs with initial investment of 1.2 lakh per hectare, because the crop can only multiply through costly methods like stem cutting or tissue culture; but once planted, the return can accrue over a period of 2-3 years.

History

P. J. Stevus, a Spanish botanist studied the different species of genus Stevia for the first time, hence the word Stevia originates by referring his name. Later on, first time the plant and its sweet taste were discovered by M. S. Bertoni in 1899. After referring the name of a Paraguayan chemist, Dr. Rebaudi, the botanical name of plant *Stevia rebaudiana* was proposed. In 1931, two French chemists (Bridel and Lavieille) extracted the chemicals namely Steviosides and Rebaudioside A from the leaves of stevia which were responsible for the sweet taste. After that, chemical structure of stevioside was formulated and expressed as aglycon, steviol with glycoside of three glucose molecule in 1952 (Wood and Fletcher, 1956). In 1970s, other new compound rebaudioside was also identified, which is having higher sweet potency than the stevioside (Kohda *et al.*, 1976).

First domestication of stevia was taking place in Japan as an alternative sweetener when saccharin was banned (Konoshima and Takasaki, 2002). Even though stevia was first domesticated in Japan but, commercial cultivation of this crop was initiated in Paraguay in 1964 (Lewis, 1992). Afterward during World War II, stevia was utilized as a sweetener for food shortage faced by Britain. Later on, extensive studies on *Stevia* revealed its useful effects on human body which favour its commercialization in several countries including Latin America, Canada, China, Japan, Indonesia, USA (Jayaraman *et al.*, 2008). Then, it was used as herbal product and increased its share in market in these countries. In 1970s and 1980s and its extracts have been allowed for using as a dietary enhancement in the US in 1994 (FDA, 1995). Later on, 58th, 63rd and 68th meeting of Joint FAO/WHO Expert Committee on Food Additives (JECFA) reviewed steviol glycosides and established a temporary specification and ADI of 0-2 mg/kg bw/day.

Chemical compositions

The chemical composition of stevia leaves changes according to geographical area and cultivars, (Khiraoui *et al.*, 2017). Method of drying and processing also affects the chemical composition of stevia active constituents (Gasmalla *et al.*, 2014). Several researchers have proved that stevia is the main substitutional source of sugars. Even though several stevia species have been studies but broad knowledge about chemical constituents of stevia is still incomplete. Soejarto *et al.* (1982) studied 110 species, out of which only 18 were having quality of commercial importance. Ent-kaurene, a diterpene glycoside occur in the leaf of stevia is responsible for its high sweeteness. Up to date nine such compounds have been isolated and their concentration varies according to plant organ as highest concentration occurs in leaves, followed by flowers, stems and seeds. Stevioside shows permanent bittery taste and have very high stability in aqueous solutions within a broad range of pH (1-10) and temperature up to 98°C. It is 150 to 300 times sweeter than sucrose depending on its concentration. Among different Rebaudioside, Rebaudioside A is the most important one and shows 250 to 450 times more sweetening property than the sucrose. It is most stable glycoside but have no bitter after taste as in case of steviosides. Besides, stevia also contains labdane diterpenes and triterpenes. Stevia leaves also contains good amount of protein, amino acid, lipids, vitamins and minerals. Initially 9 essential amino acids i.e. glutamic acid, aspartic acid, lysine, serine, alanine, proline, tyrosine, isoleucine and methionine were isolated from stevia leaves (Mohammed *et al.*, 2007). Later, Abou-Arab *et al.* (2010) isolated 17 amino acids. Stevia leaves also contain medically and commercially important several natural nutrients and vitamins such as chromium, magnesium, manganese, potassium, selenium, zinc, and vitamin B3 (Niacin). Phytochemical screening has showed that tannins are present in higher concentrations followed by alkaloids, glycosides, saponins, sterols, and triterpenes,

anthraquinones, and other reducing compounds (Tadhani and Subash, 2006). The total chemical composition of dried stevia leaves is represented in Table 1.

Stevioside and rebaudioside A are the primary glycosides of stevia plants which contributes 90% weight of all sweet glycosides present in the leaves (Bergs *et al.*, 2012). It also contains steviolbioside, rebaudioside B, D, E, and F in lower concentration. Recently, a new compound rebaudioside M (200-350 times sweeter than sucrose) was reported by Prakash *et al.* (2014). All diterpenoid glycosides isolated from stevia rebaudiana have similar steviol (chemical backbone structure) with the slight differences in content of carbohydrates residues, mono, di and tri – saccharides containing glucose and/or ramnose at positions C13 or C19 (Kobus-Moryson *et al.*, 2014). The chemical structure stevioside and Rebaudioside A given in Figure 1.

The amount of chemical components varied at different percent level such as diterpene glycosides ranged from 4 to 20 per cent stevioside ranged from 4-13 per cent of total dry weight, rebaudinoside A 2-4 per cent, rebaudinoside C 1-2 per cent and dulcoside A 0.4-0.7 per cent (Gasmalla *et al.*, 2014; Pól *et al.*, 2007).

Pharmacological aspects of stevia

Development of diet-dependent diseases and their risk can be reduced or prevented by following the healthy life style, food habit and introduction of well-balanced diet into human nutrition. Stevia is regarded as important raw material in food industry due to sweet nature of steviol

Table 1. Chemical composition of dried stevia leaves, g·100 g^{-1} dm

Components	Nutrient content in leaves, g. 100 g^{-1} dm			
	Ritu and Nandini (2016)	Khiraoui *et al.* (2017)	Gerdzhikova *et al.* (2018)	Gasmalla *et al.* (2014)
Moisture	0.70±0.1	0.70±0.80	0.82	0.73
Protein	0.98±0.02	1.18–1.62	1.02	1.07
Fat	0.40±0.06	0.39–0.58	0.21	0.61
Crude fibre	1.20±0.5	1.74–1.91	1.69	0.50
Carbohydrate	6.26±0.8	5.15–5.67	5.92	6.31
Ash	0.92±0.08	0.74–1.13	0.97	1.20
Iron	0.02±0.01	0.57–3.54	2.97	3.26

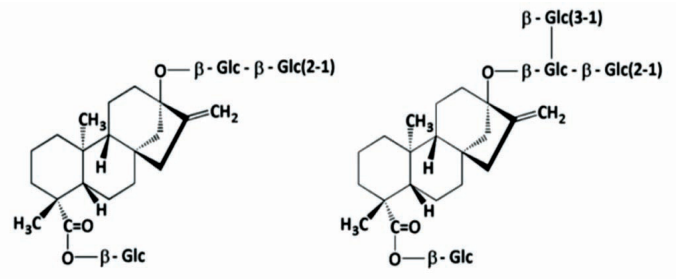
Table 2. Steviosides, its structural derivatives and related compound along with their concentration and sweetness fold than sugar

Compound	R1 chain	R2 chain	Formula	Fold change of sweetness*	Value (g/100g dry leaf weight)
Stevioside	β- Glc	β- Glc- β-Glc (2→1)	$C_{38}H_{60}O_{18}$	300	4–13%
Steviolbioside	H	β- Glc- β-Glc (2→1)	$C_{32}H_{50}O_{13}$	100-125	>0.4%
Rebaudioside A	β- Glc	β- Glc- β-Glc (2→1)|β- Glc- (3→1)	$C_{44}H_{70}O_{23}$	250-450	2–4%
Rebaudioside B	H	β- Glc- β-Glc (2→1)|β- Glc- (3→1)	$C_{38}H_{60}O_{18}$	300-350	>0.4 %
Rebaudioside C	β- Glc	β- Glc- α-Rha (2→1)|β- Glc- (3→1)	$C_{44}H_{70}O_{22}$	50-120	1–2%
Rebaudioside D	β- Glc- β-Glc (2→1)	β- Glc- β-Glc (2→1)|β- Glc- (3→1)	$C_{50}H_{80}O_{28}$	250-450	>0.4%
Rebaudioside E	β- Glc- β-Glc (2→1)	β- Glc- β-Glc (2→1)	$C_{44}H_{70}O_{23}$	150-300	>0.4%
Rebaudioside F	β-glc-	(β-glc, β-xyl)-β-glc-	$C_{43}H_{68}O_{22}$	250-350	>0.4%
Rebaudioside M	$(β\text{-glc})_2$-β-glc-	$(β\text{-glc})_2$-β-glc-	$C_{56}H_{90}O_{33}$	200-350	>0.4%
Dulcoside A	β- Glc	β- Glc- α-Rha (2→1)	$C_{38}H_{60}O_{17}$	50-120	0.4–0.7%

Glc – glucose, Xyl – xylose, Rha – rhamnose, sugar moieties

(*Source:* Crammer and Ikan, 1986; Geuns, 2003; Gasmalla *et al.*, 2014; Pól *et al.*, 2007; Prakash *et al.*, 2014)

*Sweetness is tasted at a series of dilutions to determine the concentration that is as sweet as a given percent sucrose reference. Taste panellists usually are trained to quantitate sweetness on a 15 cm line scale, using 2-15 per cent sucrose solutions as references.



a) Stevioside b) Rebaudioside A

Figure 1. Chemical structure stevioside and Rebaudioside A

glycosides and presence of high amount of proteins. As listed above, stevia plants have several biochemical components which shows significant importance in pharmaceutical and food industry. The leaf extracts of stevia have probably been used in traditional medicine and as sweetener by native people before being described; but recently, stevioside has achieved worldwide attention due to its potent sweetness (Barriocanal *et al.*, 2008). Hence, significant increased interest in therapeutic potential of stevia is being shown after reviewing the several health beneficial reports of stevia. Stevia glycosides possess valuable biological properties which are describes below:

Anti-hyperglycaemic effects

In present world, change is food habit and living style is responsible for insulin abnormalities, pancreatic alpha cell dysfunction and comparative glucosan excess which place lead role in metaboic syndrome like diabetes (Unger, 1997). It has been proved that stevia leaves contain low calorie sweeteners and regular consumption of these compound reduces glucose and cholesterol concentration (Atteh *et al.*, 2008). Many researchers found that these glycosides help in reduce blood glucose levels, protecting the organism from diabetes and obesity by enhancing not only insulin secretion but also insulin utilization in insulin deficit persons (Anton *et al.*, 2010; Chen *et al.*, 2005). So, stevia may be highly beneficial in treatment of type 2 diabetes (Barriocanal *et al.*, 2008).

Antihypertensive effect

Stevia attributed anti- hypotensive property mainly due to presence of stevioside (Melis, 1992). The arterial blood pressure comes down when feed orally or intravenously (Hsieh *et al.*, 2003). Daily consumption of 1000 mg rebaudioside A produced no clinically important changes in blood pressure in healthy adults with normal and low-normal blood pressure (Maki *et al.*, 2008).

Antioxidant activity

In recent trends more, attention is given towards antioxidant compounds, due to their ability to neutralize free radicals (Saric *et al.*, 2013; Kuzma *et al.*, 2014). Stevia leaf extract shows antioxidant activity due to scavenging mechanism of superoxide and free radical electron (JECFA, 2005). Inhibition of angiotensin II induced cell proliferation and endothelin I secretion is possible by Isosteviol, a derivative of stevioside, it also responsible for attenuation of reactive oxygen species generation (Ghanta *et al.,* 2004; Stoyanova *et al.*, 2011).

Antimicrobial activity

The bacterial diseases like gum and tooth decay can be reduced as stevia retards the growth and development of such bacteria, hence it is an excellent addition to toothpaste and mouth wash for dental hygiene (Das *et al.*, 1992). Microbes such as *Streptococcus mutans, Pseudomonas Aeruginosa* and *Proteus vulgaris* do not thrive in the presence of the non-nutritive Stevia constituents (Tadhani and Subhash, 2006). Stevia derivative such as octa - acetylombuoside, ombuine and retusine were found to have antimicrobial action against few types of gram-positive bacteria (Tomita *et al.*, 1997).

Anticancer effect

Limited research work has been done on anti-carcinogenic property of stevia. Presence of polyphenol compounds responsible for inhibitory action on tumor initiation and promotion. Steviol isolates such as stevioside, rebaudiosides A & C and ducloside A from *Stevia rebaudiana* shows strong inhibitory effect on 12- 0-tetradecanoylphorbol-13-acetate (TPA) induced inflammation in mice which is suggestive of its anticancer effect (Raskovic *et al.*, 2004; Yasukawa, 2002).

Anti-inflammatory and immunomodulatory effect

The property which reduces the swelling is known as anti-inflammatory. Steviol and stevioside shows anti-inflammatory effects on epithelial cells of colon (Chatsudthipong and Muanprasat, 2009). Stevia has been found to attenuate synthesis of the inflammatory mediators in LPS stimulated THP-1 cells by interfering with the I Kappa B kinases (IKKbeta) and Kappa B signaling pathway thus beneficial as anti-inflammatory and immunomodulatory substance (Bookaewan *et al.*, 2006).

It is also attributed to therapeutic activities such as hypoglycemic (White *et al.,* 1994), contraceptive activities

(Planas and Kuc, 1968) antidiarrheal, and diuretic (Chatsudthipong and Muanprasat, 2009).

Harmful effects of stevia on human health

Even though stevia having most of beneficial pharmaceutical properties but few minute side effects such as nausea, abdominal fullness, myalgia, muscle weakness, dizziness, asthenia and allergy were also recorded by few researchers (Genus, 2003; Goyal *et al.,* 2003). Curry and Roberts (2008) observed the reduction in body weight under high oral dose ingestion of steviol but no strong evidence of systematic toxicity was acknowledged (Carakostas *et al.*, 2008). Few studies suggested that stevioside is responsible for carcinogenic activity in urinary bladder (Hagiwara *et al.*, 1984). Variation in renal activity and perfusion, sodium excretion and urinary flow were observed so, cautious use is indicated in patients with renal disease or with impaired renal function (Melis, 1997).

Application of stevia (steviol glycosides) in food

Several nutrition and medical problems arise due to more intake of sucrose content which is associated with negative effect on human body such as obesity, high blood pressure, atherosclerosis, coronary heart disease cholesterol and insomnia (Anton *et al.*, 2010; Puri *et al.*, 2012). These all are correlated with excess availability of high calorie food and beverages. Therefore, for more than two decades, there has been a very strong increase in interest in sweeteners, which do not introduce additional energy into the organism (Brahmachari *et al.*, 2011; Pecivova *et al.*, 2013). On the other hand, quality of consumed food also having significant importance for their preference i.e. whether it fits with the motto of 'natural, healthy food'. Global food industry has recognised the importance of high purity zero calorie natural stevia extract because its natural source appeals to many consumers. Truvia, purevia and suncrystals are the major international brands uses purified stevia leaf extract to develop natural table top sweetener which keeps the calories down in a natural way and enhance the sweetness.

Hence, there is an urgent need to substitute sugar with natural low-calorie sweeteners like *Stevia rebaudiana* leaves powder which will increase the nutritional profile of the products.

The nontoxic, non-addictive, non-carcinogenic and non-mutagenic nature of stevia plants gives a new scope in processing of several food stuffs as substitute of sucrose by many food manufacturers in Japan for the last 40 years (Parsons, 2001; Thomas and Glade, 2010). Stevia and its products used in food groups such as carbonated beverages, still non-alcoholic beverages, table-top sweetener formulations, chewing gum and yogurt etc. softness in dishes can be obtained when stevioside and sodium chloride used in one combination, hence it is commercially used in preparation of pickled vegetables, dried seafood, soy sauces and miso products (Tadhani and Subhash, 2006; Goyal *et al.*, 2010). The highly purified steviol glycosides with intensive sweet taste was extracted in Japan itself. Stability of stevia at heat treatment is the major advantage which facilitates its introduction into the recipes for many food products. Stability of stevioside is observed at 95°C, hence suggested that sweetener is suitable for cooked food additive. Kroyer (2010) reported that sweetener shows good stability at 120°C even extended up to one hour while at temperatures exceeding 140°C it underwent degradation, and its complete degradation occurs when exposed to 200°C. Stevia also used in sweetening of carbonated beverages because it does not form any precipitate in acid solution.

Plant propagation

A number of countries now have been concentrating on cultivation of stevia due to its commercial importance, but non-availability of quality planting material is the major lacuna in most of countries. Hence there is a need to standardise the large-scale propagation in-vitro techniques to produce the quality and quantity of planting material (Dhananjay and Despande, 2005). Stevia can be propagated by seeds but low germination percent, small size and infertility does not allow to commercialize this method (Sativa *et al.*, 2004). Occurrence of self-incompatibility is the major problem in sexual propagation of stevia which leads to sterile seeds. Seed propagation does not allow homogeneous population which leads to great variability in important features like sweetening levels and composition (Nakamura and Tamura, 1985; Jadeja *et al.*, 1985). Propagation through plant cutting also followed in multiplication of stevia which is slight better than seed propagation but problem may arise during disease development. So, *in vitro* propagation or plant tissue culture appears as an alternative technique for rapid multiplication of stevia within a short period of time (Das *et al.*, 2005). Large number of genetically similar and disease-free plantlets can be obtained through direct organogenesis of *in vitro* propagation.

Varietal wealth of stevia

About 90 different varieties of stevia have been developed all over the would which are suitable for different climatic conditions. Most of species contains 3.5 per cent or less stevioside content under variable climatic conditions which is far less than the present-day market demand. Hence, we should purchase the planting material from reliable farms/nurseries so that they may take responsibility for availability of minimum steviosides and rebaudinoside content in particular variety. Based on glycosides content, Sun fruits limited, Pune, India has recently developed three varieties suitable for different climatic conditions. Brief description of these varieties is as follows:

SRV–123: This variety contains glycosides content of about 9-12 per cent. A total of five cutting per year can be taken under optimum management practices.

SRV–512: This variety is most suitable for North Indian conditions and four cutting can be taken per year. The amount of glycosides content varies from 9-12 per cent.

SRV–128: This variety of stevia is the best suitable for all over country and contains glycosides content of 21 per cent. It can provide four cuttings per year with better yield performance.

CONCLUSION

To fulfil the needs of consumers, combining the qualities of a sweetener and also constituting a source of many substances with a nutritional impact on the human beings stevia is accurate solution. Hence, stevia is being used in whole world due to its important chemical constituent and pharmaceutical property. Among different chemical constituents, stevioside has a potential mode of actions in controlling type 2 diabetes, and its multipurpose increased interest in food production. Stevia enriched food products brings several benefits to the society.

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Mini Review

Impacts of Land-use Paradigm Shifts on the Agricultural Economy: Sustainable Management

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India is an agrarian country. The GDP of the country has about 18% contribution from the agricultural sector. However, from the past few decades, the country's agricultural output is facing major loss due to certain issues like land degradation, climate change, land use patten, etc. Crop insurance has been the only option that could help tackle the agricultural sector's risks and problems. The country's land use pattern has changed over the years and has had drastic effects on the availability of lands for agriculture and ultimately resulted in productivity loss. Moreover, the land use pattern has created issues like degraded lands and marginalization of the lands. The best way to adopt sustainable and economic viability approaches is to deal with the issues and boost the agriculture economy. Microbial techniques have emerged as a new hope which can not only help to restore land quality, but it can also enhance the yield from small land patches. So, research should be further extended in such a way that could safeguard our resources and increase the economy.

INTRODUCTION

Our world is getting over populated, as the population has reached 7.8 billion and it is projected that will cross the 9 billion mark by 2050 (Minhas *et al.*, 2017). The burgeoning population and unmannered human settlements have shifted the land use paradigm to much higher extents. With the era of urbanization, industrialization and modernization the availability of arable land has declined with an alarming rate. The global food demands have increased with time and there is a pressure to utilize every path of land in the most appropriate way that could benefit agriculture. Crop productivity depends upon a number of environmental and anthropogenic factors. In agroecosystems, a healthy plant requires optimal environmental requisites to produce substantial yields that can create economic profit. Mainly the presence of biotic and abiotic stresses in agroecosystem limits the productivity. Abiotic stresses along with anthropogenic activities play a crucial role in increasing the impact of land degradation. According to Wang *et al.* (2007) abiotic stresses are responsible for diminishing average yields in more than 50% of major crops worldwide. Globally, approximately 91% of land area is suffering from different types of stresses (either biotic or abiotic) and only the remaining 9% area is favorable for crop productivity (Minhas *et al.*, 2017). The abiotic stresses such as high or low temperatures, soil salinization, flood, drought, soil pH imbalance, metal toxicity, nutrient deficiencies, soil pollutants, etc. are main constraints responsible for yield reduction, crop failures, and losses of agricultural economy worldwide. Many attempts have been done in the due course of time to increase the yield and production. The abiotic stress coupled with the major failures resulted in land degradation of major arable lands.

Link between land use paradigm shift and agricultural decline

Due to increasing human demands there is enormous change in land use and the pattern of modernization. The changes have led to an era where the land area available has decreased to a rate which has created immense pressure. Overpopulation has led to increase the global food demands. The land as a resource was being utilized blindly and now there is inadequacy of available arable land areas. Transformation of arable land forms into urban areas without proper planning of the consequence (unavailability of agricultural lands), has become a major trouble to the agricultural sector. Not only the food demands but also the nutritional quality is important. In agro-ecosystems the growing and developing plant demands appropriate conditions for production of sufficient amount of yield that create economic profit (Figure 1).

The decline in agricultural productivity was majorly due to inappropriate land use pattern, mismanagement of resources, and overuse of agro-chemicals. The damaged

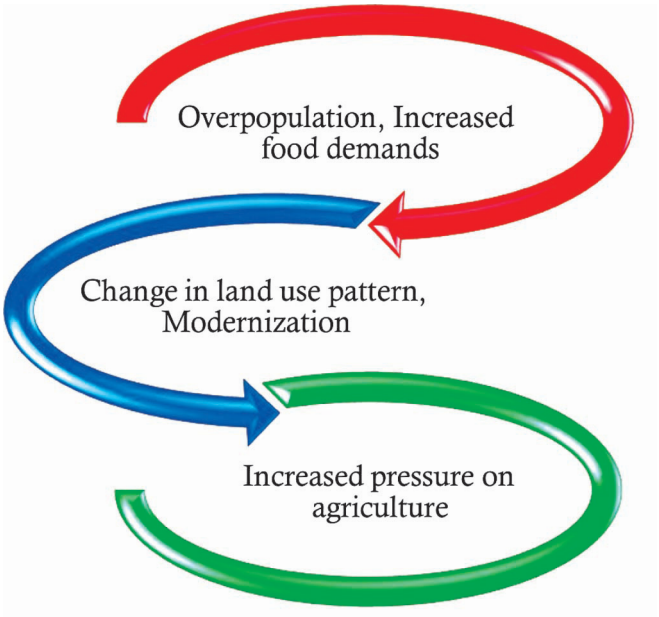

Figure 1. The link between the overpopulation, land use pattern and agriculture

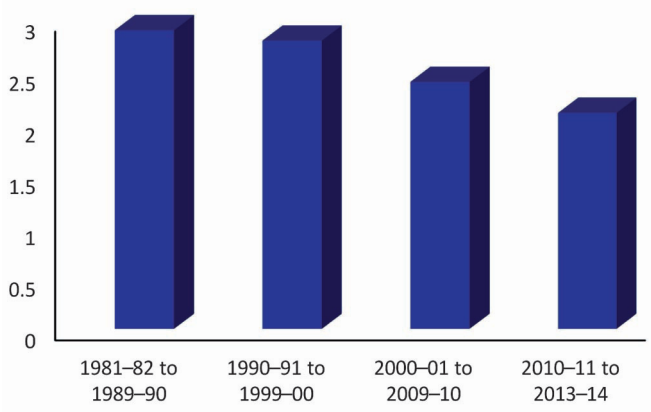

Figure 2. Agricultural growth rate (%)
Source: De Roy (2017)

physical, chemical and biological properties of the soil can be restored by applying and integrating sustainable farming and information technologies as well as private participation (Figure 2).

Agriculture and the Indian economy

The Indian agro industry is divided into sub-sections like dairy, canned, processed, frozen food, fisheries, poultry, meat, and food grains. Food grain production for the year 2014-15 is around 252.68 MT. India is the largest producer of milk with 138 MT of annual output and second largest producer of sugar with 14% of global output (Wagh and Dongre, 2016). In comparison to developed countries, agriculture plays a very vital role in developing countries for the employment generation and gives a high share of GDP. In the recent period overall share of the agricultural GDP is around 18% (Wagh and Dongre, 2016). Per capita of food quality and its consumption has a great relationship with the economy. The abiotic stress prevalence causes big loss to economy worth billions of dollars worldwide (Minhas *et al.*, 2017). Out of the country's total exports agricultural exports constitutes for about 10% (Wagh and Dongre, 2016). Over the years many policies and schemes were introduced which assured of improvement of agricultural productivity and economy, but contrary to expectations there were no such results. During the period of agricultural reforms, it was expected that agricultural sector would get great benefits but the results showed no noticeable change. Moreover, there was seen increased insecurity of the livelihood of the people who were much dependent on agriculture. The policies adopted was seen with reduction of investments by the public, for the motive of research, extension services and irrigational technologies (De Roy, 2017). The policies had a major effect on the agricultural economy of India. The agricultural share to GDP has decreased in comparison with 90s (Figure 3).

Microbes as a sustainable tool

In recent years of advancements, a new vista opened for the sustainable management of abiotic and biotic stresses i.e. microbiological management of agricultural land mass. Out of various available techniques for management of degraded and arable lands, the biological i.e., microbial application technique was found much relevant and confirmed as an efficient tool to mitigate environmental stresses (Singh *et al.*, 2016). The beneficial

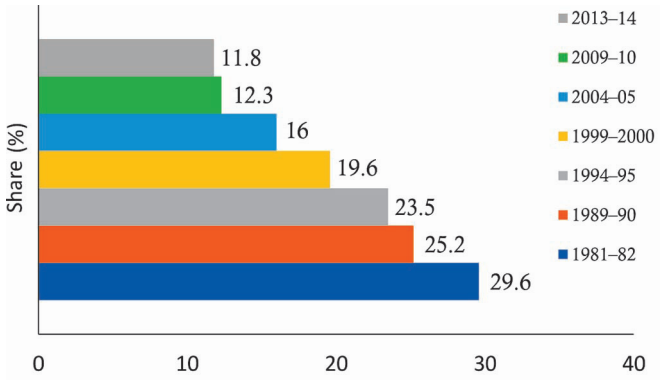

Figure 3. Agricultural share to GDP
Source: De Roy (2017)

Table 1. Some microbial communities which benefit plants in stressful conditions.

Microbial community	Microbial species	Stress	Benefitted plant / *In-vitro* analysis	Remarks	Reference
Bacteria (Free living)	*Pseudomonas putida*	Drought	Chickpea (*Cicer arietinum*)	Inoculation with bacteria increased germination percentage, root length, shoot length, and number of nodes.	Tiwari *et al.* (2016)
Fungi (Endophytic)	*Penicillium citrinum*	Drought	Mandarin plant	Fungal inoculation improved stress tolerance in plants by producing antioxidant enzymes and scavenging ROS.	Sadeghi *et al.* (2020)
Bacteria (Rhizospheric)	*Achromobacter xylosoxidans*	Flood	Tulsi (*Ocimum sanctum*)	Bacteria protected plants from waterlogging stress by producing ACC-deaminase, and reducing stress ethylene and lipid peroxidation.	Barnawal *et al.* (2012)
Bacteria (Rhizospheric)	*Ochrobactrum rhizosphaerae*	Flood	Tulsi	Bacterial isolate possessed ACC-deaminase production which protected plants from waterlogging stress.	Barnawal *et al.* (2012)
Bacteria (Rhizospheric)	*Pseudomonas aeruginosa*	Temperature	Sorghum	Bacterial inoculation improved metabolite levels such as sugars, proline, amino acids. Plant biomass is also found increased at higher temperature.	Ali *et al.* (2009)
Fungi (Endophyte)	*Rhizopus oryzae*	Temperature	*Helianthus Annus*	Fungi alleviated temperature stress in inoculated host plant by increasing catalase, proline, sugar level, and phenolic metabolites.	Ismail *et al.* (2020)
Bacteria (Rhizospheric)	*Staphylococcus sp.* R11	Salinity	Salicornia sp.	Inoculation showed better results in terms of root length, shoot length, and plant total biomass in varying NaCl salt concentrations.	Komaresofla *et al.* (2019)
Fungi (Arbuscular mycorrhizal fungi)	*Glomus etunicatum* and *Glomus intraradices*	Salinity	Cucumber (*Cucumis sativus*)	Inoculation improved tolerance to host plant at higher salinity levels by increasing antioxidant enzyme activities, and accumulation of metabolites like phenols, and proline.	Hashem *et al.* (2018)
Algae	*Grateloupia filicina*	Salinity	*Oryza sativa* (Rice)	Application of polysaccharides extracted from the algae is found to be effective in alleviating salt stress in amended plant.	Liu *et al.* (2019)
Bacteria (Free living)	*Pseudomanas aeruginosa* strain BS2	Heavy metals	*In-vitro*	Biosurfactant produced by the bacterial isolate is shown to remove 88% Pb and 92% Cd from contaminated soil after 36 hours of experiment.	Juwarkar *et al.* (2007)
Fungi (Endophytic)	*Serratia sp.* IU01	Heavy metals	*Brassica napus*	The fungal strain alleviated Cd stress and elevated plant growth properties in metal contaminated soil.	Shah *et al.* (2020)
Fungi (AMF)	*Glomus etunicatum*	Nutrient deficiency	Switchgrass (*Panicum virgatum*)	Plants inoculated with AMF showed higher nutrient acquisition because of increased nutrient uptake (such as P, K, N, S, Cu, and Zn).	Clark (2002)
Fungi (AMF)	*Glomus intraradices*	Nutrient deficiency	*Phaseolus vulgaris*	Inoculation increased the phosphorus use efficiency in host plant and resulted in higher biomass of plants.	Tajini *et al.* (2012)

microorganisms reside in soil-plant system governs a number of essential tasks including bioremediation of contaminated soil, nutrient mineralization, solubilization and mobilization, provides tolerance to the plants in stressful environment, plant growth promoting traits (PGP-traits) production, phytohormones production, antioxidant enzymes production and organic matter enrichment (Sapre *et al.*, 2019; Husain *et al.*, 2020). Beneficial microorganisms that performs these vital tasks includes various species of actinomycetes, algae, protozoa, nematodes, bacteria, fungi etc. (Selvakumar *et al.*, 2012). In order to improve agricultural output in stressful conditions, the microorganisms and their products can be applied by multiple means such as in form of bio-fertilizers, bioactive compost, direct inoculation, microbial extracts, bio-stimulants etc. (Arroussi *et al.*, 2018; Sapre *et al.*, 2019; Carillo *et al.*, 2020). Diversity of microorganisms resides inside (endophyte) and outside (exophyte) a plant, many of which imparts tolerance and endeavor advantages to the host plant (Singh *et al.*, 2016). Endophytes can be present in any part or structure of plant like inside leaves, shoot, root, and even within all tissues (Singh *et al.*, 2016). Similarly, the rhizospheric microbes live adhered (rhizobacteria) or making associations (mycorrhiza) with plant roots. In comparison to exophytes, the endophytes were observed to feature more growth and stress tolerance to plants.

CONCLUSION

The self-reliance of India is essential as food security is the basic need of the burgeoning population. Increasing private participation and organic farming is the key to have better agricultural growth and less degraded lands. The focus should be made on proper planning before utilizing the agricultural lands and transforming them into building blocks (urban areas). Integration of sustainable and feasible technologies to manage the degraded lands and leftover arable lands for the best yield and production is required. In this paper we have tried to emphasize the importance of microbial inoculation in terms of advantages to agricultural productivity, for reducing environmental stresses, benefiting plants and nourishing soil properties. Microbial techniques stand as a sustainable, feasible and viable tool for the management and utilization of each patch of land in the best way possible.

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CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Research Article

Studies on Inheritance Pattern of Part Lactation Traits in Crossbreed Cattle

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The present investigation was carried on crossbred cattle maintained at Instructional Dairy Farm, Nagla of G.B. Pant University of Agriculture and Technology, Pantnagar. The study was conducted on 700 crossbred cattle, the progeny of 68 sires distributed over 28 years from 1990-2017. The first lactation monthly milk yield (FLMMY) data were utilized, which were collected from history sheets of crossbred cattle. A total of 10 FLMTDY were taken from each animal. The data were subjected to LSMLMW and MIXMDL package of Harvey (1990) to estimate the least-square mean, the effect of genetic and non-genetic factors on trait under study, genetic and phenotypic parameters of part milk yields. The least-squares mean of monthly test-day milk yields (MTDMY) starting with 8.50 kg (MTDMY-1) showed the peak yield at MTDMY-2 (10.55 kg) and lowest for MTDMY-10 (8.07 kg). The heritability estimated for the first lactation monthly milk yield (FLMMY) was low to medium. The genetic and phenotypic correlations between FL305DMY with FLFMY and FLMMY were found positive. Our results indicated that the selection might be made based on part lactation yield at an early stage.

INTRODUCTION

Animal breeders have always stressed milk production while selecting dairy cows of higher genetic potential. The first lactation's milk production is a good indicator of an individual's net genetic merit in subsequent lactations. Since productive traits occupy a central position in the dairy industry, their magnitudes may spell out dairy cattle's lifetime economy. Besides, genetic influences, environmental factors to which the animals are exposed to such as feeding, management, climatic conditions and health-care significantly affect production and reproduction traits. Age at first calving, calving interval and service period etc., are reproductive traits that are influenced to a greater extent by the environment.

The present study was conducted using the part lactation records on crossbred dairy cattle. The average values of different economic. trait gives an idea about the performance of a herd, whereas the estimates of. genetic .and phenotypic. parameters (heritability, genetic.and. phenotypic. correlations) guide a breeder in deciding the methods of selection and intensity of selection of various traits of interest. The part lactation milk yield data were also utilized to draw the lactation curve for predicting the complete lactation milk yield data (Arya *et al.,* 2020).

MATERIALS AND METHODS

The data on 700 cows sired by 68 sires, spread over a period from 1990-2017 and maintained at IDF (University farm), Nagla of G.B.P.U.A&T, Pantnagar was taken from history sheets, and daily milk record registers were utilized. The data were grouped into seven genetic groups, seven periods and three seasons, viz. summer, rainy and winter based on the first calving year. The data were subjected to LSMLMW and MIXMDL package of Harvey (1990) to estimate the least-squares means, the effect of genetic and non-genetic factors (sires, genetic groups, season and period of calving) on trait under study, genetic and phenotypic parameters of part milk yields. Sire was considered a random effect and genetic group, season, and first calving as fixed effects. The heritability and genetic and phenotypic correlations were estimated by the paternal-half-sib correlation method (sire component of variance).

Least Squares Analysis

The standard procedure of **Harvey 1990** was used to study the effect of genetic as well as non-genetic factors on various first lactation traits as per the model given below:

$$Y_{ijklm} = \mu + S_i + Y_j + G_k + P_l + e_{ijklm}$$

Table 1. Least squares means (LSM) along with their standard errors (S.E.) of first lactation monthly milk yields (FLMMYs)

Source	No.of obs.	FLMMY-1 (kg)	FLMMY-2 (kg)	FLMMY-3 (kg)	FLMMY-4 (kg)	FLMMY-5 (kg)	FLMMY-6 (kg)	FLMMY-7 (kg)	FLMMY-8 (kg)	FLMMY-9 (kg)	FLMMY-10 (kg)
Overall mean	700	249.62±4.80	307.81±5.02	304.11±4.70	295.17±4.35	281.17±4.15	265.29±4.10	254.68±4.33	235.30±5.11	211.67±5.87	179.09±6.88
Genetic group											
G_1 (HF×S×R×J)	96	240.64±9.05	295.06±9.47	304.19±8.86	293.38±8.20	276.93±7.83	260.69±7.32	250.83±8.16	225.69±9.64	199.36±11.06	186.85±12.96
G_2 (HF×S×R)	21	248.75±15..55	301.42±16.27	276.82±15.21	292.89±14.08	264.72±13.44	258.58±13.28	261.79±14.01	253.63±16.55	215.98±19.00	200.46±22.26
G_3 (H×S)	27	259.85±13.45	313.95±14.08	315.89±13.16	292.68±12.19	278.20±11.63	249.36±11.49	247.38±12.13	225.59±14.32	202.90±16.44	167.03±19.26
G_4(HF×J×RD×S)	343	255.83±6.23	304.85±6.52	301.48±6.10	293.70±5.65	280.56±5.39	270.27±5.33	263.89±5.62	250.51±6.64	231.43±7.62	186.90±8.93
G_5 (HF×S×J)	110	256.93±7.96	320.12±8.32	313.05±7.78	299.73±7.21	289.27±6.88	279.26±6.79	258.02±7.17	242.05±8.47	226.49±9.73	194.65±11.39
G_6 (HF×S×RD)	87	253.87±8.71	310.32±9.11	305.32±8.51	296.46±7.89	279.35±7.53	270.00±7.44	261.09±7.85	241.68±9.27	216.05±10.64	176.68±12.47
G_7 (J×S)	16	231.47±17.58	308.93±18.39	311.99±17.19	297.32±15.93	299.19±15.20	268.90±15.02	239.79±15.85	207.98±18.71	189.46±21.49	141.08±25.18
Season											
S_1 (March-June)	240	254.98±4.18	311.71±4.37	299.98±4.09	282.61±3.79	257.54±3.61	243.44±3.57	235.15±3.77	220.79±4.44	209.31±5.11	197.76±5.98
S_2 (July-October)	163	238.77±4.61	287.68±4.83	286.57±4.51	285.91±4.18	280.77±3.99	271.88±3.94	269.55±4.16	253.41±4.91	219.09±5.64	174.89±6.61
S_3(Nov.-Feb.)	297	255.11±3.98	324.02±4.16	325.77±3.89	316.98±3.61	305.22±3.44	280.57±3.40	259.36±3.59	231.72±4.24	206.60±4.86	164.63±5.69
Period											
P_1 (1990-1993)	43	225.47±10.77	243.72±11.28	233.97±10.54	230.81±9.76	216.75±9.32	208.17±9.20	196.97±9.71	172.06±11.47	158.25±13.17	133.89±15.43
P_2 (1994-1997)	94	174.27±7.85	221.44±8.22	223.51±7.68	222.71±7.11	209.39±6.79	198.95±6.71	194.53±7.08	186.25±8.36	168.55±9.59	155.29±11.24
P_3 1998-2001)	142	220.62±6.62	289.65±6.92	300.94±6.47	289.05±5.99	275.12±5.72	266.50±5.65	261.92±5.97	248.36±7.04	222.27±8.08	204.72±9.47
P_4 2002-2005)	146	261.63±6.61	325.87±6.92	319.01±6.47	304.02±5.99	287.33±5.72	271.53±5.65	262.11±5.96	236.89±7.04	205.99±8.08	159.80±9.47
P_5 (2006-2009)	130	283.06±6.70	339.42±7.01	326.77±6.55	316.29±6.07	304.44±5.79	283.43±5.72	270.02±6.04	243.62±7.13	222.52±8.19	155.34±9.59
P_6 (2010-2013)	64	270.91±9.06	345.51±9.48	337.34±8.86	336.27±8.21	324.02±7.83	305.57±7.74	291.29±8.17	275.09±9.64	240.03±11.07	224.89±12.97
P_7 2014-2017)	81	311.39±8.70	389.03±9.10	386.90±8.50	367.02±7.88	351.18±7.52	322.91±7.43	305.85±7.84	284.85±9.25	264.06±10.62	219.73±12.45

Where,

Y_{ijklm} = the observation on m^{th} progeny of i^{th} sire of j^{th} genetic group in k^{th} season and l^{th} period

μ = population mean

S_i = random effect of i^{th} sire (i= 1,2,3……68)

Y_j = fixed effect of j^{th} genetic group (j=1,2,……7)

G_k = fixed effect of k^{th} season of calving (k=1,2,3)

P_l = fixed effect of l^{th} period of calving (l=1,2…..7)

e_{ijklm}= random error assumed to be normally and independently distributed with mean zero and constant variance i.e. NID (0,σ^2s)

Estimation of Heritability

$$\text{Heritability } (h^2) = \frac{\frac{1}{NR1}.\hat{\sigma}_S^2}{\frac{(1-NW)}{NR1}.\hat{\sigma}_S^2 + \hat{\sigma}_e^2}$$

Whereas, $\hat{\sigma}_e^2$ = error variance component, $\hat{\sigma}_s^2$ = Sire component of variance, **NR1** = the decimal percentage of additive genetic variance in $\hat{\sigma}_s^2$, **NW=** the decimal percentage of additive genetic variance in $\hat{\sigma}_w^2$, NR1= between variance components and is equal to 0.25 and NW = within variance component and is equal to 0.75.

Estimation of genetic and phenotypic correlation

Genetic Correlation Coefficient

The following formula was used as detailed by Becker, 1964

$$r_{g\,(hh')} = \frac{cov_{S\,(hh`)}}{\sqrt{\left[\hat{\sigma}^2_{S(h)}.\hat{\sigma}^2_{e(h)}\right]}}$$

Phenotypic Correlation Coefficient

The phenotypic correlation coefficients among different traits were calculated as:

$$r_p(hh') = \frac{\hat{\sigma}^2_e(hh`)+[((1-NW)/NR1)\,\hat{\sigma}^2_s(hh`)]}{\sqrt{\{\hat{\sigma}^2_e(h)+((1-NW)/NR1)\,\hat{\sigma}^2_s(h)\}\{\hat{\sigma}^2_e(h`)+((1-NW)/NR1)\hat{\sigma}^2_s(h`)\}}}$$

Whereas, cov_s = sire or family covariance, h= h^2 traits, h′= another traits, $\hat{\sigma}_s^2$= is among variance or covariance components, and $\hat{\sigma}_e^2$= is within variance or covariance components.

RESULTS AND DISCUSSION

First lactation monthly milk yield (FLMMY)

The least-squares means of FLMMY in the present study were found as 249.62±4.80, 307.81±5.02, 304.11±4.70, 295.17±4.35, 281.17±4.15, 265.29±4.10, 254.68±4.33, 235.30±5.11, 211.67±5.87 and 179.09± 6.88, respectively (Table 1) in crossbred cattle showing an increase in milk production from the first month to second month and then gradual decrease after that up to the tenth month. Similar findings were reported by Singh *et al.* (2016) in Karan Fries. Whereas, Kim *et al.* (2008) reported a peak of monthly test day at the third month in Korean Holstein. The results were in close agreement with the reports of Roy (1983), Singh (1984) and Kumari (2015).

Factors affecting first lactation monthly milk yield (FLMMY)

The effect of sire on first lactation monthly milk yield was found highly significant in the present study except for the ninth month, where a significant effect was seen (Table 2). Similar results with highly significant effects for all

Table 2. Least square analysis of variance showing mean square values for first lactation monthly milk yields (FLMMYs)

Traits	Sire	GG	Period	Season	Error
FLMMY-1	11586.09**	3959.90	12267.48*	18203.16*	5209.89
FLMMY-2	10606.66**	8288.04	21991.62**	61108.60**	5931.59
FLMMY-3	10029.09**	6873.16	31821.39**	84983.14**	5099.69
FLMMY-4	8044.87**	1561.74	23654.60**	88998.200**	4435.16
FLMMY-5	7315.03**	5023.56	19384.19**	136850.25**	4041.96
FLMMY-6	7221.26**	5923.55	17822.67**	79697.34**	3934.97
FLMMY-7	6899.38**	3956.92	21886.39**	52557.25**	4506.88
FLMMY-8	10934.71**	12695.83	18440.69**	47915.27**	6141.48
FLMMY-9	11995.02*	19181.35*	14808.17	13559.79	8359.10
FLMMY-10	16995.15**	6473.28	19452.74	80649.96**	11417.24

**P< 0.01, *P<0.05

monthly milk yields were also reported by Kumari (2015). While the non-significant effect of sire on FLMMY was reported by Roy (1983) with a non-significant effect on all monthly milk yields, Singh (1984) reported a non-significant effect except for the second month in various crossbred cattle.

The effect of the animal genetic group on FLMMY was non-significant except for the ninth month, where the effect was significant. Similar results with non-significant effect of genetic group on FLMMY were reported by Singh (1984) and Kumari (2015).

The effect of the calving period on FLMMY was found highly significant except for the ninth and tenth months, where the effect was non-significant. Similar results with the significant effect of the period of calving on FLMMY were observed by Roy (1983) for first to the fifth month, Singh (1984) for first to the tenth month and Kumari (2015) for the second, third and fourth month. While the non-significant effect of calving period on FLMMY for all monthly milk yield except M2, M3, M4 was reported by Kumari (2015) in crossbred cattle.

The highly significant effect of calving season on all FLMMY was found in the present study except for the first and ninth months where the effect found was significant and non-significant respectively. Similar results with highly significant effect of season of calving for all monthly milk yield by was also reported by Kumari (2015), significant effect by Singh (1984) for second to tenth month and Roy (1983) for third to sixth month in different crossbred cattle. However, non-significant effect of season of calving on FLMMY was reported by Roy (1983) for first, second, seventh, eighth, ninth and tenth month in different crossbred cattle.

Table 3. Heritability estimates along with their standard errors (S.E.) of first lactation monthly milk yields (FLMMYs)

S.No.	Days	Heritability ± S.E.
1	FLMMY-1	0.486 ± 0.132
2	FLMMY-2	0.327 ± 0.116
3	FLMMY-3	0.394 ± 0.123
4	FLMMY-4	0.337 ± 0.117
5	FLMMY-5	0.335 ± 0.117
6	FLMMY-6	0.345 ± 0.118
7	FLMMY-7	0.226 ± 0.105
8	FLMMY-8	0.324 ± 0.116
9	FLMMY-9	0.187 ± 0.100
10	FLMMY-10	0.209 ± 0.103

Table 4. Genetic (r_g) and phenotypic (r_p) correlations among first lactation 305 day milk yield (FL305DMY) with first lactation monthly milk yields (FLMMYs)

Traits		FLMMY-1	FLMMY-2	FLMMY-3	FLMMY-4	FLMMY-5	FLMMY-6	FLMMY-7	FLMMY-8	FLMMY-9	FLMMY-10
FL305DMY	r_g	0.645±0.162**	0.820±0.120**	0.850±0.101**	0.958±0.085**	0.996±0.085**	0.893±0.111**	0.726±0.188**	0.620±0.207**	0.428±0.308	0.718±0.286*
	r_p	0.594±0.03*	0.698±0.02*	0.726±0.026*	0.713±0.027**	0.694±0.027**	0.652±0.029**	0.582±0.031**	0.456±0.034**	0.327±0.036**	0.211±0.037**

**P<0.01, *P<0.05; r_g = genetic correlation; r_p = phenotypic correlation
FLMMY-First Lactation Monthly Milk Yield, FL305DMY- First Lactation 305 Day Milk Yield

Heritability Estimates of First Lactation Monthly Milk Yield (FLMMY)

The heritability estimated for first lactation monthly milk yield (FLMMY) in the present study was found to be 0.486 ± 0.132, 0.327 ± 0.116, 0.394 ± 0.123, 0.337 ± 0.117, 0.335 ± 0.117, 0.345 ± 0.118, 0.226 ± 0.105, 0.324 ± 0.116, 0.187 ± 0.100 and 0.209 ± 0.103 respectively (Table 3) from first to tenth month. With minimum heritability at ninth month and maximum at first month, the heritability estimates ranged between 0.187 ± 0.100 and 0.486 ± 0.132 in crossbred cattle. While Kumari (2015) reported the heritability range for FLMMY between 0.324±0.142 at third month and 0.621±0.167 at sixth month.

Genetic and phenotypic correlations among FL305DMY with FLMMY

The genetic correlation between FL305DMY and FLMMY observed in the present study was 0.645±0.162, 0.820±0.120, 0.850±0.101, 0.958±0.085, 0.996±0.085, 0.893±0.111, 0.726±0.188, 0.620±0.207, 0.428±0.308 and 0.718±0.286, respectively, from first to tenth monthly milk yield. The phenotypic correlations between the traits were observed as 0.594±0.03, 0.698±0.02, 0.726±0.026, 0.713±0.027, 0.694±0.027, 0.652±0.029, 0.582±0.031, 0.456±0.034, 0.327±0.036 and 0.211±0.037, respectively, from first to tenth monthly milk yield (Table 4).

The least-squares means of monthly test-day milk yields (MTDMY) starting with 8.50 kg (MTDMY-1) showed the peak yield at MTDMY-2 (10.55 kg) and lowest for MTDMY-10 (8.07 kg). Based on reasonably good estimates of heritability of first lactation monthly milk yields as well as their high positive genetic and phenotypic correlations with FL305DMY, indicated that the selection might be made based on part lactation yield at an early stage.

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Research Article

Battery-assisted Offset Rotary Cutter for Leafy Green Spinach and Coriander

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Offset rotary cutter, green leafy vegetables, gender-friendly, walk-behind, electric power

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Spinach and coriander are the most common vegetable items for kitchen in India. Traditional method (using sickle or knife in sitting or squatting posture) of its cutting is prevalent in the country. In this practice, cut crops are gathered by hand and kept in loose or in bundle. Multiple times (4-6 times/season) harvesting of these crops increases harvesting cost including time and labour. The traditional method of cutting develops strains to the workers due to the static uncomfortable posture. Since mechanization in this area is very limited or scarce, therefore, a walk behind offset rotary cutter has been developed to cut and lay the cut crop in windrow. It consists of frame, 250W geared DC motor, two 12V-12ah batteries, power transmission, cutting unit and handle. A worker with the developed cutter provided output of 145 m^2/h for green spinach and 153 m^2/h coriander. The leftover leaves rate after manual and machine cut per m^2 area was 0.35 and 1.4% respectively. Time taken in collection of cut crop by the developed cutter and making bundle manually was incorporated in getting overall output with this system was found 2.56 times more than traditional system of harvesting the crops. This equipment provides powered mechanical aid in cutting operation to avoid squatting or sitting or changing posture while performing this activity which further helped in reducing drudgery of farm worker with increased output.

INTRODUCTION

Spinach (*Spinacia oleracea*) is a perennial vegetable which is cultivated throughout the world. It is a rich source of iron, vitamin and anti-oxidants with many health benefits. Andhra Pradesh, Telangana, Kerala, Tamil Nadu, Uttar Pradesh, Karnataka, Maharashtra, West Bengal and Gujarat are the leading producing states of spinach in the country. Spinach leaves becomes ready for cutting in 30 days after sowing. The average yield of spinach in first stage is 25-30 tonne green leaves/ha.

Coriander (*Coriandrum sativum)* is an annual herb in the family Apiaceae and its all parts of the plant are edible, but the fresh leaves and the dried seeds are the parts most traditionally used in cooking. Coriander is cultivated in Rajasthan, Madhya Pradesh, Uttar Pradesh and southern states like Andhra Pradesh, Karnataka and Tamil Nadu. Coriander leaves becomes ready for harvesting in 30 or 40 days after sowing and gives average yield of 6-7 tonne/ha. Harvesting/cutting of leafy vegetables like spinach and coriander are performed mostly by hand using sickle or knife in sitting or squatting posture. Uprooting is also a common harvesting method in many places. Leaf vegetables like spinach and coriander are harvested number of times (4-6 cutting) in a season. Multiple times harvesting increase its cost including time and labour which demands high man-power per hour. Harvested spinach and coriander are gathered by hand and kept in loose or in bundle. The traditional cutting processes develop physical strain to the workers due to the static uncomfortable posture. Calvin and Martin (2010) supported use of mechanized harvesters which has potential to reduce the production cost and the work intensity. Labour saving also promotes its farming and in development process of leaf vegetables industry. Structural complexities of a harvester/ cutter depend on a lot of factors which include plant architecture, end use of the crop and agronomic characteristics (Dingke *et al.*, 2007; Glancey, 2007; Savoie *et al.*, 2006). Other factors like ergonomics, soil and weather conditions should also be considered in design or development of cutter/harvester.

In India, the mechanization level of paddy and wheat harvesting is 60 to 70% (Mehta *et al.,* 2019). Harvesting machines for potato, onion and garlic, pluckers, platforms, tree and canopy shakers are also available for fruits (Pates, 2013). Kiran *et al.* (2017) developed a battery powered reaper for harvesting rice and wheat crops in Bangladesh. The reaper consists of a brushless DC Motor of 1100 W, 48V with rated rpm of 450 to drive the cutting mechanism and traction wheels. The brushless DC motor was powered

with four 12 V batteries. The cutting width of the reaper was observed to be 0.6 m. The average effective field capacity and cutting efficiency were found to be 0.13 ha/h at forward speed of 2.17 km/h and 98.24%, respectively. The harvesting cost of developed battery powered reaper was 85% less as compared to manual harvesting. Recently, Song *et al.* (2019) developed an experimental prototype of spinach continuous harvester for single stage cutting which is a walk behind battery-assisted machine. They found the success rate of harvesting is about 95% with less than 5% spinach damage rate. Another walk behind type harvester was developed in France for leafy green plant (spinach and lettuce) with cutting width of 114 cm, 72 kg total weight of machine with 24V electric prime mover (www.terrateck.com/en/vegetable-harvester/154-babyleaf-harvester.html). Olowojola *et al.* (2011) developed a tractor mounted leafy vegetable harvester for cutting Amaranthus crop using reciprocating cutter knife at crank speed of 447 rpm and operated at 3.27 km/h forward speed. Packaging of harvested vegetable into sizes is done alongside by 3–5 labour/day. The developed machine had effective field capacity of 0.27 ha/h and efficiency of 92%. Richey *et al.* (1961) found out the factors used to evaluate the effective field capacity and efficiency of the tractor operated harvester i.e. forward speeds of the harvester during harvesting and different vegetable heights.

Riedner *et al.* (2019) highlighted clear challenges for the agricultural sector in era of a growing population and the impact of climate change. They analysed their case studies on 13 parameters for adapting agricultural machinery, e.g., raising the use of electric vehicles (EVs), as one way of meeting such challenges and found an important factor for the respondents is the on-farm generation of electricity (mainly Photo Voltaic) and the infrastructure needed to charge EVs. Singh *et al.* (2019 a, c) developed electric powered wide row weeder for vegetable crops and seeder for spinach and coriander, respectively using 24V- 14/12 Ah batteries and DC motor. Present challenges in harvesting of leafy vegetables create restriction for large area farming, quality maintenance and efficiency. The review on the topic clearly indicated the lack of availability of cutter/ harvester for selected crop in the country. Considering the advantage of using electric power through battery for mobile operation in agriculture, an attempt has been made to develop walk behind battery-assisted cutter for multiple cutting green leaves of spinach and coriander.

MATERIALS AND METHODS

The study was conducted at ICAR-IARI, New Delhi (28.08 ^{o}N and 77.12 ^{o}E, the height above mean sea level being 228.61 meters) in year 2016-2019. The lab experiment was carried out during May to October months when mean maximum daily temperature ranges from 32.2^{o}C to 40^{o}C and the mean minimum temperature from 12.2^{o}C to 27.5^{o}C. The field experiment was carried out during November to January months. The design considerations for developing battery-assisted cutter for spinach and coriander leaves are,

- Cultivation practice of raising the crops
- Drudgery reduction of workers
- Power unit for rotary cutting
- Windrow formation of cut crop in a line
- Swinging effect of cutting unit to cut from ground level
- Balanced unit for operation
- Ease in fabrication, repair & maintenance, and user friendly field operation

The design of components of the e-powered cutter for spinach and coriander are described below.

Force assessment in cutting the leaves

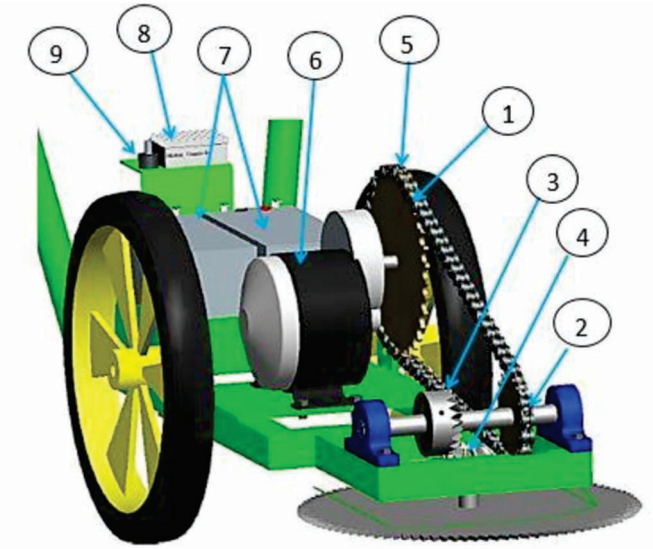
Coriander stems erect mostly straight and cutting may be easy with tool but spinach leaves are bushy in nature. Therefore, different bunch of spinach leaves were selected for assessing the shear cutting force using Texture Analyser, UK in laboratory and force data are given in Table 1.

Cutting mechanism and power transmission unit

Out of various cutting mechanism and principle, two element scissor type and rotary cutting was tried to develop the unit. Cutting of spinach from field was not smooth with two element type cutting mechanism due to lodging characteristics of spinach. Principle of slicing action of the blades was considered for cutting the green spinach and coriander. Two type of a circular blade was selected for assessing the cutting behaviour.

The selection of motor for developing a cutter was based on shear cutting force data obtained from lab experiment and speed of single element sharp-edge blade. Considering average cutting force of single leaf (12-18N) and 10m/s cutting, the power requirement comes to 120-180W. Hence, DC motor of 250W was considered for cutting operation through rotary blade. Geared DC motor was selected based on requirement of torque (11.5 N-m at rpm of 315) for smooth operation in field.

Power transmission unit was designed for cutting the green spinach and coriander considering the speed of 10 m/s for single element sharp-edge blade (ICAR, 2013). The power transmission unit consisted of chain, sprocket and bevel gear (Figure 1). Chain-sprocket was used to transfer power from motor to shaft. Rotary blade was mounted with secondary chassis at front part of the frame connected in a vertical axis that allows rotating in horizontal plane. Vertically downward to rotary blade using bevel gear was used to transmit the power in right angle to the prime mover unit. An arch-shaped reflector was provided for making windrow of cut crop and it also covers the power transmission unit for safety to worker.



1. 34 teeth sprocket, 2. 18 teeth sprocket, 3. 20 teeth bevel gear, 4. 14 teeth bevel gear, 5. 12.7 mm pitch chain, 6. 24V DC motor, 7. 12V, 7Ah battery, 8. Motor controller, 9. 10 K potentiometer

Figure 1. Power transmission in offset cutter

Windrowing mechanism

Spinach and coriander were sown using e-powered two-row seeder (Singh *et al.,* 2019 c) at row spacing of 215 mm. The plant height of cut spinach and coriander was normally 200-250 mm. Under this circumstance, an offset cutter position was decided to get windrow spacing for cut crop. Rotary cutting blade exposure to the spinach crop was kept at 35% of blade periphery and rest of the area was covered with arc shaped structure. The end point of the structure was directed towards the rotational direction of the cutting blade which helps in proper windrowing with help of conveyor. This will facilitate ease in collecting manually and making bundle, if needed.

Platform/chassis

Chassis is fabricated in two pieces i.e., one for housing handle, battery tray, ground wheels, motor and another as offset for power transmission unit and cutting blade. The width of primary chassis was 165 mm and length was kept 410mm. A rectangular shaped (135 x 170 mm) tray was provided for placing batteries (Figure 2). The width of secondary chassis was equal to with width of primary chassis, i.e. 165 mm. Its length was more in left side (130 mm) and less (110 mm) in right side. The secondary chassis was mounted at 30 mm offset to 1st platform to get smooth windrowing after cutting in right side. Therefore, the total length of chassis is 540 mm. The sprockets and bevel gear were mounted above 50 mm to secondary chassis. Diagonal shaped mounting conveyor from 20 mm of right-hand side was made to mount for windrowing of crops. A conveyor was arch shaped with 10° angles to this side.

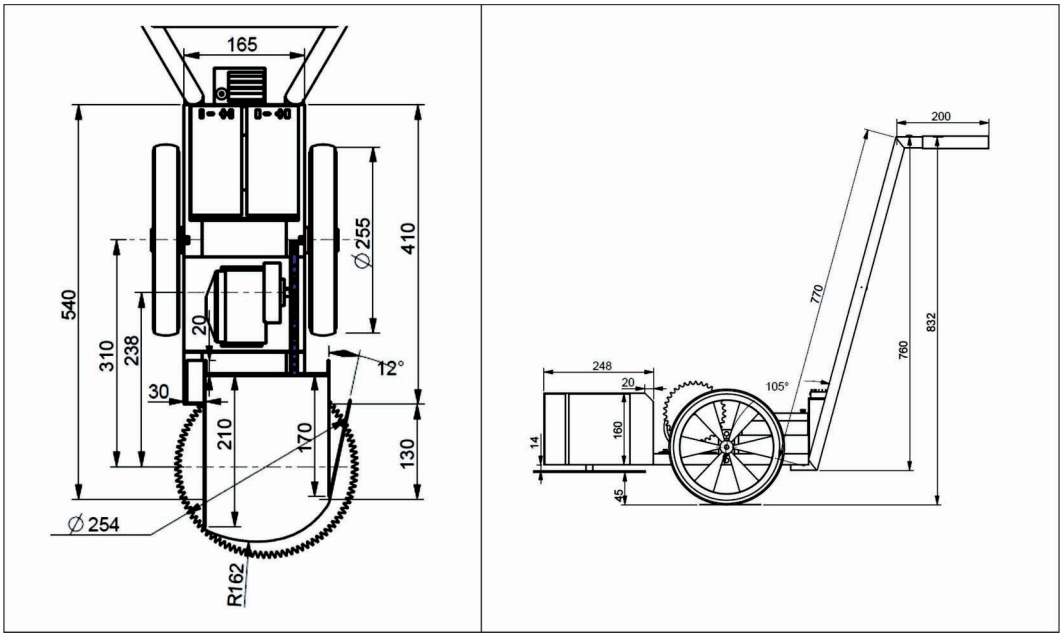
Handle

A trapezium shaped (770 mm length x 370 mm top width & 165 mm bottom width) handle was designed for the unit and lower side (bottom width) was mounted to platform with nut and bolt. The grip diameter (20 mm), width (370 mm) and height (760 mm) from ground length of handle were kept as per ergonomic criteria (Singh *et al.,* 2019b) to facilitate men or women operator/worker.

Ground wheel

The fields of the crops are used to have some clods and bumps so at fixed position of cut may do not perform satisfactory result hence a cutting unit was kept in swinging position so that as per need operator may adjust accordingly to have close cutting from ground. This condition can only be met if unit is balanced in operation. The weight of unit was kept low for minimal utilisation of power. The unit was mounted on two wheels in such a way that swinging effect is provided while cutting. Two wheels of size 255 mm diameter and 30 mm thickness were provided for this unit and mounted at 180 mm from handle side (one third of total platform length) to take advantage of swinging effect and also making a balance unit while cutting. The location for wheel was decided based on weight transfer method. The diameter of wheel was decided based on observation of bumps in the field. Wheel was mounted above platform to get minimum 45mm ground clearance. A provision was made to increase ground clearance up to 65 mm.

Figure 2. Schematic design of offset rotary cutter



Performance evaluation

The total speed ratio of the designed power transmission was 1:2.7 that enables the required cutting speed and torque with no clogging of crop in front of cutting unit. Final unit of offset type rotary cutter was fabricated in the workshop and tested in field for harvesting line sown spinach and coriander green leaves (Figure 3). The developed cutter was operated by a worker in field. The speed of operation, soil moisture content of field while harvesting, speed of rotary blade, windrow formation, leftover spinach leaves after cut, ease in operation and time for collection and making bundle of cut crop in windrow as per standard procedure. The force was measured in pulling the rotary cutter in same field using load cell. Data obtained and analysed are given in Table 2.

Figure 3. Offset Rotary Cutter

Table 1. Cutting force data

Parameters	Value
Number of leaves of sample per bunch	6-7
Weight of 7 cut sample leaves having petiole diameter 5.42 mm, g	47.6
Weight of 10 cut sample leaves having petiole diameter 4.22 mm, g	45
Cutting force for bunch of 10 leaves, N	120
Cutting force for bunch of 7 leaves, N	131.3

RESULTS AND DISCUSSION

Force required in cutting the spinach leaves

Shear force in cutting the leaves in bunches was assessed (Table 1). It is observed from the table that the force requirement depends on petiole diameter. The force requirement in cutting a bunch of 10 leaves with 4.22 mm petiole diameter was less than a bunch of 7 leaves having petiole diameter of 5.42mm. Based on the observation, the average force requirement for cutting a leaf was found to be 12 to 18.8N depending on petiole diameter.

Speed of cutting blade

Study was made to assess the speed of efficient cutting for spinach and coriander green leaves in line sown crop

under field condition using two diameters of rotary blades (194 and 254 mm) at peripheral speed of 2.6 and 12.7m/s, respectively with 250W DC geared motor powered by two 12V-12ah lead acid batteries (Table 2). Correspondingly the pitch and depth of teeth in both blades were 6mm & 4mm and 8 mm & 3mm. The angle of cut per unit time for cutting spinach was 44-45° from horizontal. At this angle, numbers of teeth involved were 12 and 11 for 194 and 254 mm rotary blades, respectively. During cutting operation with both blades, it was observed that the cutting peripheral speed of 2.6 m/s may be satisfactory for coriander leaves due to its erectness but it was unsatisfactory for cutting of spinach leaves due to its foliage drop behaviour. Moreover, this speed was not sufficient for windrow formation of even coriander leaves. The cutting speed of 12.7m/s was tried for cutting both crops and found that this speed cut both the crops evenly and helped in making proper windrow. It is found while cutting coriander leaves with increasing the peripheral speed more than 12.7m/s affects the cutting as it throws the cut crop due to its erect characteristics. The findings are also in agreement to the literature for cutting speed (about 10m/s) of single element sharp-edge blade to other crops (ICAR, 2013).

Performance evaluation

Performance evaluation of battery-assisted offset rotary cutter was assessed for harvesting spinach and coriander green leaves in field using 254 mm diameter of serrated blade. The pushing force of the 21 kg cutter in same field was assessed and found the initial force of 44-54N (Table 3). The force was reduced to 15-29N than initial while in acceleration. This is natural trend of increasing force initially than gradual reduction afterword. Average push strength data of 5th percentile of farm workers by both hands in standing posture was 79N and 132N for women and men workers (Gite *et al.,* 2009). The initial pushing force of this equipment (54N) is 40.9 and 68.3% of strength value of men and women workers, respectively. While after acceleration of equipment, the push force requirement is below 30 percent of their 5th percentile force. Therefore, the equipment can easily be operated by men or women workers.

The turning time with the cutter at the end of row to get 2nd row was 3-5s. This shows the ease in handling the machine. The output with the cutter for cutting 120-235mm spinach leaves was 193.3 m^2/h at operating speed of 0.9-1 km/h while it was 172 m^2/h at operating speed of 0.8 m^2/h for cutting 200-250mm coriander green leaves. The field efficiency was 89.91% for both the crops. The power consumption in cutting was assessed using energy meter and it was about same for both the crops. The higher range of power consumption was due to some soil clods and pebbles appear near crop. The output in collection of cut crop in windrow and making bundles was also assessed which was 145 m^2/h for spinach and 153 m^2/h for coriander.

The output obtained with a worker in manual cutting of spinach green leaves was 32.3 m^2/h (Table 4). The output includes the collection and making bundle

Table 2. Effect of speed and diameter of serrated blades on spinach and coriander leaves cutting

Particulars	Values	
RPM of motor	354	
Cutter diameter, mm	194	254
Number of teeth	102	100
Angle of teeth, °	72	60
Pitch of teeth, mm	6	8
Depth of teeth, mm	4	3
Number of teeth involved in cutting	12	11
Maximum cutting width, mm	72	100
Cutting angle, degree	44-45	44-45
Cutting speed of blade, m/s	2.6	12.7

Table 3. Performance evaluation of offset rotary cutter for cutting spinach and coriander green leaves

Particulars	Values	
	Spinach	Coriander
Soil moisture content of the field, %	20.63	
Cutting height, mm	20-30	
Force requirement in pulling, N	15-54	
Turning time, s	3-5	
Plant height, mm	120-235	200-250
Yield per m^2 area, kg	3.05	0.912
Average speed of operation, km/h	0.9-1	0.8
Output, m^2/h	193.3	172
Power consumption in cutting green leaves, W	110-178	100-175
Output in collection & making bundle manually, m^2/h	145	153
Overall output with cutter, m^2/h	82.8	80.9
Field efficiency, %	89.91	

Table 4. Data on manual cutting of spinach with serrated sickle

Parameters	Value
Plant height, mm	110-170
Change of posture per m length of crop cut	2
Output, m^2/h	32.3
Cut crop left in field/ m^2	
Manual cutting, g	11.0
Machine cutting, g	44
Spinach leaves leftover rate, %	
Manual cutting	0.35
Machine cutting	1.4

simultaneously. The change of posture while cutting was 2 per m of crop length. The overall output (including collection and making bundle) of cutter by a worker was found 2.56 times more than traditional cutting of crops. This shows the enhancement of output and ease in operation as it avoids squatting or sitting or changing posture while cutting. Spinach damage (leftover) rate was found to be 1.4% with offset rotary cutter and 0.35% with manual cutting with sickle. The spinach damage rate with offset rotary cutter was below than the reported damage rate of 5% with continuous harvester (Song *et al.*, 2019). The developed walk-behind battery-assisted offset rotary cutter has potential to reduce drudgery of farm worker with increased productivity.

CONCLUSION

A walk behind 250W DC motor powered by 24V,12ah batteries successfully performs the indented cutting of spinach and coriander green leaves. The initial pulling force of this offset rotary cutter is within the acceptable limit of push force for both men and women workers. The output including collection and making bundle, of cutter by a worker was found 2.56 times more than traditional cutting of crops with low damage rate. The e-powered (battery-assisted) cutter is suitable for small farmers and also helped in reducing drudgery of farm worker with increased productivity.

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Research Article

Performance and Economic Evaluation of Solar Sprayer

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Solar power, spraying, knapsack sprayer, solar sprayer, economics

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A study was conducted to perform the performance and economic evaluation of Solar Photovoltaic (SPV) sprayer. The test of SPV sprayer and economic analyses was compared with knap sack sprayer and manual operation. The field test was conducted in vegetable crops i.e., okra and tomato. The efficiency and effective field capacity of SPV sprayer were maximum 88.75% and 0.71 ha/h at 200 ml/min discharge, whereas it was 87.14%, 86.30% and 0.63, 0.70 ha/h at different discharge rates of 100 ml/min and 150 ml/min, respectively. Theoretical field capacity of SPV sprayer were found maximum 0.80 ha/h at 200ml/min whereas it was 0.70 ha/h and 0.73 ha/h at 100 ml/min and 150 ml/min, respectively. The SPV operated sprayer had higher field capacity compared to manually operated knapsack sprayer and manual operation. The minimum operational cost of SPV per hectare was found Rs. 221.8 which is less than manually operated knapsack sprayer (557.6 Rs./ha) and manual operation (1462 Rs./ha). Thus, the SPV operated sprayer (for discharge rate 200 ml/min) is economical as compared to manual operation as well manually operated knapsack sprayer, and it is very useful to small scale farmers.

INTRODUCTION

Insecticide, [pesticide and weedicide uses are an important aspect of the intensive agricultural farming to protect the plants from insect, diseases and weeds. A massive use of herbicides in developed countries, arable weeds continue to be a serious threat to agricultural production. Total annual losses of agricultural produce from various causes were weeds 45%, insect 30%, disease 2% and others 5% (Kwaga and Fredrick, 2014). The reduction in crop yield and quality has direct correlation to weed competition.

Weed control broadly classified as cultural, mechanical, biological and chemical methods. Cultural method includes irrigation, lawn moving and mulching, but more expensive and time-consuming. Manual weeding is very laborious requiring to be repeated twice or three times before crop maturity. Thus, manual weeding is effective only for gardens and very small farms (Amonye, 2014). Mechanical method includes various methods like tilling, hand pulling, string trimming, flame, burning and solarization. Biological methods include the use of carefully screening of insects that attack portions of the weed. The chemical method is the best method for weed control. Use of herbicides is effective, cost-effective, and provides quick control. It requires less labour and less time (Opeke, 2005). Herbicides are basically of two nature, either pre-emergent (applied before weed seeds germination), or post-emergent (applied after weed-seed germination).

The main drawback of hand operated spray pump is that the user can't use it for more than 5-6 hours continuously as he gets tired after some hours. The fuel operated spray pump required fuel which, expensive and not easily available at rural places. At the same time, fuel operated sprayer adds carbon dioxide as pollutant which is harmful to environment (Khan 2014). The solar sprayer might be the solution for spraying of insecticide, pesticide and weedicide for effective controls of insect, diseases and weeds with minimum drudgery and saving the conventional fuel. Keeping in view, a performance evaluation of solar photovoltaic operated sprayer was conducted for insecticide, pesticide and weedicide application in different vegetable crops.

MATERIALS AND METHODS

A solar sprayer was procured from local market at Prayagraj for assessing performance evaluation in the different vegetable crops. A solar photovoltaic operated sprayer consisted of different components, like, photovoltaic panel, motor and control system and spray lance with spinning disc. The Photovoltaic (PV) panel of

12 V capacity was used for operating the sprayer. The technical specification of developed SPV operated sprayer is summarized in Table 1. The photovoltaic panel charged a 12V battery 1Ah. The spinning disc nozzle was fixed on 12V D.C. motor to operate the spinning disc having 4000 - 4400 rpm. Liquid enters on spinning disc by rotating spinning disc nozzle and centrifugal force at a velocity breaks the liquid into fine droplet sizes. The 16 liters capacity tank made of High Density Poly Ethylene (HDPE) materials were used and connected to the spray lance pipe with spinning disc nozzle. A solar charge controller regulated the voltage and current from solar panel.

The experiment was conducted at Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, Sam Higgin Bottom University of Agricultural Technology and Sciences (SHUATS), Prayagraj (UP) during year 2019. The field parameters were recorded i.e. area, shape and topography of field and crop parameters i.e. name of crop, crop spacing, height of crop and wind direction. The field test was conducted in tomato and okra fields. The effective field capacity and field efficiency was observed during test. Three trials were carried out at three different nozzle flow rates, i.e., 100 ml/min, 150 ml/min and 200 ml/min.

RESULTS AND DISCUSSION

Field performance of SPV operated sprayer

The size of field of okra was 15 m × 30 m. Row to row spacing of crop was 0.5m and plant to plant spacing was 0.55m. The plant height during evaluation was 0.85 m. In tomato crop, the size of field was 20 m × 40 m. Row to row spacing was 0.90 m row to row and plant to plant spacing was 0.5m. The plant height was 0.50 m. The data recorded and analysed are given in Table 2.

It is clear from Table 2 that the effective field capacity of the SPV operated sprayer were 0.61 ha/h, 0.63 ha/h and 0.71 ha/h at discharge level of 100 ml/min, 150 ml/min and 200 ml/min, respectively. Whereas, correspondingly theoretical field capacity was 0.70 ha/h., 0.73 ha/h and 0.80 ha/h. The maximum field efficiency of SPV operated sprayer was found 88.75% at the discharge rate of 200 ml/min.

The effective field capacity, field efficiency of SPV operated sprayer at 200 ml/min discharge rate was found to be most suitable and economical for the field operation.

Economics of SPV operated sprayer

The economic evaluation of SPV operated sprayer for the discharge rate of 200 ml/min, manually operated knapsack sprayer and manual operation was calculated. The summarized results are given in Table 3. It was observed that SPV operated sprayer was having higher field capacity as compared to manually operated knapsack sprayer and manual operation. The field capacity of SPV operated sprayer 0.71 ha/h for the discharge rate 200 ml/min. The field capacity of manual sprayer and knapsack sprayer were found 0.1305 ha/h with 32 workers and 0.1 ha/h.

The minimum operational cost of SPV per hectare was found Rs. 221.8 which is less than manually operated knapsack sprayer (557.6 Rs./ha) and manually operation (11200 Rs./ha). Thus, the SPV operated sprayer (for discharge rate 200ml/min) was more economical than

Table 1. Technical specifications of SPV operated weedicide sprayer

S.No.	Component	Specification	Material used
1.	Solar Photovoltaic Panel	12 V Size: 33.5*27.8 cm	
2.	D.C. Motor	Voltage :12 volt	-
3.	Spinning Disc Nozzle	Dia.: 9cm, Speed :4000-4400rpm	HDPE
4.	Battery	Voltage :12 V Current: 1 A	Sealed Lead Acid
5.	Lance	Length :2.1m, Dia.:4cm	HDPE
6.	Connecting Rod	H:48.5m, Bend Pipe L: 138.5 Dia:2cm	GI Pipe
7.	Switch	1 No. on/off	-
8.	Switch	1 No. on/off	-
9.	Tank	Capacity:16 liters, H:47cm, B:34cm, T:16cm	HDPE
10.	Total Weight with solution: 20kg		-
11.	Cost of Sprayer : Rs. 3500/-		

The cost of economics of SPV operated sprayer were carried out as per standard techniques.

Table 2. Field performance of SPV operated sprayer in okra plantation

S.No.	Particulars	Discharge (ml/min)		
		100	150	200
1.	Row to row spacing (m)	0.50	0.50	0.50
2.	Plant to plant distance (m)	0.55	0.55	0.55
3.	Type of soil		Alluvial soil	
4.	Chemical consumed (glyphosate rate) (ml/l)	3	3	3
5.	Travelling speed (km/h)	2.13	2.13	2.13
6.	Effective field capacity (ha/h)	0.61	0.63	0.71
7.	Theoretical field capacity (ha/h)	0.70	0.73	0.80
8.	Field efficiency (%)	87.14	86.30	88.75

Table 3. Economics of SPV operated weedicide sprayer

S.No.	Description	SPV Operated Sprayer	Manually operated knapsack sprayer	Manual operation
I	Fixed cost			
	Cost of sprayer (Rs./h)	3500	1500	-
	Depreciation (Rs./h)	1.23	0.56	-
	Interest (Rs./h)	0.67	0.28	-
	Total fixed cost (Rs./h)	1.90	0.84	-
II	Variable cost			
	Cost of chemical (Rs./h)	42.30	10.92	
	Operator cost (Rs./h)	43.75	43.75	22.50
	Repair and maintenance (Rs./h)	5.83	2.50	-
	Total variable cost (Rs./h)	91.88	57.17	22.50
	No. of labour @ 350/day	1	1	32
	Operating spraying time (h/ha)	2.56	10	8
	Field capacity (ha/h)	0.71	0.1	0.1305
III	Operational cost (Rs./ha)	240.08	580.10	11200

manual operation as well manually operated knapsack sprayer.

CONCLUSION

Over all analysis of solar operated sprayer puts weight of panel as well as sprayer on shoulder, which has ultimately provided effortless operation. Solar panel provides shadow on the head of the operator which gives protection from high solar intensity. Solar panel facilities to use it for other applications sprayer can run 2.5 hours more after 5 hours operation in full solar intensity. It was getting maximum field efficiency of SPV operated sprayer were found at the discharge of 200 ml/min (88.77%) and minimum field efficiency was found at the discharge rate 150 ml/min (86.30%). The cost of operation of SPV operated sprayer (221.8 Rs/ha) was economical than manual operation (1462 Rs./ha) and manually operated knapsack sprayer (557.6 Rs./ha).

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Annexure-I

I. Economics parameter of SPV operated weedicide sprayer

Assumptions

Life of sprayer (L) = 8 year — Salvage value (S) = 10% fixed cost,

Annual use of machine (H) = 300 h — Interest rate (i) = 10 % of fixed cost

No. of Labour required = 1

A. Fixed cost

1. Initial cost of sprayer = 3500/-
2. Depreciation rate (Rs./h) = $\frac{C - S}{L \times H}$ = $\frac{3500 - 350}{8 \times 300}$ = 1.31 Rs./h
3. Interest rate (Rs. /hr) = $\frac{(C + S)}{2H} \times \frac{I}{2}$ = $\frac{(3500 + 350)}{300} \times \frac{10/100}{}$ = 0.64 Rs./h

Total fixed cost = 1.31 + 0.64 = 1.98 Rs./h

B. Variable cost

4. Chemical cost = (chemical consumption lit/h) × Rate of chemical (Rs./lit) = 0.08134 × 520 = 42.30 Rs. /h
5. Operating cost of labour (Rs./h) = 350/8 = 43.75 Rs./h.
6. Repair & maintenance cost (Rs./h) = 5% of initial cost/H = $\frac{0.5 \times 3500}{300}$ = 0.58 Rs./h

Total variable cost = 42.30 + 43.75 + 0.58 = 86.63 Rs/h

Total operating cost = 1.98 + 86.63 = 88.61 Rs./h.

6. Capacity of SPV operated sprayer discharge rate @ 200 ml/min = 0.39 ha/h
7. Operating time of spraying (h/ha) = 2.56 h/ha

Actual Operating cost of spraying (Rs./ha) = 2.56 × 86.63 = 221.8 Rs. /ha

II. Economics parameter of Manually operated knapsack sprayer

Assumptions

Life of sprayer (L) = 8 year, — Salvage value (S) = 10% fixed cost,

Annual use of machine (H) = 300 hrs — Interest rate (i) = 10 % of fixed cost

No. of Labour required = 1 — Area covered = 0.1 ha /h

A. Fixed cost

3. Initial cost of sprayer = 1500/-
4. Depreciation rate (Rs./h) = $\frac{C - S}{L \times H}$ = $\frac{1500 - 150}{8 \times 300}$ = 0.56 Rs./h
3. Interest rate (Rs. /hr) = $\frac{(C + S)}{2H} \times \frac{I}{2}$ = $\frac{(1500 + 150)}{300} \times \frac{10/100}{}$ = 0.28 Rs./h

Total fixed cost = 0.56 + 0.28 = 0.84 Rs./h

B. Variable cost

7. Chemical cost = (chemical consumption. lit/h) × Rate of chemical (Rs./lit) = 0.021 × 520 = 10.92 Rs./h
8. Operating cost of labour (Rs./h) = 350/8 = 43.75 Rs./h
9. Repair & maintenance cost (Rs./h) = 5% of initial cost = $\frac{0.05 \times 1500}{300}$ = 0.25 Rs./h

Total variable cost = 10.92 + 43.75 + 0.25 = 54.92 Rs/h

Total operating cost = 0.84 + 54.92 = 55.76 Rs/h

8. Capacity of SPV operated sprayer discharge rate @ 200 ml/min = 0.39 ha/h
9. Operating time of spraying (h/ha) = 10 h/ha

Actual Operating cost of spraying (Rs./ha) = 10 × 55.76 = 557.6 Rs /ha

III. Economics parameter of manually operation

Assumptions

No. man hours required = 367 h/ha; No. of Labour required =32

Operating capacity of manual by one person = 0.033 ha/day

1. Capacity of manually operation (32 person) per day = 0.1305 ha/h
2. Operating cost of manual operation (Rs./ha) = 32 × 350 = 11200 Rs

Actual Operating cost of spraying (Rs./ha) = 1462 Rs/ha

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Research Article

Effect of Sea Buckthorn Leaf Meal on Production Performance and Immunity in Coloured Breeder Chicken During Summer Season

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Supplement meal, chicken, egg production, cell-mediated immune response, breeder birds

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The experiment was conducted to study the effect of sea buckthorn leaf meal (SBTLM) supplementation on egg production performances and immunity in ninety coloured Chabro breeder hens and 18 viable cocks in 1:5 sex ratio. The birds were randomly distributed into three dietary treatment groups: Control (Basal), standard breeder diet (BIS, 2007); basal+0.5% and basal+1.0% SBTLM. The average hen house egg production during 4-8, 8-12 and 0-12 week were significantly higher (P<0.05) in both the SBTLM supplemented group as compared to control group throughout the experimentation. No significant differences were observed among the three treatment groups in terms of humoral immune response *viz.* IgG in respect to 1% SRBC and mercaptoethanol sensitive IgM and likewise the cell mediated immune response (response to PHA-P) (Foot web index) of breeder birds at 12th weeks of experimentation. However, the humoral as well as cell mediated immune responses were numerically better in both the sea buckthorn supplemented groups as compared to control group. Looking at the results of present investigations, it was observed that supplementation of sea buckthorn leaf meal results in better egg production and immunity for sustainable poultry production.

INTRODUCTION

Impressive growth in poultry sector is due to the technological breakthrough in feeding, breeding, management and health care (Pathak *et al.*, 2015). Herbal medicines or formulations may serve as safer alternatives as growth promoters due to presence of different active metabloites, lower cost of production, improved feed efficiency, fast growth, reduced mortality, reduced risk of diseases, minimum health hazards and environmental friendliness (Singh *et al.*, 2019b). Feed alone contributes around 60 to 70 per cent of total cost of rearing of poultry. Therefore, the production economy can be improved mainly by minimizing the feed cost by herbal feed supplementation (Singh *et al.*, 2016).

India has a rich heritage of herbal wealth and innumerable plants, which have interesting pharmacological properties that need exploitation by the advanced methods (Singh *et al.*, 2016). Feed and fodder availability in India is one of the considerable issues in livestock production now a days, where the available fodder can meet the demand of only 56 percent of the total livestock (DAHD, 2014). In such situation, it is necessary to bridge this gap between demand and supply and some alternative feed for livestock and poultry must be discovered and provided to meet the nutritional requirements. This goal is possible by exploiting the Non Conventional Feed Resources (NCFR). One such plant which can be exploited as NCFR is "sea buckthorn" *(Hippophae spps,* the 'Golden Bush').

Sea buckthorn (*Hippophae rhamnoides* L.), a unique and valuable plant has gained worldwide attention, mainly for its medicinal and nutritional potential (Nazir *et al.*, 2017). Sea buckthorn is a thorny, dioecious, wind pollinated, multipurpose temperate bush plant bearing yellow or orange berries with nitrogen fixing abilities (Singh *et al.*, 2019). It is commonly known as "cold desert gold" due to its various beneficial effects over plant, animal, human and soil health. Sea buckthorn (SBT) is a thorny nitrogen fixing deciduous shrub of cold arid region native to Europe and Asia (Shaker *et al.*, 2018). Sea buckthorn is an important medicinal resource and is found in abundance in Indian subcontinent especially in the North Western Himalayan regions (Dhanze *et al.*, 2013). The plant inhabits dry temperate region and high altitude regions of Himachal Pradesh, Jammu & Kashmir and Uttarakhand. Sea buckthorn plays an important role in

improving the efficiency of feed and as a safer alternative non-conventional feed resources particularly in poultry, to maintain their production, performance and high quality yield (Sharma *et al.* 2018; Singh *et al.*, 2020). It is a small shrub comprising of fruit and leaves that are rich in nutrients and bioactive components such as vitamins (Kudritskaya *et al.*, 1989), amino acids (Repyakh *et al.*, 1990), lipids (Goncharova and Glushenkova, 1993), sugars and acids (Yang, 2009), and flavonoids (Häkkinen *et al.*, 1999). Several experiment showed that the leaves and fruit residues of SBT could be used to feed poultry and livestock without the accumulation of toxins, and that the feed also had a stimulating effect on growth and performance of poultry and livestock (Liu *et al.*, 1989).

Sea buckthorn has antioxidant (Geetha *et al.*, 2002a,b, 2009; Chawla *et al.*, 2007; Püssa *et al.*, 2007), anti infective (Larmo *et al.*, 2008) function and exerts beneficial effects on liver fibrosis (Gao *et al.*, 2003) and immune function (Dorhoi *et al.*, 2006). The body weight of poultry have increased greatly after feeding leaves, seeds and fruit residues of SBT (Wang, 1997). Sea buckthorn has a large content of vitamin C, several folds as compared to other fruits (Christaki, 2012). Thus, SBT leaves, seeds and fruit residues play an important role in improving the efficiency of feed and may be considered to be utilized as an alternative feedstuff, particularly in poultry to maintain their production, performance and high quality yield (Shaker *et al.*, 2018).

MATERIALS AND METHODS

Ninety coloured chabro breeder hens and eighteen viable cocks were obtained from the Department of Poultry Science of the U.P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (DUVASU), Mathura, University. These birds were randomly distributed into three dietary treatment groups having three replicates of 10 hens and 2 cock each of uniform age, production and in good health condition. The basal/control group was kept on standard breeder diet (BIS, 2007) and other two treatment groups were supplemented with 0.5% and 1.0% sea buckthorn leaf meal (SBTLM). These breeder birds were reared under deep litter system and standard management conditions at college poultry farm. Throughout the experimental period the birds were offered fixed weighed quantity (110 g/day) feed (adequate in all nutrients) as per BIS (2007) and water *ad lib*. The egg production were observed in different phases whereas humoral and cell mediated immune response were observed at 12 weeks of experimentation. The data analyzed as per the standard statistical procedure given by Snedecor and Cochran (1994). Significant differences among treatment means were calculated as per DMRT test Duncan (1955).

RESULTS AND DISCUSSION

Hen house and Hen day egg production

The basal diet + 1.0% SBTLM supplemented group had significantly better (P<0.05) hen house egg production as compared to control group during phases of 4-8 weeks, 8-12 weeks and Overall egg production at 0-12 weeks (Table 1). In addition, it was also observed that basal diet + 1.0% SBTLM supplemented group had significantly better (P<0.05) response in phase wise hen house egg production as compared to basal diet + 0.5% SBTLM group, while it was lowest in control group. The increase in hen house egg production could be due to the supplementation of sea buckthorn leaves, rich in nutrients and bioactive components such as vitamins, amino acids, lipids, flavonoides, higher content of essential oils and have as anti oxidant properties. During the experimental study period,

Table 1. Effect of dietary supplementation of sea buckthorn leaf meal on the hen house egg production (HHEP) of breeder birds during different phases and overall HHEP of breeder birds during summer season

Treatments	Week 0-4	Week 4-8	Week 8-12	Week 0-12
Basal diet	61.55	59.88^{a}	58.57^{a}	57.10^{a}
Basal diet + 0.5% SBTLM	65.36	65.24^{ab}	64.29^{ab}	63.29^{ab}
Basal diet + 1.0% SBTLM	67.98	70.60^{b}	70.36^{b}	67.70^{b}
SEM	1.52	1.90	1.97	1.89
Sig. Level	NS	P<0.05	P<0.05	P<0.05

Means bearing different superscripts within a column differ significantly (P<0.05)
NS: Not significant (P>0.05) SEM: Pooled standard error of means
SBTLM: Sea buckthorn leaf meal

there was no mortality in any treatment group. Hence, the hen day egg production per week and phase wise hem day egg production per week was equal to the hen house egg production per week and phase wise egg production per week, respectively.

The results obtained in the present study also supported by earlier studies (Yang, 2007; Dumbrava *et al.,* 2006; Singh and Sharma, 2008; Ambatkar, 2009; Biswas *et al.*, 2010; Chand *et al.*, 2018; Shaker *et al.*, 2018; Singh *et al.,* 2016, 2019a; Hasanuzzaman, 2011) observed that egg production of layers were higher after replacing CP content of ration up to 20% by sea buckthorn cake. On contrary Rao *et al.* (2011) and Latshaw and Zhao (2011) reported that changes in the level of protein in diet did not affect the rate of egg production and egg mass.

Immune response

No significant differences were observed in HA and IgM response to 1% SRBC (log2 titre) among the various dietary treatment groups (Table 2). In addition, it was also observed that HA and IgM response were apparently better in SBTLM supplemented groups as compare to control group. The results of the present study suggested that there was no adverse effect of dietary sea buckthorn leaf meal supplementation on the immune system of coloured breeder birds. The findings of our present study collaborate well with earlier reports (Geetha *et al.,* 2005; Mishra *et al.*, 2011). There were no significant differences in the cell mediated response to PHA-P (foot web index) among the various treatment groups (Table 3). The results of present study revealed that there was no adverse effect of SBTLM supplementation on the immune system of coloured breeder birds throughout the experimentation.

Table 2. Effect of supplementation of sea buckthorn leaf meal on the humoral immune response [antibody titer (log2) values] to 1% SRBC of breeder birds at 12th weeks of experimentation during summer season

Treatments	HA	IgG	IgM
Basal diet	7.17	3.17	4.00
Basal diet + 0.5% SBTLM	7.50	3.33	4.17
Basal diet + 1.0% SBTLM	7.67	3.33	4.33
SEM	0.26	0.14	0.19
Sig. Level	NS	NS	NS

NS: Not significant (P>0.05) SEM: Pooled standard error of means
SBTLM: Sea buckthorn leaf meal

Table 3. Effect of supplementation of sea buckthorn leaf meal on the cell mediated immune response (response to PHA-P) (Foot web index) of breeder birds at 12th weeks of experimentation during summer season

Treatments	Foot web Index (FWI)
Basal diet	0.25
Basal diet + 0.5% SBTLM	0.29
Basal diet + 1.0% SBTLM	0.29
SEM	0.01
Sig. Level	NS

NS: Not significant (P>0.05) SEM: Pooled standard error of means
SBTLM: Sea buckthorn leaf meal

CONCLUSION

The leaves, seeds and fruit residues of sea buckthorn (SBT) contains high crude protein, amino acid, calcium and phosphorus, they have advantages as basic materials for feed formulations for poultry. Due to presence of several nutritional and bio active compounds in fruit, leaves, seed oil and cakes of sea buckthorn, it serves as good growth promoter as well as enhance egg productivity. It was found that the basal diet + 1.0% SBTLM supplemented group had significantly higher (P<0.05) hen house and hen day egg production as compared to control group during different weeks and overall experimental period.

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Conflict of interest

The authors declare no conflicts of interest.

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Preamble

Innovations of Science do not reach the needy people timely. Science-led interventions carry potential for development of people. Efforts from all responsible organizations and citizens including Government is needed to ensure that the potential of scientific innovations are realized for the benefit of the masses, to improve their income and living conditions.

A group of like-minded Scientists/ Technocrats/ Business persons and other luminaries joined together to create this platform, for helping the needy people to improve the status of society, in the name of 'Royal Association for Science-led Socio-cultural Advancement (RASSA)' to attain noble goals for overall advancement of the people in a sustainable manner, protecting natural resources and eco-systems.

Vision

To create a strong and coherent community sensitive to the social, cultural & educational needs to serve the society especially the resource poor people by adopting science-led approaches.

Mission

To engage like-minded intellectuals in serving the needy people of the society though science-led interventions.

Objectives

1) To create a platform of like minded people for overall sustainable advancement of the society.
2) To promote educational and economic well-being of society in changing social dynamics by formulating the plans and creating interest for entrepreneurial activities through skill development.
3) To mentor and provide economic support to bright young individuals from the unprivileged section of the society.
4) To provide opportunity and help to business professionals to setup and run their businesses in emerging fields.

Major Activities

i. To promote social cohesion among the members for their social causes like religious, cultural activities, marriage, education, job, etc. for enhancing bonding and solidarity
ii. To device strategic plan for help to needy people in education, job, entrepreneurship etc.
iii. To explore and nourish social and cultural heritage.
iv. To empower the farming community through knowledge acquisition and technology dissemination.
v. To organize health camps for rural masses, creating awareness and facilitating access to rural cleanliness, sanitation and hygiene
vi. To take action for conservation, development and management of natural resources for sustainable eco- friendly development.
vii. To publish scientific literature, technical bulletins & extension magazines for welfare of society.
viii. To provide consultancy and advisory services to the society by the expert professionals.
ix. To organise conferences, meet, fare, kisan gosthi, etc., to update community on science-led techniques.
x. To propagate vision & mission of the society through sharing of information and publishing literature.
xi. To formulate strategy for developing corpus fund to carry out the activities.
xii. To establish and foster cooperation with other like minded societies in India and abroad working with similar objectives.

For more information and to become member please write to:
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