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Agriculture Science: Research and Review Volume V

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Dr. Rajendra V. Salunkhe

Dr. Gargi Goswami

Mr. Vivek Kumar Patel

Mr. Kumar Chiranjeeb

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Editors

Dr. Rajendra V. Salunkhe

Department of Zoology,

Arts, Science & Commerce College,

Indapur, Dist. Pune

Dr. Gargi Goswami

Department of Agronomy,

College of Horticulture, VCSG UUHF,

Bharsar, Pauri (U.K.)

Mr. Vivek Kumar Patel

Department of Plant Pathology,

PGCA, RPCAU, Pusa,

Samastipur, Bihar

Mr. Kumar Chiranjeeb

Department of Soil Science,

CSK HPKV, Palampur,

HP, India

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PREFACE

We are delighted to publish our book entitled ***"Agricultural Science: Research and Reviews Volume V".*** *This book is the compilation of esteemed articles of acknowledged experts in the fields of basic and applied agricultural science.*

The Indian as well as world population is ever increasing. Hence, it is imperative to boost up agriculture production. This problem can be turned into opportunity by developing skilled manpower to utilize the available resources for food security. Agricultural research can meet this challenge. New technologies have to be evolved and taken from lab to land for sustained yield. The present book on agriculture is to serve as a source of information covering maximum aspects, which can help understand the topics with eagerness to study further research. We developed this digital book with the goal of helping people achieve that feeling of accomplishment.

The articles in the book have been contributed by eminent scientists, academicians. Our special thanks and appreciation goes to experts and research workers whose contributions have enriched this book. We thank our publisher Bhumi Publishing, India for taking pains in bringing out the book.

Finally, we will always remain a debtor to all our well-wishers for their blessings, without which this book would not have come into existence.

- **Editors**

CONTENT

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MANAGEMENT OF MAJOR LAC HOST FLORA AND LAC CULTIVATION

Devendra Singh Porte and Pushpraj Singh

Department of Rural Technology and Social Development,

Guru Ghasidas Vishwavidyalaya (A Central University),

Bilaspur-495009, Chhattisgarh, India

*Corresponding Author E-mail: portedevendra26@gmail.com

Abstract:

Lac has gained popularity in recent years as a result of its wide range of applications and biodegradable nature. Lac is in high demand all over the world. In India, the Indian lac insect, Kerria lacca (Kerr.), is the most commonly used insect for lac production. It is sedentary, phytosuccivorous, and feeds on the phloem sap of specific host plants, such as Palas (Butea monosperma), Kusum (Schleichera oleosa), Ber (Zizyphus mauritiana), Flemingia semialata, Ficus spp., etc. Indian lac is regarded as having the highest quality in the world. To meet the growing global demand, lac farming and productivity must be increased at the local level. Lac farming provides supplementary income to mainly poor subsistence level tribal farmers in the country's forest tracts. Lac has been one of the most important non-wood forest products used by human society since time immemorial. The present article will provide a complete knowledge about the management of major host flora of lac insects for improved lac cultivation.

Keywords: Lac insect, host flora, tree selection, canopy management

Introduction:

Lac has gained popularity in recent years as a result of its wide range of applications and biodegradable nature. Lac is in high demand all over the world. Lac exports totaled 6339 tonnes in 2010-11, while productions total 17900 tonnes in 2011-12. Indian lac is regarded as having the highest quality in the world. To meet the growing global demand, lac production and productivity must be increased at the local level. Lac farming provides supplementary income to mainly poor subsistence level tribal farmers in the country's forest tracts. Lac has been one of the most important non-wood forest products used by human society since time immemorial. It contributes a small but significant amount to the country's foreign exchange earnings, but the lac's most important role in the economy is that it provides a secondary income to roughly 3-4 million tribal people, who are the socioeconomically weakest segment of the Indian population.

Lac culture practises are spreading across the country, and the need for a comprehensive account of lac culture was felt strongly by all parties involved. In India, the Indian lac insect, *Kerria lacca* (Kerr), is the most commonly used insect for lac production. It is sedentary, phytosuccivorous, and feeds on the phloem sap of specific host plants, such as *Butea monosperma, Schleichera oleosa, Zizyphus mauritiana, Flemingia semialata, Ficus* spp. and many others.

Lac crop production is highly dependent on the host species and, of course, the health of the lac host. Again, the fertility of the soil determines the health of the lac host. Furthermore, a number of abiotic factors have a significant impact on lac production. A few of these factors are good for lac production, a few are good for host tree growth, and the rest are good for both. For optimal lac production, each of these factors is effective at a critical level. As a result of the influence of so many factors, the challenges of lac cultivation differ from those of general agriculture. In a lac production system, sustainable soil and crop management can only increase profitability.

A long list of such factors could exist. Crop rotation, irrigation and drainage, plant breeding, plant physiology, soil classification, soil fertility, weed control, insect and pest control are all examples of these techniques. As a result, maximisation of production is possible when all of these factors are combined in a way that harnesses the positive interaction of factors on lac yield. When compared to global demand, the commodity's total production is very lowThere could be a variety of factors influencing the country's lac production. Quickly raising lac hosts, proper fertiliser management for establishment, proper fertilisation under lac cultivation, manipulation of the effect of direction on lac yield, selection of trees, understanding weather for better lac yield, adoption of proper pruning time and method for different hosts, alteration of hosts, use of proper brood rate for different crops, host propagation and crop sanitation, and so on are just a few of these issues.

Growing saplings of host flora for lac cultivation

- *F. semialata* seedlings are raised on seedbeds or in polythene bags, depending on how quickly they grow. Raised nursery beds with dimensions of 9.0 x 1.2 sq m have been prepared for raising nursery. For termite protection, 50 kg of well rotten Farm Yard Manure (FYM) and 250 g of chlorpyriphos (10 percent D) are mixed into the soil. Seeds are sown at 15 cm line spacing and a 5-6 cm plant to plant spacing. Planting depth is kept to 1-2 cm below ground level. April/May is the best time to sow in the nursery. If sowing is done in April/May, the nursery should be located in the shade and irrigated twice daily. If sowing is done after the monsoon has begun, it should be done in an open area.

Weeding takes place 20-25 days after sowing, followed by a 1 kg urea application per seedbed. When the seedling reaches a height of 30-45 cm, it is ready to be transplanted. Polythene bags measuring 25 x 15 cm are filled with a 1:2:1 sand-soil-FYM mixture to raise seedlings in bags. At the bottom of the bags, holes are punched for proper drainage.

- *Butea monosperma*, *Schleichera oleosa* and *Zizyphus mauritiana* seedlings are only raised in polythene bags. Because the seed coat of ber is hard, germination is poor when sown as is. The hard seed coats are carefully broken to collect the kernels inside the seed, which improves germination. Per bag, two kernels are sown at a depth of 2-3 cm. Kusum and palas seedlings can be sown without cracking the seed coat. Germination can be improved by soaking seeds in a 100 ppm GA3 solution overnight. Weeding is done on a case-by-case basis. Nursery sowing can be done with well-preserved seeds from the previous year or seeds from the same year. Because sunlight is important for germination, nursery work is done in open areas if sowing occurs after the monsoon has begun. To avoid toppling disease of seedlings caused by many soil born micro organisms such as Rhizoctonia, Sclerotium, Pythium, and others, only well rotten farm yard manure is used in poly bags. Adequate measures, such as soil drenching or fungicide spraying, should be taken as soon as possible.
- Kusum seedlings are the most vulnerable of the three major lac hosts in terms of transplantation survival. August and September are the best months for transplanting it. Semialata, Ber, and Palas. During the rainy season, the best seedling survival is associated with transplanting done during a brief period of rain.

Methods of planting host flora for lac cultivation

A wider root system is found in trees with a larger crown. As a result, the size of the pits differs depending on the species. Kusum seedlings are transplanted into 1x1x1 m3 pits. For Ber and Palas, the dimensions are 45x45x45 cm3. In April-May, pits of the desired size are dug and allowed to cure in the sun before being filled with soil mixed with farm yard manure (FYM) in such a way that the top soil flows down to the bottom and vice versa. Seedlings of Kusum, Ber, and Palas are grown in nurseries and transplanted into the field when they are 4-12 months old during the monsoon season.

Fertilizers and manures utilization for host flora in lac cultivation

The majority of Jharkhand's soils are acidic, with pH ranging from 4.5 to 5.5. Plant root growth is hampered in this situation. Furthermore, the majority of soil nutrients are still unavailable. As a result, it takes a long time for tree hosts to develop properly for lac cultivation.

During transplanting, approximately 40 kg FYM/ vermicompost for kusum and 20 kg FYM/ vermicompost for Ber and Palas are applied per pit. Fertilizer planning begins in the second year. In addition to 20 kg FYM from the second year, nitrogen, phosphorus, and potassium at 100, 100, and 80 g per seedling per year will ensure the establishment of Kusum seedlings in five years, though commercial lac cultivation will begin after a few more years.

If fertilisation with nitrogen, phosphorus, and potassium at 100-170-80 g/plant is done for the first three years, a good ber plantation for lac cultivation can be established in five years. It's important to avoid using chemical fertilisers in close proximity to plants. In the first year of planting, it should be thoroughly mixed with FYM and the entire soil volume dug from the pit. Semialata growth can be aided by applying nitrogen, phosphorus, and potassium at rates of 10, 5, and 10 g/plant, respectively, along with 2-3 kg FYM at the time of planting. In addition, 30 days after transplanting, another 5 g N/plant can be applied as a top dressing. Because the majority of the lac growing region has acid soil, liming aids in the rapid establishment of plantations. During planting, apply 650 g of agriculture lime to Ber and Palas, and double the amount to Kusum, mixed well with dug soil and FYM.

Tree choice criterion for lac cultivation

Humidity, like temperature and light, is critical for insect survival. Lac crop mortality occurs when it is exposed to humid conditions for an extended period of time. As a result, lac yield on trees in lowland conditions or along river banks produces less lac. The average lac yield from trees growing in upland conditions, such as on hill slopes or tops, has been found to be more than double that of trees growing in lowland conditions.

In the presence of sunlight, larval emergence from broodlac is accelerated. Plants with dense canopy do not allow sunlight to penetrate, resulting in lower lac yields, especially during the winter and rainy seasons. Even though it is succulent, the lac insect does not prefer branches inside the dense canopy. Ber trees with a sparse canopy allow for better ventilation as well as light penetration. Lac insect growth is best on Ber plants with branches exposed to moderate sunlight and warmth. This must be taken into account when choosing plants for lac production. As a result, trees with dense canopy can be pruned judiciously to provide a well-ventilated canopy, resulting in a higher lac yield. The same can be said for the Kusum tree. As a result, the Kusmi lac yield on the Kusum tree is higher in the summer than in the winter.

Advantage of Ber as Kusmi lac production

Jharkhand, West Bengal, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Orissa, Andhra Pradesh, and Maharashtra are among the states where Ber is a common lac host. Lac growers prefer the ber tree because of its abundance and higher yield, and both the kusmi and rangeeni

strains of lac thrive on it. Lace production accounts for more than half of the available ber plants. Despite the low yield of both raw lac and broodlac, growing rangeeni lac on ber trees for baisakhi (summer season) crop is a common practise. However, growing a winter season (Aghani) crop of kusmi lac on ber can increase lac productivity by almost twice as much as growing rangeeni on it. Broodlac yield ratio on ber is typically harvested with an output: input ratio of 6 or higher, which is significantly higher than that obtained from Rangeeni lac, which typically has an output: input ratio of 3. Immature lac cultivation of Rangeeni lac on ber produces significantly less than broodlac cultivation.

Canopy management of host flora in lac cultivation

Plants with spreading, semi-erect, erect, and umbrella (bushy type) shapes were found in a natural Ber stand. Spreading type trees are typically vigorous and good lac producers, as long as insect settlement is not hampered by poor light interception. Because of the even distribution of sunlight and ventilation throughout the canopy, erect type trees produce the most consistently. Due to poor light distribution and inadequate ventilation within the canopy, umbrella-shaped or bushy trees produce low lac yields. Branching behaviour, shoot dimension, internode length, and other factors all play a role in yield variation

Small shoots (1.0 cm basal diameter at maturity i.e. 0.7 cm during inoculation) are not good for lac production due to high lac mortality on such shoots, regardless of canopy structure. For the most part, such shoots (60-75%) are unproductive for brood lac. If these unproductive shoots are removed, light absorption can be improved. So, on the one hand, by removing such shoots, we can create a favourable environment for lac growth on larger shoots, while on the other hand, we can reduce broodlac waste. Similarly, shoots with a basal diameter of approximately 6 mm in Semialata may be removed to allow for better ventilation.

Shoot Characteristics of host flora in lac cultivation

Lac production capacity is influenced by the physiological characteristics of the host species as well as the availability of nutrients. With age, the texture and size of the shoot changes. When lac cultivation is practised on a regular basis under normal soil fertility conditions, shoots with a basal diameter ranging from 1.0 cm to 2.5 cm are considered to be the best for various lac hosts. Lac survival percent (living lac encrustation to length of settlement) increases with branch diameter, but lac insect settlement length decreases and tends to settle on secondary branches as branch diameter increases. In the case of ber, the diameter of the branch increases by about 35 percent between broodlac inoculations in July and harvesting in February. As a result, branches with diameters ranging from 0.75 cm to 1.85 cm are considered ideal for inoculation. Shoots for kusum are best when they are 18 months old, while those for ber and

palas are best when they are 6 months old. The best shoots aren't too tender or too old. When it reaches the appropriate age, a portion of it takes on a distinctive greyish hue. The lac insect encrustation that has grown on it is very firmly attached to the stem and does not detach. These shoots produce high-quality broodlac with a smooth encrustation. Succulency is one of the most important characteristics of a shoot because it has a significant impact on lac yield. The higher the succulency, the lower the dry matter percent of the shoots. Even though the dry matter percent in such cases is very low, tender ones are not at all suitable for lac culture. Potassium plays an important role in the succulent nature of shoots. In the case of ber and semialata, application of this nutrient has been found to reduce dry matter by up to 2%.

Usefulness of different lac insect genotypes in lac cultivation

Color (crimson and yellow), emergence and harvesting time (crimson early, crimson late, Kulajunga, Nawadih, etc.), resin colour index, lac productivity, and other factors all influence lac insect strains. Namkum's Indian Institute of Natural Resins and Gums has collections of four well-defined kusmi lac stocks. Crimson's early maturing strain is best for bushy hosts, while the late maturing strain is best for ber. The main difference between the stocks is their maturity time, which varies between 1.0 and 1.5 months depending on the stock. If early maturing insects emerge during a period of high temperature prior to the onset of the monsoon, they will die. Farmers can cultivate stocks that mature during the monsoon season in such cases. Similarly, late maturing strain larvae emerge between the end of March and the beginning of April. Cultivating such stocks on ber exposes the host to water stress, especially during the later stages of insect development. Lac growers can use strategic planning to increase productivity and avoid crop failure by selecting different kusmi lac strains.

Consequence of direction on lac cultivation

As previously stated, the lac insect prefers to settle in well-ventilated areas on plants with moderate sunlight. To avoid continuous exposure to sunlight, the insect settles on the lower side of horizontal branches. Over and under exposure to sunlight should be avoided during broodlac inoculation. During the months of July to December in the northern hemisphere, the southern half of the trees is more exposed to sunlight and thus warmer than the northern half.

Effects of climate in lac cultivation

Lac production is influenced by the weather, especially during the rainy season. Lac insect thrives in mild climates. Lace cultivation may benefit from annual rainfall of 1000 to 1500 mm and moderate temperatures (24-27^{o}C). A total rainfall of 650 mm in the first three months may be considered favorable for the lac crop. Rainfall distribution is also critical for a successful harvest. When 80 percent of the rainfall falls before sexual maturity, a good crop can be

expected. The insect's growth accelerates after sexual maturity, and wax secretion also increases significantly. Wax, when wet, encourages the growth of sooty mould, which stunts the insect's growth and eventually kills the lac crop. In general, after sexual maturity, less rainfall leads to increased lac production. Lac yield is also affected by weeks with more than 50 mm of rain in a row. Even if four such weeks occur in the first three months, a good lac yield can be expected; however, after that, lac yield suffers. Lac mortality is higher on thick shoots when there is more rain, but it is lower on thinner shoots when there is less rain. Lac mortality on thin shoots (0.7 cm) may be due to favourable weather for lac insect growth during periods of low rainfall, as the supply of assimilates is lower in such shoots than in thicker ones.

Significance of plant nourishment in lac cultivation

Continuous lac cultivation on host trees, particularly kusmi lac on ber, has a negative impact on tree health in Jharkhand's acid lateritic soils. The biomass production of a medium-sized, unfertilized tree under lac cultivation is reduced by 0.8 kg/tree/year when it is pruned. Lac hosts' growth is significantly influenced by plant nutrients. Because lac insects feed on the twigs of these hosts, the application of these plant nutrients has a significant impact on the former's growth. Rangeeni lac in palas usually has sparse settlement, whereas Kusmi lac has dense settlement on ber and Kusum. However, through proper fertiliser application and the use of shoots of sufficient age, Rangeeni brood lac comparable to Kusmi brood from Kusum was obtained from Palas. The fact revealed that plant nutrition influences both the quality and yield of broodlac to a large extent. In Bhalia, lac producing performance is not very promising. However, when bhalia plants were fertilised with potassium, there was a significant increase in yield as well as better quality broodlac. A non-performing host can only be transformed into a useful one by implementing proper agronomic management.

Function of various nourishment

Nitrogen and phosphorus have no effect on yield ratio (broodlac yield per unit inoculation of broodlac). Excess liming has a negative correlation with lac yield, whereas potassium application plays an important role in increasing lac production. Another important factor governing lac production is the interaction of liming and potassium application. Lac yield is reduced when potassium and lime are applied at the same time in a soil with a higher pH (5.6) and a calcium carbonate content of more than 3%. Potassium application increases lac yield significantly when soil pH is low (4.5). Because of the higher rate of liming, the thickness of lac encrustation also decreases. In crop production, the interaction of lime and potassium is crucial. When the soil pH is around 4.5, the pH dependent charges of the soil matrix are very low or even positive. In this situation, soil potassium retention is extremely unlikely. As a result, the impact

of added potassium on lac cultivation is very clear. Excess calcium in the soil, on the other hand, forces plants to uptake more calcium, increasing the plant's resistance to insect attack. As a result, the insect's growth is hampered, and the thickness of the lac encrustation is reduced, lowering broodlac quality. Potassium aids in the translocation of assimilates in plants, resulting in an increase in shoot succulence and female lac insect percentage in plants growing in potassium-rich soil because lac is primarily produced by female lac insects, potassium application increases the likelihood of a higher lac yield. Similar sex determination phenomena due to the influence of external factors have been observed in other animals. Every year, apply 450 g urea, 950 g single super phosphate, and 800 g muriate of potash (approximately 200, 150, and 500 g N, P_2O_5, and K2O) as well as 2.0- 2.25 kg lime per tree to help maintain the tree's vitality (canopy area 4.5 x 4.0 m2) and promote the growth of healthy shoots for the next crop. 2-3 months before the monsoon, finely ground lime should be applied, followed by light irrigation. During the monsoon, the full doses of P_2O_5 and K_2O, as well as half of the nitrogen, are applied, and the remaining nitrogen is applied during male emergence. In winter season lac cultivation (Aghani) in *Z. mauritiana*, experimental evidence shows that dry matter production decreased 8.7% under unfertilized conditions at the end of the third year, while it increased by 8.7% under fertilised conditions (as per above dose). The fertiliser is applied to shallow trenches dug at a radius of 60% of the canopy radius. Because higher nitrogen application rates increase termite infestation, nitrogen application should be kept to a minimum. Fertilization of the above elements can be done proportionately for other hosts, depending on the size of the concerned host. During the monsoon, the full doses of P2O5 and K2O, as well as half of the nitrogen, are applied, and the remaining nitrogen is applied during male emergence. In winter season lac cultivation (Aghani) in *Z. mauritiana*, experimental evidence shows that dry matter production decreased 8.7% under unfertilized conditions at the end of the third year, while it increased by 8.7% under fertilised conditions (as per above dose). The fertiliser is applied to shallow trenches dug at a radius of 60% of the canopy radius. Because higher nitrogen application rates increase termite infestation, nitrogen application should be kept to a minimum. Fertilization of the above elements can be done proportionately for other hosts, depending on the size of the concerned host.

Practices of lac production on different host flora:

Pruning is an essential part of successful lac cultivation. Ber tree pruning is usually done in February or March in order for the trees to be inoculated in July. Pruning may be postponed in the case of Kusmi lac strains that emerge in August. Unexploited Ber trees that have not been pruned in several years can be pruned up to mid-April for inoculation in July for the winter

season Kusmi lac, but pruning should be done in February or March the following year. Pruning Ber trees is not recommended between June and July because Kusmi lac cultivation is not possible during this time. The normal pruning season for immature rangeeni lac is April-May.

However, pruned trees (pruned in February) can be used for inoculation in October-November. Both Kusmi lac insect crops can be grown successfully on the Kusum tree. As a result, harvesting cum pruning is done in the months of January-February or June-July. Similarly, both crops can be grown on the Palas tree in the case of Rangeeni lac. The palas tree has a very specific pruning season. When pruning is done in April-May, the shooting response is clearly visible. Semialata has proven to be an excellent lac host for the Kusmi lac crop in the winter. Under irrigated conditions, a good harvest of the same can also be obtained from a summer crop. Depending on the crop, harvesting cum pruning can be done in January-February or June-July. One of the most important factors in lac cultivation success is good quality broodlac inoculation at the right rate. Predators and pests should not be present. Inoculation at a higher rate will have an impact on the tree's health.

The normal brood rate for kusmi lac cultivation on kusum and ber, regardless of season, is 20 g/m shoot length. In the case of rangeeni lac cultivation, there is little variation in brood rate and process. Summer crop inoculation rate is much lower, at 10 g/ m shoot length. As a result, a medium-sized tree can be inoculated with 500 g of broodlac per tree, keeping both the lac and the tree safe during the summer. In June and July, partial harvesting is completed, and self-inoculation for the following crop is permitted. The rate of inoculation for fresh inoculation on Palas trees is 15-20 g/ m shoot length, implying that the brood rate nearly doubles for the rainy season crop. In contrast to summer crops, rainy season crops are harvested completely. During April-May, very small spots of settlements are left on branches for immature harvesting and pruning. If a farmer wants to harvest immature lac in the summer, the broodrate used for Palas and Per should be much higher, around 20-25 g/ m shoot length. Before summer arrives, the immature crop is harvested. As a result, the goal of using a higher brood rate is to maximise production. At the same time, harvesting the lac crop before the summer arrives protects the tree's health. When cultivating lac in palas, keep in mind that pruning should take place in April-May, regardless of the crop or harvest season.

Semialata is a lac host with a bushy appearance. As a result, the first year's broodrate is 20 g/plant, and the second year's broodrate is 50 g/plant. During the summer, the ber tree is unable to produce broodlac. Semialata plants that do not have access to irrigation have a similar problem. As a result, farmers who only have these hosts will not be able to grow broodlac all year. During the months of June and July, they run out of broodlac for inoculation against Kusmi

and/or Rangeeni lac. Only by arranging Kusum tree and semialata plants under irrigated conditions for summer Kusmi crop and Palas trees for summer Rangeeni crop can the problem be solved. Because *Ficus* spp. are excellent brood preservers in the summer, using *Ficus* trees for summer crop can alleviate the problem of Rangeeni crop to some extent.

Inoculation on Kusum trees is usually done when the shoot reaches the age of 18 months. Ber, Palas, and Semialata take about 6 months to mature. If the farmer inoculates all of his hosts, there will be no host trees available for lac cultivation the following season. As a result, farmers should keep at least two coupes for the majority of hosts on which lac cultivation is possible, taking into account the season. Because Kusum trees require an 18-month rest period before they can cultivate lac again, a 4/5 coupe system is required to grow lac all year. Palas trees can be used to harvest both immature crop and broodlac. As a result, in the case of Rangeeni lac cultivation on Palas, the three coupe system is used. In alternate years, the first two coupes are used for broodlac production. The third coupe is used for immature crop cultivation. The following is the crop cycle:

- The first coupe is pruned in April (First year).
- In November, a light inoculation is given to the first coupe (First year)..
- Pruning in the second and third coupes in April (Second year).
- In the first coupe, self-inoculation took place in July of the second year.
- Harvesting the entire crop in November of the second year in the first coupe, light inoculation in the second coupe, and a higher rate of inoculation in the third coupe.
- In April of the third year, the first coupe is pruned, and the third coupe is harvested completely. Ber trees can be planted in the third coupe to harvest immature lac crops.

Conclusion:

Lac insect is an economically and ecologically important insect. Lac production is a lucrative business for Central Indian rainfed farmers and forest dependents. Chemical, cultural, and biological approaches to biotic factor management may be used. This method will save money while also protecting the environment. Manipulation of the host and location to combat climate change could be strategically planned, resulting in lac production that is both sustainable and cost-effective.

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ROLE OF LEGUMES IN MAINTAINING AGRICULTURAL AND ENVIRONMENTAL SUSTAINABILITY

Shivani Ranjan*, Sumit Sow and D. K. Roy

Department of Agronomy,

Dr. Rajendra Prasad Central Agricultural University,

Pusa, Samastipur, Bihar (848125), India

*Corresponding author E-mail: ranjanshivani54@gmail.com

Abstract:

Global population will reach upto 9.6 billion by the year 2050 leading to an increase in global challenges such as achieving food security, reducing the impact of climate change by lowering the emission of greenhouse gases into the atmosphere. The adverse effect of climate change and associated biotic and abiotic stresses will hamper food production. To deal with these issues, sustainability of the production, as well as consumption pattern, should be maintained. Growing legumes or introducing legumes in the cropping pattern can help in meeting these goals. They possess multiple benefits such as it can be used as a source of protein for humans as well as livestock, fixes atmospheric nitrogen (N) in the soil, breaks the cycle of pests and decreases chances of diseases occurrence. Low requirement of fertilizer as well as other inputs makes it highly profitable and economical. It is widely used as an intercrop, cover crops and helps to obtain yield in case of failure of the main crop due to its short life cycle. Legumes can help farmers in generating more income by reducing the fallow periods between the crops so that the farmers can utilize both the time and space. In a nutshell, this crop has the ability to be an important tool for agricultural and environmental sustainability.

Keywords: Climate change, Food security, Legumes, Sustainability

Introduction:

Legumes belong to *Fabaceae* family comprising herbaceous plants including some shrubs and few trees. Some examples are chickpea, pigeonpea, green gram, black gram, cowpea, field pea, lentil, groundnut, soybean, *etc*. Legume ranks second in both production and nutritional aspects after cereals in the world (Kumar *et al*., 2018). They are considered to be an economically feasible source of protein in comparison to other animal sources mainly in developing countries. In addition, they play a vital role in enhancing soil carbon sequestration. Legumes have the potential to add N to the soil by biological nitrogen fixation which not only

reduces environmental hazards due to excessive use of fertilizers but also decreases N loss in agricultural fields (Dhakal *et al*., 2015; Graham and Vance-Carroll, 2003). *Sesbania rostrata*, *Sesbania aculeata*, *Crotalaria juncea* are some legumes that are used as green manures and incorporated into the soil for the improvement of soil health and agricultural sustainability (Fageria, 2007). Cultivation of legumes leads to an enhanced diversity of soil flora and fauna. Legumes enhance the production of greater total biomass in the soil by providing additional N. Soil microbes uses the increased N to decompose carbon-rich residues of crops such as wheat or corn. Several studies have focused on the role of legumes in decreasing GHG emissions. Jeuffroy *et al*. (2013) observed that legumes emit around 5-7 times less GHG per unit area in comparison to other crops. Certain legumes release organic acids from their roots, which solubilize the phosphorous present in the soil and make it available to the plant. Thus, a major focus on legumes and their contribution to sustainable agriculture is required.

Biological Nitrogen Fixation

There is a symbiotic relationship between rhizobium and legume crops through which atmospheric nitrogen is fixed and is made available to the plants. Crops secrete certain chemical substances such as flavonoids which will attract the particular rhizobium species related to the specific crop. Then, rhizobium will infect the roots leading to the formation of nodules. These nodules can also be called as bacteroids. There is aerobic condition inside the nodules and it is changed to anaerobic by leghaemoglobin. Due to the presence of leghaemoglobin, the colour of the nodules becomes pink. Inoculation with a suitable strain of Rhizobia bacteria, legumes can utilize up to 90% of their own N. Shortly after a legume seed germinates in the presence of Rhizobia microorganism in the soil, the bacteria start penetrating into the root hairs and cross into the root itself. The bacteria multiply leading to swelling of the roots and nodules become pink in colour. The bacteria produce ammonia (NH_3) from the hydrogen procured from the plant's carbohydrates and nitrogen from the air. The ammonia then helps in plant growth. This symbiotic relationship between bacteria and legumes results in the production of a highly proteinaceous crop (Lindström and Mousavi, 2019). Nitrogen from the legume crops are returned to the soil through the process of decomposition by soil microorganisms. Usually, about two-thirds of the nitrogen fixed by legumes becomes available to the subsequent crop (Deakin *et al*., 2009).

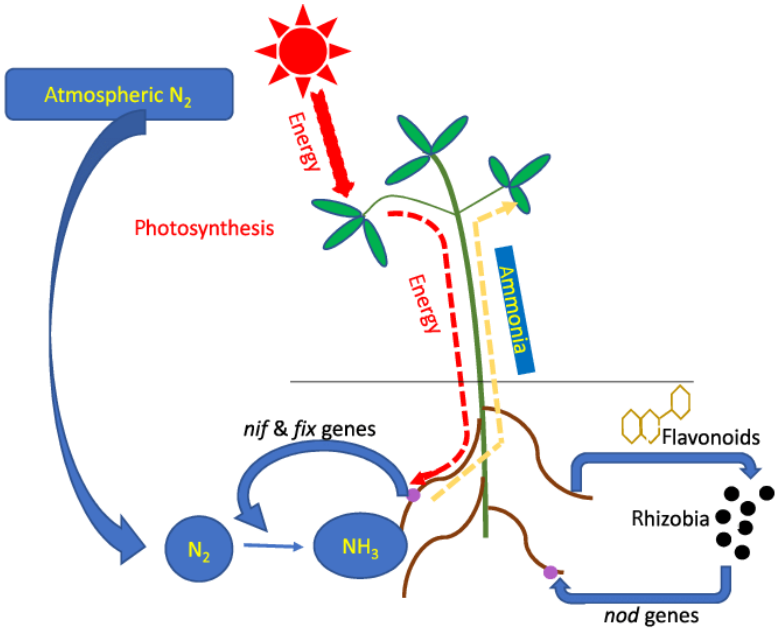

Figure 1: Symbiotic nitrogen fixation in legumes by rhizobia (Lindström and Mousavi, 2019)

Table 1: Cross Inoculation Groups (Datta *et al*., 2014)

Sl. No.	Rhizobium species	Cross inoculation groups	Legume crops
1	*R. leguminosarum*	Pea group	Pisum, Vicia, Lens
2	*R. phaseoli*	Bean group	Phaseolus
3	*R. trifoli*	Clover group	Trifolium
4	*R. meliloti*	Alfalfa group	Melilotus, Medicago, Trigonella
5	*R. lupini*	Lupini group	Lupinus, Orinthopus
6	*R. japonicum*	Soybean group	Glycine

Role of Legumes in Maintaining Soil Health

Legumes are rich in protein content. Crop residues contain more amount of carbon as compared to nitrogen. Microbes present in the soil need both carbon as well as nitrogen. So, the nitrogen provided by legumes helps in the decomposition of crop residues. Association of soil microbes with legumes is one of the most efficient ways for regenerating soil health without disturbing the natural biota (Prashar and Shah, 2016). They can be considered as soil conditioners as they improve soil physical properties by forming more stable soil aggregates. The protein known as glomalin is present along with the roots of legume and other plants. It functions as a “glue” that binds soil particles together into stable aggregates. This aggregate stability

enhances pore space and tilth, decreasing soil erosion. Soil organic carbon (SOC) and nutrient availability are increased in legume-based cropping systems (Jensen *et al*., 2012). Researchers have suggested that in comparison to other plant species, legume can store 30% more carbon due to their N-fixing ability (Ram and Meena, 2014). Rutkowska and Pikula (2013) reported that growing legumes with other crops or in the rotation is the principal factor toward stabilization of SOC pool. Kausadikar *et al*. (2020) observed that, subabul leaves mixture was found superior over the other organic residues in N mineralization such as ammoniacal nitrogen and nitrate nitrogen. Whereas, maximum P mineralization for 30, 60 (7.33 mg kg^{-1}), 90 (7.55 mg kg^{-1}) and 120 (7.45 mg kg^{-1}) days of experimentation as well as sulphur mineralization was also found highest in by application of gliricidia lopping. Hence, for fast decomposition and nutrient mineralization legume residue is more efficient than cereal or other organic residues.

Green Manuring

It deals with ploughing and turning of undecomposed green plant tissue into the soil for improving soil fertility status as well as productivity. It enhances soil fertility by the direct addition of nitrogen. Besides, it also improves soil structure, water holding capacity and microbial population of soil through the addition of humus or organic matter. Green manuring depends on soil as well as climatic conditions. Incorporation of leguminous crops producing 8 to 25 tonnes ha^{-1} green matter will add up to 60 to 90 kg ha^{-1} of nitrogen, which is equivalent to an application of 3 to 10 tonnes of farmyard manure. *Kharif* green manure legumes like dhanicha, sunhemp, mung bean and guar are found to contribute 8-21 tonnes of organic matter with 42-95 kg of N ha^{-1} and *rabi* green manures such as Khesari, cowpea and berseem have the potential to contribute 12-29 tonnes of organic matter with 67-68 kg of N ha^{-1} (Kumar *et al*., 2014). Legumes are preferred as a green manure crop as it adds nitrogen into the soil due to symbiotic relationship with Rhizobium. Rhizobium has the potential to fix nitrogen in association with leguminous plants which helps in meeting the nitrogen demand of the plant. Rhizobium inoculation ensures an adequate supply of nitrogen (N) for legumes such as cowpea, green gram, blackgram, pea, chickpea, groundnut, soybean, berseem, subabul, *etc*., in place of N fertilizer and it can fix about 50-300 Kg N ha^{-1}. Either grown in situ (green manuring) or brought from a distance (green leaf manuring), the value of green manuring depends on the incorporation of organic matter which is recognized as most valuable constituents for maintaining soil fertility (Lokesh *et al.*, 2015). Green manure crop should be incorporated into the soil at proper growth stage of crop to obtain maximum advantage. It should be turned into soil 7-8 weeks after sowing that is at the flowering stage. Dhaincha achieves maximum growth 8 weeks after sowing, while sunhemp crop flower around 8-10 weeks after sowing. Commonly used crops for green

manuring are sunhemp (*Crotolaria juncea*), dhaincha (*Sesbania aculeata*), senji (*Melilotus parviflora*), berseem (*Trifolium alexandrinum*) *etc*. Sunhemp is dominant among green manure crops. Dhaincha as a green manure crop can grow in waterlogged as well as alkaline soils.

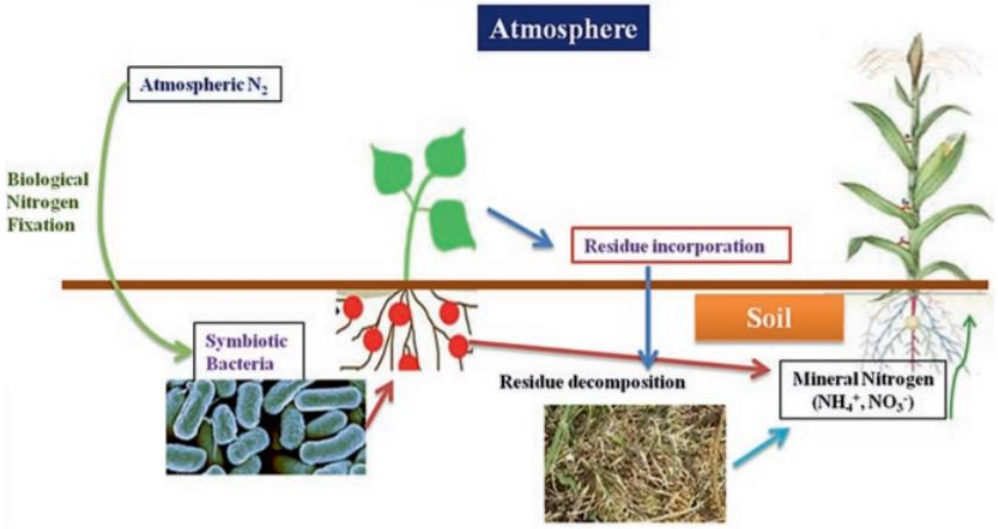

Figure 2: N fixation and mineralization of leguminous green manure crop in soil

Table 2: N accumulation by different green manure crops (Ramanjaneyulu *et al*., 2017)

Sl. No.	Green manure crops	Nitrogen accumulation (kg ha^{-1})
1	*Sesbania aculeata*	130-185
2	*Crotalaria juncea*	80-130
3	*Tephrosia purpurea*	70-115
4	*Phaseolus tribolus*	85-125

Greenhouse Gas (GHG) Emission

The introduction of legumes in crop rotation helps in decreasing fertilizer and energy use in arable systems and therefore lowering the GHG emissions. N fertilizer savings across Europe, in rotations including leguminous crops, range approximately 277 kg ha^{-1} of CO_2 per year *i.e*., 1 kg N is equal to 3.15 kg CO_2 (Jensen *et al*., 2012). It has been found that half of the CO_2 generated during production of ammonia can be reutilized if ammonia is converted to urea. This is, however, only a time shift of CO_2 release in the atmosphere since, once the urea is applied to the soil, the hydrolyzation activity by urease will release CO_2 originally captured during urea production. Taking into account, an efficiency of 2.6-3.7 kg CO_2 generated per kg of N synthesized, the annual release due to fertilizer is 300 kg of CO_2 globally into the atmosphere each year. However, it is crucial to focus on the thing that CO_2 respired from nodulated roots of

legumes comes from the atmosphere through photosynthesis. Conversely, all the CO_2 released during the process of N-fertilizer production is acquired from fossil energy, thus determining a net contribution to the atmospheric amount of CO_2. In addition, there is no direct relation between N_2O emissions and biological nitrogen fixation, since organic N from legume residues is decomposed, mineralized and are rapidly immobilized by microorganisms (Peoples *et al*., 2009). Emissions of N_2O can occur either during nitrification or denitrification. During the winter or early spring in cold wet soils, it is impacted by timing of mineralized N supply and a synchrony between supply and utilisation by succeeding crops, resulting in increased nitrogen loss (Magid *et al*., 2009).

Importance of Grain Legumes in Cropping Systems

When it comes to environmental and economical benefits, legumes can compete with other crops as a competitive crop. In modern intensive cropping systems, which are characterized by a reduction in crop diversity as well as an excessive reliance on external inputs, legumes have the ability to be introduced.

Grain Legumes into Crop-Sequences

In recent years, many studies have focussed on the sustainable re-introduction of grain legumes into crop rotations, due to their positive effects on yield as well as quality characteristics on succeeding crops (Preissel *et al*., 2015). The agronomic pre-crop advantages of grain legumes can be classified into nitrogen effect component and break crop effect component. The 'nitrogen effect' component is a result of the N provision from biological nitrogen fixation (BNF), which is maximum in conditions of low N fertilization to succeeding crop cycles. The second one that is break crop effect comprises of non-legume-specific advantages, such as improvement in soil organic matter content and structure (Hernanz *et al*., 2009), phosphorus mobilization (Shen *et al*., 2011), soil water retention and availability (Angus *et al*., 2015), and decreased problem due to diseases and weeds. Among other advantageous effects of legumes, one is the production of hydrogen gas (H_2) as a by-product of BNF that largely influence the composition of the soil microbial population, further favouring the development of plant growth-promoting bacteria (PGPR). Some legume crops such as chickpea, pigeonpea and white lupin have the ability to mobilize unavailable forms of soil P by secreting organic acids like citrate and malate and other phosphorous mobilizing compounds from their roots. Among grain legumes, white lupin is the strongest solubilizer of phosphorous, a function that can be facilitated by its proteoid roots that have the ability to englobe small portions of soil. Glasshouse experiments using a highly P-fixing soil showed better growth of wheat following white lupin than soybean, showing that the cereal was able to access more P made available by the preceding white lupin break crop. The effect of

break crop includes increased soil water content, since the break-crop stubble affects the water holding capacity of soil and infiltration rate of the rain water (Kirkegaard *et al*., 2014). Generally, grain legumes are not susceptible to the same pests and diseases as the main cereal crops as they are non-host crops for them, due to this reason legume are considered suitable as break crops in wheat-based rotations. Grain legumes as break crops can also contribute to weed control (Seymour *et al*., 2012) by contrasting their specialization and helping in stabilizing the agricultural crop weed community composition.

Grain Legumes in Intercropping

Intercropping systems consist in synchronous growth of two or more crop species in the same area as well as at the same time. Intercropping is extensively used in developing countries or in low-input and low-yield farming systems (Ngwira *et al*., 2012). In spite of several recognized advantageous effects of intercropping like better pest control (Lopes *et al*., 2016), competitive yields with decreased inputs (Monti *et al*., 2016), pollution mitigation (Luo *et al*., 2016), more stable aggregate food or forage yields per unit area (Smith *et al*., 2013), there are a number of constraints that make intercropping not common in modern agriculture such as the request of a single and standardized product and the acceptability for mechanization or use of other inputs as an advantage in intensive farming system. Hence, it is essential to enhance intercropping systems to increase resource-use efficiency and crop yield simultaneously (Li *et al*., 2014), while also promoting multiple ecosystem services. One of the fundamental spatial arrangements used in intercropping is strip intercropping, in which two or more crops grow together in wide strips that are sufficient to allow separate crop production using inputs but close enough for the crops to interact.

Smothering Effect

The magnitude of crop-weed competition is generally dependent on component crops. It was observed that nutrient draining by weeds was decreased in pigeon pea-based intercropping system. Cowpea with large canopy cover was more efficient in weed control than sesame.

Conclusion:

The importances of grain legumes in terms of sustainability in agriculture can be enhanced by the emerging research opportunities. They have significant additional benefits beyond their significance involving nitrogen fixation and excessive protein feeds. These consist of positive impacts on biodiversity as well as soil quality. There is a great need for strong emphasis on the role of legumes and their contribution towards sustainable intensification of manufacturing and the livelihoods of small holder farmers in many parts of the world. Apart

from their makes use of as food and fodder they play a crucial role in retaining soil fertility by fixing atmospheric nitrogen and improving soil structure. It is critical to select legume species and cultivars that can be introduced productively across a range of cropping systems in order to balance yield, which provides an economic return, with environmental and agronomic benefits. Nitrogen fixation activity of grain legumes should be assessed in relation with soil, climatic, plant characteristics and management conditions to find the appropriate approach to achieve the best improvements. The ability of the host plant to store fixed nitrogen is a major component of increasing nitrogen fixation input. A particular focus should be given on studying abiotic stress limitations and in particular water deficit, salinity and thermal shocks require extensive investigation. Legumes that are capable of recovering unavailable form of soil phosphorus can be an important asset in cropping systems. Hence, legumes that may accumulate phosphorus from non-available sources need to be explored further, as phosphorus is an expensive and scarce resource in many farming systems. Increasing demands for plant products, such as protein and oils, and the increasing economic and environmental constraints on agro-ecosystems, grain legumes appear to be a viable option for agricultural sustainability.

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MICRO PLASTICS IN SOIL ECOSYSTEM: TYPES, IMPACT ON SOIL PROPERTIES AND ITS REMEDIAL MEASURES

Kumar Chiranjeeb*, Narender K. Sankhyan, Shivani and Chhaviraj Baghel

Department of Soil Science,

CSK HPKV, Palampur, HP, India-176062

*Corresponding author E-mail: kumar.chiranjeeb3@gmail.com

Abstract:

Micro plastics have emerged as an alarming threat to all ecosystems for its harmful and destructive nature on ecosystem. Micro plastics have very minute size in nature and in turn associate with every ecosystem easily and accumulation of micro plastics causes degradation of properties and nature of that ecosystem. Global population and demand for food production is increasing day by day, due to which the farmers use heavy application of compost, fertilizer and sewage and sludge, those act as potential source of micro plastic in agricultural soil. Accumulation of micro plastic hampers the microbial growth and proliferation, harmful hazards on plant health, human with animal health with declining soil properties thus reducing fertility status and thus declining crop production along with sustainability for future. Micro plastic harmful effects must be controlled and strict legal framework should be developed with its adaptation by countries can ensure a better future.

Keywords: Agriculture, Ecosystem, Micro Plastics, Remedies, Soil.

Introduction:

Micro plastics are the very minute debris form of plastic having size range less than 5mm in nature. In recent studies it has been found that these micro form of plastic particles affect and pollute the environment at various ecosystem levels such as soil, air and as well as marine environment. Micro plastic due to its smaller size and high interactive ability with environmental components can enter in any ecosystem and creates hindrance as well as toxicity in specific ecosystem with alteration of existing sustainable properties of each ecosystem for longer period of time. In soil ecosystem the micro plastic has various means of entering such as through application of organic fertilizers, bio solid compounds and use of plastic mulches etc. Micro plastics create potential threat for soil micro biome and soil store more micro plastic waste than oceanic basins and near about 30% present in various continental systems. Micro plastics can interfere with aerosol particles and move in air stream, thus affecting air quality and standards.

Plastic garbage dumping in water sources can lead to accumulate in marine and other water ecosystems and biomagnifications of these micro plastic hamper the marine food ecosystems. Micro plastic alters the soil properties and thus affect the crop growth with declining its sustainability.

Micro plastics and its Types:

Micro plastics are the very minute dimension based heterogenic plastic compound including various granules and fragments with a limit of 5mm with higher surface area. Although micro plastics are minute in size but affect the environment at a larger stake. Micro plastic can integrate in any ecosystem and alter the existence and various important processes in that ecosystem.

Types of Micro Plastics:

A. Primary Micro Plastics:

They play a key role in the environment having higher quantity, regular use and enter the environmental ecosystems without any interference. They are of following types:

1. Micro beads:

Micro beads are minute in nature, non bio-degradable in nature having diameter dimension of nearly 1mm. Micro beads are used in production of toothpastes and different facial scrubbing materials. Due to this minute size the micro beads can enter in plants, lakes and other systems without altering the basic properties. The demerit of these micro beads is with marine and aquatic animals as they ingest micro plastic as food material which is non biodegradable in nature thus biomagnifications elevates the concentration of micro beads in food web and food chains. Micro beads are toxic in nature.

Figure 1: Micro beads

Figure 2: Nurdles

2. Scrubbers:

These scrubbers containing plastic integrated substances generally used as a cleaning substance in the environment.

3. Nurdles:

Nurdles are used for production of various plastic related goods and having small size. Large companies burn and melt these materials to manufacture other plastic materials. Nurdles interact with storms, hurricanes and other devastating natural calamities and deposit in other ecosystems to pollute and disturb the ecological balance.

4. Pellets:

Plastic pellets are very much common in use and used as raw material for manufacturing of other goods. Due to spill way mechanism micro plastics enter other ecosystems.

5. Plastic powders:

Plastic powders are used in case of moulding industries.

6. Fibres:

Fibres constitute to about 71% of the total micro plastic pollution in marine and other aquatic ecosystems. Diapers, cigarette materials are also act as various sources of micro plastic. Air conditioners, washing machine sources used substances act as potential source for microfiber entry into water sources. The use of synthetic and various organic fertilizers in agricultural fields are the prominent source of micro plastic in soil ecosystem. These microfibers are generally non-biodegradable in nature**.**

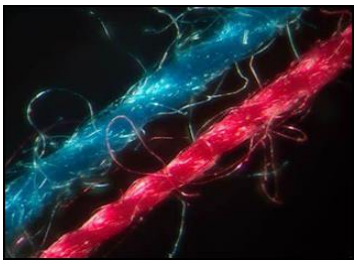

Figure 3: Fibres

Figure 4: Fragments

Figure 5: Foams

7. Fragments:

Fragments are the broken pieces of plastics from a large segment of plastic material. The lids and small segment plastics are the examples in this section. Exposure of UV radiation for a longer period of time may even break the micro plastics into further smaller pieces.

8. Foam:

Foam particles are also act as the source of micro plastic contamination in ecosystems with having multiple uses.

B. Secondary Micro Plastics:-

Secondary micro plastics are derived from primary micro plastics in various processes such as weathering, UV light exposure, wear and tear, wind abrasion etc. These mentioned

processes breakdown the primary micro plastic and produce secondary micro plastic substances. These secondary micro plastics are comparatively less effective than primary micro plastics.

Micro Plastic in Soil Ecosystem:

Micro plastic compounds are very much microscopic in nature and due to this advantage it can enter into any ecosystem without compromising its characteristics. Large and intensive agricultural system use a huge plastic input through various practices and accumulate micro plastic quantity in soil. Plastics are non biodegradable in nature thus affecting the growth and sustainability of soil microorganisms. Micro plastic accumulation in soil creates an impermeable layer which in turn reduces infiltration, permeability and also affects the translocation of nutrients in soil profile.

Micro plastics can enter the soil ecosystem through various possible means such as (Yang *et al.,* 2021):

1. Irrigation water:

Micro plastics can enter the soil ecosystem through irrigation water by using plastic pipes. The plastic pipes may act as a source of micro plastic and continuous use of plastic pipes for irrigation supply to the crops may pave a pathway for accumulation of micro plastic in soil.

2. Sewage and Sludge:

The application of sewage and sludge on soil as a source of nutrient for the crop production contain potential quantity of micro plastics and thus accumulate micro plastics in soil for a longer period of time.

3. Compost and Synthetic fertilizers:

Heavy use of compost and various synthetic fertilizers are the prominent sources of micro plastics in soil ecosystem. To achieve higher productivity farmers use more quantity of the nutrient sources which in turn accumulate plastic in soil.

E.g. Synthetic urea and urea granules may have plastic components and heavy use of urea sources add plastic to the soil environment.

4. Plastic mulching:

Mulching helps in restoration of moisture and control soil surface temperature reduces evaporation losses. So there is need of use of plastic mulches for better crop production and long time exposure of these plastic mulching materials with crop and soil accumulate plastic contents in soil ecosystem.

5. Atmospheric entry:

Transmission of micro plastic through atmospheric phenomena is also an important input in soil. In catchment areas the micro plastics are accumulated in soil environment. The micro

plastic flux can deposit and settle on land in a long period of time. The aerosol containing minute plastic fraction along with irrigation water deposit on land and accumulate in it.

6. Litters:

Various litters generated from agriculture and non agriculture sources have the potential means for accumulation of micro plastic in soil. Littering materials when loaded on soil and during its decomposition the plastic materials as they are non degradable accumulate in soil.

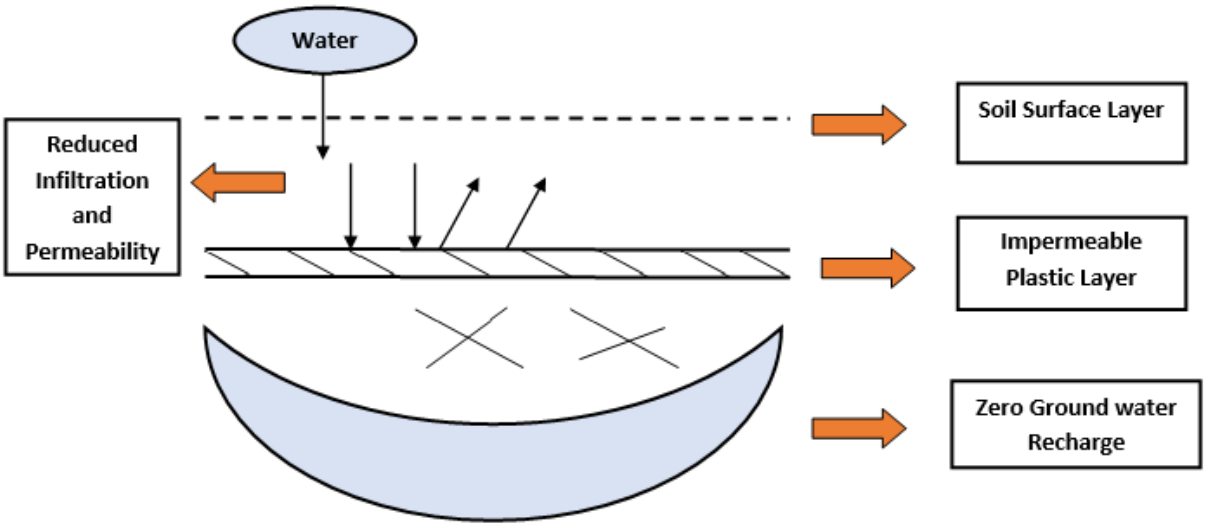

Figure 6: Harmful Impact of Micro Plastic on Infiltration, Permeability and Ground water Recharge

Effect of Micro Plastic on Soil Properties:

The persistent natures of micro plastics can results into various possibilities of hazards to soil environment. Micro plastic decreases the aggregate stability by preventing micro aggregates from effectively being integrated into macro aggregates or by introducing fracture points into aggregates (Lozano *et al.,* 2021).Besides this, the formation of pores in soil resulted in loss of microhabitat and changes in the water holding capacity as well as bulk density (Veresoglou *et al.,* 2015; de Souza Machado *et al.*, 2018) and also accelerates the soil water evaporation (Wan*et al*.,2019) affecting the soil microbial community. Apart from this some studies revealed that micro plastic accumulate in the gut and stomach of earthworm affecting their feeding behaviour and development (Huerta Lwanga *et al.,* 2016; Hodson *et al.*, 2017). Also, presence of micro plastics in soil significantly affect soil microbial respiration and activity of soil β-glucosidase, urease, and phosphatase (Yang *et al*., 2018; Wang *et al*., 2020).Furthermore, owing to their small size, they also interact with other substances such aspesticides, antibioticsand heavy metals (Zn,

Cd and Pb) in soilcausing greater harmto soil biota and affecting several soil properties (Brenneck*et al.* 2016; Li *et al.* 2018; Rillig*et al.* 2019).

Mitigation Strategies:

Minimizing the use and discharge of micro plastic is the best way to reduce the accumulation of micro plastic in soil. Minimizing the use of micro plastic is most beneficial but it is hard to achieve due to lack of convenience. Landfills and application of sewage sludge and waste water for irrigation are potential source of micro plastic in soil, therefore, restricting land filling of plastics and reducing the usage of sewage sludge and waste water can aid in minimizing micro plastic accumulation. Restricted single use plastic and banning the industrial use of plastic micro beads are some of the preventive measures in controlling micro plastic accumulation. Some of the countries like the USA, Canada, and UK have banned the industrial use of plastic micro beads in 2015, 2017 and 2018, respectively (Yu *et al*., 2022).Use of bio-based and biodegradable plastic can be an alternative to conventional plastic. Therefore, the development of biodegradable plastics and engineered microorganisms which can easily mineralize micro plastic would be the key to micro plastic mitigation.

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WOODAPPLE (*FERONIA LIMONIA* S.)

Pradeep Kumar*[1], Om Prakash[2], Aranav Yadav[3],
Suneel Kumar Patel[4], Surendra Kumar[5] and Usha Shukla[6]

[1, 4] Department of Fruit science,
Chandra Shekhar Azad University of Agriculture and Technology Kanpur, (U.P.) 208002

[2]Department of Fruit Science,
Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

[3, 5]Department of Genetics and Plant Breeding,
Chandra Shekhar Azad University of Agriculture and Technology Kanpur, (U.P.) 208002

[6]Department of Horticulture,
Babasaheb Bhimrao Ambedkar University (A Central University) Lucknow-226025

*Corresponding author E-mail: pky1221@gmail.com

Introduction:

The wood apple is one of the common names of an edible fruit from several trees, mainly those belonging to genus *Limonia acidissima* L. (synonyms: *Feronia limonia* syns, *Feronia elephantum* Correa; *Schinus limonia* L.). The fruit from the genus Aegle marmelos, a native tree from India, where the fruit is known as "Bael," is also known as the wood apple. The fruit shape resembles an apple and the name wood apple is due to the fruit hard shell. Native to India, the tree is cultivated in other countries such in Pakistan, Sri-Lanka, and Bangladesh. The fruit is also known as elephant-apple, monkey fruit or crud fruit. The plant belongs to the Rutaceae family (Muthumperumal and Parthasarathy, 2009). It is deciduous and grows up to 9 m. The bark is rough, and the fruits are woody and rough. The wood apple is common in dry plains and a monsoon climate with a distinct dry season. The tree might grow up to an elevation of 450 m, as in the western Himalayas. The tree is drought tolerant and adapted to light soils. The spines are axillary, short, straight, 2-5 cm long on some of the zigzag twigs. The leaves are deciduous, alternate, dark green, leathery and 3-5 in. long with oil glands and slightly lemon-scented when crushed. The flowers are normally bisexual, small numerous, dull-red or greenish, borne in small, loose, terminal or lateral panicles. The berry fruit is globose, the shape is round to oval and 2-5 in. wide, with a hard, woody rind. The brown pulp is resinous, astringent, aromatic odorous, acid or sweetish with scattered seeds. Extensive root system and synchronization of its reproductive phase with high moisture availability make it a suitable crop for arid zones. The fruit might be large and sweet or small and acid (Vijayvargia and Vijayvergia, 2014). The fruits

contain a myriad of phytochemicals such as polyphenols, phytosterols, saponins, tannins, coumarins, triterpenoids, vitamins, amino acids, tyramine derivatives, etc. (Dar *et al.,* 2013).

Origin and Distribution

The wood apple is native and common in wild in dry plains of India and Srilanka and cultivated along roads and edges of fields and occasionally in archands. It is also grown throughout Southeast Asia, in Northern Malaysia and Penane Island. Prior to the development of processing methods in the middle of the 1950s, the fruit was historically a pper mante cuisine in India. One of the hardiest trees that may be found all over India's plains, particularly in the arid areas. It is more prevalent in the Deccan Maharashtra, Madhya Pradesh, Uttar Pradesh, Chhatishgarh, Bihar, and the Jharkhand. Additionally lighted are the Western Himalayas up to an altitude of roughly 500 m. Can be obtained from a plantation of one hectare. This fruit has a lot of processing potential since it can be turned into a variety of goods with additional value or combined with other fruit products to improve nutrition for the domestic and global markets.

Genetic Diversity and Utilization

Bundelkhand region is rich in biodiversity for wood apple but less harnessed. The agro-climatic conditions of Bundelkhand have great potential for its commercial cultivation. Keeping these points in view, twenty-five genotypes of wood apple, fruit sample with shoot were collected from diverse areas of Bundelkhand region of utter Pradesh and analysed for various physic-chemical attributes and results of study revealed wide range of variability in morphological quantitative qualitative and biochemical etc. The quantitative variability of different genotypes in wood apple viz for fruit length (4.22 cm to 7.46 cm), fruit width (3.06 cm to 6.41 cm), shell thickness (0.10 cm to 0.31 cm), fruit weight (65.9 g to 238.7 g), leaf length (2 cm to 4.3 cm), leaf width (.97 cm to 2.3 cm), seed length (4.7 mm to 8.0 mm), seed width (2.97 mm to 4.77 mm), seed weight (23.76 g to 30.4 g), and No. of seed per fruit (102 to 614). The bio-chemical parameters also showed wide range of variation i.e. TSS (10.87 0Brix to18.09 0Brix), acidity (2.3% to 6.25%), total sugar (1.55% to 2.38%), reducing sugar (0.86% to 1.28%), non-reducing sugar (0.69% to 1.25%), ascorbic acid (12.63 mg/100g to 35.56 mg/100g) (Kumar *et al*. 2021).

In Gujarat, it was found that wood apples exhibit a great genetic variation in terms of tree size, fruiting, fruit weight, and size (Hare Krishna *et al*. 2016). Seven accessions of wood apple from West Bengal have been obtained after a thorough survey was conducted. The fruit's weight ranges from 130 to 225 g, its pulp percentage from 42.9 to 60.6%, its T.S.S. ranges from 15.0 to 18.4 °Brix, its acidity ranges from 1.7 to 4.6 percent, and its total sugar content is from 5.1 to 14.3%. (Ghosh *et al.* 2012). Additionally, they stated that grafting was superior to budding and

that when the operation was carried out in September, grafting success rates ranged from 85% to 95%.A survey was made by Shukla *et al.* (2006) in Madhya Pradesh (Tikamgarh and Datiya) and Uttar Pradesh (Jhanshi and Lucknow), they were collected seventeen genotype. Fruit weight ranged between 230g to 640g, fruit length 6.4 to 9.5 cm, fruit width 5.9 to 10.1 cm, T.S.S 9.4 to 16.3° brix, acidity 0.83 to 2.76 %, vitamin c 1.68 to 3.04 mg/ 100g pulp, total sugar from 3.46 to 5.64% and shell weight from 100.0 to 366.66g recorded in different accession. Shukla *et al.* (2007) reported three promising wood apple genotype (CISH-WA-4, CISH-WA-10 and CISH WA-16). Also conducted a survey in Maharashtra and reported physic-chemical property of 15 genotype of wood apple. The fruit weight (173-540g), pulp content (58.0-75.93%), TSS (14-18.5), total sugar (4.8-8.45), acidity (1.0-5 %) and rind thickness (0.2-0.5 cm). Variability in plant morphology and fruit characters of different genotype has been also reported by Singh *et al.* (2016) and Yadav *et al.* (2018).

Varieties

Yellora: Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, Maharashtra, introduced the wood apple variety in 1986. The tree has rather spreading growth patterns. The fruits are huge, green, and rounded in shape (350.0). It is appropriate for dry ground conditions and a regular bearer. Through soft wood grafting, the plants are commercially propagated. The fruits mature in December and each plant produces 250–350 fruits.

Dharwar Selections: At UAS, Dharwad, work has been done on the wood apple crop to improve and produce types. Wood apple varieties like Dharwad Selection-1 and Dharwad Selection-2 have evolved and are the best types for fruit production on dry ground.

Thar Gaurav: Thar Gaurav evolved only in a hot, semi-arid ecosystem that is supplied by rain. This selection was created in the Madhya Pradesh district of Indore in the 2004–2005 growing season and was established using soft wood in-situ grafting in the field. At the institute level, it has been recognised and made available as variety in 2019. It grows in a spreading manner with branches that droop. 230 days after fruit set, the fruit is ready to eat. Fruits have high levels of pectin and protein.

Soil and Climate

The wood apple is adaptable to a variety of soil types. Sandi loam or deep loam with a pH of 7–7.5 and well-drained soils are required for high yield potential and good plant growth. Its extensive geographic distribution, from tropical and subtropical to dry and semi-arid regions, reflects its ability to adapt to a variety of ecological situations. For semi-arid and arid ecosystems, it is a fruit tree that is quite suited.

Nutritional value

Wood apple seeds have the following nutritional value per 100 g of (ripe) edible pulp: moisture 4%, protein 26.18%, fat 27.1%, carbs 35.49%, ash 5.03%, calcium 1.58%, phosphorus 1.43%, iron 0.03%, and tannins 0.08% (Sivakkolundu and Loganathan, 2013).

Table 1: Nutritive value of wood apple

Nutrients	Value	Nutrients	Value
Phosphorous	110 (mg)	Minerals	1.90(g)
Protein	7.10(g)	Crude Fibre	5.00(g)
Iron	0.48(mg)	Carotene	61.0(g)
Fat	3.70(g)	Thiamine	0.02(mg)
Riboflavin	0.05(mg)	Niacin	0.07(mg)
Carbohydrates	18.10(g)	Energy	134(kcal)
Calcium	130 (mg)	Vitamin C	3.00(mg)
Magnesium	41.0(mg)	Manganese	0.18(mg)
Zinc	0.46(gm)	Chromium	0.06(mg)
Copper	0.21(mg)	Tannins	1.03(%)

The raw fruits are used to prevent diarrhoea, pruritus, and pharyngodynia. They have a generally sour flavour and are fragrant, astringent, constipating, and alexipharmic. The unripe fruit reduces bodily itch and elevates vata, pita, and kapha. Additionally, it helps with whooping cough. As an alternative to bael (Eagle marmelos), it is used to treat diarrhoea and dysentery. The ripe fruits are bittersweet, acrid, and difficult to digest. They are also refrigerant, aphrodisiac, and cure coughs, dysentery, heart conditions, and vomiting. They also remove biliousness, "vata," "tridosah," and blood impurities, as well as fatigue, thirst, and hiccoughs. They are also beneficial for throat, asthma, consumption, tumours, opthalmia, le According to Yunani, the fruits are cardiotonic, tonic to the liver and lungs, astringent and binding, diuretic, strengthening the gums; the juice is effective for sore throat and stomtitis; helpful in biliousness; topically, it soothes pain from wasp and other insect stings. They are helpful for sore throats and scurvy. The pulp is used externally as a treatment for venous insect bites. For hiccoughs and breathing difficulties, pulp mixed with honey and pipli is administered. Pulp is used to tone the breast and treat throat and mouth infections. Native Americans in the Madhya Pradesh district of Rewa utilise fruit pulp as a remedy for boils and amoebiasis (Qureshi *et al.*, 2010). The leaves

are beneficial for treating children's dyspepsia and minor bowel infections because they are often fragrant and carminative in nature. Leaf juice is beneficial for stomach issues. In the Uttar Pradesh area of Shahjahanpur, the leaves are used as an astringent to treat vomiting, hiccoughs, and dysentery. The pectin content of the wood apple, after desirable purification, offers the potential for numerous uses in pectin-short India. Following the rainy season, the trunk and branches especially exude a white, translucent gum. It can be used to make watercolours, ink, dyes, and varnish for artists as well as to replace or adulterate gum Arabic. It has a composition of 42.7% d-galactose, 35.5% arabinose and xylose, and traces of rhamnose and glucuronic acid. An other beneficial medicinal plant is wood apple. In addition to having diuretic effects, it also has insecticidal, antifungal, and antibacterial (against Cladesporium cladesporioides) capabilities **(Kamrul, 2013).** The seed protein concentrate (WSPC) has excellent water absorption, low oil absorption, stable foam, and important minerals in addition to its high protein content (77g/100g). It can be applied industrially and utilised for nutritional supplements (Rao *et al.*, 2011).

Botanical description

The scientific name for the wood-apple is Swingle, also known as F elephantum Correa, Limonia acidissima L., and Schinus limonia L. Anisifolium curvispina and Anisifolium spectabile (Miq.) Hesperethusa acidissima Kuntze (Miq. Kuntze M. Roem's Hesperethusa ambigua Limonia dulcis, M. Roem., Limonia ambigua DC., and Limonia curvispina Miq. Schinus limonia L., Limonia engleriana Perkins, Limonia laureola Blanco, Limonia spectabilis Miq., J. F. Gmel., and Limonia elephantum (Correa) G. Panigrahi are examples of different species of lime tree. It belongs to the citrus family and has the chromosome number 2n=18. It is a small to medium-sized deciduous tree that has thorny branches and can grow up to 10 metres tall and 0.6 to 1.6 metres in diameter.It is aromatic, grows all throughout India in dry, warm climates up to 450 metres elevation, and has rough, prickly bark. The spines are axillary, short, straight, 2-5 cm long (Raghavandra, 2011).

It is often a slow-growing, upright tree with a few upward-reaching branches that curve outward and split into thin branchlets with drooping tips. The bark has ridges, cracks, and scales. The 7.5–12.5 cm long, alternate, deciduous leaves are leathery, dark green, and frequently minutely serrated at the margins. They have oil glands all over them and when crushed they give out a light lemon scent (Sivakkolundu and Loganathan, 2013). The petiole, rachis, midribs, young twigs, and spines of very juvenile leaves are covered in tiny, constricted yellowish-gray or practically colourless hairs. These hairs cover the most recent new growth almost to the same degree as the glycosmis, which is still forming. With the exception of the joints of the rachis and

the base of the petiole, these hairs vanish soon (USDA 1967). Small blossoms of the wood apple variety are abundant, especially on young stems of the terminal or axillary panicle. From February to the first week of June, flowers are in bloom. Flowers are mostly staminate hermaphrodite species. Ovary, style, and stigma are present in hermaphrodite and male flowers, but they are primitive in later species (Sappandi, 2005). Both the type of flowers have normally bisexual in nature. Flowers are Dullred or greenish or pale green with red purple stained in colour. Additionally, Brandis (1906) reported that male and female flowers frequently grow on the same inflorescence, and that flowers might be unisexual, in slack panicles. The calyx might be deciduous, he continued. The 1.25 cm in diameter flowers are supported by small, loose, terminal or lateral panicles. A small, triangular-lobed calyx with 5–6 lobes is present on flowers. The flower has 5–6 free, spreading, or deflexed petals that are elliptic–oblong and 5 mm long. The 10–12 l–seriate stamens are equally distributed with big, linear–oblong anthers. Equally subulate and densely hairy at the base are the filaments. The two pollen sacs between each lobe's two anthers basifixedly dehisced via silt. The fresh pollen grains ranged in size from 28.0 to 35.80 micron (Karale, 2002).

Fruit physiology and biochemistry:

According to Lakshmi *et al*. (2015), the wood apple is a ripening fruit and the changes observed at the three characteristic stages (unripe, semi ripe, and ripe) are the increase of total sugars reaching up to about 5 g/100 g, acidity decrease reaching about 3 g/100 g. Sucrose is the predominant sugar in all ripening stages. Citric acid is the main organic acid, with levels peaking in unripe fruits (B2 g/100 g) and falling in ripe fruits (B1.6 g/100 g). Given that the fruit also belongs to the Rutaceae family, the higher level of citric acid is expected. In contrast to other fruits, the fruit's soluble solids decreased as it ripened, going from 20 to 14 Brix. On the other hand, ripe fruit had higher total phenolic and total protein levels. The phenolic found in the wood apple are primarily bonded, and the phenolic concentration and reducing power have a positive association.

Propagation

During the months of March and April, it is commercially grown via seed and soft wood grafting or patch budding in both field and nursery conditions (Hiwale, 2008; Raguvendra, 2011). In Gujarat's semi-arid climate, in situ soft wood grafting on wood apples has a success rate of more than 80% (Hiwale, 2015).

Planting

The 90cm x 90cm x 90cm pits are typically excavated in the summer. Pits are filled with soil that has been mixed with decomposed organic matter. When the soil in the pits has already settled during the rainy season, planting is done. After planting, the plants should be watered right away. For maximum productivity, it can be planted at a distance of 8 m x 6 m. In arid areas, the initial growth of plants is slow.

Irrigation

Management Under semi-arid conditions, it can be grown well without irrigation. Plants should be watered during the summer when they are young (up to two years old) to ensure optimal growth and better plant establishment. Even though wood apple can be grown in a rainfed, semi-arid environment without irrigation, planting should be done as soon as rain starts to fall so that the plant can thrive during the rainy season. Techniques for collecting water during the rainy season should be taken into consideration since they promote development and fruiting during the following post-monsoon season.

Nutrient Management

A full-grown tree should get a yearly dose of around 50 kg of FYM, 1.5 kg N, 500g P, O, and 500g K, applied in two separate applications each year, one in July and the other in the final week of August.

Training and Pruning

Wood apple plant should be trained with removing cross branches at initial growth stage of plant because grafted plant are vulnerable to lanky and uneven spreading in growth habits. Because of this, proper frame work essentially requires initial to three year training and trimming. Although pruning is not typically necessary for wood apples, it is crucial to remove dry, dead, and cross branches from trees in December and January.

Plant Protection

There are no major insects and diseases have reported in wood apple. Insect larvae can be found in the fruit pulp. Insects also defoliate and harm wood. Wood apple has been observed to have a bacterial infection of the leaves, fruits, twigs, and thorns (Anon., 1956). Although uncommon, other illnesses such aspergillosis and gummosis have been reported. By removing the affected area and applying Blitox (copper oxychloride), gummosis can be treated

Pests and Diseases

There are no known major issues with this plant because it is not regularly orchard, but the same pests and diseases that harm citrus and bael also harm this crop. Insect larvae can be discovered in fruit pulp. Additionally, insects defoliate and harm wood.

Harvesting and Yield

In various parts of the country, the fruit begins to mature in October and continues through the month of January. Fruits begin to mature in semi-arid and arid environments in September and are fully developed by December. Strong and pleasant perfume is the primary attribute of ripe fruit. The mature fruits are carefully selected by hand pickers, and care should always be taken to prevent any damage to the fruits during harvesting and storage in order to prevent post-harvest losses. In a semiarid ecosystem with rainfed conditions, the fruit output per plant ranged from 70.0 to 120.0 kg during ten years of cultivation.

Post-Harvest Management

Fruits from wood apple trees are used to produce a variety of value-added goods, including powder, chutney, pickles, etc. Pickle-making process: Choose fruit that is totally ripe and mature (5.0), then scoop out and gather the fruit pulp. The gathered pulp needs to be well combined before being gradually crushed. Check the material's acidity and TSS before adding 250 g of chilli powder, 130 g of fenugreek, 30 g of turmeric, 170 g of salt, 280 g of gingly or mustard oil, and 15 g of asafoetida. Then, put the mixture in the refrigerator for a month to allow the flavours to ferment and develop. The idea behind wood apple pickle is the binding of moisture with salt and spices.

Chemical Composition and Nutritional Value Including Vitamins, Mineral, Phenolic and Antioxidant Compounds

Fresh wood apple fruit contains butanoic acid, methyl hexanoate, and ethyl-3-hydroxyhexanoate, three volatile flavouring compounds (Qureshi *et al*., 2010; Patel, 2013). The fruit is used to treat hepatitis, tumours, dysentery, wounds, asthma, and heart weakness. Flavonoids, saponin, tannins, and glycosides are present in the fruit. The fruits were used to isolate coumarins and tyramine derivatives. The fruit shells contain antifungal substances such psoralene, xanthotoxin, 2,6-dimethoxybenzoquinone, and osthenol, and the leaves have hepatoprotective properties (Pradhan *et al*., 2012). 36% of the total fruit is made up of the pulp. The pulp's pectin level ranges from 3 to 5 percent. The seeds are rich in unsaturated fatty acids and have a bland, non-bitter oil **(Morton, 1987)**.

Potential industrial application:

Medicinal Use

In addition to being a tonic for the liver and lungs, wood apple fruits are also said to stimulate the stomach, be astringent, aphrodisiac, diuretic, cardiotonic, relieve coughs and hiccups, be helpful for tumours, ophthalmia, and leucorrhea, and be good for asthma and

tumours. Fruit that is not quite ripe is astringent, and heart disease is treated with the seeds. In cases of diarrhoea and dysentery, the fruits are used in place of bael (Eagle marmelos). The astringent properties of leaves can help with diarrhoea, hiccups, indigestion, and vomiting. Hepatoprotective effects are present in the leaves. The gum helps with diarrhoea, dysentery, gastropathy, haemorrhoids, and diabetes and is demulcent and constipating (Vijayvargia and Vijayvergia, 2014). Children with vomiting, hiccups, dysentery, indigestion, and mild bowel disorders should take the fruits and leaves (Patel, 2013).

Food Uses

A number of beverages and sweets can be made using wood apple fruit, and the fruit can also be preserved as jam (Vidhya and Narain, 2011). The pulp that has been scooped out is either consumed raw, with or without sugar, or it is combined with coconut milk and palm sugar syrup and frozen as ice cream. Wood apple is a breakfast food in Indonesia that is combined with honey (Morton, 1987). While the pulp in India is used to make savoury chutneys, the leaves are consumed in Thailand as salads. According to Vidhya & Narain (2011), the fruit pulp is utilised to make ready-to-serve beverages, jam, jellies, chutney, and fruit bars (Lande *et al*., 2010). The seasonal fruit wood apple is incredibly neglected. Past years have seen a marked growth in the demand for wood apple fruit.

Machines including presses, decanters, centrifuges, and pulpers/finishers can be used to extract the juice. Presses come in a variety of designs, including the conventional rack and cloth press, hydraulic presses, screw presses, horizontal presses, and belt presses. The type of the material to be processed must be considered while choosing juice extraction equipment **(**Patel, 2013).

Value added product

Wood apple fruit, which ripens to become soft, is used to make fruit bars, drinks, sweets, and fruit crush for jam and ready-to-serve beverages. Fruit pulp can be used to make blended drinks with coconut milk and palm sugar syrup. Despite the fruit's many nutritional and physiological advantages, it is currently underused and has little market value. In order to explore the various physicochemical aspects of the manufactured product, an effort was made to use wood apple fruit as a value-added product (Nisha e*t al*., 2019).

Wood apple syrup

Fruits are manually deshelled, and the pulp and seeds are combined with the necessary amount of water and cooked. There are two pulp extractions done. By adding sugar from its original brix, brix is increased to 13°B. After 30 minutes of boiling, the prepared juice is put into

cans while still hot. For more than 1.5 years, the cans are sealed and kept at room temperature **(Hiwale, 2006)**.

Jelly: Choose healthy, semi-ripe fruits, remove the fruit's hard exterior, and utilise the pulp to make jelly. Juice can be extracted by adding 1.5 times as much water as fruit pulp. To retain juice and its colour and heat juice evenly, use stainless steel and aluminium containers while keeping juice. Pectin is turned into pectic acid by overheating, and the colour and aroma are also lost. Decide how long the juice will be cooked. Jelly should be removed by tying in fabric and letting the juice fall naturally in order to make it translucent. Do not manually press it. Juice should be filtered using muslin cloth.

Procedure of chutney: Pick five ripe, healthy fruits; break them, remove the flesh of the wood apple, and add it to a mortar for thorough grinding and blending. Salt to taste, cumin seeds, red chilli powder, and jaggery (gur) should all be added after that.

Future Thrust

- The creation of enhanced cultivars to take advantage of genetic diversity and orcharding.
- The promotion of the health benefits of wood apple fruit.
- Marketing and value enhancement

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AN OUTLINE OF PIG FARMING: A SOURCE OF LIVELIHOOD IN THE INDIAN CONTEXT

Devendra Singh Porte* and Pushpraj Singh

Department of Rural Technology and Social Development,

Guru Ghasidas Vishwavidyalaya (A Central University),

Bilaspur-495009, Chhattisgarh, India

*Corresponding Author E-mail: portedevendra26@gmail.com

Abstract:

Pigs are an important part of the Indian livestock industry. Pigs are typically raised by economically disadvantaged members of society, and they not only provide better nutritional support but also serve as a valuable source of income. Pigs can meet the needs of the weaker members of society as a low-cost source of healthy animal protein. In India, six different pig breeds have been recognised. The larger population of nondescript pigs, on the other hand, has lower production ability and provides a meagre return to the farmers. However, proper cross-breeding programmes have increased the popularity of pig rearing, as has the development of popular and locally acceptable new breeds by crossing desi pigs with high-yielding exotic breeds. An increase in demand has resulted from an increase in pork consumption in India's cities and a greater acceptance of pig meat by society. To meet this demand and eliminate the production shortfall, a more detailed examination of the pig population and the state of pig farming at the village level will aid in the development of new schemes.

Keywords: Pig, rearing, husbandry, breeds, livelihood

Introduction:

The majority of pigs in India are raised in small-scale subsistence-based production systems. Pigs in low-input systems provide farmers with value-added output by consuming feed that would otherwise go to waste. Smallholder farming systems help the poorest people improve their livelihoods and food security. Pigs are often one of the main sources of cash income in rural areas and provide manure for cropping, in addition to providing protein for human consumption. It also serves as a financial safety net in times of distress, as well as contributing to community cultural traditions. Pig production, in particular, promotes greater self-sufficiency, increases incomes, and provides greater food security to urban households. Smallholder pig rearing

provides nutritional and financial benefits to tribal communities in India, as well as the conversion of household waste into fertilizer for agricultural crops.

According to the 19th Livestock census of India pigs comprises 2.01% to the total livestock population (http://dahd.nic.in). Pig population in India is estimated to be 10.29 million and it ranks 5th in the world. Pig rearing has the potential to become an important and inclusive farm practise that can assist socioeconomically disadvantaged people and poor farmers in achieving nutritional stability at a relatively low cost while also providing a sustainable source of income by meeting the ever-increasing demand for pork. The exotic or crossbred pigs account for 23.85% of the total pigs, while the rest are indigenous. Rural areas are home to 89.62 percent of all pigs. Farmers in rural areas, on the other hand, keep these pigs as scavengers, making them more vulnerable to disease and skin infections. This method of rearing makes them less appealing to customers who prefer a clean and sanitary pork product. Scavenging by pigs exposes them to a wide range of diseases, and pigs serve as an important reservoir for the majority of zoonotic diseases, posing a significant threat to the human and animal populations. As a result, a clean, hygienic, and scientific approach will not only aid in the healthy development of animals, but will also aid in increasing the appeal of pork production and consumption, thus increasing overall profit.

Status of pig population distribution:

The 18th livestock census identified six exotic pig breeds, six crossbred pig breeds, and five indigenous pig breeds. NBAGR (http://www.nbagr.res.in) has reported that there are six indigenous pig breeds in total. The majority of our indigenous pigs are locally well adapted and have excellent disease resistance properties; however, 78 percent of the total indigenous pigs are nondescript. As a result, characterising and improving our vast nondescript population is critical. In comparison to the 2007 census, the 2012 census revealed a 9.06 percent decrease in pig population (http://dahd.nic.in). If we look at the distribution of this indigenous pig population, we can see that the majority of them are concentrated in central and north eastern India, necessitating a concentrated area-specific improvement strategy.

According to the overall pig population distribution in the country, Assam has the highest pig population (15.89%), followed by Uttar Pradesh (12.96%), and Jharkhand (12.96%). (9.35 percent). In India, there are 2.46 million crossbred people, the majority of whom live in Assam, Nagaland, and Mizoram. The Doom breed, which has a population of around 2 lakhs, is the most populous among indigenous breeds. NBAGR has identified and classified a total of six pig breeds. Ghoongroo (West Bengal), Niang Megha (Meghalaya),

Agonda Goan (Goa), Tenyi Vo (Nagaland), Nicobari (Andaman & Nicobar), and Doom (Andaman & Nicobar) are among them (Assam)

Possibility of improvement:

To improve the local stock, cross breeding programmes have been implemented using Middle White Yorkshire boars. During the last five years, a massive public awareness campaign and extensive training programmes have gotten a boost, and there has been a huge increase in the number of piggery farms established by the educated class of society. At C.D.F. Aligarh, the department has established a piggery development training centre. Tamworth has been used in Ranchi by crossing it with local Purnia pigs to produce a population of pigs with a shiny black coat, no skin problems, large litters, and higher body growth. Landrace has also been used to cross with the local pig population in western Uttar Pradesh, in addition to these two exotic breeds.

The majority of pigs raised by farmers are of an unremarkable breed. Low feed conversion efficiency, small litters, longer farrowing intervals, slow growth, and lower slaughter weight are all common characteristics of these pigs. Since pig rearing is one of the most important occupations for the rural poor and weaker sections of society, even these unremarkable pigs are an important part of the poor farmers' socio-economic status. It serves as a direct form of insurance for the downtrodden and socially vulnerable members of society. It not only provides employment for educated unemployed youth, but it also serves as a vital source of low-cost animal protein for those who cannot afford more expensive meat. Pork has a unique composition that includes a high amount of animal fat, which is a rich source of energy, as well as other important micronutrients and macronutrients, particularly fat soluble vitamins. The lard found in pig meat gives cooked pork a distinct flavour that has made it popular with a wide range of people. Though the demand for pork is growing by the day, production is decreasing, as evidenced by a comparison of the 18th and 19th livestock censuses, which show a decrease in the number of pigs.

In India's rural areas, farmers frequently keep locally available pigs that are unable to provide a satisfactory return. They may also be afflicted with skin diseases. These pigs are bred for scavenging, which makes them unappealing to the majority of the population. Farmers use scavenging to save money on the cost of raising these pigs. However, this practise makes them more vulnerable to parasites, both external and internal, as well as other common diseases. This practise is unacceptable because pigs are a reservoir for many zoonotic diseases. A clean and tidy pig rearing practise will not only protect the animals from

disease and complications, but will also contribute to the improvement of the surrounding environment and sanitation. This will also keep any major zoonotic disease from spreading. As a result, they require a concept that can provide them with an ideal model for profitable and sanitary pig rearing. Furthermore, the introduction of high-quality boars/sires for the sows already present in villages will aid in the up-grading of these animals in subsequent generations, resulting in a faster and higher return per animal.

Pork production increased slowly from 2009-10 to 2014-15, with a compound annual growth rate of 1.4 percent, due to population growth. Indigenous pigs are small, grow slowly, have small litters, and produce low-quality pork. In India, the average meat yield of indigenous breeds is around 35 kg/animal, which is very low compared to the global average of 78 kg/animal (http://gain.fas.usda.gov). The lack of sufficient breeder farms, lack of knowledge and management practise, and diseases such as classical swine fever, porcine reproductive and respiratory syndrome (PRRS), and porcine rotavirus are all major obstacles to the pork sector's growth. Pig farming and consumption are also limited because most pig farmers are from the lower socio-economic strata of society and pig farming is viewed as a source of income rather than well-managed and hygienic pig rearing with improved foundation stock, clean housing, management, and health care.

Problems and opportunities:

The country's challenges in securing food and nutritional security for a rapidly growing population necessitate an integrated approach to livestock farming. Pigs are the choice of animal for securing animal protein security, as they are the most efficient feed converters after chicken broiler flocks, among the various livestock species. It is a source of meat, bristles, and manure in addition to meat. Pig manure can be used as a fertiliser as well as a slurry to promote plankton growth in fish ponds. They produce bristles that are used to make high-quality brushes, including shaving brushes of the highest quality. Pig farming has the potential to provide employment and supplemental income to seasonal rural farmers, allowing them to improve their living standards. Except for broilers, pigs have one of the highest feed conversion efficiency, which means they gain more live weight from a given weight of feed than any other class of meat-producing animals. Pigs can convert a wide range of feeds, including grains, forages, damaged feeds, and garbage, into valuable nutritious meat. Damaged grains, garbage, and other unbalanced rations, on the other hand, may result in lower feed efficiency. They are one of the most prolific breeders, with a high fecundity and a shorter generation interval than most other species.

A sow can be bred as young as 8-9 months old and can give birth twice a year. They have a gestation period that is less than three months long (114 days). In each farrowing, they produce 6-12 or even more piglets. These piglets mature quickly, reaching market weights of over 70 kilogrammes. Pig farming necessitates a minimal investment in terms of structures, equipment, disease protection, and management. Pigs are known for their high meat yield, which ranges from 60 to 80 percent in terms of dressing percentage or carcass yield, which is significantly higher than that of ruminants (55 percent). Pork is one of the most nutritious meats due to its high fat content and low water content, as well as its higher energy value than other meats. Vitamins like thiamin, niacin, and riboflavin are abundant in it. Pig manure is widely used in agriculture and fish ponds as a fertiliser. Pigs store fat quickly, and the demand for it is growing in the poultry feed, soap, paint, and other chemical industries. Pig farming yields quick returns because fatteners can reach marketable weight in as little as 6-8 months. Pork, bacon, ham, sausages, lard, and other pig products are in high demand both domestically and internationally.

Limitations their solutions:

Despite the fact that six pig breeds have been identified in India, the majority of the pig population in the country is made up of nondescript desi pigs, which are typically black in colour, small in size, late breeders, and prone to skin problems due to deficiency or parasitic or fungal infestations. They also have smaller litters (low fecundity), are less prolific, and have a lower feed conversion efficiency. These animals are kept by the poorest and lowest strata of society, who leave them to scavenge around the village, exposing them to diseases (especially parasitic) and unbalanced growth due to inadequate nutrition. All of these factors, however, can be addressed by crossing them with excellent exotic breeds such as Landrace, Tamworth, Yorkshire, Hampshire, and others, and then selecting the most suitable progeny for inter-se-mating based on the needs of local farmers.

A synthetic population can be created through repeated selection and inter-se-mating that is suitable for local conditions, environment, and demand. Farmers should be given proper guidance and incentives by the government in order to raise pigs in a clean and sanitary environment. Clean housing and feeding facilities will not only improve the health of the pigs, but will also help to prevent the transmission of zoonotic diseases to their consumers. Pork will also become a more popular alternative for a larger number of people.

Pig farming will provide employment and supplemental income to seasonal rural farmers, allowing them to improve their living standards. Pig farming has the following advantages:

- The pig can convert a wide range of feed items, such as grains, forages, damaged feeds, and garbage, into valuable nutritious meat. Damaged grains, garbage, and other unbalanced rations, on the other hand, may result in lower feed efficiency.
- Pig farming necessitates a minimal investment in terms of structures and equipment.
- The pig has the highest feed conversion efficiency of any meat-producing animal, with the exception of broilers, producing more live weight gain from a given weight of feed.
- They have a shorter generation interval and are more prolific. A sow can be bred as young as 8-9 months old and can have two litters per year. In each farrowing, they produce 6-12 piglets.
- Pigs are known for their high meat yields, which range from 65 to 80 percent dressing percentage, compared to less than 65 percent for other livestock species.
- Pig meat is the most nutritious, as it is high in fat and low in water, and it has a higher energy value than other meats. Vitamins like thiamin, niacin, and riboflavin are abundant in it.
- Pig manure is widely used in agriculture and fish ponds as a fertiliser.
- Pigs produce a lot of fat, which is in high demand in the poultry feed, soap, paint, and other chemical industries.
- Pork, bacon, ham, sausages, lard, and other pig products are in high demand both domestically and internationally.
- Pig farming yields quick returns because marketable fattener weight can be reached in as little as six to eight months.

Conclusion:

The various aspects discussed provide an overview of the problems and benefits that farmers may encounter. Pork, on the other hand, is an exceptional, inexpensive, and delicious source of animal protein, making the keeping of pigs by the socioeconomically disadvantaged very appealing. The ever-increasing demand also provides a good market for pig farmers looking for a better return on their investment. However, it should always be done in a sanitary environment, with strong scientific guidelines and technological support that can instil enthusiasm and commitment in the farmer.

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CHEMICAL RESIDUES IN MEAT AND ITS PUBLIC HEALTH SIGNIFICANCE

Mukesh Gangwar[1], Shalu Swami[1], Apeksha Jangir[1],

Pranav chuahan[2], and Deepali T. Sakunde[3]

[1]Division of Livestock Products Technology,

ICAR-IVRI, Izatnagar Bareilly, Uttar Pradesh, India

[2]Department of Livestock Products Technology,

College of Veterinary Science and A.H., (NDVSU), Mhow, India

[3]Department of Livestock Products Technology,

KNP College of Veterinary Science, Shirwal, MAFSU, Nagpur, India

Abstract:

In recent years food safety has been at the forefront of societal concerns and presence of chemical residues such as chlorinated pesticides, organophosphates, herbicides, mycotoxins and veterinary drug residues in meat and meat products has increased consumer's attention regarding their safety. There is concern that these drugs or chemicals and their biologically active principles or metabolites may accumulate in edible tissues, potentially increasing the risk of exposure for consumers after consumption of meat. Chemical residues in animal tissues above the legal tolerance clearly have an impact on human health. This chapter discuss about the different chemical residue found in meat, their sources, possible public health effects, methods of detection and their prevention and control.

Keywords: Chemical residue, Pesticides, Veterinary Drug Residue, Meat, Public Health

Introduction:

Globally meat consumption is increasing and meat and meat products have become an integral part of the human diet due to their richness in proteins, essential amino acids, vitamins and minerals. However, animal production is continuously developing and residues of veterinary drugs, anabolic steroids and pesticides have become an important issue for meat product safety. Although meat is considered as healthy source of nutrients but presence of chemical residues may influence its healthy image. Consumers are concerned about the safety of food they are consuming. In the widest sense residues can be defined as undesirable substances either chemical or biological present in meat. They are mostly present in a small amount or can enter into food chain due to inappropriate storage of food or by various modern agricultural or technological practices. Feed and water consumed by animal can also be a source of chemical residues. Until

last decade surveillance for presence of chemical residues in products of animal origin was relatively a neglected area but the chances of residues in meat and meat products increased enormously with the advancement of technological intervention in livestock rearing, disease control and intensive crop production system. Veterinary drug residues can also enter in to the meat by chemotherapeutic or chemoprophylactic use of veterinary medicines in animals. Drugs residues will persist in the animal tissues which are not readily excreted or metabolized from the body of animal thus enter the human food chain causing consumer's health risks such as hypersensitivity, tissue damage, gastrointestinal disturbance, leukemia, reproductive disorder and bacterial resistant strain etc. The presence of chemical residues in food of animal origin can adversely affect consumer's trust which resultantly impact global economy. Thus control of veterinary drug residue is an important measure in ensuring consumer protection.

Ideally, meat food should be completely free from such types of contaminants. This is a utopian goal considering current agricultural and technological practices. Many develop countries in the world have already been tracking this problem by fixing statutory limitations of pesticides, veterinary drug residues and microbial toxins in meat and meat products and their enforcement through monitoring to ensure safe food supply to consumers. Monitoring of such types residues in foods of animal origin can reveal current status of contamination, thus enabling preventive and control measures to be initiated before contamination becomes so serious or wide spread that threatens human health or causes serious economic losses.

Sources of chemical residues in meat:

Pesticides

To meet global food demand pesticides are regularly used in agricultural fields thus posses a unique status among all food residues. Incorrect use of pesticides has caused intoxication in animals and/or accumulation of residues in animal tissue. Use of pesticides in commercial crops to enhance production has resulted in indirect exposure to animal through feed. Pesticides that mostly persistent in the environment such as organochlorines like DDT, heptachlor, heptachlor epoxide, lindane or hexachlorobenzene and aldrin/dieldrin cause major health hazard effects. Some of these compounds such as mercury, arsenic etc. also contain toxic elements which, when break down in the soil, produce the actual residues. The industrial chemicals such as chlorinated hydrocarbons including PCB, the dioxin, or perchlorethylene (PER) play the major role, but organometal compounds such as tetraethyl lead in fuel, benzopyrene and other substances are also important. Pesticides can be absorbed by any routes

such as inhalation, ingestion and dermal/ percutaneous absorption. These pesticides have affinity for fat/adipose tissue and in liver their accumulation is 100 times higher than any other tissues.

Veterinary drugs residues

Animals are directly exposed to the veterinary drugs thus their presence in animal tissue is most common but by following sufficient withdrawal period of times this could be avoided. Overdose of drugs and use of drugs that are banned for treatment of animals and improper maintenance of treatment records or failure to identify treated animals adequately that may lead to their omission etc are some reason that are responsible for presence of drug residues in meat. These drugs can be given via oral or parental route or as feed additives in food animals. The veterinary medicinal products may range from teat dips to hormonal preparation and approximately, 42% of all veterinary pharmaceuticals used world-wide are used as feed additives, 19% are used as anti-infectives, 13% as parasiticides, 11% are used as biologicals and 15% represent other pharmaceuticals. The maximum contributor for presence of violative residues in meat were injectables (46%) followed by oral administration (20%) and ultimately intra-mammary infusions (7%).

Antibiotics/Antimicrobials

Common cause of certain antimicrobials residue in meat can be fecal recycling, housing of unmedicated animals in boxes where animals had previously been treated, extra-label use of drugs and poor treatment records. The most commonly used antimicrobials in food animals are ß-lactams, amino glycosides, tetracycline, macrolides, lincosamides, pleuromutilins and sulfonamides. All of them are administered to animals orally in the feed and water, topically on the skin, as injectables (intramuscularly, intravenous, subcutaneous) and by intra-mammary and intra-uterine infusions. Potential of drug residues increases at the injection sites when drugs are administered by subcutaneous and intramuscular routes. At any stage of processing of meat and meat products including poultry and eggs, sea foods including shrimps, prawns or other fish and fishery products the given antibiotics and veterinary drugs such as nitrofurans (furaltadone, furazolidone, nitrofurnatoin, nitrofurazone), chloramphenicol, sulphamethoxazole, aristolochia spp and preparations, chloroform, chloropromazine, colchicine, dapsone, dimetridazole, metronidazol, ronidazole, ipronidazole, clenbuterol, diethylstibestrol, glycopeptides, crystal violet, malachite green, stilbenes and other steroids are not permitted to be used.

Anthelmintic drugs

Globally parasitic infestation is common in food animals that make animal unproductive, subsequently results in economic losses. Ivermectin is most commonly used broad spectrum antiparasitic drug for the treatment and prevention of both nematode and arthropod parasites in

food animals. It has lipophilic nature thus residues are found in fat/adipose tissues of food animal and the meat withdrawal time of ivermectin in mammalian livestock is also long.

Growth Promoters

Animal feed plays a large role in the sustainability of animal production systems. Growth promoters are hormone and hormone like substances that are given to food animals to enhance yield and performance in a shorter period of time. Most commonly used compounds are steroids and their semi-synthetic and synthetic analogues that are used to enhance growth of animals for food production, muscle protein storage, fertility and to decrease degree of fatness. Antibiotic growth promoters (AGP) are medicines that administered at a low subtherapeutic dosage to obliterate or inhibit bacterial growth. Besides estrogenic, androgenic and progestagenic compounds, thyreostatic, corticosteroidal and b-adrenergic compounds are also used alone or in "smart" combinations.

Mycotoxins

Mycotoxins are secondary metabolites of toxigenic molds/fungi such as Aspergillus, Fusarium and Penicillium present in feedstuffs cause acute and chronic toxicity, while some of them are potent carcinogens. Most studied mycotoxins are aflatoxins, ochratoxins, zearalenone, trichothecenes and fumonisins. Although animals are effective toxin eliminator but direct consumption of cereal grains contaminated with mycotoxin results in more exposure of animal tissue to residues.

Residues of heavy metals

Water from ponds, streams, rivers and other water sources and disposal of industrial effluents sewage sludge on pastures grasses or forages can be a possible source of heavy metals thus animals grazing freely may be exposed to high levels of these metals in the environment. Industrial revolution is the major factor behind the presence of heavy metal residues in environment and has made this an international issue. The heavy metals of primary concern are cadmium, copper and mercury due to their known high toxicity to humans.

Public health concerns

Consumption of edible animal tissues containing secretion of chemical residues can affect the public health. Some study have shown that exposure to antimicrobial residues in food of animal products could result to the transfer of resistant strains of microorganisms such as salmonella, campylobacter and staphylococcus to humans. Another example is antibiotic resistance in E. coli which is widespread globally and penicillin is showing decreased efficacy against it. Sub-therapeutic dose of penicillin, tetracycline and sulfa drugs in agriculture is responsible for arising resistant strains thus WHO has suggested this as a high priority issue.

Immune reactions such as hypersensitivity, serum sickness and cutaneous reactions also occur following administration of drugs such as penicillin. According to some reports consumption of hormone (beta-adrenergic agonist such as clenbuterol, salbuterol, cimeterol and diethylstilbesterol) treated meat has found responsible for hormone related cancer such as ovarian, prostate, testes, colon and breast cancer. Few anthelmintic drugs such as benzimidazole have teratogenic effect if it is given during early stage of pregnancy in animal. Other harmful effects includes reversible bone marrow suppression, gray baby syndrome, aplastic anemia, aminoglycosides induced urinary, vestibular and auditory damage. The presence of veterinary medicinal products and their metabolites above the violative level is illegal and subject to financial penalties in many countries.

In recent years pesticides are receiving most interest globally. Although violative level of pesticides are uncommon but a low violation rate even remain an important public health consideration because of their wide spread use in meat and poultry production, their persistence in environment and varying toxicity. Studies suggest an increase in risk in brain cancer, leukemia, Wilm's tumors, Ewing's sarcoma and germ cell tumors associated with paternal occupational exposure to pesticides prior to and during pregnancy. Heavy metals lead to renal damage, cardiovascular disorders, hypertension, growth retardation, irreversible neural and cerebral changes and disturbance in haeme synthesis. Arsenic has more affinity for pulmonary and nervous systems and skins and cadmium produce kidney damage and lead has been associated with learning deficits in children. Being an essential micronutrient copper and zinc may produce metallic taste to the product in higher amount resulting in unacceptability of the product. Along with these chemical residues mycotoxins are also mutagenic, teratogenic, carcinogenic or hepatotoxic to most domestic animals and man. Aflatoxin B1 is the most potent mycotoxin, in terms of occurrence and toxicity and has a potential hepatocarcinogenic effect in various species of laboratory animals tested.

Method of detection of residues in meat:

Pesticides

There are common established conventional method for the detection and quantification of pesticides residues in food of animal origin such as Gas Liquid Chromatography (GLC), Gas Chromatography-Mass Spectrometry (GC-MS), Thin Layer Chromatography (TLC), High Performance-Thin Layer Chromatography (HP-TLC), Liquid Chromatography-Mass Spectrometry-Mass Photometry (LC-MS-MS), High Performance Liquid Chromatography (HPLC), etc. However among these methods colorimetric methods are used only for qualitative

determination due to their low sensitivity and for determination of synthetic pyrethroid and N-methyl carbamate like thermolabile compounds gas chromatography is used.

Now a day along with the conventional methods modern methods based on assays and sensors for cheaper and faster on-site analysis are being developed. Sensitive enzymatic sensors are available that functions by the selective inhibition of an enzyme but only limited to quantification of either an individual or a class of pesticides. Beside this biosensors based on immunological assays have been developed with detection limit of 0.1 μg L-1. Although application of biosensors in meat system for detection of pesticide residues is very limited.

Veterinary drug residue

The currently used conventional methods for determination of veterinary drug residue in food are microbiological assays (microbial receptor assays, microbial growth inhibition assays and enzymatic colorimetric assays), receptor binding assays, immunoassays (ELISA kits) and chromatographic methods (Liquid chromatography). In recent years biosensors have been developed as an alternative approach to detect veterinary drug residues in meat. With the help of biosensors simultaneous real time detection of single or veterinary drugs residues in a sample at a time is possible. In general these new technologies are getting good reception in control laboratories due to the reduction in total time and possibility to analyze multiple residues in short time for a large number of samples.

Mycotoxins and Bacterial toxins

Thin layer chromatography (TLC) and HP-TLC are conventionally used for mycotoxin detection in foods but for food and environmental control a great number of specific sensors for detection of bacterial toxins and mycotoxins have been developed. Various evanescent wave immunosensors have also been reported to be capable of detecting botulin with very low limits of detection. A rapid and sensitive immunosensor for the detection of the Clostridium botulinum toxin A has also been developed.

Prevention and Control:

To control the residue problems in food government agencies are spending lots of time and money and besides having high public awareness regarding the drug residue problem in food and animal tissues it is still an important concern today. When the animal is slaughtered or its edible products are collected there should be a safe established legal level for residues by the relevant regulatory authority in the country of origin.

Statutory limits:

For harmonization of chemical residues in food Codex Alimentarius Commission (CAC) have established various statutory limitations such as Acceptable Daily Intake (ADI), Maximum Residue Limits (MRLs), No Observed Adverse Effect Levels (NOAEL), acute reference dose (ARfD) etc and for risk assessment of residues all these statutory limits has an importance.

Acceptable Daily Intake (ADI)

Acceptable Daily Intake (ADI) can be defined as the quantity that will have no adverse effect on consumer health if consumed over a human lifetime and expressed on body weight basis and can be considered as the safety standard for that compound.

Maximum residue limit (MRL)

Maximum Residue Limits (MRLs) are frequently used for residues as statutory limit by regulatory agencies. In United States MRL is termed as tolerance. According to CAC maximum residue limit (MRL) is the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly in accordance with Good Agricultural Practice. MRL is maximum concentration of marker residue such as parent compound, metabolites etc. and it is expressed as parts per million (ppm) or parts per billion (ppb) on fresh weight basis. The Extraneous Maximum Residue Limit of antibiotics of 0.001 mg/kg will be applicable except for Chloramphinicol for which it shall be 0.0003mg/kg or 0.3ug/kg in meat and meat products.

No observed adverse effect level (NOAEL)

The no observed adverse effect level (NOAEL) is defined as the highest dose where the effects observed in the treated group do not imply an adverse effect to the subject. It does not, however, address the interpretation of risk based on toxicologically relevant effects, nor does it consider the progression of effect with respect to duration and/or dose.

Acceptable Operator Exposure Level (AOEL)

The AOEL term is generally used by European Union (EU) and defined as the highest amount of active substance to which the operator may be exposed without any adverse health effect and is based on the maximum level at which no adverse effect is observed in tests in the most sensitive relevance animal species. It is expressed as mg of chemical/kg body weight of the operator.

Acute reference dose (ARfD)

ARfD is a new concept and generally used for assessment of health effect from brief exposure to environmental chemicals. ARfD is an estimate of a substance in food or drinking water, expressed on a body weight basis that can be ingested over a short period of time, usually

during one meal or one day, without appreciable health risk to the consumer on the basis of all the known facts at the time of the evaluation.

Withdrawal Period

Withdrawal Period is a time allowed for residues to deplete to safe levels (tolerances). It is the time between the last dose of the administered drug and the time when the animal can be safely slaughtered for food and it promote consumer safety by certifying that the MRL is not exceeded. They also ensure reinforced safety in case when the MRL is not met. Prevention and control of drug residues can only be resolved by taking into consideration three steps such as risk assessment, risk management and risk communication. There is requirement for the applications of HACCP system and/or GMPs at the farm and slaughterhouse that is usually not available in developing countries. There is a need for strict implementation of conditions such as standardization of methods of for determining minimum residue levels, standardization of testing methods to detect drug residues and establishment of active surveillance programs to monitor residues to prevent international trade barriers associated with drug residues in meat.

Conclusion:

The food of animal origin has become an integral part of the human lifestyle but consumption of contaminated food with chemical substances can lead to chronic exposure leading to the presentation of diseases lacking an apparent cause and being difficult to diagnose. The key to eliminating unacceptable residues lies in their prevention during all stages of animal production. Thus there is a need of strict control for these substances in food by availing appropriate equipment, institutional facilities, and qualified personnel which is still a great challenge for developing nations. All the nations must exercise strict sanitary control to ensure safe food consumption by their population and to prevent agro food industry and global trade in foodstuffs by appearance of new problems.

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FOOD WASTAGE: A THOUGHT BEFORE EAT

Anusha A Thakkannawar* and Nataraj A Durgannavar

Department of Food Processing and Nutrition,

Karnataka State Akkamahadevi Women's University, Vijayapura

*Corresponding author E-mail: anushathakkannawar@gmail.com

Introduction:

Food satisfies the basic need of all beings and it is essential for living. Perceived differently by dissimilar people under diverse contexts, food can be considered as medicine, health essential or it may have symbolic meaning (Strauss, 1963; Lupton, 1996). A suitable definition of food waste was rightly worded by Lipinski *et al.* (2013), who suggested that food, although of good quality and ideal for consumption, does not get consumed, as it is discarded, it means food supplies (grains, vegetables, poultry, & meat) or drinks which was predetermined to feed people now lies in landfills as garbage despite it being fit for human consumption.

"Food waste" is defined under UNEP Food Waste Index as "food and the associated inedible parts removed from the human food supply chain in the sectors viz., retain, food service and households" (UNEP, 2021).

According to the Food and Agriculture Organization of the United Nations (FAO Report, 2011), one third (which accounts to be 56 per cent of the world's food produced in the developed countries and 44 per cent in the underdeveloped countries (Gustavsson *et al.*, 2011) of the total food produced for consumption is either misplaced or wasted globally. If we calculate then it is approximately 1.6 billion tons a year (Gustavsson *et al*., 2011, FAO Report, 2021).

Sources of food wastage at different levels of food supply chain can be classified such as agricultural production, postharvest handling, food processing, storage and warehousing, wholesale and retail distribution, consumption, food service and households.

Unfortunately, the entire supply chain of food in India is crippled with the problem of food losses largely owed to mismanagement. This negligence is taking place at each stage of food system such as harvesting, transporting, processing, packaging and consuming leading to a loss or wastage of around 40 per cent of the total food production as estimated by the aforementioned report.

Food Wastage around Globe

We assume that developed nations, like United States of America, Canada or the United Kingdom, don't contribute towards food wastage, but it was surprising to know that they add to

the global food wastage on a massive scale and that too on a per capita basis. The developed nations grow their food in massive quantities due to the high subsidies and flood the market with their produce. With the overflow of the produce, the excess is kept in warehouses. If the food is kept for long-time in these warehouses it decays, therefore, reducing the eatable food. This is further reduced due to the consumer buying pattern and their obsession with aesthetic quality of food. Vegetables & fruits aside from being healthy tend to wilt, brown, bruise or discolour, this is something the consumers do not prefer to buy. Due to this buying pattern and thinking of the consumers, even grocers refuse to stock such imperfect looking food on their shelves or stands.

The following table 1 suggests a total of around 931 million tonnes of food waste across these three sectors: 61 per cent from households, 26 per cent from food service and 13 per cent from retail around the globe.

Table 1: Estimates of global food waste by sector

	Global average food waste (kg/capita/year)	**2019 total (million tonnes)**
Household	74	569
Food Service	32	244
Retail	15	118
Total	121	931

(UNEP, 2021)

Food Wastage in Developing Nations

It is not just the industrialized nations that have a high percentage of food wastage, but now the developing nations are also closing unto these numbers. This primarily takes place due to the poor infrastructure, dysfunctional distribution systems, and corruption. More than half of the produce in these countries doesn't reach the market and even less to the people who reside there. This is causing a loss of billions, children and adults are micronutrient undernourished, and blighting numerous lives. In these nations, the wastage occurs at early stages of the chain and they can be traced back to the financial, managerial and technical constraints during harvest and the basic problem of storage and cooling units. These countries dissipate 630 million tonnes of food worth US $310 Billion. In sub- Saharan Africa, South & South-Eastern Asia, the per capita waste by a single consumer is between 6-11 kg a year. In developed nations, more than 40 per cent losses transpire at the consumer and retail levels, while in the developing nations 40 per

cent of the losses transpires at post-harvest and processing levels. These losses that takes place during harvest and storage converts into lost income for the farmers and high food prices for the consumers.

For example, despite producing 28 per cent of the world's bananas, India is only able to export 0.3 per cent of it internationally. With the help of cold storage units, the number of exported bananas could increase from 4,000 to 190,000 containers thus creating 95,000 additional jobs and benefitting many small-scale). According to reports, developing countries faced food wastage problem due to inadequate infrastructure for production and trade while in developed countries, retailer- consumer interaction led to food wastage (Parfitt *et al*., 2010). Dung *et al*. (2014) have reported that the per capita food wastage in developed countries is 107 kg/year and in developing countries it is 56 kg/year.

Table 2: Estimated food losses in different regions:

Sl. No.	Region	Estimated food loss per capita (kg/year)
1	South and Southern Asia	120
2	Sub-Sahara	170
3	North Africa, West and Central Asia	120
4	Latina	220
5	Europe	280
6	North America	300

Source: Abu Saadat *et. al*., (2016)

Estimated food losses in different regions of the world are mentioned in the table 2. In South and Southern Asia, it is estimated to be 120Kg/year which is the lowest and the highest being reported in North America (300 kg/year).

Scenario of Food Wastage in India

In a CSR Journal report, it stated that "Indians waste as much food as the whole of United Kingdom consumes" Our traditions and culture play one of the major role in these situations where the policies of the government aren't responsible for such wastages. Here in India, the bigger the wedding, the bigger the food wastage is expected to be. Today the number of individuals who are hungry in India are more than 65 million, which is statistically higher than

the population of few countries in the world. Despite India's largest livelihood being agriculture, there is a struggle to feed it's ever- growing population. As India is a developing nation, 40 per cent of the produce is lost during post-harvesting and processing level. The farmers in India do not have money to be technologically ahead of their counterpart in America, so they don't have the facility to store their produce in cold storage, therefore, they end up losing some part of their harvest to decay. Another aspect on which India's farmer lose out is transportation. India suffers losses of up to £4.4 billion in fruit and vegetables each year due to the absence of effective technologies to keep produce cool. As per the Food Waste Index Report 2021, an overwhelming 50 kg of food is thrown away per person every year in Indian homes.

With the growing economy, lifestyle changes are seen where rich people throw lavish parties where the quantity of food cooked is over estimated on most occasions and the left over or surplus food goes to the waste-bins in large quantities. A huge amount of food waste usually takes place at Weddings, Religious feasts, Parsad, and various social gatherings. At Bangalore, annually 943 tonnes of food wasted during weddings is enough to serve 2.6 crore people a normal meal and at an average cost of 40/- per meal the food worth rupees 339 crore is wasted. Wastage is more with buffet (22%) than served meals (20%). In Bhubaneswar food waste contributes to 26.6 per cent of the city waste which is directly thrown into the bins. In Jaipur 835 tonnes of food is wasted every day out of the approximately 7500 tonnes food purchased every day. Most of the food waste occurs at catering services and in marriages because of the leftover food in plates, this accounts to 30 per cent followed by hotels and wholesalers about 17 per cent, hospitals about 15 per cent, households about 13 per cent and the minimum wastage is at Community centers of about 10 per cent. In terms of money, food thrown away in Jaipur city costs about Rs. 6.2 million per day. About 40,000 marriages take place in Jaipur every year and the wastage in such events accounts to more than 25-30 per cent; which is enough to serve another 5000 marriage parties5. All this food goes waste when there is no channel to distribute it to the needy. The caterer needs to vacate the party place overnight and therefore; much of the surplus food is thrown away in the bins (Agrawal, 2013).

Factors influencing Food Wastage

Food wastage happens at several levels of supply chain of food such as agriculture, food processing and warehousing, wholesale and retail distribution, food service and households. A considerable share of such waste takes place at the consumer level and is attributed to consumer behaviour and wide ranging socio-economic factors along with practices followed at the stages of processing and retailing (Evans, 2011; Quested *et al*., 2013). Previous studies highlighted the

huge role of consumers in determining total size of food wastage (Griffin *et al*., 2009) which is far greater than the waste generated during food harvesting, processing and distribution (Neff *et al.,* 2015). Food retailers play a key role in food wastage as well as prevention of wastage (Aschemann-Witzel *et al*., 2015). Studying consumers' perception about behaviour related to food waste would be useful as consumers do not recognize the repercussions of food waste on environment (Stefan *et al.,* 2013).

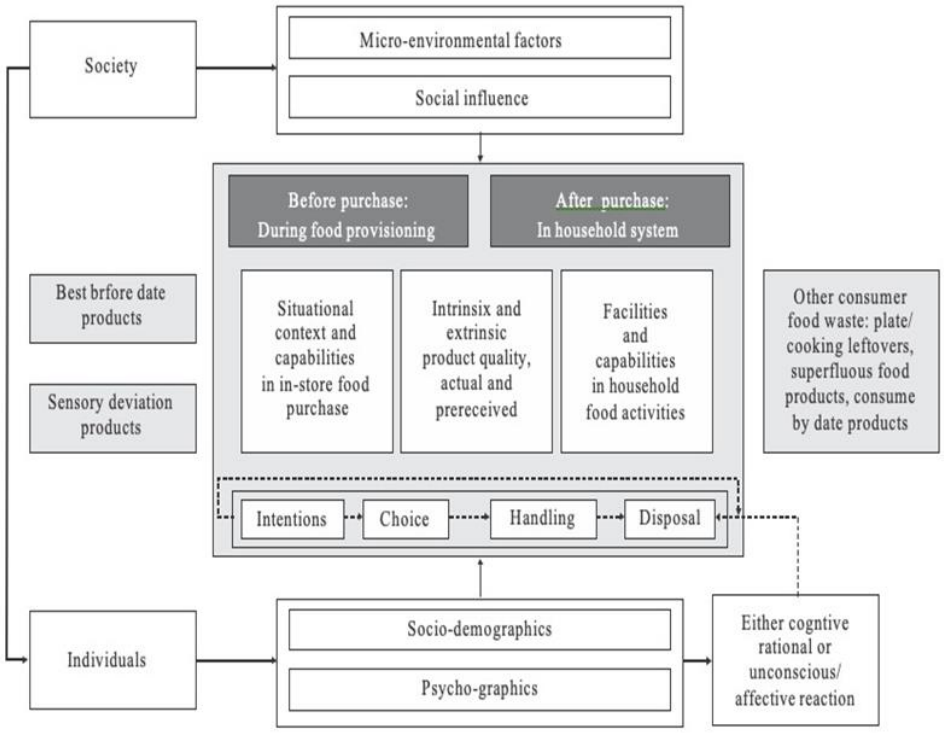

Figure 1: Model of the factors of influence on consumer related food waste

Source: Aschemann-Witzel *et.al.* (2015)

Consequences

Wastage of food can cripple a nation's economy to such an extent that most of us are uninformed. Wastage of food not only has a negative impact on the individuals of the nations but the economy and the environment. The excess food waste usually ends up in landfills, creating potent greenhouse gases which have dire environmental implications.

'The State of Food Security and Nutrition in the world, 2017' report of Food and Agriculture organization (FAO), UN claimed that 190.7 million people in India are malnourished which indicates towards the gravity of situation at present, it even stated that close to 190.7 million Indians are severely undernourished, it refers to 14.5 percent of the population With over 1.3 billion people in a nation like India, millions are still sleeping hungry. In the Global Hungry

Index - 2017, India ranks 100 among the 119 countries. Further, in the report, it stated that 38.4 per cent of the children are malnourished and 51.4 per cent of the women in their reproductive age (15-49) are anaemic.

Table 3: Causes and Consequences of food wastage in India

Sr. No.	Causes of food wastage in India	Consequences of food wastage in India
1)	Poor infrastructure in terms of roads insufficient number of cold storage, connectivity of ports, Railways etc.	Global greenhouse gas emission
2)	Inefficient food management at function such as marriage , conference etc.	Aggravated level of poverty and nutrition in the country
3)	Acceptance of over consumption a social norm	Wastage of valuable input resource such as water
4)	Availability of excessive number of varieties or options	Adverse effect on natural resources

Source: Shrivastava S. K. *et al*. (2019)

This table gives information about the causes of food wastage in India and the consequences. It shows the areas that need to be worked upon in order to curb the problem of food wastage in India are:

1. Developing a robust system of storage and distribution
2. **Household management**: Planned purchasing and consumption in households can create an effective impact over the amount of food wastage at household level.
3. **Proactive policy related measures**: Since a significant part of wastage of food in India takes place at the level of consumption, policy makers need to shift their attention to consumer antecedents of food wastage and draft rules to encourage responsible consumption.
4. **Environment friendly consumer preferences**: Some of the immediate steps as suggested by EU are planned buying, awareness about consumption dates, consideration for budgetary constraints, healthy refrigeration and storage, serving small portions, reuse of leftovers and compost production.

5. **Sustainable corporate practices**: Corporate should step forward to undertake social audits and evaluate their environmental and social footprints. Food wasted while moving through the supply chain or at the retailers' outlets is a cause for concern and should be taken as such by the business houses as well. The players of food chains need to treat elimination of wastage as a crucial component of their CSR practices and look into the ways to redefine proper means of profitability.

Measures undertaken to prevent food wastage

Every piece of food wasted is an opportunity lost to improve world hunger and global food security. The Annakshetra is a unique initiative by Centre for Development Communication (CDC), Jaipur that aims to minimize food wastage by effectively rescuing the excess food from weddings, parties, restaurants and temples. It is aimed at filling the gaps in existing society by delivering the spare food collected from donors to the needy people of local community.

a. Developing a robust system of storage and distribution: In a bid to offer solutions for the problem of food wastage, Kumar (2015) advised that there is an urgent need for developing cold storages and boosting connectivity in terms of railway, road or highways in order to make fruits and vegetables available for consumption at remote Indian locations.
b. Household management: Planned purchasing and consumption in households can create an effective impact over the amount of food wastage at household level. Learning and practicing ways to increase shelf life of food items, retain freshness of food, keep them dry, cooking in adequate measures, need based purchasing at regular intervals etc. are important to curb the problem of food going rotten and inedible.
c. Proactive policy related measures: Since a significant part of wastage of food in India takes place at the level of consumption, policy makers need to shift their attention to consumer antecedents of food wastage and draft rules to encourage responsible consumption. This calls for changes in public's perception, attitude and behaviour with regard to consumption as well as disposal of food that is available to them. Organization of educational campaigns and awareness programmes intended to enlighten the public about causes and prevention of food wastage in homes, offices and events needs to be accelerated throughout the country
d. Environment friendly consumer preferences: Some of the immediate steps as suggested by EU are planned buying, awareness about consumption dates, consideration for budgetary constraints, healthy refrigeration and storage, serving small portions, reuse of leftovers and compost production.

Conclusion:

In India, as it is a developing nation 40 per cent of our produce is lost during post-harvesting and processing level, Indians waste as much food as the whole of United Kingdom consumes, if we prevent this food wastage by following various preventive measures to reduce food wastage in India then we will be able to achieve food security, reduce the hunger of the population thereby decreasing the hunger index of the country.

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Suryawanshi, J. R., 2019, System to Reduce and Manage Waste Food. *IRJET Journal*, 6(3) waste in developed and less developed countries: opportunities to improve resource use. Journal of Agricultural Science 149: 37-45.

OPPORTUNITIES AND SCOPE OF AGRI-ENTREPRENEURSHIP IN INDIA

Berjesh Ajrawat[1] and Anamika Jamwal[2]

[1]Department of Agril. Extension

[2]Department of Plant Protection

Krishi Vigyan Kendra, Kathua,

Sher-e- Kashmir University of Agricultural Sciences & Technology of Jammu

Corresponding author E-mail: bajrawat@gmail.com, annajamwal@gmail.com

Abstract:

A shift from agriculture to agribusiness is an important pathway to revitalize Indian agriculture and to make more striking and lucrative business enterprise. Agripreneurship have the potential to contribute to a range of social and economic development such as income generation, poverty reduction, employment generation and improvements in nutrition, overall food security and health in the national economy. Agripreneurship has potential to diversifying income, providing widespread employment; generate growth and entrepreneurial opportunities and income generating activities in rural areas. Agripreneurship is the need of hours to make agriculture a more attractive and profitable business enterprise. An individual with risk bearing capacity and a quest for latest technical knowhow in agriculture sector can prove to be a right and successful agripreneur. The agriculture sector has a vast and immense potential to contribute to the national income and economy while at the same time providing direct employment and income to the numerically larger and vulnerable section of the society. Agri-entrepreneurship is not only an opportunity but also a necessity for improving the production, productivity and profitability in agriculture and allied sector. The traditional approach to rural development was top down and from below technology has been adopted to gear the entrepreneurship in rural and urban areas. Nowadays easy access to technology, emergence of micro financing, liberalized government rules, awareness and training programmes on agriculture and allied sectors and finally changing mindset of highly qualified people to go for self employment in the field of agriculture have contributed significantly in enhancing the potentiality for agripreneurship in India.

Keywords: Agriculture, opportunities, scope, agripreneurship

Introduction:

Agriculture sector is contributing 16.5 percent to the GDP of the nation and it has enclosed more than 50% of workforce who are still busy in Agriculture and different allied activities. Though higher workforce is involved, they are not self reliable to earn their earning and is not essential to rethink about the shift in agriculture sector. In this situation, the concept emerged was agri entrepreneurship or farm entrepreneurship which apparently reimbursement the small scale farmers to be self reliant and independent. The National Institute of Agricultural Extension Management (MANAGE) has classified 32 different activities of agribusiness all over India covering Agri-clinics , soil testing, piggery, floriculture, poultry, dairying, apiculture etc. There are different types of research are undertaken to identify the opportunities and challenges in agribusiness and also coming up with suggestive measures to encourages and develop agri entrepreneurship in India.

The well being of the farmers is imperative to nation's wealth, farmers as agriculture is lookout of our food security. Our Nation ranks second in worldwide in farm produces and in India most of the people depend on agriculture for their earnings but the contribution from this sector to Gross Domestic Product is not up to the mark and is trifling when compared to workforce it has involved. If technology and policy intervention are not blended with agriculture, the productivity would continue to remain same and load on agriculture is continue with huge number of disguised unemployment. In this context bringing the structural transformation in Indian agriculture through innovative and pioneer agriculture entrepreneurship is most essential. Entrepreneurship can be defined as a process where inculcating the essential entrepreneurial skills to a common man by providing the attractive knowledge and getting higher the managerial, finance and technical know-how. But since the dawn entrepreneurship it has been only confined to the industries and business undertakings but now bringing the entrepreneurship to the agriculture sector could help the country to be self sufficient and sustainable in agriculture.

Formerly, agriculture is considered as life leading movement with huge numbers of disguised unemployment in pastoral household, consequently the involvement from agriculture sector also been abandoned and it was considered as a low tech business which has no potentiality to gear more input to the economy and development. Since most agriculture outliers are forced to migrate to nearby cities and towns in the search of food and work, often in the unorganized and unskilled sector. This highlights the need for developing more innovative mechanism in the rural economy that boosts employment opportunities in the agriculture and allied sector, which can be called entrepreneurship in agriculture. Since the new mechanism not

only develops an alternate source of employment but also helps radicalize farming techniques and brings innovation to improve yield per hectare.

Entrepreneurship is one of the main drivers for economic development. During an economic crisis, the importance of entrepreneurship development increases. Entrepreneurship has been linked to increased wealth; improve growth and quality of life. In developing countries like India planning and implementation for development of entrepreneurial programmes and activities are essential to raise the living standard of the high majority of the backward areas and regions because of their over-dependence on agriculture for employment. Therefore entrepreneurship development appears to be the best substitute to find employment opportunities, income generation, poverty reduction and improvements in health, nutrition and overall food security in Indian Economy.

Agriculture is considered as the main economic activity which adds to the overall wealth of the country. In the past, agriculture was seen as a low tech industry dominated by numerous small family firms which are mostly focused on doing things better rather than doing new things. However in the last two decades, this situation has changed drastically due to economic liberalization and a fast changing society. Agricultural companies have to adopt to the erratic demands to the market, varying consumer habits, stringent environment regulations, new requirements for product quality, food safety, sustainability and so on. These changes have opened the way for new entrants, innovations and portfolio entrepreneurship, researchers, farmers, agricultural business and governments have recognized this and emphasized for a more entrepreneurial environment in the agriculture sector.

The entrepreneurial skill and business related activities of the farmers and youth needs to be developed and addressed by all stakeholders in the agricultural socio economic network. There is various strategies available to the farmers for survival and changing their economic environment which results in business growth for example the farm enterprise may be expanded through agri ecotourism or other forms of non agricultural business or by integration of the value chain by engaging in direct marketing, food processing or through organic crop production. The social and economic environment of farming should not be under estimated when studying and promoting the development of entrepreneurial skills. Entrepreneurship can only be improved when the entire agricultural socio technical network is involved in the process. Thus strategies to strengthen and stimulate the entrepreneurship culture of the farming business and sustainable in rural areas are needed. Entrepreneurship is the capability and ability to develop ideas and attain success with them. Innovation ability to accept change and risk and the organizations of resources are the major factors involved in creating a sustainable enterprise. The entrepreneurial

spirit is responsible for generating employment, competitiveness and the ability to exploit any sector or business. Entrepreneurship is a feasible approach for upward mobility as a 1 percent increases in entrepreneurial activities decrease the poverty rate of 2 percent.

The word entrepreneurship means a dynamic process of creating progressive asset. This asset is produced by individuals who take the risk in the form of time, equity and career obligation of giving worth to some product or services. There are chances that the product or service may or may not be new or unique but value must be inculcated by the entrepreneur. Simply we can say that entrepreneurship is the use of energy for commencing and building an enterprise. Consequently entrepreneurship is a fascinating notion, widely used and defined as a creative and innovative response to the environment. It can also be defined as a process in which a representative manages to visualize and implement an idea, belief, service, product or activity (Bernier and Hafsi, 2003).

Investigation and different studies suggests that agricultural sector is comparably more effective in reducing poverty as any other sector. Food prices reduce for poor people by increased crop production and productivity resultant decreased poverty.

Agri-entrepreneurship in common language can be defines as sustainable, community oriented, directly marketed agriculture. Sustainable agriculture refers a system oriented approach to farming that put emphasis on the interrelations of social economic and environmental processes. It is the beneficial combination of agriculture and entrepreneurship and it converts your farm into an agribusiness. This association of agriculture with business promotes agripreneur who identify markets, innovates and satisfy needs by developing different ways.

Agri-entrepreneurship has the prospect of social and economic development for employment generation, poverty reduction and improvements in nutrition, health and overall food security in the national economy especially in rural areas. In the face of growing unemployment and poverty in rural areas, there is urgency of entrepreneurship in agriculture for more production, productivity and profitability. Agri-entrepreneurship can be used as a chief remedy for the solution of this complexity such as lower the burden of agriculture, produce employment for rural youth, control migration from rural to urban areas boost national income, sustain industrial development in rural areas and cut down the pressure on urban areas.

Entrepreneurial development is an efficient and a prescribed development of a person to an entrepreneur. The development of an entrepreneur refers to inculcate the entrepreneurial skills in to common person including the desirable knowledge, higher technical, financial, marketing and managerial expertise and building the entrepreneurial outlook. Entrepreneurial development programmes may be defined as a program planned to assist an individual in escalating his

entrepreneurial drive and inculcating skills and capabilities necessary for playing his entrepreneurial role effectively. In real sense, entrepreneurship expertises are those competencies which are vital to carry out different tasks and activities related to the farm business can be developed by learning by doing and experience.

Due to liberalization and globalization of trade in agriculture and the policy reforms at national level, the scope and opportunities in the agri-entrepreneurship have significantly extended, leading to an extraordinary business interest in this sector. The world wonders and hopeful for the fast growing Indian rural market, which is crucial for building corporate growth strategy in the country. According to different surveys conducted by different organization and agencies total rural market in India is larger than urban market.

Agribusiness has offered a huge number of prospects for value addition, packaging, retailing and exports of agricultural products with advance technology and management. A lager part of Indian population is dependent on agriculture and this area also supplies raw material for different industries. Agri business is most likely to control the progressive growth of Indian economy. In the present scenario about one fourth of our fruits and vegetables are getting spoiled before reaching to the consumer due to lack of adequate infrastructure facilities, however due to rapid shift in the nature of agribusiness demand for competent and dynamic professionals has developed multiples times from last few years. Since policy reforms are introduces by the World Trade Organization (WTO) regime, the opportunity and scope in the agri business has been increased. A large number of opportunities have opened in the industries like packaging, processed agri food manufacture, supply of raw materials, export of agricultural products and other allied fields. Rising of micro financing related government regulations, accessibility to high technology, guidance and workshop on agri enterprises and related areas have changing outlook of highly skilled personnel and resultant they are opting for self employment in agriculture mounting the agripreneurship prospective in India. There are various areas in agriculture where entrepreneurship can be developed which includes mushroom cultivation, apiculture, dairying, sericulture, goat and sheep rearing, rabbit rearing, floriculture, pisciculture, viticulture, shrimp farming, vegetable cultivation, nursery farming and agro forestry.

Kathua district has more potential for round the year mushroom cultivation in the district due to different types of agro-climatic conditions right from sub-tropical to temperate. The total mushroom production in the Union Territory of Jammu & Kashmir is around 630 metric tons, with ample demand in the market. The youths of the district are showing intense curiosity in cultivation of different species of mushroom because mushroom cultivation generates more income as compared to other crops. Krishi Vigyan Kendra, Kathua is promoting mushroom

production under ARYA project. Year round cultivation of the mushroom is being promoted with minimal processing in the form of mushroom pickle, mushroom powder. Hands on training are being provided on low cost mushroom production.

- Enterprise: Mushroom Production
- Number of youths trained: 60
- Number of groups formed: 5
- Number of youths established their own units: 26
- Number of youths running the units sustainably: 26
- Average size of each unit: 500 bags
- Cost of production per unit: Rs. 55/bag
- Sale Value of the produce: Rs. 60/ Kg
- Net Economic gain (Rs./Unit/year): Rs.52500
- Employment generation: 52 youth employed for 240 days in a year.

Mushroom Unit established under ARYA project

Extension activities carried under ARYA Project

The youth of the district were encouraged to grow white button and oyster mushroom during the month of September to March and milky mushroom during the month of June to August to supplement their family income. Annual production of mushroom in the district increased from 517 quintals in 2010-11 to 1350 quintals in 2017-18. Numbers of mushroom grower increased subsequently, after the initiation of the project in KVK, Kathua. During the year 2011-12, sixty-eight beneficiaries were covered under different activities conducted by KVK, Kathua but in the subsequent years their numbers rose to 1350 till 2017-18 indicating an increase of nearly hundred percent.

Conclusion:

Agri entrepreneurship is the call of the hour to make agriculture a more profitable and attractive business enterprise. Agriculture has immense scope for entrepreneurship and this can be harnessed only by effective management of agri-components like seed, soil, water and market needs. Agriculture and domestic business provide about fifty percent of employment in half of all jobs in developing countries but do not produce adequate income to raise people out of poverty. Thus enterprenurial actions associated with agriculture generate a solution for growing household incomes. The good managerial skills and entrepreneurial expertise infuse with government measures would facilitate accomplishment of the growing needs of agri business. An

individual who is confident, risk bearer, honest, visionary and innovative can prove to be a right agri entrepreneur. Agri entrepreneurship contributes to the national income along with direct employment and income to the larger and especially in rural area. Value added products offers entrepreneurship with larger returns on investment and profits. Therefore entrepreneurs' have to take benefit change in consumers demand and satisfy consumer needs with value added products.

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STUDY ON WEED SPECIES IN SPRING MUNGBEAN UNDER *TARAI* REGION OF UTTARAKHAND

Gargi Goswami*[1], Chandra Bhushan[2] and Arunima Paliwal[3]

[1]VCSG UUHF Bharsar (U.K.),

[2] Institute of Agricultural Science, BHU (U.P.)

[3]VCSG UUHF, Ranichauri (U.K.)

*Correspondiing author E-mail: gargi.goswami1423@gmail.com

In a developing country like India, pulses play a vital role in Indian agriculture and their cultivation is well spread all over the country. They serve as a chief source of protein for predominantly vegetarian Indian population. Substantial quantity of essential amino acids like lysine, which is deficient in cereals, and a moderate amount of calcium and iron are supplemented by the pulses. Mungbean [*Vigna radiata* L. Wilczek], subgenus also known as greengram is more palatable, nutritive, digestible and non-flatulent than the other pulses. It is mainly consumed as *dal* in India. The green plants can also be used as animal feed and green manure, and its residues have manurial value. The crop is potentially useful in improving the cropping pattern as it can be grown as a catch crop due to its rapid growth and early maturing characteristics. Seeds of mungbean are highly nutritious and rich source of easily digestible protein (26%) and iron with some improved variety containing 6 mg of iron per 100 g raw seed (Vijayalakshmi *et al.*, 2003). Mungbean grain contains 51% carbohydrate, 26% protein, 10% moisture, 4% minerals and 3% vitamins like vitamin A (94 mg), iron (7.3 mg), calcium (124 mg), zinc (3 mg) and folate (549 mg) per 100 g of dry seed. Mungbean sprout is a good source of vitamin C (8 mg per 100 g).

Agriculture is a resultant of “controversy with weeds”. Indeed, the crop losses due to weeds are often more than that of insects and diseases, combined. About 37 per cent of the total losses in agriculture are due to weed competition. Weeds compete with crop plants and utilize considerable amount of moisture, nutrients and space in lithosphere and atmosphere and, thus, deprive opportunities for the crop to express its potential. The competition becomes intense in hot and humid climate. Being a spring season crop, mungbean suffers badly from weed competition especially at the early stages.

A field experiment was conducted at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, during spring season of 2012 to study the effect of

fertility levels and weed management practices on spring mungbean. The soil of experimental area was sandy loam in texture, high in organic carbon (0.87 %), while medium in nitrogen (320.81kg/ha), phosphorus (12.2 kg/ha) and potassium (218 kg/ha) content with a slightly alkaline soil reaction (pH 7.7).

The experiment consisted of twenty treatments comprising four fertility levels (Recommended dose of fertilizer 'RDF' [20 kg N: 55 kg P_2O_5: 25 kg K_2O/ha], ½ RDF + 2% urea spray at 40 DAS, two sprays of 2% at urea 25 and 45 DAS, and control) and five weed management practices (Pendimethalin @ 1 kg/ha PE, Imazethapyr @ 50 g/ha PoE, Chlorimuron-ethyl @ 4 g/ha PPI, hand weeding @ 25 DAS and weedy check) tested in split plot design with three replications. Spring mungbean (Pant Mung 5) was sown at a row spacing of 25 cm apart in March and was harvested as per the maturity of different treatment plots. Weed flora of experimental field were collected, identified and classified as sedges, grassy and broad leaf weeds. It was observed that out of 5 weed species identified (Table 1), 3 species *Cyperus rotundus*, *Cyanodon dactylon* and *Parthenium hysterophorus* were predominant under weedy condition accounting for 40.7, 34.7 and 18.8 per cent contribution of the total weed population, respectively during whole crop growth periods (Table 2, Fig. 1). Also it was seen that there was an increase in weed population upto 60 DAS, while it decreased at the harvest. Further, it was observed that maximum population of the *Cyperus rotundus and Cyanodon dactylon* were observed with the recommended fertilizer dose (RFD) followed by ½ RFD + 2% urea spray while the minimum in control among the fertility levels and amongst weed management practices, the lowest weed population was observed with one hand weeding at 25 DAS followed by PE application of pendimethalin. Maximum weed population of these two weeds were in the weedy check. Population of *Parthenium hysterophorus* was observed from 45 DAS and was found maximum with recommended fertility level and weedy check, while the minimum in control and hand weeding among fertility levels and weed management practices, respectively. Other weeds were observed maximum under the recommended fertility level and the weedy check, while the minimum in control and the hand weeding among fertility levels and weed management practices, respectively. Pendimethalin @ 1 kg/ha PE proved to be the most effective among herbicides in controlling weed population.

Table 1: Weed flora of experimental field during spring season, 2012

Botanical name	Family	Common name	Annual/Biennial/Perennial
Grassy weeds			
Cynodon dactylon L. Pers.	Poaceae	Doob grass	Perennial
Digitaria sanguinalis L.	Poaceae	Tackri ghas	Annual
Broad leaved weeds			
Parthenium hysterophorus L.	Asteraceae	Gajar ghas	Perennial
Ageratum conyzoides L.	Asteraceae	Mahakaua	Annual
Sedges			
Cyperus rotundus L.	Cyperaceae	Motha	Perennial

Table 2: Percent composition of the major weeds species in the weedy treatment at different stages of crop growth

Days after sowing (stages)	*Cyperus rotundus*	*Cynodon dactylon*	*Parthenium hysterophorus*	Other weeds
30	47.2	40.2	-	12.0
45	38.4	34.1	15.5	12.0
60	41.1	32.8	17.3	8.4
Harvest	36.1	31.8	23.5	8.6
Average	40.7	34.7	18.8	10.3

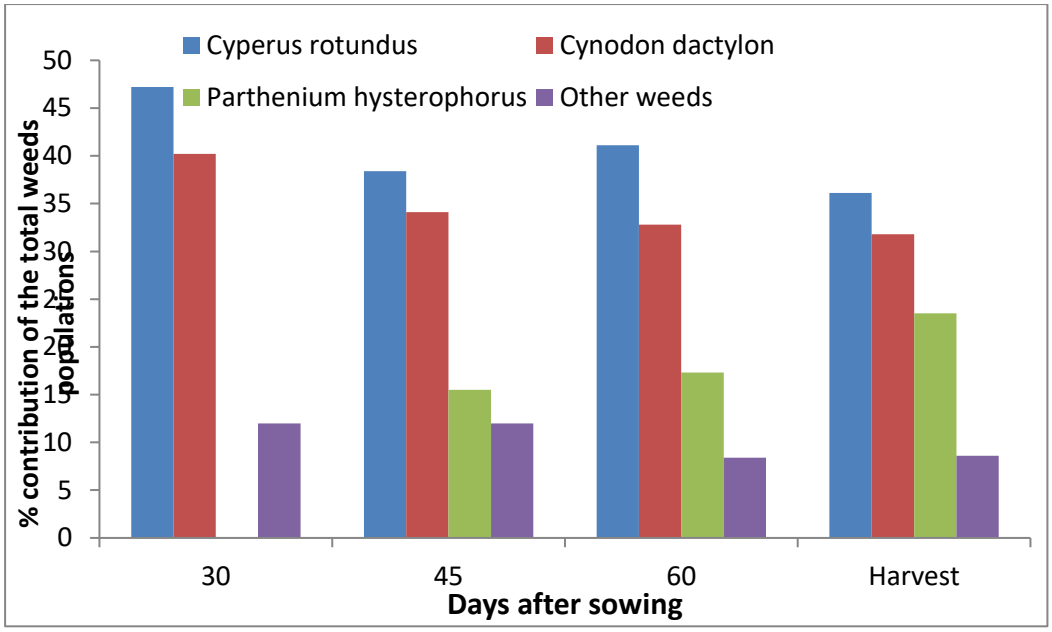

Figure 1: Per cent composition of the major weed species in the weedy treatment at different stages of crop growth

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ECO-FRIENDLY MANAGEMENT OF WILT DISEASE OF PIGEON PEA

M. A. Patekar* and R. P. Biradar

PG Department of Botany,

Shivaji College, Udgir, Dist. Latur, Maharashtra

*Corresponding author E-mail: manisha.patekar@gmail.com

Abstract:

Pigeon pea is an important legume crop of rain-fed agriculture in the semiarid tropics. Pigeon peas are very drought resistant and can be grown in areas less than 650mm annual rainfall. More than 80% of Tur production comes from 6 states of Maharashtra, Madhya Pradesh, Karnataka, Uttar Pradesh, Gujarat, and Jharkhand. India is the world's largest producers and consumers of pulses. Wilt diseases caused by *Fusarium* sp. are an important factor that limit yields and reduce quality of edible legumes. The yield losses amount around 50% in pulse crop. In pigeon pea, wilt is predominant in all major pigeon pea growing areas throughout the world and causes 30-100% yield loss. Eco-friendly control of fungal pathogens by medicinal plant extracts is a potential alternative to the use of synthetic agrochemicals, which have already been proved to be harmful to the environment. The present study was conducted to evaluate the effect of aqueous leaf extracts from *Azadirachta indica* on the growth of Wilt pathogen. The different concentrations (2.5%, 5.0%, 7.5% and 10.0%) prepared from the leaf extract inhibited the growth of the test pathogen and the effect gradually found increased with increase in the concentration.

Keywords: Eco-friendly control, Legume seed pathogens, *Fusarium*.

Introduction:

India is the largest producer of Legumes with over a dozen of pulse crop grown on about 25.43 ha. of land and 18.24 MT of production with an average of 679 kg. per ha. yield (Sinha et al., 2018). Pulses, sometimes known as "poor man's meat" and "rich man's vegetable," are key sources of proteins, vitamins, and minerals that help to ensure the world's nutritional security (Singh et al., 2015). They are rich in macro and micro-nutrients, and they provide nutritional security to the whole world.

India is the worlds largest producer and consumer of the Pluses. Pulses production of India is around 19.3 MT (ESI, 2015; Singh *et al.*, 2017). Pulses are grown in all three seasons in the Indian subcontinent *viz.* i. Kharif, covering *Cajanus cajan* (L.) Millsp, Arhar (Tur); *Vigna mungo* (L.) Hepper, Urd (Blackgram); *Vigna radiate* (L.) Wilezek, Moong (Green gram); *Vigna*

unguiculate (L.) Walp, Lobia (Cowpea); *Macrotyloma uniflorum* (Lam.) Verdc., Kulthi (Horsegram) and *Vigna acontifolia* (Jacq.) Marechal., Moth; ii. Rabi – *Cicer arietinum* (L.), Gram; *Lens culinaris* Medik, Lentil; *Pisum sativum* (L.), Pea, and *Phaseolus vulgaris* (L.), Rajmash iii. Summer – *Vigna radiate* (L.) Wilezek, Greengram; *Vigna mungo* (L.) Hepper, Blackgram and *Vigna unguiculate* (L.) Walp, Cowpea (Sinha *et al.*, 2018).

Pigeon peas are abundant in nutritious components. Here's a breakdown of what's in a 160g or 1 cup serving of pigeon peas. According to reports, the protein level of widely produced pigeon peas ranges from 18.26% to 18.36%. (Swaminathan and Jain, 1973). India has produced a high protein line (HPL) with a protein content of up to 32.5 percent and considerably greater sulphur-containing amino acids (Cysteine and Methionine). As a result, pigeon pea is an excellent supplier of amino acids. The seed contains 51.4-58.8% carbs, 1.2-8.1% crude fibre, and 0.6-3.8 % lipids (Faris and Singh, 1990). It's high in nutritional minerals including calcium, magnesium, iron, and potassium, as well as water-soluble vitamins like thiamine, riboflavin, and niacin.

Diseases are a major influence in limiting yields and lowering the quality of edible legumes. Although legume crops are susceptible to a variety of insects, pests and disease, seed-borne disease is a significant source of worry since its occurrence, if not managed, may destroy the crop. Pigeon pea is infected with 210 pathogens (83 fungi, 4 bacteria, 19 viruses and mycoplasma, and 58 nematodes) from 58 nations worldwide, with 98 infections recorded in India (Nene, 1996). *Cercospora cajani* (27 nations) and *Fusarium udum* (20 countries) are the diseases with the most widespread distribution. Among these diseases, *Fusarium* wilt is widespread in legumes growing regions. Wilt diseases caused by *Fusarium spp.* found to be important factor in limiting the overall yield and the quality of edible legumes. In pigeon pea, wilt is predominant in all major pigeon pea growing areas throughout the world and causes 30-100% yield loss (Nongmaithem *et al.*, 2017).

Fusarium is a fungus that may be found in soil from all over the globe. It may be found not just in temperate and tropical climates, but also in extreme environments like the arctic and deserts (Gerlach and Nirenberg, 1982; Nelson, 1983). Vascular wilt caused by *Fusarium oxysporum* f. sp *udum* (Butler) is one of the most serious and damaging disease of Pigeon Pea in India.

The use of biologically based compounds in plant extracts may found to be an alternative to currently used fungicides to control phytopathogenic fungi, because they virtually constitute a rich source of bioactive chemicals such as phenols, flavonoids, quinons, tannins, alkaloids,

saponins and sterols (Burt, 2004). Medicinal plant leaf extracts were used to suppress disease-causing pathogens in this study, since medicinal plant extracts have been given a lot of attention.

Azadirachta indica, also known as Neem, Nim tree and Indian Lilac is a tree in the mahogany family - Meliaceae. It is one of two species of the genus *Azadirachta,* and is native to India, Pakistan and Bangladesh, growing in tropical and semitropical regions. The neem tree has a high concentration of triterpenoids. Over 100 structurally similar chemicals have been identified from various portions of the neem tree (Johnson *et al.,* 1996). The limonoids, also known as tetranortriterpenoids, are a class of highly oxygenated heterocyclic compounds having alkoxy and hydroxyl groups, the most well-known of which is azadirachtin. Salannin, nimbin, 3-desacetylsalannin, and 6-desacetylnimbin are other related chemicals (Jarvis *et al.,* 1999).

Materials and Methods:

Isolation, purification and identification of pathogen from infected pigeon pea plant:

Disease samples, naturally infected pigeon pea plants showing typical vascular wilt symptoms just after the initiation of the diseases at different development stages were collected from pigeon pea crop grown at nearby farm of Udgir. Collected samples were brought to laboratory for isolation, for identification and description of pathogen. The samples were examined under compound microscope to confim1 the presence of fungus. After confirming for the presence of fungal spores, isolation was done by following standard tissue isolation method.

The plants parts showing brown discoloration of vascular tissues were cut into small bits and washed well in running tap water. The bits then surface sterilized with 0.1 % mercuric chloride solution for 1 minute followed by three washing with sterilized distilled water, dried by placing in between the two sterile blotters and finally kept on previously poured glucose nitrate agar medium in petriplates for isolation of fungus.

Spores of *Fusarium oxysporum* f. sp *udum* was taken from the pure culture and mounted on the clear glass slide. Spores were mixed thoroughly with Lactophenol in order to obtain a uniform spread over on which a cover slip was placed. The spores and hyphae of the fungus were observed by using camera Lucida attached to compound microscope.

Bio-control of disease causing pathogen by using plant extracts:

Leaf extracts of various concentrations (2.5%, 5.0%, 7.5% and 10.0%) of *Azadirachta indica* A. Juss was examined against isolated *Fusarium oxysporum* f. sp *udum.*

Preparation of aqueous extracts:

Green leaf samples (100gm) were collected and washed very carefully with distilled water. Then plant parts were ground with conventional grinder called '*Mortar and pastel*' which is available and popular in every Indian farmer's house. Then grounded material were

dipped in to 100 ml distilled water for 48 hours for complete extraction of the active ingredient from the extracted samples (Ahmed et al., 2013). After that the water and ground material were filtered with the help of muslin cloth. This extract filtered with the help of Whatman's grade filter paper no. 1. Then crude extracts were preserved in glass bottles and kept in refrigerator at 4 +/- 2^0C for further use.

Mycelial growth inhibition by poison food technique (Nene and Thapliyal, 1993):

Efficacy of leaf extracts with different concentrations were examined by Food poison technique. (Nene and Thapliyal, 1993). The linear mycelial growth of fungi has been taken after seventh day of incubation.

The required concentrations of plant extracts were obtained by taking 2.5, 5.0, 7.5, and 10.0 mL of extracts in 100 mL of warm agar PDA /GNA media.

The different concentrations of plant extracts prepared in agar media were 2.5, 5.0, 7.5, and 10.0 %. The media were poured in sterilized petriplates and allowed to solidify. The control plates were maintained where media was not treated with plant extracts. These plates were inoculated by 4mm disc of ***Fusarium oxysporum*** in the center aseptically. These plates were incubated at 28 $\pm$ 1^0C. The observations were recorded in the form of linear growth of fungal pathogen in centimeter (cm.) after seven days of incubation period.

Linear mycelial growth inhibition was calculated by following formula:

$$\text{Percentage of fungal growth inhibition} = \frac{gC+gT}{gC} X \quad 100$$

Where,

gC= Mycelial growth of fungus in control plate (cm)

gT= Mycelial growth of fungus in treated plates (cm)

Data Analysis

Data was analysed by Analysis of Variance (ANNOVA) and LSD was calculated at P=0.05 for significance.

Experimental Results:

Effect of leaf extract of *Azadirachta indica* A. Juss. on growth of *Fusarium oxysporum*

Results are depicted in Table 1, Table 2, Fig. 1 and Plate I. Control plate which was without leaf extract showed 7.9 cm. linear growth of *Fusarium oxysporum* after seventh days of incubation. While plates with 2.5%, 5.0%, 7.5% and 10.0% concentration of aqueous extract were showed an average 5.6 cm., 3.3 cm., 1.8 cm. and 0.2 cm. linear growth; whereas, percentage inhibition recorded was 29.11%, 58.23%, 77.21% and 97.46% respectively.

The values of F (Table 2) indicated that there was significant variation due to various concentrations of aqueous extracts. The mycelial growth significantly and gradually decreased from 7.9 cm. in control to nil at the concentration of 10.0%.

Table 1: Effect of *Azadirachta indica* A. Juss. on growth of *Fusarium oxysporum*

Sr. No.	Aq. Extract concentration (%)	Linear mycelial growth in cm.				Growth inhibition %
		R1	R2	R3	Mean	
1	0	8	7.8	7.9	7.9	0
2	2.5	5.6	5.8	5.4	5.6	29.11
3	5	3.4	3.3	3.2	3.3	58.22
4	7.5	2	1.8	1.6	1.8	77.21
5	10	0	0.6	0	0	97.46
SE ±	0.1538					
CD 5%	0.3554					
CD 1%	0.5169					

Table 2: Analysis of variance (ANOVA)

Source	df	SS	MSS	F	S/NS
Concentration	4	111.756	27.939	787.01408	S
Replications	2	0.156	0.078	2.1972	NS
Error	8	0.284	0.0355	-	-
Total	14	112.196	-	-	-

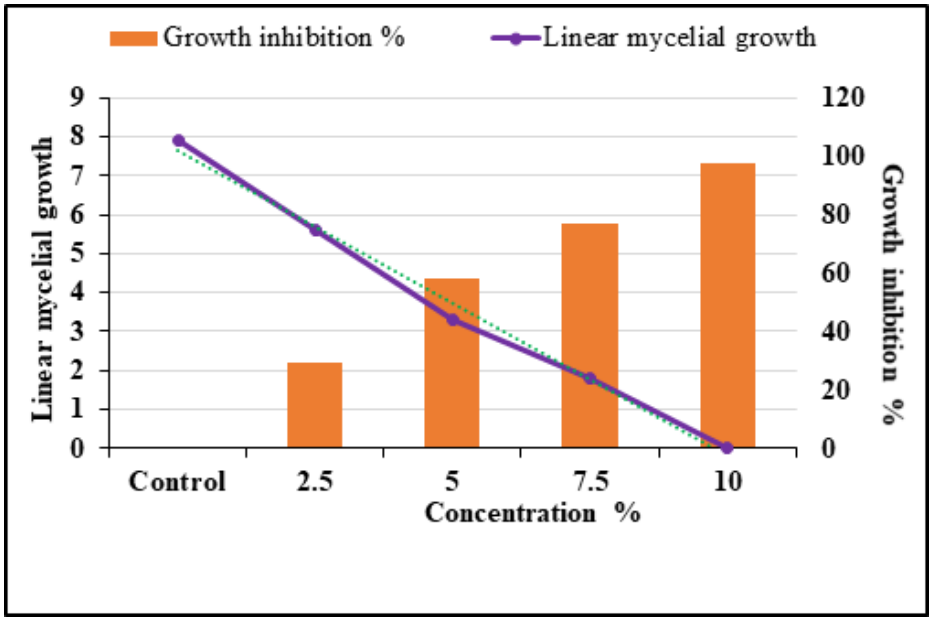
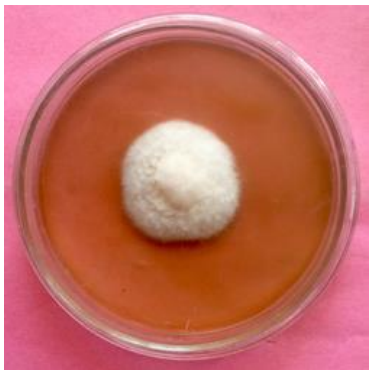


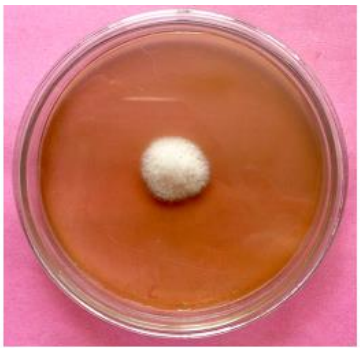
Figure 1: Effect of *Azadirachta indica* A. Juss. on growth of *Fusarium oxysporum*

2.5%



5.0%

Control



7.5%

10.0%

Discussion:

In medicinal plants secondary metabolites are present. Phytochemical analysis of medicinal plants worked by Chiejind and Ukeh (2012) reported the presence of *Tannins*,

Phlobatannins, Steroids, Tarpenes, Saponins, Flavonoids and *Alkaloids.* The presence of these phenolic compound in the extracts indicates that these plants can serve as antimicrobial agents.

During the present investigation *Azadirachta indica* leaf extracts of different concentrations showed encouraging effect on pathogenic fungi. Leaf extract was found to be most effective with increasing concentration to control the growth of fungi.

After seventh day of incubation, control plate without leaf extract showed 7.9 cm. linear growth of *Fusarium oxysporum*. Petriplates with 2.5%, 5.0%, 7.5% and 10.0% concentration of aqueous extract showed an average 5.6 cm., 3.3 cm., 1.8 cm. and 0.2 cm. linear growth; whereas, percentage inhibition recorded was 29.11%, 58.23%, 77.21% and 97.46% respectively.

The antifungal effect of aqueous extracts of four plant species viz; *Azadaracta indica* A. Juss., *Datura metel* L. var. *quinquecuspida* Torr., *Ocimum sanctum* L. and *Parthenium hysterophorus* L. was observed *in vitro* study. Leaf extract of *Azadirachta indica* at 100% conc. completely inhibited germination of pathogen spores (Singh et al., 2004; Lodhi et al., 2016). Chand et al., 2005 explained the inhibitory activity of *Eucalyptus globulus*, *Jatropha multifida*, *Azadirachta indica*, and *Allium sativum* against wilt incidence in chickpea. Sharma and Kumar, 2009 reported that the extract of three weed plants, namely, *Capparis decidua, Lantana camara* and *Tridax procumbens,* showed antifungal property against *Fusarium oxysporum*. Belabid et al., 2010 studied local medicinal plants (*Anacyclus valentinus* L., *Artemisia herba* alba Asso., *Eucalyptus* sp, *Inula viscosa* (L.) Aiton, *Laurus nobilis* L., *Mentha pepirita* L., *Rosmarinus officinalis* L., *Salvia officinalis* L., *Tetraclinis articulata* (Vahl) Masters and *Thymus vulgaris* L.) and reported that these plants have shown good antifungal property against F. *oxysporum* f.sp. *lentis*. Chaudhary et al., 2013 reported the antifungal activity of *Solanum nigrum* L., *Tagetes erecta, Polyalthia longifolia*, *Parthenium hysterophorus* L., *Zingiber officinale* against *F. udam*. Khaleel et al., 2014 recorded fungitoxic effect of *Allium sativum* extract, *Azadirachta indica* leaf extract, *Zingiber officinale* Extract, *Calatropis procera* leaf extract, *Moringa oleifera* leaf extract and *Parthenium hysterophorus* L. leaf extract shows against F. *oxysporum* f.sp. *pisi.*

The result of the present study showed identical output with *Azadirachta indica* leaf extracts as most effective antifungal agent against F. *oxysporum* f sp *udam* at 10% concentration.

Conclusions:

The aqueous leaf extract of *Azadirachta indica* A. juss. was found significantly strong inhibitory on wilt pathogen. All applied concentration of leaf extracts significantly found to be decreasing the growth of wilt pathogen. Whereas the 10% concentration of leaf extract was found to be highly effective against F. *oxysporum* f sp *udam.*

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EFFECT OF MEDICINAL PLANTS LEAF EXTRACT ON SEED-BORNE MYCOFLORA, SEED GERMINATION AND SEEDLING HEALTH OF TOMATO

M. A. Patekar* and R. P. Biradar

PG Department of Botany,

Shivaji College, Udgir, Dist. Latur, Maharashtra

*Corresponding author E-mail: manisha.patekar@gmail.com

Abstract:

Tomato seed samples collected from *Marathwada* region have been used for the detection of seedborne mycoflora. Eight seed-borne fungi have been identified *viz. Aspergillus niger, Alternaria alternata, Alternaria solani, Fusarium oxysporum, Fusarium solani, Rhizopus stolonifer, Cephalosporum* spp. and *Helminthosporium* spp. Ten different medicinal plant extracts *viz. Azadirachta indica* A. Juss, *Aegle marmelos* Corr., *Calotropis procera* L., *Catharanthus roseus* L., *Datura metel* L., *Moringa oleifera* Lam., *Murraya koenigii* L., *Polyalthia longifolia* Sonn., *Ocimum sanctum* L. and *Tridax procumbens* L. were selected and tested for seed treatment at 10.0 % concentration. Treatments with leaf extracts of all plants showed significantly increased percentage seed germination over control (73.3 % to 96.7 %). The germination failure significantly decreased with increased vigour index and seedling health.

Keywords: Leaf extracts, seed-borne mycoflora, seedling health

Introduction:

Vegetables are an essential element of a healthy diet since they provide a variety of nutrients such as potassium, fibre, foliates, and vitamins A, B, and C. Because vegetables produce more per unit time than grains and other crops, they are a major source of agricultural revenue. Tomato (*Solanum lycopersicum*) is the most significant vegetable crop in India, ranking second in terms of output and area globally. Tomatoes are claimed to be a tropical American native that spread around the globe in the 16th century, and they have been popular in India for the last six decades. In 2009-10, the world produced 136 million tonnes of tomato from an area of 48 lakh hectares. In 2016, the world's tomato output was 177 million tonnes, with China accounting for 32% of the total, followed by the European Union, India, the United States, and Turkey. With an annual output of 5962.21 thousand tonnes, Andhra Pradesh is India's leading tomato producer. Andhra Pradesh was responsible for over 35% of India's total tomato output. However, Andhra Pradesh's entire tomato consumption is just 7% of India's overall demand (Ruhani Prasad *et al.*, 2021)

It is one of the most extensively grown vegetable crops, with India being the second-largest producer after China. Bacterial, viral, nematode, and fungal diseases may all affect tomato crops. Early blight, caused by *Alternaria solani*, is one of the most devastating diseases in tomato-growing regions in the United States. Tomato production is hampered by the early blight disease, which is particularly prevalent in subtropical and tropical areas.

Fungi, which are an important category of microorganisms, are also responsible for tomato seed-borne illnesses, which result in a significant loss of output. Several seed-borne fungi, such as *Fusarium solani, Aspergillus flavus, Rhyzopus stolonifer*, and *Curvularia* spp., induce problems in tomato seeds, including seed toxification, seed rotting, necrosis, and seed abortion (Neergard, 1977; Fakir and Khan, 1992). Seed pathologists are using several seed health detection tests to screen and remove contaminated seed lots before planting, owing to the economic relevance of seed-borne fungus and their influence on seed vigour (ISTA, 1976). Farmers are encountering financial difficulties as a result of significant crop losses caused by seed-borne mycoflora on their crops. Control of seed-borne infections via diverse ways is a crucial element in every agricultural crop production and protection programme. As a result, single or combined techniques of mechanical, physical, biological, and chemical treatments may be used to effectively manage seed-borne diseases.

Today medicinal plant extract has been accorded a lot of importance for crop protection against pest and diseases due to their target specificity and safety. Botanicals like leaf, root, stem, rhizomes, bulbs and other plant parts are used as extracts to control seed-borne pathogens by seed treatment. (Sangvikar and Wadje, 2012). During this investigation, ten medicinal plant leaf extracts were used for seed treatment and the results were found very promising with all treatments responsible to reduce seed mycoflora, seed germination failure and with enhanced seed germination, vigour index and seedling health. Kadam *et al.* (2008) also studied the efficacy of leaf extract of *Azadirachta indica* against seed borne fungi of groundnut. Their results indicated that the longer duration of seed treatment with plant extract was effective in controlling the growth of all surface borne seed mycoflora. Telang (2010) worked on similar lines with Chilli seed mycoflora and found that the seed treated with leaf extracts of *Azadirachta indica*, leaf and root extracts of *Ocimum sanctum* and leaf extracts of *Murraya koenigii* showed reduced incidence of seed mycoflora and maximum seed germination. By considering these facts the present investigation was carried out to assess the effect of selected medicinal plant extracts on seed borne mycoflora, seed germination and seedling health of Tomato.

Materials and Methods:

The experiment was carried out at Aerobiology research center of Mahatma Gandhi Mahavidyalaya, Ahmedpur, Dist: Latur, Maharashtra. Randomly selected seed samples (250 gm each) were collected using method described by Neergaard (1973). The seeds were collected from local farmers and marketplaces of *Marathwada* region of Maharashtra state of India.

Treatment of medicinal plant extracts on tomato seeds:

Ten common plants namely *Azadirachta indica* A. Juss, *Aegle marmelos* Corr., *Calotropis procera* L., *Catharanthus roseus* L., *Datura metel* L., *Moringa oleifera* Lam., *Murraya koenigii* L., *Polyalthia longifolia* Sonn., *Ocimum sanctum* L. and *Tridax procumbens* L. were selected. The identification of plants was confirmed using the flora of Marathwada (Naik, 1998). These plants were surface sterilized with 0.1% $HgCl_2$ and washed repeatedly with sterile distilled water for three times. Vegetable seeds were treated by soaking the seeds in 10.0% concentration for 30 minutes with each of the plant extracts. Treated seeds were dried on blotter paper sheet in sun light for 30 minutes. The treated seeds were grown and incidence of fungi, rate of germination, vigour index and seedling health were studied by using blotter paper method as described by International Seed Testing Association (ISTA, 1966)

Table 1: Plants used for seed treatment

Sr. No.	Local Name	English Name	Scientific Name	Family
1	Neem	Indian lilac	*Azadirachta indica* A. Juss	Meliaceae
2	Bel	Indian quince	*Aegle marmelos* Corr.	Rutaceae
3	Ruchki	Rubber bush	*Calotropis procera* L.	Asclepiadaceae
4	Sadafuli	Periwinkle	*Catharanthus roseus* L.	Apocynaceae
5	Dhotara	Thorn apple	*Datura metel* L.	Solanaceae
6	Shevga	Drumstick	*Moringa oleifera* Lam.	Moringaceae
7	Kadhipatta	Curry leaves	*Murraya koenigii* L.	Rutaceae
8	Ashok	Mast tree	*Polyalthia longifolia* Sonn.	Annonaceae
9	Tulsi	Holy basil	*Ocimum sanctum* L.	Lamiaceae
10	Tantani	Coat buttons	*Tridax procumbens* L.	Asteraceae

Preparation of aqueous extracts:

Green leaf samples (100gm) were collected and washed very carefully with distilled water. Then plant parts were ground with conventional grinder called '*Mortar and pastel*' which is available and popular in every Indian farmer's house. Then grounded material were dipped in to 100 ml distilled water for 48 hours for complete extraction of the active ingredient from the extracted samples (Ahmed et al., 2013). After that the water and ground material were filtered with the help of muslin cloth. This extract filtered with the help of Whatman's grade filter paper no. 1. Then crude extracts were preserved in glass bottles and kept in refrigerator at 4 +/- 2^0C for further use.

Formulas used

For observations and results, following formulas were used:

$$\text{Percentage incidence of fungus} = \frac{\text{No. of seeds containing particular fungus}}{\text{Total Seeds}} \text{ X } 100$$

$$\text{Percentage incidence of seed mycoflora} = \frac{\text{No. of seed infected by fungi}}{\text{Total no. of Seeds}} \text{ X } 100$$

$$\text{Percentage germination} = \frac{\text{No. of seeds germinated}}{\text{Total no. of Seeds}} \text{ X } 100$$

$$\text{Vigour Index} = \text{Percentage germination} \text{ X } \text{Length of seedling}$$

Data analysis

The experiment has been conducted in completely randomised design with three replications. All the observation data were compiled, tabulated and put to statistical computation for the presentation and interpretation of the results. Analysis of variance (ANOVA) was prepared for each study. Standard error between the means (SEm), critical difference (C.D.) and coefficient of variation (C.V.).

Experimental Results:

Effect of plant extracts on incidence of seed borne mycoflora, seed germination and vigour index of Tomato

Results depicted in Table 2, Fig 1. and Plate I indicated that treated seeds with all tested plant extract gave good effect on germination, seedling length and vigour index over the control.

Table 2: Effect of plant extracts on seed borne mycoflora, seed germination and vigour index of Tomato

Sr. No.	Leaf Extract	Incidence of mycoflora (%)	Seed germination (%)	Seedling length (cm)	Vigour index
1	Control	46.7	73.3	3.6	263.88
2	*Azadirachta indica* A. Juss.	10	93.3	5	466.5
3	*Aegle marmelos* Corr.	13.3	90	4.8	432
4	*Calotropis procera* L.	13.3	86.7	4.4	381.48
5	*Catharanthus roseus* L.	16.7	90	4.3	387
6	*Datura metel* L.	13.3	83.3	3.8	316.54
7	*Moringa oleifera* Lam.	16.7	80	4	320
8	*Murraya koenigii* L.	10	93.3	4.4	410.52
9	*Polyalthia longifolia* Sonn.	23.3	76.7	4.6	352.82
10	*Ocimum sanctum* L.	3.3	96.7	4.8	464.16
11	*Tridax procumbens* L.	20	83.3	4.5	374.85
	Mean	17.8727	86.0545	4.3818	379.0682
	SD	9.8873	7.0832	0.4152	60.3916
	CV	55.3205	8.2310	9.4757	15.9316
	SE	2.9811	2.1357	0.1252	18.2087
	CD 5%	6.6479	4.7625	0.2792	40.6055
	CD 1%	9.4502	6.7700	0.3969	57.7217

The highest (46.7%) incidence of mycoflora were recorded in an untreated seeds, while lowest incidence of seedborne mycoflora was recorded in seeds treated with *Ocimum sanctum* L. extract and with highest (96.7%) germination rate. *Azadirachta indica* A. Juss. and *Murraya koenigii* L. extract treated seed were showed minimum (10.0% each) incidence of seedborne mycoflora and maximum (93.3% each) percentage of seed germination followed by *Aegle*

marmelos Corr., *Calotropis procera* L. and *Catharanthus roseus* L. with 10.0%, 13.3% and 16.7% incidence of mycoflora and 90.0%, 86.7% and 90.0% germination respectively. Lowest (73.3%) germination was recorded in control seeds. Rest of plant extracts were also showed significant results for controlling seed borne mycoflora and enhanced rate of seed germination over the control. The tested plant extracts also improved the length of seedling and vigour index. Seedling length ranged from 3.6 cm. to 5.0 cm. highest (5 cm.) length of seedling recorded in seeds treated with extracts of *Azadirachta indica* A. Juss. followed by *Aegle marmelos* Corr. and *Ocimum sanctum* L. extract treated seeds (4.8 cm. each). Rest of the extracts showed intermediate seedling length. Seed treatment also improved vigour index over untreated seeds. Highest vigour index was found statistically identical (466.5 and 464.16) with the extracts of *Azadirachta indica* A. Juss. and *Ocimum sanctum* L. respectively, followed by *Aegle marmelos* Corr. (432) and *Murraya oleifera* L. (410.52). Remaining plant extracts showed significant results in an increased vigour index over the control.

Effect of plant extracts on seed germination, seedling health and germination failure

Aqueous extracts of selected plants showed significant results with respect to seed germination and seedling health as presented in Table 3 and Fig. 2. All leaf extracts were significantly showed increased germination over control. The highest (31.5%) germination over the control was recorded with *Ocimum sanctum* L. extracts followed by *Azadirachta indica* A. Juss. (27.39%) and *Murraya koenigii* L. (27.39%). However, *Aegle marmelos* Corr. (28%), *Catharanthus roseus* L. (23.28%), *Calotropis procera* L. (17.8%), *Datura metel* L. (13.69%), *Moringa oleifera* Lam. (9.58%) and *Tridax procumbens* L. (9.58%) plant extracts treated seeds showed increased germination failure over the control. The ability of the extracts to increased seed germination would be attributed to the suppression of incidence of seed borne fungi and ultimately seed germination failure within the range of 3.3 to 26.7%. Minimum seed germination failure was recorded when (3.3%) seeds were treated with *Ocimum sanctum* L. extracts; followed by *Azadirachta indica* A. Juss. and *Murraya* koenigii L. (6.7% each). The highest (96.42%) healthy and lowest (3.58%) infected seedling were recorded in seeds treated with extracts of *Azadirachta indica* A. Juss. *Ocimum sanctum* L. treated seeds showed 93.1% healthy and 6.9% infected seedlings, followed by the extracts of *Catharanthus roseus* L. and *Calotropis procera* L. treated seeds which showed statistically identical healthy (92.69% and 92.3%) and infected seedling (7.7 and 7.3%) respectively. Rest of the plant extracts were also showed significantly good effect.

Table 3: Efficacy of plant extracts on seed germination, seedling health and germination failure of Tomato

Sr. No.	Leaf Extract	Seed germinati	Germination %	Germination	Healthy seedling	Infected seedling
1	Control	73.3	0	26.7	68.18	31.82
2	*Azadirachta indica* A. Juss.	93.3	27.39	6.7	96.42	3.58
3	*Aegle marmelos* Corr.	90	23.28	10	88.88	11.12
4	*Calotropis procera* L.	86.7	17.8	13.3	92.3	7.7
5	*Catharanthus roseus* L.	90	23.28	10	92.69	7.31
6	*Datura metel* L.	83.3	13.69	16.7	88	12
7	*Moringa oleifera* Lam.	80	9.58	20	87.5	12.5
8	*Murraya koenigii* L.	93.3	27.39	6.7	89.28	10.72
9	*Polyalthia longifolia* Sonn.	76.7	4.1	23.3	91.3	8.7
10	*Ocimum sanctum* L.	96.7	31.5	3.3	93.1	6.9
11	*Tridax procumbens* L.	83.3	9.58	16.7	91.66	8.34
	Mean	86.0545	17.0536	13.9455	89.0282	10.9718
	SD	7.0832	9.9184	7.0832	7.0424	7.0424
	CV	8.2310	58.1599	50.7921	7.9103	64.1860
	SE	2.1357	2.9905	2.1357	2.1234	19.3528
	CD 5%	4.7625	6.6688	4.7625	4.7351	43.1567
	CD 1%	6.7700	9.4799	6.7700	6.7310	61.3484

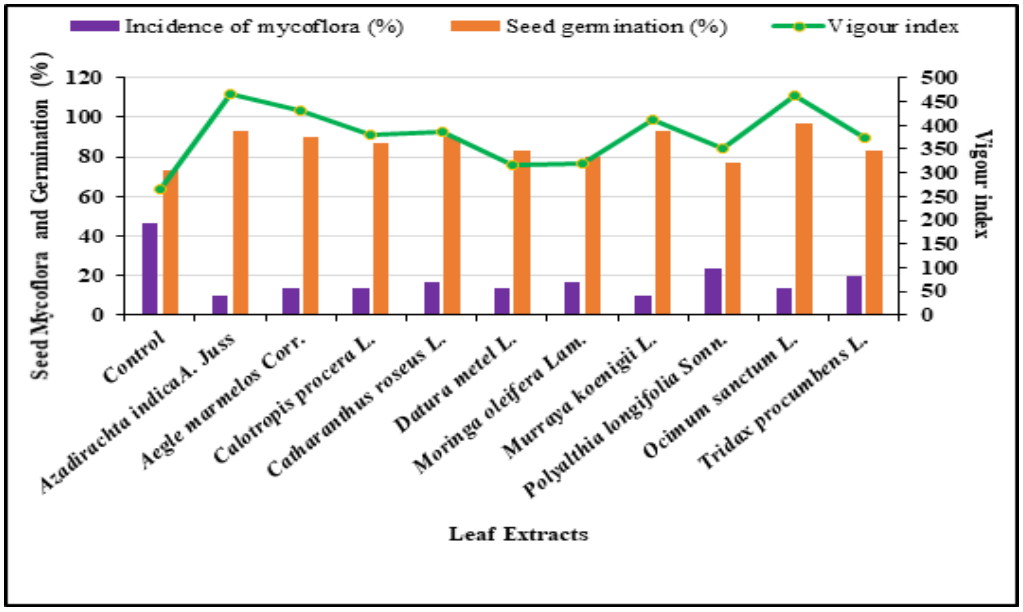


Figure 1: Effect of plant extracts on seed mycoflora, germination and vigour index of Tomato

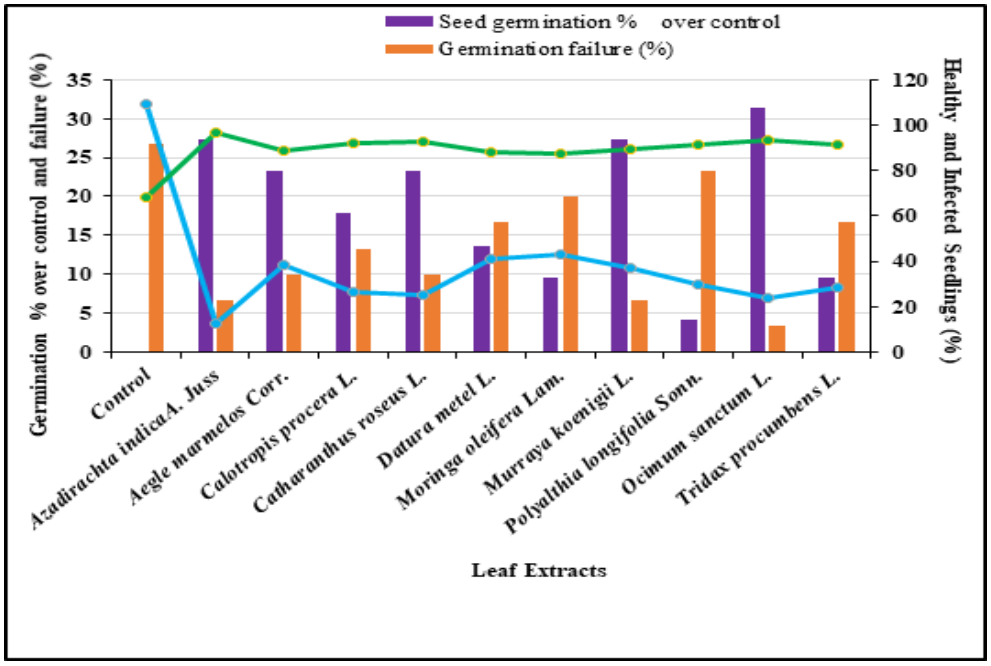


Figure 2: Effect of plant extracts on seed germination % over control, seedling health and germination failure of Tomato

Discussion:

Tomato is the most significant vegetable crop in India, ranking second in terms of output and area globally. China is the world's largest producer, accounting for 27.8%, followed by India (11.2%) (Kumar et al., 2016; Harisha et al., 2019; Gupta et al., 2021). It is one of the most extensively grown vegetable crops, with India being the second-largest producer after China.

Bacterial, viral, nematode, and fungal diseases may all affect tomato crops. Early blight, caused by *Alternaria solani* and wilt caused by *Fusarium oxysporum*, are most devastating diseases in tomato-growing regions. Tomato production is hampered by the early wilt and blight diseases, which are particularly prevalent in subtropical and tropical areas.

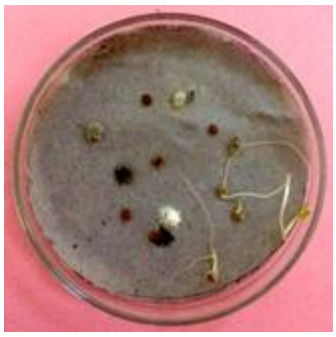
During the present investigation eight seed-borne fungi have been identified *viz. Aspergillus niger, Alternaria alternata, Alternaria solani, Fusarium oxysporum, Fusarium solani, Rhizopus stolonifer, Cephalosporum* spp. and *Helminthosporium* spp.

Previously, Ahmad *et al.* (1993) discovered 15 fungi, while Perveen and Ghaffar (1995) discovered 22 new species of seed-borne mycoflora on tomato in Pakistan. *Fusarium solani, Fusarium moniliformae, Alternaria alternata,* and *Drechslera australiensis* were the most common fungi. Similar fungi such as *Alternaria solani, Fusarium oxysporum, Aspergillus flavus*, and *Aspergillus fumigatus* have been found on tomato in Bangladesh, causing significant seed damage (Fakir, 2001). Similarly, *Bipolaris* spp., *Curvularia lunata*, *F. moniliformae*, and *F. semitectum* were found in tomato seeds by Bhatti *et al.* (2010).

In crop disease control, seed health is fundamental. The rise of endemic diseases as a result of changing global environment poses a difficulty in maintaining plant health. To eliminate pathogens from seeds both inside and externally, as well as to protect seeds from soil-borne diseases, a variety of chemical, biological, physical, and mechanical techniques have been applied (Neergard, 1977; McGee, 1995; Maude, 1996).

In medicinal plants, secondary metabolites are present. Phytochemical analysis of medicinal plants worked by Chiejina and Ukeh (2012) reported the presence of Tannins, Phlobatannins, Steroids, Tarpenes, Saponins, Flavonoids and Alkaloids. The presence of these phenolic compound in the extracts indicates that these plants can serve as antimicrobial agents. In the present study, all treated seeds recorded lower incidence of seed borne mycoflora (3.3 % to 23.3 %) compared to untreated seeds (46.7 %). Vigour index also significantly increased under the influence of leaf extracts from 263.88 in control to within the range of 316.54 to 466.5. The percentage increase in seed germination ranged from 4.1 % to 27.39 %. The germination failure significantly decreased with enhanced seedling health. Survase (2012) evaluated the effect of medicinal plants leaf extract of ten plants on the seed mycoflora, seedling emergence and growth of seed borne fungi of methi. He reported that leaf extract of all the test medicinal plants were found to be inhibitory in more or less degree for incident of seed mycoflora. All the selected plants plant except Vitex negundo were found to be stimulatory for the seed germination and seedling emergence of methi. The leaf extract of *Semecarpus ancardium* (88.0%), *Solanum xanthocarpum* (79.0%), *Abrus precatorius* (81.0%),

Aegle marmelos (84.0%), were found to be more inhibitory for incidence of seed mycoflora and more stimulatory for the seed germination and seedling emergence of methi.



Control

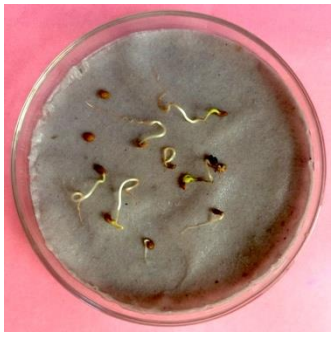
***Azadirachta indica* A. Juss**

***Aegle marmelos* Corr.**

***Calotropis procera* L**

***Catharanthus roseus* L.**

***Datura metel* L.**



***Moringa oleifera* Lam.**

***Murraya koenigii* L.**

***Polyalthia longifolia* Sonn**

***Ocimum sanctum* L.**

***Tridax procumbens* L.**

Plate I: Effect of plant extracts on seeds of Tomato

Plants create a vast range of environmentally benign secondary metabolites and are the richest source of organic compounds (Okigbo and Nmeka, 2005; Jamil *et al.*, 2007; Riaz *et al.*, 2010). Botanicals, rather than chemical fungicides, are one of the most modern techniques of managing seed-borne and other plant diseases (Howlader, 2003; Islam *et al.*, 2006). Various plant extracts, including garlic clove, neem leaf, allamonda leaf, ginger rhizome, kalijira seed, bel leaf, turmeric rhizome, katamehedi leaf, and onion bulb, were tested for antifungal effectiveness against tomato seed-borne damping-off. Seed treatment with plant extracts had varying degrees of success in terms of tomato percent damping-off. However, neem leaf extract had the greatest seed germination (86.67%) and the lowest incidence of damping-off of tomato, followed by garlic clove and allamonda leaf extract (Islam and Faruq, 2012).

Conclusions:

Tomato seed-borne infections are a major source of worry in the seed business because they have a negative impact on seedling germination and vigour, resulting in lower yield and product quality. As a result, a significant aspect in increasing productivity is the adoption of healthy seed and a good seed certification scheme. Seed treatments with medicinal plant extracts are economic for managing seed-borne illnesses, hence an integrated strategy is proposed to reduce disease transmission via seeds of diverse crops, including tomatoes.

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ROOT ENDOPHYTES AS A PLANT GROWTH PROMOTER

Sayed Sohail[1], Rahul More[1], Govind Sanap[2] and Kailash Sontakke[3]

[1]Department of Microbiology,

Dayanand Science College, Latur

[2]Department of Zoology,

KDB College, Guhagar- 415726, Dist: Ratnagiri

[3]Department of Botany,

Gopikabai Sitaram Gawande Mahavidyalaya, Umarkhed-445206, Dist: Yavatmal

Corresponding author E-mail: sohelaquadri@gmail.com, drmoremicrodscl@gmail.com, raju.sanp33@gmail.com, sontakke@gsgcollege.edu.in

Abstract:

Bacterial and fungal endophytes are widespread inhabitants inside plant tissues and have been shown to assist plant growth and health. Endophytes are one of the widely explored phenomena related to bacteria and fungi. Root endophytes live inside the plant tissue and they play an important role as plant growth promoting endophytes. Because endophytes confer profound impacts on their host plants by influencing their physiology and development, by the action of phytochromes or the production of metabolites. Plant-growth-promoting bacterial and fungal endophytes have been identified, but the predictive success at positively influencing plant growth in field conditions has been limited. The isolated endophytes differentially produced indole acetic acid (IAA), ACC deaminase which helps in plant growth. Phytohormones or Plant hormones (auxin, gibberellin (GA), cytokinin, ethylene and abscisic acid (ABA) are chemical messengers that coordinate cellular activities of plants. Some microbial endophytes isolated from medicinal plants possess a vital role to improve plant growth and could be used in agriculture as endophytes have extensive applications in the field of agriculture and medicine.

In this review efforts are made to summarize plant growth promoting bacterial and fungal root endophytes in which studies are mostly focused on its biocontrol, biostimulation and biofertilizer.

Keywords: root endophytes, plant growth promoting agents, bacterial and fungal root endophytes, plant-microbe interaction.

Introduction:

Root endophytes have been studied for many decades. Therefore the complete understanding of the mechanisms utilized by plant growth promoting root endophytes (bacterial,

fungal) is still difficult to find. These microbial communities are present in internal tissues and organs in plants as endophytes [24].Plants and microorganisms form a symbiotic association which benefits both. More importantly, plant-microbe symbiosis influences plant growth and health which effectively make better agricultural traits and improve soil quality and nutrient cycling [25].The engineering of the colonization pattern of the bacterial root endophytes holds the entire ecosystem of the planet [27].

Some endophytes can contribute in alleviating abiotic stresses of host plants via a variety of mechanisms like exopolysaccharide (EPS) production, dropping off the ethylene level utilizing1-aminocyclopropane-1-carboxylate (ACC) deaminase which plays an important role in supporting plant growth under salinity and water stress conditions [16] plant growth promotion and productivity in plants is associated with biocontrol agents, biofertilization and phytostimulation [17,3]. In this review we mainly focus on the plant growth promoting bacterial and fungal root endophytes and their importance.

Review literature:

Bacterial root endophytes

Endophytes are defined as those that colonize the internal tissues of plants during the entire or part of the host's lifecycle without causing apparent damage [15, 3].Bacterial endophytes could have advantages over bacteria inhabiting the rhizosphere, since living within the tissues of a plant represents an opportunity to always be in contact with plant cells (and their metabolites), and therefore they can readily exert a direct beneficial effect. Determining the diversity of bacterial endophytes is as complicated as analyzing each of the nearly 300,000 plant species that exist on the earth [3].The composition of bacterial endophytes varied among the plants, tissues, organs, genotypes, varieties, soil and location and bacterial endophytes are host specific [24] These beneficial endophytes can positively influence plant growth through various mechanisms, such as the production of hormones, improvement of nutrient uptake and protection against biotic or abiotic stresses.

For example, the beneficial endophytes *Paraburkholderia phytofirmans* PsJN (PsJN), previously isolated from surface-sterilized onion roots and classified as *Pseudomonas* and then *Burkholderia*, was able to promote plant growth and up regulate the genes related to protein metabolism, transcription, transport, defense pathways, signal transduction and hormone metabolism in tomato [26]. Some bacterial endophytes of medicinal plants have much therapeutic properties. *Alkanna tinctoria* (family *Boraginaceae*) compared to other *Alkanna species* [15]. several genera of bacteria other than rhizobia have been isolated which include *Agrobacterium, Bacillus, Enterobacter, Flavimonas, Erwinia, Aerobacter, Chryseomonas,*

Aeromonas, Shingomonas and *Pseudomonas* Bacillus being prevalent species of rhizospheric soil, has better chance of getting entry into nodules and roots of leguminous plants. It has been isolated as endophytes from a number of leguminous crops and studied extensively for its plant growth promoting traits. Plant growth is influenced by endophytic bacteria either directly or indirectly. In case of medicinal plants endophytes contribute to or are responsible for their host pharmaceutical properties [15].

Plant growth promotion by bacterial root endophytes

Plant growth promoting bacterial endophytes (PGPBEs) facilitate plant growth via three interrelated mechanisms: phytostimulation, biofertilization, and biocontrol [3].

Phytostimulation:

Phytostimulation is the direct promotion of plant growth through the production of phytohormones. Phytostimulation involves dropping off the ethylene level utilizing 1-aminocyclopropane-1-carboxylate (ACC) deaminase which plays an important role in supporting plant growth under salinity and water stress conditions [16].in a recent research of characterization of root endophytic actinobacteria from cactus ACC deaminase activity is considered a very potent PGP trait as it enhances the plant growth by overcoming the deleterious effects of ethylene-induced abiotic stress responses. ACC deaminase activity also improved growth of wheat seedling by *Streptomyces tuirus* VL-70-IX and *S. psedogriseolus* VL-70-XII [13]. Several root endophytes that release ACC deaminase have been shown to increase plant growth i.e *Streptomyces species*, *Bacillus species* and also medicinal plant i.e *Aloe vera* [13, 1].
Variations in the levels of IAA can be explained by the location of genes responsible for biosynthesis, and the locations of these genes modulate the levels of this phytohormone. When the genes are located on chromosomal DNA, they result in lower production; however, when they are located on the plasmid, they result in greater auxin production, as several copies of the gene are present [4]. In medicinal plant *A. vera* the finding support the hypothesis that root endophytic bacteria display multifunctionality and some have biotechnological potential [4] IAA stimulates cell division, cell and tissue differentiation, cell elongation, lateral root formation [19].

Biocontrol:

The promotion of plant growth through protection from phytopathogens is known as biocontrol. Several mechanisms may be involved, including the production of siderophores or antibiotics [26, 1] *Brevibacillus* inhibited the growth of *S. sclerotiorum*, and the formation of sclerotia, and confirmed the effect of rhizospheric *Brevibacillus* on several species of *Fusarium*. Strains of this genus are considered potential candidates for biocontrol agents, owing to

antibiotics production and biofilm formation [4] bacteria from the genus *Stenotrophomonas* seem to only be able to produce siderophores [15].

Some PGPB can also colonize the internal tissues of numerous plant species. These beneficial endophytes can positively influence plant growth through various mechanisms, such as the production of hormones, improvement of nutrient uptake and protection against biotic or abiotic stresses For example, the beneficial endophyte *Paraburkholderia phytofirmans* PsJN (PsJN), previously isolated from surface-sterilized onion roots and classified as *Pseudomonas* and then *Burkholderia* , was able to promote plant growth and up regulate the genes related to protein metabolism, transcription, transport, defense pathways, signal transduction and hormone metabolism in tomato. Similarly, *Enterobacter sp.* 32A (32A) was isolated from the grapevine endosphere and promoted plant growth, activating a complex transcriptional reprogramming in tomato and defense pathways in grapevine plants. Moreover, 32A inhibited the growth of plant pathogens (e.g., *Botrytis cinerea, Botryosphaeria dothidea and B. obtusa*) suggesting the use of PGPB to improve plant growth and health [26].The metabolites present in bacterial extract were identified using GC-MS. The presence of plant phytohormone IAA shows its role in root development and plant growth [27].

Table 1: List of the various compounds identified by GC-MS analysis present in the untreated plant extract

Peak	Retention Time	Name	Base Peak	Reported biological function
1	10.410	Hexadecanoic acid, methyl ester	74.10	Antimicrobial activity [15]
2	11.125	Heptadecanoic acid, heptadecyl ester	43.15	Antimicrobial activity [15]
3	12.930	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	57.15	Antimicrobial activity [15]
4	13.580	d-Mannitol, 1-O-(22-hydroxydocosyl)-	73.10	Role in abiotic and biotic stress [14]
6	17.850	Ethyl iso-allocholate	55.10	Antimicrobial acitivity [17]
7	19.445	d-Mannitol, 1-O-(22-hydroxydocosyl)-	73.10	Role in abiotic and biotic stress [19]
8	28.080	Ethyl iso-allocholate	43.15	Antimicrobial acitivity [17]

Some classes of Bacilli synthesize antimicrobial substances, such as ethyl paraben, and enzymes that attack the cell walls of phytopathogenic fungi, such as chitinases and lipopeptides with antifungal properties. Thus, several studies confirmed the potential of *Bacilli* as biocontrol agents and encouraged their use in agriculture [4]. S*treptomycetes* has been considered as a prospective biocontrol agent in agriculture. Indeed, their ability to produce antibiotics may be used to control plant pathogenic bacteria and fungi.

Biofertilization:

The promotion of plant growth by increasing the accessibility or supply of major nutrients is termed biofertilization. A well-studied form of biofertilization is nitrogen fixation, which is the conversion of atmospheric nitrogen to ammonia [1]. The association between endophytic plants and microorganisms results in direct physiological effects on plant growth and development, such as: nitrogen fixation and phosphate solubilization as well as the production of ammonia, siderophore, phytohormones, and hydrolytic enzymes. These benefits meet the needs of current plant cultivation through sustainable methods that reduce the use of chemical fertilizers and pesticides, replacing conventional mechanisms to preserve soil biological diversity, endophytic bacteria from *A. vera*, including *Pseudomonas hibiscicola, Macrococcus caseolyticus, Enterobacter ludwigii, and B. anthracis* produce bioactive compounds of medical importance with antimicrobial activity against bacterial pathogens [4]. Nitrogen fixing ability based on growth in nitrogen free medium and nitrogenase activity based acetylene reduction assay of an endophytic *Streptomyces chartreusis* starin WZS021 isolated from sugarcane shows enhanced crop biomass [13].

Importance:

PGPB can directly stimulate plant growth by providing plants with fixed nitrogen, soluble phosphates, and siderophores. PGPB also stimulates plant growth through the production of metabolites such as IAA and ACC. These bacteria can indirectly stimulate plant growth by preventing the development of plant pathogens [1]. Bacteria of the genus *Bacillus* have demonstrated resistance to metals and can be used in phytoremediation. In addition, they produce enzymes such as cellulases, amylases, and xylanases [4]. PGP trait of the cactus-origin endophytic actinobacteria is the production of phytohormone, auxins Indole 3-acetic acid (IAA) is one of the most physiologically important auxins, having pivotal functions in the lateral, adventitious root formation and in root elongation. Rhizo-microbial auxin synthesis contributes to the enhanced total plant auxin pool thereby influencing the overall root growth and plant development [13].

Applying suitable endophytes to facilitate plant growth by increasing the plant biomass and/or by inducing A/S production can be a sustainable approach toward increasing plant yield and production of these valuable compounds [15]. The potential for microbial inoculants to reduce the need for chemicals such as pesticides and fertilizers makes them important in the development of sustainable agricultural practices.

Fungal root endophytes

Fungal endophytes are symbiotic microorganisms that are often found in asymptomatic plants, fungi assist plants by supplementing nutrient acquisition, and synthesis of plant growth regulators [20, 5]. Endophytic fungi can be beneficial to their host plants through mutualistic symbiosis, but they can also become latent pathogens or saprophytes during certain phases of the hosts growth cycles and/or under certain environmental conditions [28]. In recent research in Buan Salt Marsh the fungi live in host plants for at least a portion of their lives without generating any immediate overt disease symptoms. These associations can encourage tissue differentiation and plant growth and can help in managing abiotic and biotic stresses to which the host plants are subjected [21].

Association between fungal endophytes and their host plant is due to their unique adaptations which enable the endophytes to harmonize their growth with their host plant. According to endogenous hypothesis, endophytes are gagged from the mitochondria and chloroplast of the plant, and so it has comparable genetic backgrounds to the host whereas exogenous hypothesis believes that endophytes arrive from outside of the plant and got inserted into the host from root wound, induced channels, or surface [6].

In agriculture Categorization of fungal endophytes is based on the differences in taxonomy, host range, tissue specificity, ecological functions, and transmission and colonization pattern into two major groups, First group/class is the *clavicipitaceous* endophytes or C-endophytes known for their host specificity infecting some grasses mainly belong to grass family *poaceae* in tropical and temperate regions [12]. One of the most known endophytes is the entomo pathogenic fungus *Beauveria bassiana*, (Hypocreales: *Cordycipitaceae*) (Bals.-Criv.) Vuill, which is considered one of the most abundant species globally [2]. In one finding *Aspergillus niger, Alternaria alternate, Nigrospora sphaerica, Penicillium corylophilum, Penicillium chrysogenum* and white sterile mycelia isolated from *T. polium* endophytes displayed various direct and indirect mechanisms for plant growth promoting without symptomatic injury; therefore, inoculation of maize plants with endophytic representative isolates stimulated plant growth and increased biomass production compared to un inoculated plants [25]. Mycorrhizal fungi that live symbiotically in cortical tissues of the roots and grow around the root zone, other fungal endophytes grow either intercellularly or intracellularly in the plant tissue and may inhabit stems, leaves, branches, twigs, bark, fruits and seeds [12].

Plant growth promotion by fungal root endophytes

Plant growth promoting fungal root endophytes have three main mechanisms interrelated i.e phytostimulation, biocontrol and biofertilization [6].

Phytostimulation:

Fungal Endophytes can actively or passively regulate the plant growth by solubilization of phosphate, enhance uptake of phosphorus (P), and/ or plant hormones such as auxin, abscisins, ethylene, gibberellic acid (GA), and indole acetic acid (IAA), among these Gibberellic acid is an important phytohormone [6].

Fusarium solani (PVR1), *Fusarium sp*. (PVR2), *Mycoleptodiscus sp*. (PVR3) from the root section. were able to synthesize IAA without tryptophan or by using different concentrations of tryptophan supplemented growth medium [5] Kapri and Tiwari (2010) had isolated 14 *Trichoderma species* from different plant species and all these strains were capable to solubilize complex form of phosphates. *Vanda cristata* is an epiphytic orchid so nutrient availability is quite challenging for this. Endophytic fungi may help in increasing the nutrient resources by decomposing inorganic phosphate complexes and help in the overall growth of host orchid [7].The *P. variotii* isolate has shown a high ability to produce siderophores and IAA, but low ability to solubilize [8] endophytes *P. fortinii* and *Rhizodermea veluwensis* showed an ability to produce siderophores that probably affects heavy metal exclusion in the rhizosphere [6].

Plant signaling compounds, also called phytohormones, regulate plant responses to environmental change as well as control plant growth and development [11]. Notably, recent studies have reported that certain endophytes encourage host plant growth through the synthesis of phytohormones, for example, gibberellins (GAs), cytokinins, and indole-3-acetic acid (IAA) [21].

Biocontrol:

Fungal endophytes act as biocontrol agents as they can protect their host plants from pathogens and pests. The mechanism whereby endophytes deter herbivory is through production of antiherbivory/bioactive compounds. Defensive compounds may be categorized into various functional groups: alkaloids, terpenoids, isocoumarin derivatives, quinones, flavonoids, chlorinated metabolites, phenol and phenolic acids and many others [6].

The *P. variotii* isolate has shown the ability to produce siderophores and IAA. Biostimulation is generally associated with increased nutrient availability, similar to biofertilization, but it is also caused by multiple other factors, such as mechanisms including enhancement of plant systemic resistance. Thus, siderophore production plays a key role by enhancing the Fe uptake of plant sand can be considered an ecofriendly alternative to the use of chemical fertilizers and pesticides in the agricultural sector [8].

Plants can tolerate abiotic stress by two mechanisms: (I) via activation of response systems directly after exposure to stress (ii) biochemical compounds that are synthesized by

fungal endophytes, acts as anti-stress agents with the help of *Neotyphodium* spp. *Chaetomium globosum* and *P. resedanum Piriformospora indica D. lanuginosum Phialocephala fortinii* [6]. *Streptomyces spp*. and their metabolites may have great potential as excellent agents for controlling various fungal and bacterial phytopathogens [17]. Endophytic fungi promote plant growth by secreting gibberellins in the rhizosphere of their hosts, which leads to an increase in plant biomass production as well as disease resistance [21].

Biofertilization:

The use of plant probiotic microorganisms (PPMs) is an elective alternative to the use of chemical fertilizers. The most studied PPMs are plant growth-promoting bacteria (PGPB), although there are numerous examples of plant growth-promoting fungi (PGPF), which increase crop yield. Thus, the most relevant are those that establish endosymbiotic relationships, such as arbuscular mycorrhizal fungi, which solubilize nutrients, such as phosphorus, and micronutrients absorbed by plants. *Trichoderma* is one of the most studied genera as PGPF, although many others fungi have demonstrated their potential growth-promoting capacity, such as *Penicillium oxalicum, Penicillium simplicissimum, Fusarium oxysporum, Fusarium equiseti, Alternaria sp., Aspergillus spp. and Phoma,* among others [8]. The use of microbial inoculants (biofertilizers) possessing P-solubilizing activities in crop productivity is considered as an alternative to further application of mineral P fertilizers.

The aquatic hyphomycetes such as*; C. parvula* and *T. setigerum* would be the good source of new secondary metabolites required for bio-controlling agents as well as bio-fertilizers [30].

Importance:

The application of beneficial microorganisms (biopriming) may not only help to improve germination and vigor parameters but also relieve a wide range of physiological, abiotic and biotic stresses in both seeds and seedlings. *P. variotii* extract has a very high biological activity, with a low cost, which has a great application prospect [8]. Fungal endophytes act as nematicidal agents as they are known to produce some compounds which are toxic to nematodes [6].

Fungal symbionts associated with plants in natural ecosystems help plants overcome abiotic stress, such as soil salinity, drought and heat [20].Some aquatic root hyphomycetes act as a plant growth promoter which is beneficial in the field of agriculture for better plant productivity [30].

Conclusion:

Ubiquity of beneficial naturally occurring bacterial and fungal endophytes in plant roots is undisputed. One of our main aims for this study was to identify the beneficial plant-associated bacterial and fungal root endophytes which increase plant growth, health, and yield.

The internal root microbiome is dynamic and determined by many interacting biotic and biotic factors that occur at various spatial and temporal scales. Findings could significantly aid the development of novel, efficient, and sustainable strategies for improving crop quality and productivity while reducing the application of harmful chemicals. Plant growth promoting endophytes, abundance differed across different plant tissues, being significantly higher in roots.

Plant growth promoting root endophytes can directly stimulate plant growth by providing plants with fixed nitrogen, soluble phosphates, and siderophores .Root endophytes also stimulate plant growth through the production of metabolites such as IAA and ACC. These endophytes can indirectly stimulate plant growth by preventing the development of plant pathogens. Study demonstrated the multifunctionality of endophytic bacteria and fungi, importantly related to agriculture and medicinal field. Future research should aim to confirm the potential of the bacterial and fungal strains for use as inoculants, biofertilizers, or biological control agents of phytopathogens in order to replace chemicals and increase crop growth, health, and productivity and also root endophyte community dynamics remain an important area of future research.

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TEMPORAL ANALYSIS OF PRICES OF MILK AND MILK PRODUCTS IN TELANGANA STATE

Gayathri Sandrala*, M. Sivaram, P. K. Dixit, B. Rakesh and S. Khalandar

Dairy Economics and Statistics Section, Southern Regional Station,

ICAR-National Dairy Research Institute, Bangalore – 560 030

*Corresponding author E-maile: gayathrisandrala@gmail.com

Abstract:

Dairy sector Gross Value Added from livestock sector was 66 per cent. Dairy farming is one of the major livelihoods support systems for landless laborers, small and marginal farmers. The feed cost constitutes about 60 to 70 per cent of the total cost of milk production and thus has a significant bearing on profitability of milk. The policy makers and planners need to consider the present cost of milk production while fixing procurement prices of milk. At the same time, periodic calculation of cost of milk production is very difficult and time consuming. In this regard, a time series database on prices of milk and its related factors and its analysis will be useful tools for policymakers. Against this backdrop, a study on time series analysis of the prices of feed, milk and milk products in Telangana state was undertaken. The data used for the study pertained to the period 2005-06 to 2019-20. The procurement and retail prices of milk were collected from Nalgonda and Rangareddy Milk Producers Mutually Aided Cooperative Union Limited (NARMUL) and Telangana State Dairy Development Cooperative Federation Limited (TSDDCF-Vijaya Dairy)

The regression analysis of annual prices of milk for the period 2005-06 to 2019-20 revealed that the average annual increase in nominal procurement prices of buffalo milk (NARMUL Mother Dairy) was Rs.1.99/litre whereas the cow milk was around Rs.1.40/litre. An increase of about Rs.1.92/litre in the annual nominal milk procurement prices of buffalo milk (Vijaya Dairy) but cow milk was Rs.1.45/litre. The annual nominal retail price increase for milk, butter, ghee and curd for the period 2005-06 to 2019-20 was Rs.1.75/litre, Rs.23.73/kg, Rs.26.34/kg and Rs.3.86/litre respectively. The Compound Annual Growth Rate (CAGR) of real procurement prices of buffalo milk during 2012-13 to 2018-19 was around 4.27 per cent. However, the CAGR of real prices of cattle feed during the period was over 6 per cent. This indicates that the procurement prices of milk were not found to increase with the increase in feed prices. Hence, there should be a revision of milk prices based on latest feed prices.

Introduction:

In the Indian economy, the livestock sector plays a crucial role. About 20.5 million people depend upon livestock for their livelihood. Contribution from the livestock sector to the Gross Value Added (GVA) from agriculture and allied activities at current prices was approximately 29.35 per cent (2019-20). Livestock sector contributed 4.35 per cent of total GVA in 2019-20 (Economic Survey 2021-22). Dairy sector's share of GVA in the livestock sector was about 66 per cent (MoSPI, 2015-16). According to the 20th Livestock census, India stands first in the Livestock population with 535.78 million, (DAH&D, 2019). In India, milk production increased from 84.4 million tonnes in 2001–02 to 209.9 million tonnes in 2020-21 (NDDB, 2020-21).

In Telangana, agriculture adds about 18 per cent to the total GVA (DoES, 2017-18). The value of livestock production at current prices was estimated to be Rs.12,403 crore, and the livestock sector contributes 9.9 per cent to GVA (DAHDD&F, 2020-21). Telangana is a wealthy state in livestock resources, with a population of 32.6 million (22.21 per cent of India Livestock population), particularly cattle and sheep (DAH&D, 2019). The state ranks 8th in the population of Livestock and 1st in the population of sheep. About 29 lakh families are involved for their livelihood in the livestock industry in the State. Animal husbandry offers farmers with extra revenue and jobs, particularly during droughts.

Telangana ranks 13th in milk production with an annual output of 42.07 lakh MTs of milk (CEA, 2017-18). Approximately 105 lakh liters of milk are produced daily in the state. Of which about 48 per cent is procured by milk co-operatives (Telangana Today, May 31st, 2019). The remaining 52 per cent (55 lakh liters) of milk is consumed by individuals.

With the rise in input expenses, the cost of milk production has increased. On the other side, the consumer's milk prices have also risen. In the Demand-Supply-Production system of any product, price is the most important factor. Controlling the prices of food items forms an important agenda of every government and policy makers. Therefore, the spatio-temporal analysis of prices draws practical significance. The policy makers and planners must consider the latest cost of milk production while fixing procurement prices of milk. At the same time, periodic calculation of cost of milk production is very difficult. In this regard, a study was undertaken with the objective to undertake a time series analysis of prices of milk and factors affecting the milk prices.

Materials and Methods:

1. Data used

Prices of Milk: The price data of milk and milk products were compiled from the monthly progress reports and annual reports of NARMUL Mother Dairy and Vijaya Dairy from Telangana and price database was developed for the period 2005-06 to 2019-20 (up to July 2019). The Vijaya Dairy sells 7 varieties of milk and 10 varieties of milk products. However, for the purpose of analysis only the major products were considered which included milk, curd, butter, and ghee. Among the several milk varieties sold in sachets by Vijaya Dairy the sale volume of toned milk is high. Therefore, to analyze the trends in the prices of milk in the state, toned milk was considered.

Feed and fodder: The cost of feed and fodder accounts for 60 to 70 per cent of the total cost of milk production. So, with the increasing feed and fodder cost the prices of milk are expected to go up. For practical convenience, the feed is divided into three subgroups viz., concentrates, dry fodder, and green fodder.

Concentrates: The feed price database was developed for the period 2005-06 to 2019-20 (up to July 2019). The data collected from International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Directorate of Economics and Statistics (DoES) of Telangana.

Dry fodder: Paddy straw, ragi straw, maize straw, sorghum straw are the major sources of dry fodder in the state. The available time series prices of different fodders were collected from ICRISAT, Hyderabad.

Green fodder: Hybrid napier, guinea grass, jowar, maize and lucerne are the main green fodder sources in the state. The reliable time series price data of these items are difficult to collect and therefore, imputed costs were used for analysis. The prices of green fodder were collected from ICRISAT, Hyderabad

Labour wage: With the increasing agricultural labour wage the farmers will be expecting attractive milk price. If it is not attractive they may leave the dairying and joining other remunerative jobs. This will lead to short supply of milk. Rakesh *et al*., (2018) found that the positive correlation between milk prices and agricultural labour wages. The labour wages were collected in the form of Consumer Price Index (CPI) of agricultural labourers (base year 1986-87=100). (Source: Labour Bureau CPI 2005-06 to 2019-20)

2. Statistical analysis

Nominal Price: Nominal price is the current market price at which a product is sold. Nominal price does not take inflation into account.

Real Price: It is the price, which is adjusted for the inflation, enabling comparison of quantities as if prices had not changed. Changes in real terms therefore exclude the effect of inflation. Thus, the formula for real price is

$$\boldsymbol{Real\ Price} = \frac{Nominal\ Price}{WPI} \times 100$$

The real prices of various commodities such as retail prices of milk and milk products, procurement prices of milk and prices of feed and fodder items were worked out using WPI.

Construction of WPI series with new base year using linking factor

In order to accurately estimate inflation WPI series are published with different base years at regular time intervals. However, for time series analysis it is essential to bring WPI series with different base years to the same base year. For this purpos, there are three methods available.

(i) Arithmetic conversion method: The relationship between indices in the new series(x) and the old series(y) is assumed to be linear, i.e., $y = cx$, where c is the conversion factor or linking factor. Hence, c is calculated using y (bar) and x (bar). Generally x (bar) is 100.

(ii) Ratio method: In this method, month wise ratios of new indices and old indices are calculated first and then their average is taken as linking factor.

(iii) Regression method: In this method, the relation is based on $y = a + bx$, where a and b are regression coefficients.

In this study, arithmetic conversion method was employed to link WPI series 2004-05 with that of 2011-12 (with base year 2011-12=100). The linking factor is 1.561. (https://eaindustry.nic.in/)

Trend analysis

The graphs such as line graphs and bar chart were drawn to depict the annual tends in the prices of milk, milk products, feed and fodder items. The CAGR and regression equations were also worked out to know the growth pattern in the prices. Most of the results of the analysis of trends in current prices of milk and milk products are for the period 2005-06 to 2019-20 (up to July 2019).

Percentage volatility

Co-efficient of variation (% volatility) is the ratio of standard deviation to mean. The following formula is used to obtain co-efficient of variation,

$$\boldsymbol{Volatality}(\%) = \frac{Standard\ devation}{Mean} \times 100$$

Growth trends of prices of feed, milk and milk products

The CAGR was estimated to comprehend the growth trend in procurement and retail prices of milk, milk products and feed. The CAGR was calculated for the period 2005-06 to 2011-12 and 2012-13 to 2019-20 (up to July 2019) separately and also for the overall period 2005-06 to 2019-20. Two approaches were used to calculate CAGR. One is using exponential regression models if the time series data is available for the defined time period and the other is using point to point method wherever limited data is available.

Calculation of CAGR from exponential regression model

Exponential growth model fitted for time series data from 2005-06 to 2019-20

$$Y_t = ab^t$$

where,

Y_t = Price

a = Constant term

b = (1+r) where 'r' is the CAGR

t = Time period

Based on the estimated slope parameter (b), the CAGR (%) was calculated as:

$$r(\%) = [\text{Antilog of } (b^*)\text{-}1] \times 100$$

where, b^*=Log b

Point to point formula for calculating CAGR

$$CAGR = [(Yn/Y_0)^{1/n}\text{-}1] \times 100$$

where,

Yn = Value at terminal year

Y_0 = Value at the beginning year

n = Number of years between terminal and beginning years

Results and Discussion:

1. Trends in prices of buffalo and cow milk in Telangana (Nominal Prices) NARMUL Mother dairy

Figure 1 presents the trends in procurement and retail prices of Buffalo milk. The regression equations fitted to the price trends showed an increase of Rs.1.99/litre in nominal annual milk procurement prices. The annual increase in nominal retail prices of buffalo milk was by Rs.1.75/litre. The price rise during 2005-06 to 2019-20 could be attributed to increased demand for milk and milk products with the increased purchasing power and standard of living besides high level of general inflation.

Figure 2 presents the trends in nominal procurement and retail prices of cow milk. The average annual increase in milk procurement prices was Rs.1.40/litre. The procurement prices of cow milk were lower than the retail prices of cow milk. The procurement of cow milk by milk unions was very low in the state due to lack of demand for this milk. In the state price trends of toned milk of buffalo was almost similar to that of price trends of cow milk so we considered only retail price of toned milk as base to compare procurement prices of cow and buffalo with toned milk prices.

2. Trends in prices of buffalo and cow milk (Vijaya Dairy) in Telangana (Nominal Prices)

Figure 3 presents the trends in nominal procurement and retail prices of buffalo milk. The regression equations showed an increase of Rs.1.92/litre in annual milk procurement prices. The Vijaya Dairy is the brand name for TSDDCF which is under the guidance of state government. The decision of the State Government to provide an incentive of Rs 4/litre of milk to dairy farmers has turned out a boon for both dairy farmers and cooperative dairies.

Figure 4 presents the trends in nominal procurement and retail prices of cow milk. The regression equations showed an increase of Rs.1.45/litre in average annual milk procurement prices. It is noted that the volatility in milk procurement prices was higher than in retail milk prices. The procurement of cow milk less due to lack of demand for this milk in the state.

3. Trends in retail prices of milk products in Telangana (Nominal Prices)

Figure 5 represents trends in nominal retail prices of milk products. The average annual price increase for milk, butter, ghee and curd for the period 2005-06 to 2019-20 was Rs.1.75/litre, Rs.23.73/kg, Rs.26.34/kg and Rs.3.86/litre. The prices of milk products such as butter and ghee were more volatile than milk but less than curd. This could be because of availability of more choices for butter and ghee in the market and different brand preferences of the consumers in the state.

4. Trends in procurement price of milk and feed price in Telangana (Nominal Prices)

Figure 6 presents trends in procurement prices of milk and feed price. The regression equation shows that the retail prices of cattle feed rose by Rs.1494.34/tonne, Rs.253.7/tonne for paddy straw and Rs.819.29/tonne. The data pertaining to prices of feed was collected from ICRISAT. The prices of feed are very difficult to collect as many of the farmers do not buy paddy straw from retailers, mostly they use from their own field. So, to estimate the prices of feed is a difficult task. The procurement prices of milk were increasing hand-in-hand with increase in feed prices. So, there should be a revision of milk prices based on latest feed prices.

5. CAGR of prices of buffalo and cow milk (NARMUL Mother Dairy) in Telangana (Real Prices)

The CAGR, of procurement price of buffalo milk, for the period 2005-06 to 2011-12 was around 6.28 per cent ($p<0.05$) and for the period 2012-13 to 2018-19 it was about 3.83 per cent ($p<0.05$) (Table 1). In terms of retail prices of buffalo milk, from 2005-06 to 2011-12 was 1.21 per cent ($p<0.05$)and from 2012-13 to 2018-19 it was 3.90 per cent ($p<0.05$). The difference in the growth rates of procurement and retail prices was due to lack of supply as compared to demand. In order to reduce this gap, the government is providing an incentive of Rs.4/litre for the milk procured by TSDDCF with effect from November 1st, 2014 to benefit the rural dairy farmers. The scheme is extended to NARMUL Mother Dairy.

The CAGR, for procurement price of cow milk was about 6.87 per cent ($p<0.05$) for the period 2005-06 to 2011-12 and 3.64 per cent ($p<0.05$) for the period 2012-13 to 2018-19 (Table 1). The reduction in growth rate of procurement price of cow milk was attributed to lack of demand in the state. Compared to buffalo milk, the cow milk contains less fat, hence it has low demand.

6. CAGR of prices of buffalo and cow milk (Vijaya Dairy) in Telangana (Real Prices)

The CAGR of procurement prices of buffalo milk was 7.48 per cent ($p<0.05$) for the period 2005-06 to 2011-12 and 3.44 per cent ($p<0.05$) for the period 2012-13 to 2018-19 (Table 2). The decrease in rate of growth of procurement prices of buffalo milk was due to more demand than supply as in the case of NARMUL Mother Dairy. To overcome this gap, government is providing Rs. 4/litre from November 2014. To increase the supply of buffalo milk the government has cleared the proposals for distribution of buffaloes to around 2.17 lakh dairy farmers through cooperative dairies in the State. Each buffalo costing an estimated Rs 80,000 will be supplied to the beneficiary at about 50 per cent subsidy. Through cattle distribution, the State government aims to achieve daily procurement of 8.5 lakh litres through Vijaya Dairy alone for the year 2019-20.The CAGR of procurement price of cow milk was around 5.71 per cent ($p<0.05$) for the period 2005-06 to 2011-12 and 4.27 per cent ($p<0.05$) for the period 2012-13 to 2019-20 (Table 2). There exists a gap of 1.44 per cent of rate of growth of cow milk in the state was due to lack of demand for this milk.

7. CAGR of retail prices of milk products in Telangana (Real Prices)

The CAGR for milk and curd was 1.21 per cent ($p<0.05$) and 3.78 per cent ($p<0.05$)for the period 2005-06 to 2011-12, while the CAGR for butter and ghee was 1.42 per cent ($p<0.05$)and 3.81 per cent ($p<0.05$)respectively (Table 3). The real butter and ghee prices were more volatile than the actual milk but less than curd prices. This may be due to the various

factors including the entry of private players on the butter and ghee market with innovative packaging and brand development along with the improved product quality that attracts consumers (Sunilkumar *et al*., 2017).

8. CAGR of prices of milk and feed prices in Telangana (Real Prices)

The CAGR of cattle feed, paddy straw and rice bran were 10.94 per cent ($p<0.05$), 12.86 per cent ($p<0.05$) and 6.33 per cent ($p<0.05$) respectively for the period 2009-10 to 2015-16 whereas CAGR of procurement prices of milk was 11.05 per cent ($p<0.05$). The volatility of feed prices for cattle feed and paddy straw was higher than the milk procurement prices (Table 4). The data pertaining to prices of feed was collected from ICRISAT. The prices of feed are very difficult to collect as many of the farmers do not buy paddy straw from retailers, mostly they use from their own field. So, to estimate the prices of feed is a great task for all of them. The results showed that the rise in milk procurement prices was not in consistent with the rise in feed prices. The government must take decisions objectively based on updated facts and figures to reduce the inequality between prices.

Conclusion:

- The current procurement and retail prices of milk should be revised in Telangana State based on the recent trends in feed costs and labor wages.
- Database on dairy sector should be developed and updated from time to time and used for trend analysis and forecasting which will be useful for policy making.
- Adequate support and funding are required for the above activities

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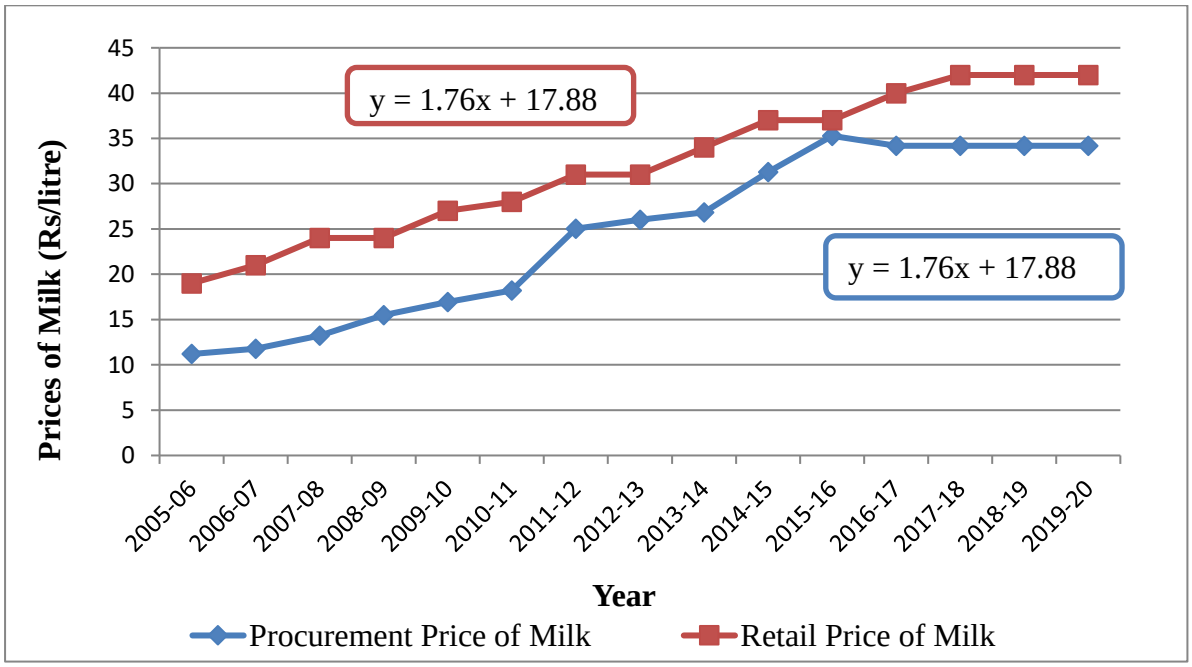

Figure 1: Trends in procurement and retail prices of buffalo milk of NARMUL Mother Dairy-Nominal Prices (2005-06 to 2019-20)

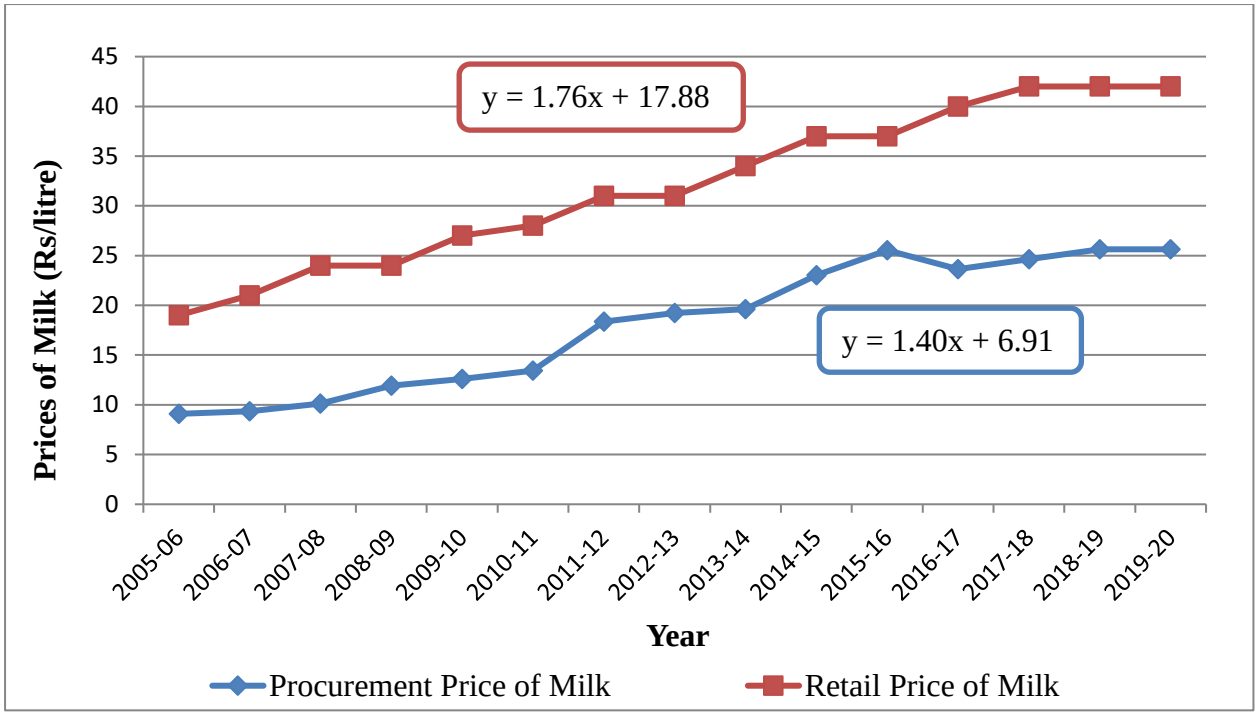

Figure 2: Trends in procurement and retail prices of cow milk of NARMUL Mother Dairy- Nominal Prices (2005-06 to 2019-20)

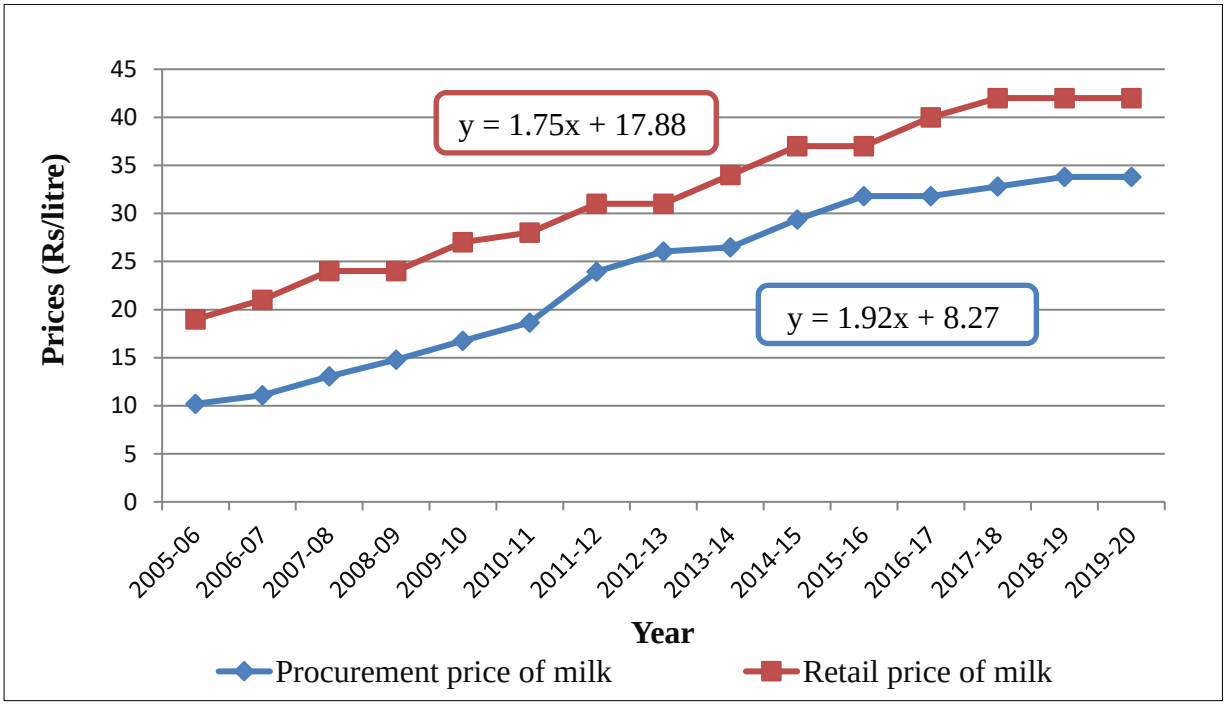

Figure 3: Trends in procurement and retail prices of buffalo milk of Vijaya Dairy – Nominal Prices (2005-06 to 2019-20)

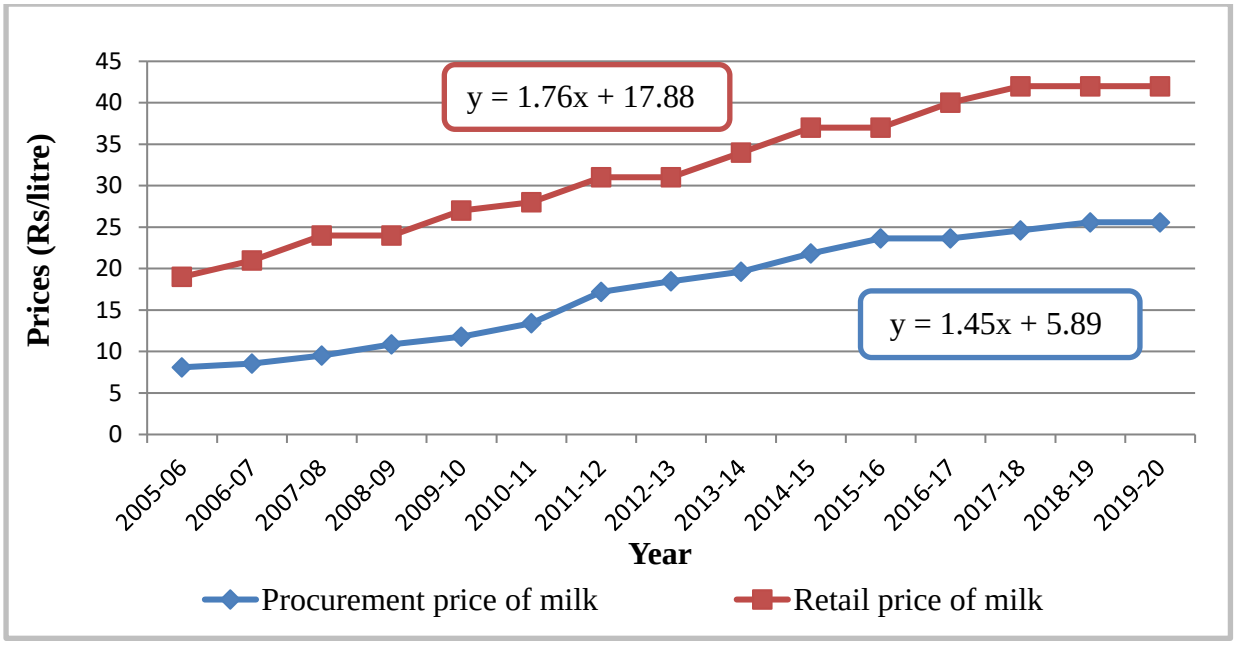

Figure 4: Trends in procurement and retail prices of cow milk of Vijaya Dairy- Nominal Prices (2005-06 to 2019-20)

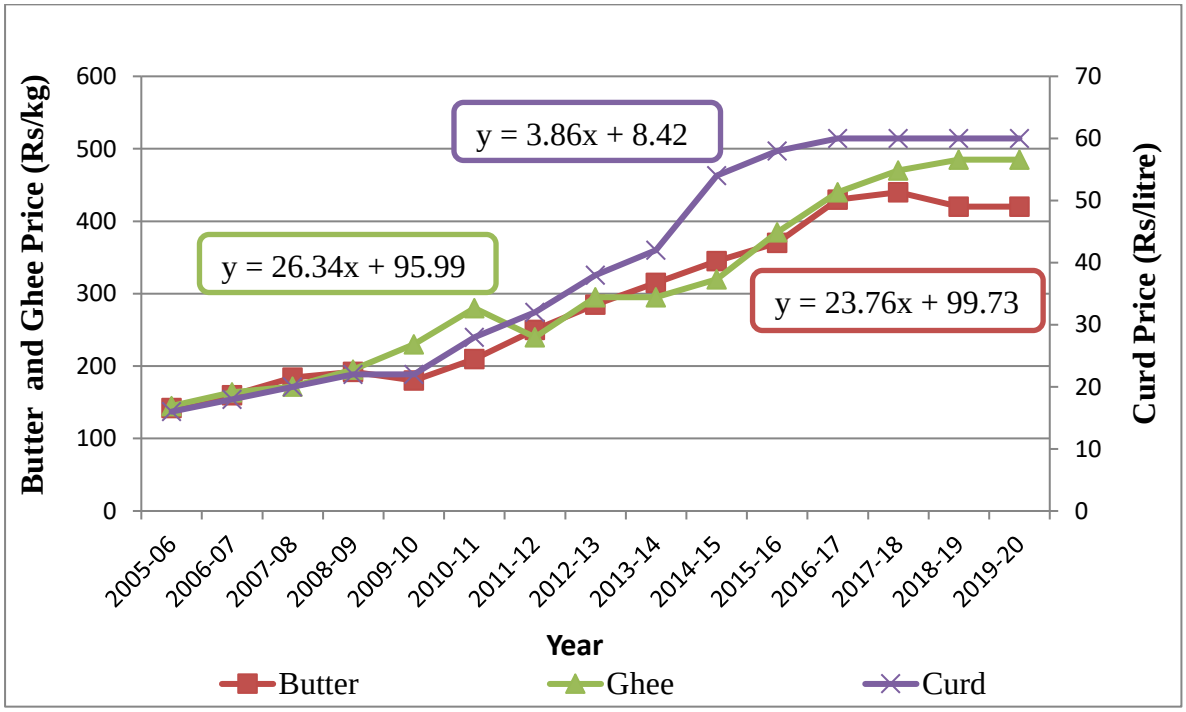

Figure 5: Trends in retail prices of milk products –Nominal Prices (2005-06 to 2019-20)

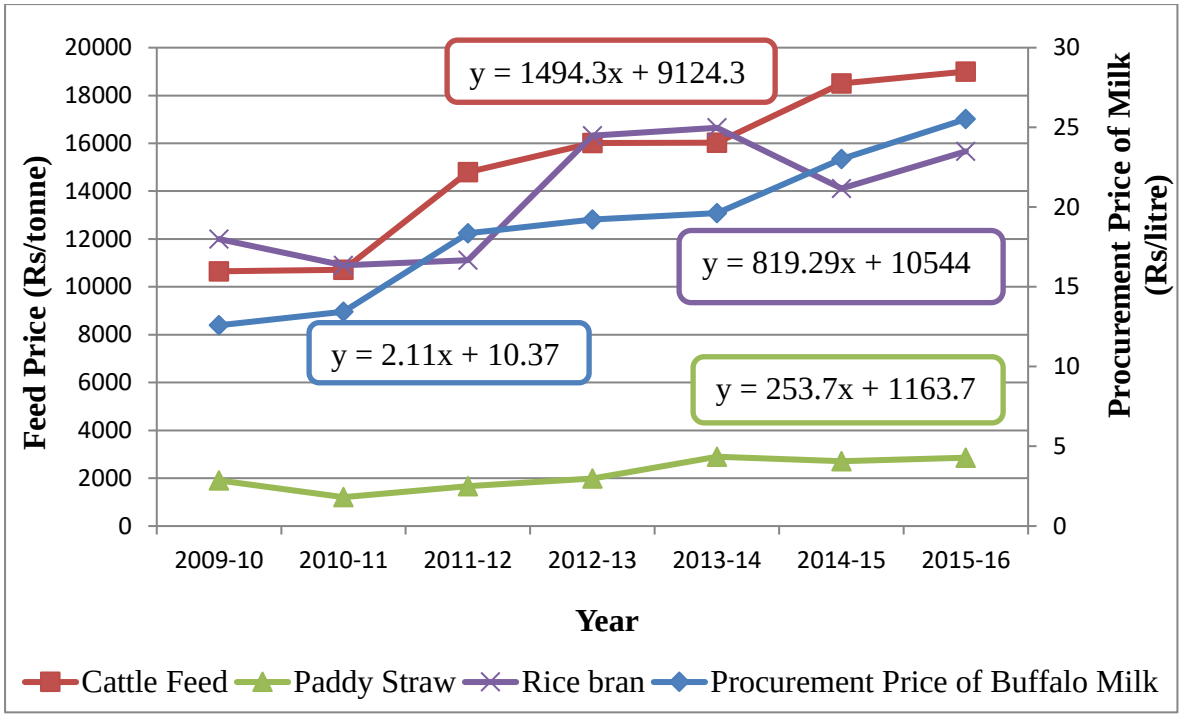

Figure 6: Trends in procurement price of milk and feed price-Nominal Prices (2009-10 to 2015-16)

Table 1: CAGR of real prices of buffalo and cow milk (NARMUL Mother Dairy)

Item	Percent per annum (2005-06 to2011-12)	Percent per annum (2012-13 to 2018-19)	Percent per annum (2005-06 to 2018-19)
Procurement price of buffalo milk	6.28	3.83	5.44
Procurement price of cow milk	6.87	3.64	5.44
Retail milk price	1.21	3.90	1.56

Table 2: CAGR of real prices of buffalo and cow milk (Vijaya Dairy)

Item	Percent per annum (2005-06 to2011-12)	Percent per annum (2012-13 to 2018-19)	Percent per annum (2005-06 to 2018-19)
Procurement price of buffalo milk	7.48	3.44	5.45
Procurement price of cow milk	5.71	4.27	5.39
Retail milk price	1.21	3.90	1.56

Table 3: CAGR of real retail prices of milk and milk products in Telangana

Item	Percent per annum (2005-06 to 2011-12)	Percent per annum (2012-13 to 2018-19)	Percent per annum (2005-06 to 2018-19)
Butter	1.42	6.30	4.81
Ghee	3.81	8.95	4.91
Curd	3.78	5.53	5.48

Table 4: CAGR of real prices of milk and feed price (2009-10 to 2015-16)

Item	Percent per annum (2009-10 to 2015-16)
Procurement Milk Price	5.80
Cattle feed	5.70
Paddy straw	7.52
Rice bran	1.30

AN OVERVIEW OF BIOFERTILIZERS

Santosh Vitthalrao Jadhav

Department of Microbiology,

Khare, Dhere and Bhosale College, Guhagar, Dist. Ratnagiri, M.S., 415 703

Corresponding author E-mail: jadhavsantoshkdbc@gmail.com

Biofertilizers:

Biofertilizers are like the superheroes of agriculture—they're natural, living organisms that boost soil fertility and promote plant growth. Unlike traditional fertilizers, which often rely on synthetic chemicals, biofertilizers harness the power of beneficial bacteria, fungi, or other microorganisms. These tiny allies form symbiotic relationships with plants, enhancing nutrient uptake, fixing atmospheric nitrogen, and even warding off harmful pathogens. In a nutshell, biofertilizers are the eco-friendly sidekicks that help farmers cultivate healthier crops while minimizing environmental impact.

Biofertilizers are substance that contains microbes, which helps in promoting the growth of plants and trees by increasing the supply of essential nutrients to the plants. It comprises living organisms which include mycorrhizal fungi, blue-green algae, and bacteria. Mycorrhizal fungi preferentially withdraw minerals from organic matter for the plant whereas cyanobacteria are characterized by the property of nitrogen fixation.

Nitrogen fixation is defined as a process of converting di-nitrogen molecules into ammonia. For instance, some bacteria convert nitrogen to ammonia. As a result, nitrogen becomes available for plants (Wikipedia).

Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances.

Biofertilizers are means of fixing the nutrient availability in the soil. Generally, Nitrogen deficiencies.

***Azolla-Anabaena* symbiosis**: Azolla is a small, eukaryotic, aquatic fern having global distribution. Prokaryotic blue green algae Anabaena- azolla resides in its leaves as a symbiont. Azolla is an alternative nitrogen source. This association has gained wide interest because of its potential use as an alternative to chemical fertilizers.

***Rhizobium*:** Symbiotic nitrogen fixation by *Rhizobium* with legumes contribute substantially to total nitrogen fixation. *Rhizobium* inoculation is a well-known agronomic practice to ensure adequate nitrogen (Soe and Yamakawa, 2013).

Types of biofertilizers

Following are the important types of biofertilizers:

Symbiotic nitrogen-fixing bacteria

Rhizobium is one of the vital symbiotic nitrogen-fixing bacteria. Here bacteria seek shelter and obtain food from plants. In return, they help by providing fixed nitrogen to the plants.

Symbiotic nitrogen-fixing cyanobacteria

Blue-Green algae or Cyanobacteria from the symbiotic association with several plants. Liverworts, cycad roots, fern, and lichens are some of the Nitrogen-fixing cyanobacteria. Anabaena is found at the leaf cavities of the fern. It is responsible for nitrogen fixation. The fern plants decay and release the same for utilization of the rice plants. Azolla pinnate is a fern that resides in rice fields but they do not regulate the growth of the plant.

Free-living nitrogen-fixing bacteria

They are free-living soil bacteria that perform nitrogen fixation. They are saprotrophic anaerobes such as *Clostridium beijerinckii*, Azotobacter, etc. Among all the types of biofertilizers, Rhizobium and *Azospirillum* are most widely used (John *et al.,* 2011; vedantu.com).

Importance of Biofertilizers

Biofertilizers are important for the following reasons:

- Biofertilizers improve the soil texture and yield of plants.
- They do not allow pathogens to flourish.
- They are eco-friendly and cost-effective.
- Biofertilizers protect the environment from pollutants since they are natural fertilizers.
- They destroy many harmful substances present in the soil that can cause plant diseases.
- Biofertilizers are proved to be effective even under semi-arid conditions.[1][4]
- Enhanced nutrient availability
- Phytohormone production
- Siderophore production
- Enzyme production
- Antibiotic production
- Production of hydrogen cyanide and ammonia

- Potassium-solubilizing microbes.
- Zinc solubilizing microbes.
- Sulphur oxidizing microbes
- Plant growth promoting rhizobacteria

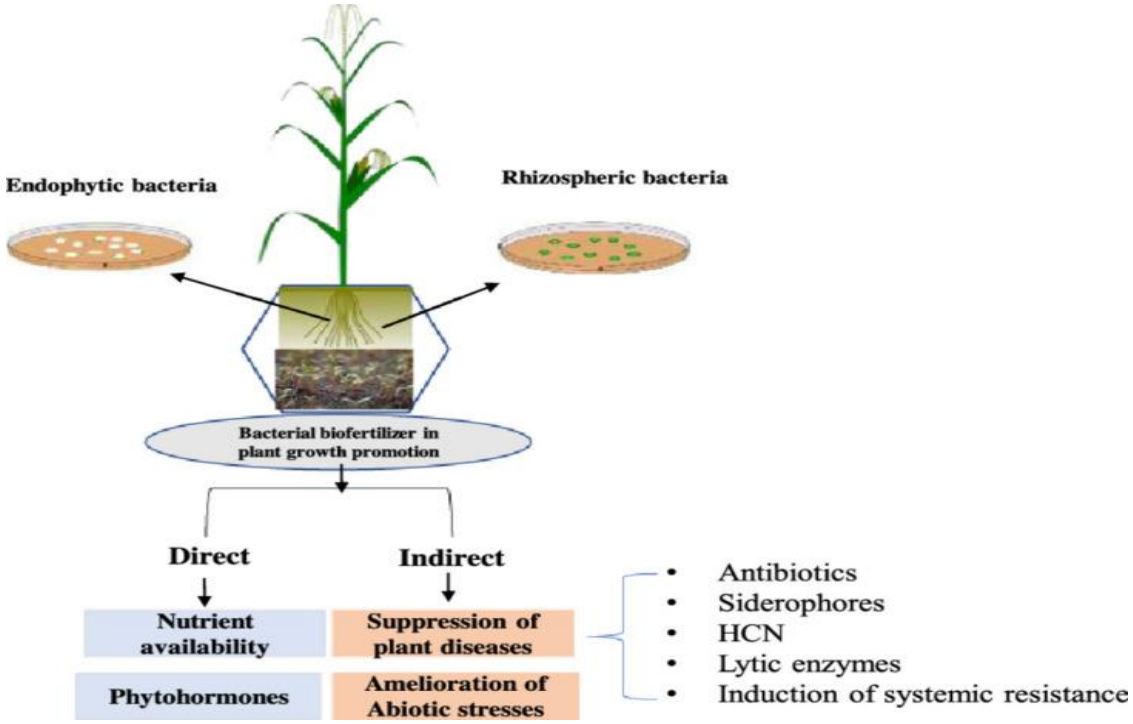

Figure 1: Bacterial biofertilizers in plant growth promotions (ncbi.nlm.nih.gov)

- **Applications of biofertilizers:**

  Following are the important applications of biofertilizers:

- **Seedling root dip**

  This method is applicable to rice crops. The seedlings are planted in the bed of water for 8-10 hours.

- **Seed treatment**

  The seeds are dipped in a mixture of nitrogen and phosphorus fertilizers. These seeds are then dried and sown as soon as possible.

- **Soil treatment**

  The biofertilizers along with the compost fertilizers are mixed and kept for one night. This mixture is then spread on the soil where the seeds have to be sown.[1][4]

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About Editors

Dr. Rajendra Vishnu Salunkhe is currently working as Associate Professor at Department of Zoology and Head of the Department of Microbology at Arts, Science and Commerce College, Indapur, Dist. Pune. He has teaching experience of 31 years at graduate and post graduate level at Savitribai Phule Pune University, Pune. He has published research papers in leading national and international journals. He is working as a member of examination committee at Punyashlok Ahilyadevi Holkar Solapur University. He has received a 'Best research paper presentation award' at national conference. His biography has been published as 'Herpetologist and Educationist' in Asia-Pacific Who's Who by Rifacimento International, Delhi. He is a life member of Indian Science Congress Association. He has worked on snake research project and submitted to Pune University in 2014. He has massive contribution in the snake rescuing. He rescued 2750 snakes from Indapur tehsil and doing work since 30 years. He is good in bird watching and has collection of 245 bird species identification data from tehsil area.He conducted the certificate courses and demonstrated the college students that how to rescue the venomous snakes at an ease. In his youtube channel 'Dr. Rajendra Salunkhe' many videos are famous for snake rescuing and releasing activities. He is a good trekker climbed many difficult forts.

Dr. Gargi Goswami born in Almora passed her high school from Koormanchal Academy and intermediate from Kendriya Vidyalaya, Almora. Then she completed graduation in Agriculture (2011) and post graduation in (Ag.) Agronomy (2013) from G.B.P.U.A. & T., Pantnagar (U.K.). Further, Dr. Gargi received Doctorate degree in Agriculture Agronomy from Banaras Hindu University, Varanasi, Uttar Pradesh. She is working as Assistant Professor (Agronomy) at College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri (U.K.) since March 2018. She is deeply involved with research on organic farming focusing mainly on hill agriculture. Till date Dr. Goswami have guided 05 M.Sc. students, published 13 research papers in reputed journals, 1 book and 04 book chapters and participated for oral and poster presentation in various seminars, symposium, workshops and conferences. In addition to teaching she is actively engaged in research, extension and administrative duties. Also she has been awarded with Young woman scientist award (2018), Young scientist award (2019) and Young agronomist award (2021) from different organizations.

Mr. Vivek Kumar Patel was born in Ayodhya, Uttar Pradesh and completed his schooling from Uttar Pradesh. He did his B. Sc. (Agriculture) in 2017 and M.Sc. (Agriculture) in Soil Science and Agricultural Chemistry in 2019 from Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, (Uttar Pradesh). Currently he is working at Rajendra Prasad Central Agriculture University, Pusa, Samastipur, Bihar. He has published a book, a manual, a technical bulletins and many research papers, review papers, book chapters, abstract and popular articles. He also participated in several National and International conferences, training and workshop. He is highly enthusiastic towards variable research in different branches of Agricultural Sciences. He is highly positive towards imparting his knowledge among the different educational and farming societies.

Mr. Kumar Chiranjeeb, now perusing Ph.D. in Soil Science from Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, HP. He completed his B.Sc.(Ag) in 2017 from OUAT, Odisha and Masters in Soil Science in 2019 from RPCAU, Pusa with ICAR-NTS fellowship. Mr. Kumar cleared ICAR-ASRB NET in 2021 in Soil Science. He has published 6 research articles, 5 book chapters in CRC press and other journals, 6 review papers, 16 popular articles, 2 co-editorship in agriculture books, 1 book chapter in edited book. He got awards like Emerging Scientist Award in 2021 and Excellence in Research Award in 2022. His research interest fields are Vermicompost Technology, Soil Fertility, Nutrient Management, Rice-wheat, Silicon Technology, and Soil Microbiology.

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