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REVIEW PAPER

Traditional Fermented Food and Drinks of Western Orissa

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ABSTRACT

Fermented foods arise in the human relationship to the microbial environment. Human survival is connected to yeasts and bacteria that produce lactic acid and alcohol in preserved foods. The people in Orissa, like many other states in India, have a tradition of relishing a variety of cakes locally called as *pitha*, specially prepared during various festivals and rituals. Some of these foods are prepared from cereal-legume batters. These product includes *Chakuli, enduri pitha, podo pitha* and *bara pitha* which are unknown to the scientific community. Other fermented food which the people of Orissa consumed is *Basi pej, tentuli bata (Tamarindus indica Linn.)* and Hendua cake *(Dendrocalamus strictus Nees*) and Fermented liquors included *Pendum*, and *Salap* which are considered as the most nutritious liquor of Orissa people and have been consumed as a regular food over a long period of time. In the study, all these foods and liquor are described with respect to the nature of product, method of preparation, mode of consumption and ethnic values.

Key words *Salap, traditional, fermented liquor, Pitha*

A food is considered fermented when one or more of its constituents have been acted upon by microorgan-isms to produce a considerably altered product ac-ceptable for human use. Food fermentation represents one of the oldest known uses of biotechnology and the main advantages of food fermentation can be categorized as follows. Food fermentation develops a diversity of appealing exteriors, textures, aromas and flavours in food substrates. The increasing popularity of different types of e.g., fermented milks has as much to do with different textures that are created during the fermentation, as with significant flavour changes. The formation of diacetyl by heterofermentative lactic acid bacteria in fermentations of yoghurt and butter is not only important as a major flavour component, but it may also help inhibit less desirable microorganisms.

Food fermentations not only enrich the food substrates with protein, essential amino acids and fatty acids, but also with vitamins. Biosynthesis of B vitamins in food fermentations has been recognized to be of major nutritional significance, especially in the area where high-carbohydrate diets, particularly maize and sorghum diets can be deficient in essential B vitamins. Food fermentations also have functions in digestibility, bio-availability, and detoxification. Fermented foods generally have a very good safety record even in the developing world where foods are often manufactured by people without formal training, and under conditions of poor hygiene. (Padhan S, 2017)

Traditional or indigenous fermented foods are those popular products, that since early history have formed an integral part of the diet and that can be prepared in the household or in cot-tage industry using relatively simple techniques and equipment". The origins of most fermentation tech-nologies have been lost in the mists of history. Many fermented foods are now receiving world attention for their health-promoting or disease-preventing effects. Fermentation improves pulse digestibility for humans. The process can detoxify pulses by reducing haemag-glutinin, phytate, oligosaccharides and trypsin inhibi-tors. Other attributes are improved flavour, nutritional value, appearance and reduced cooking time. In some fermented products containing spices and salt, the keeping quality is considerably enhanced. Fermented foods provide variety in the diet (Padhan S, 2014)

Although several legume-based fermented foods, like *idli, dosa, dhokla, khaman, wadi and Papad* from different parts of India have been well studied and even several of these are scaled-up. There is no documentation on similar foods, Indige-nous to the state of Orissa. Therefore the objective of this study is to look for legume-based fermented foods and different liquors consumed by the Western Orissa people, if any, Practiced traditionally in Orissa.

MATERIALS AND METHODS

The documentation study was carried out in villages of different district like Sambalpur, Balangir, Nuapada and Kalahandi of Western Orissa. From each of the district two villages were purposively studied. The idea here was to document the traditional knowledge associated with indigenous fermented foods preparation processes in step by step. It is important to note here that the legume based and plant materials traditionally used were taxonomically identified and the local name of those materials also included. Traditional methods of preparation, modes of consumption, shelf life and ethnic value of legume- based fermented foods were studied and the local people were studied through a well-structured pre-tested Performa, and by personal interview method.

RESULTS AND DISCUSSION

Some important steps of preparation of differ-ent types of legume-based fermented foods, plant product and fermented liquor tradition-ally practiced in Orissa are presented. As all these foods are delicious and easily digestible, these are also suitable for ailing person, pre- or post-natal women and children. These foods, prepared and con-sumed by all the communities irrespective of caste and creed, are described below.

Podo pitha: During the preparation of *podo pitha*, Kang *(Panicum sumatrense Roth ex Roem. & Schult.),* and Kushla (*Panicum vulgare*) mixed are grinded and left for 5-7 hours to ferment. Then the fermented batter is mixed with minced coconut, raisins, cashew nuts and sugar. Pre heat the pan

for 10 minutes and grease it with ghee. Pour the paste into the tray and keep it on the fire. The batter is then covered all round with hot charcoal and Keep the pan very hot for 30 minutes. Then keep it moderately hot for 30 minutes. It should be checked with a needle and when its colour is golden brown the *Poda Pitha* is ready to eat. Then remove the whole *Poda Pitha* (cake) from the fire and allow it to cool down. Cut it into small pieces and serve it with any chutney preferably with coconut chutney. It is prepared during different festivals including *bijaya dashami* festivals.

Enduri pitha: *Endure pitha* is a steamed flavored cake, prepared by taking the fermented batter (as done for making *chakuli*) in a turmeric (*Curcuma longa L.)* leaf and folding the leaf through oven. It is also stuffed with coconut, *dahi-chhena* and sugar fillings. The batter-filled folded leaves are then cooked over steam. Its shelf life and mode of consumption is similar to that of *chhuchipatra pitha*. *Prathama astami* is the festival during which *enduri pitha* is prepared.

Chakuli: *Chakuli*, which resembles *dosa*, is a round, fried pancake. It is prepared (fig.1) from varying proportions of par-boiled rice (*Oryza sativa L.*) and black gram (*Phaseolus mungoL.*). A little amount of boiled rice may be added, and blackgram may be substituted with juice of jack fruit (*Articarpus heterophyllus Lam.*) or palmyra palm (*Borassus*

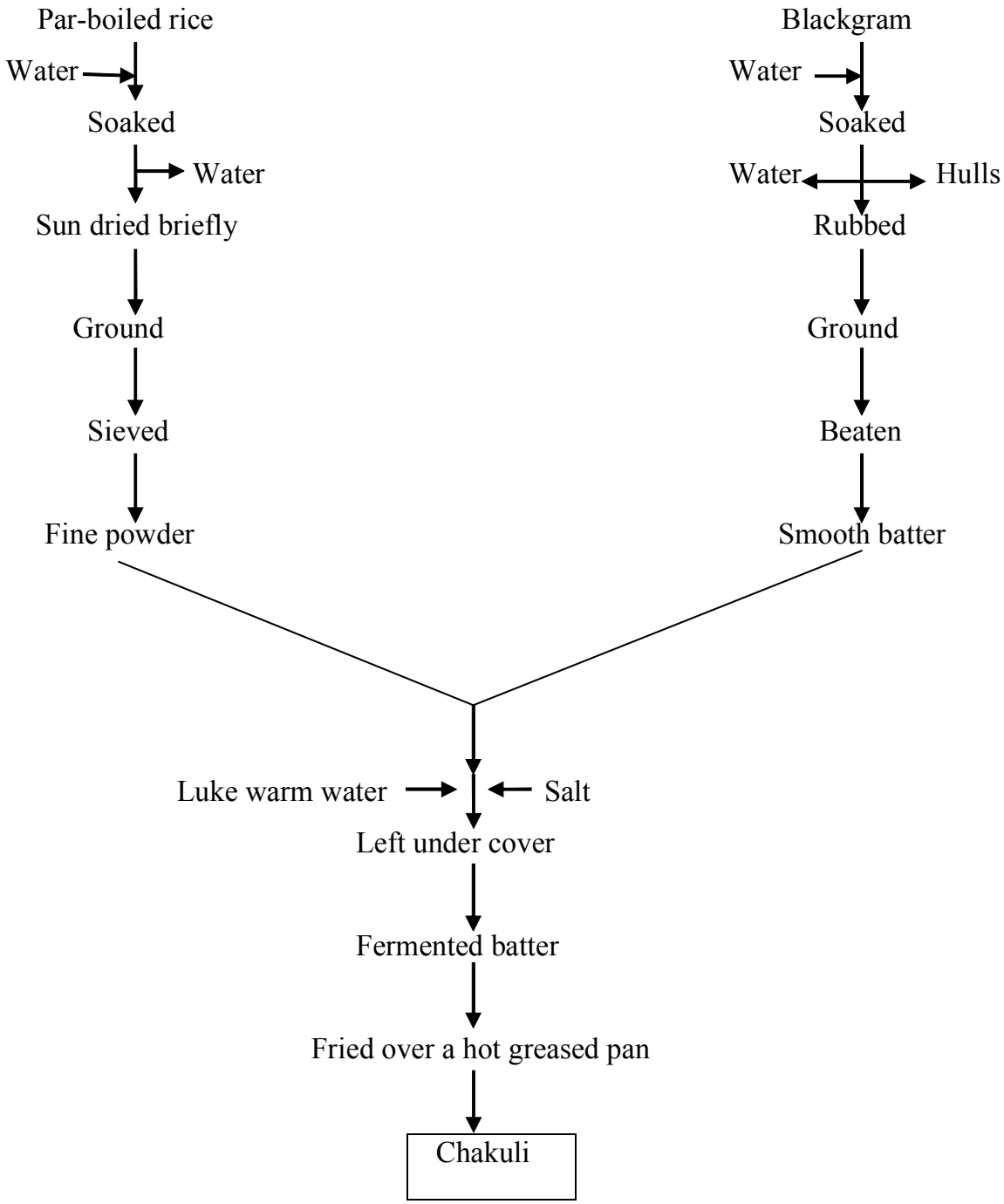

Fig. 1. Flow chart showing production of *chakuli*

Bara pitha

Podo pitha

Fermented rice (Basi pej)

Salap *(Caryota urens Linn.)*

Madhuca indica J.F.Gmel.

Dendrocalamus strictus Nees

Fig. 2. Traditional food products

flabellifer L.) fruit during summer.

Chakuli is taken as breakfast food or snacks with a variety of side dishes including *sambar,* sugar, jiggery, tea, milk, vegetable curry, or even without any side dish. Though the shelf life of *chakuli* is one day, they are consumed hot and fresh for optimum delicacy. It is prepared during all the festivals.

Bara pitha: *Bara pitha* is prepared by mixing the fermented batter (as prepared in making *chakuli*) with sugar and grated coconut. The pan is heated with oil. Small ball are prepared and added in the oil one by one. More than 15 small balls are deep fried at a time. It is fried on a low heat and deep frying method is used for frying. Although it has a shelf life of one day, *bara pitha* is delicious when taken fresh and hot. Generally it is taken with sugar syrup and tea. Bara is prepared in popular festivals like, *makara sakranti* and *Nuakhai*.

Fermented rice (*Basi pej*): The cooked rice is ferment with rice soup for whole night. The food gets ferment. Then add salt, curd/lemon and chili pieces in the fermented food. Add onion pieces into the dish. It is ready to eat. *Basi pej* mainly is the poor's people diet and it is tastier during summer season. A good flavor is developing due to fermentation and easy to digest.

Bamboo (*Dendrocalamus strictus Nees),* Kardi: Shoot tips of youngling bamboo collected, sliced into pieces are called *Kardi*. These pieces are dipped in water for a day for fermentation and consumption. After a day of fermentation, the bitterness is washed off and further cooked. It is also sometimes pounded in stone mortar and pestle and sun dried. It is locally called as *Hendua*, which is taken as a curry throughout the year. It is also used as a medicine against any digestive problem, particularly against constipation. The important *Hendua* producing sites in Western Orissa are mostly in the hills and have been localized according to the abundency of the raw material.

Mahua flowers (*Madhuca indica J.F.Gmel.),* Mahul chaki: Wild flowers are dried under the sun and are stored for

further use as food. Dried flowers are soaked in water, rubbed to separate the outer flower skins, boiled till water gets totally dried up and leave it for fermentation and stored for consumption.

Salap *(Caryota urens Linn.)*

Salap tree
↓
Pricked with a stick (top of the tree)
↓
Hang a pot
↓
Liquid dribbles down
↓
Collected in the pot
↓
Rice is added to speed up fermentation
↓
Liquid is gathered in pot
↓
Remove the liquid from pot in an interval of 4-5 days
↓
Salap

Fig. 3. Flow chart showing *Salap* production

Salap is the most favorite drink of the Western Orissa people. The people consume *salap* for refresh their mood.

CONCLUSION

Traditional fermented foods and liquors of Western Orissa are prepared at the household level through the indigenous practices of food processing and preservation. There is a need of awareness about basic hygienic knowledge of production for good manufacturing practices (GMP) and safety of the marketed food products as per HACCP system are the major issues to be focused with immediate attention. To provide the increasing global population with a source of protein other than meat is a worldwide challenge. Alternative sources are legumes and cereals. But plant protein by itself often lacks desirable flavours. In Western Orissa, fermented food and drinks are one of the most important traditional products consumed during festivals and ceremony. Throughout history, the Western Orissa people seemed to follow their own ways in developing the product without outside influences. Although a pure culture method for preparing *pitha* and liquor has been developed, further studies are still needed to guarantee uniform high quality products. If innovations in taste, flavour and product quality are made, *pitha* and different liquor may become more widely popular all over the world. There has been a growing interest world over to explore search and collect microbial germplasm in search of gene pool, which can help biotechnologist to develop value added products for human welfare.

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REVIEW PAPER

Recent Technological Interventions in Rice Based Cropping Systems - A Review

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Rice (*Oryza sativa* L.) is the most important staple food crop in India that holds key to food security. Rice-based production systems provide livelihood for more than 50 million households. In India, rice is grown on more than 44 m ha under three major ecosystems; rainfed uplands (16% area), irrigated medium lands (45%) and rainfed lowlands (39%), with a productivity of 0.87, 2.24 and 1.55 t ha^{-1}, respectively. The change in climate has been attributed to global warming and has many facts, including changes in long term trend in temperature and rainfall regimes as well as increasing yearto- year variability and a greater prevalence of extreme events. Agricultural systems will be affected by both short and long term changes in climate, and will have serious implications on rural livelihoods, particularly of the poor being the most vulnerable. The impact of climate change poses serious threats to productivity and sustainability of various rice- based cropping systems including rice- wheat cropping system, the backbone of food security of India. Despite some projected increase in photosynthesis caused by increased concentrations of carbon dioxide, increased temperature will have a far greater detrimental effect, resulting reduced crop productivity. The rice - based cropping systems will continue to be important cropping systems in India in the years to come. Therefore, there is a strong need to monitor these systems in terms of nutrient dynamics and to develop efficient integrated nutrient supply and management system in different grgions using locally available resources like compost, farm yard manure, farm wastes, crop residues and green manures. There is also a need to monitor insect, disease and weed problems, water table and water harvesting techniques. Crop establishment of succeeding crops after rice and dry seeding methods of rice need greater attention. There is a need for the choice of genotypes and introduction of short duration, photoperiod insensitive varieties, the possibilities for crop intensification/ diversification have to be studied. Thus, ample scope exists for improving the total land productivity through generation of appropriate production technologies for diverse agro-climatic situations.

Based on rational spread of crops in different agroclimatic regions of the country, about 500 cropping systems have been identified by the PDCSR, but only 30 cropping systems are important because of their sizable area. (Yadav *et al.* 2013). Among them, different rice based cropping systems such as rice-wheat, rice-rice, rice-chickpea/lentil, rice-mustard/linseed and rice-groundnut etc. Together occupy the largest area in the country. Rice-wheat and rice-rice cropping systems contribute to major share of food grain pool of the nation, while other rice based cropping systems have their significance to contribute the national production of oil-seed and pulse crops. With the introduction of high yielding photo and thermo insensitive rice varieties of relatively shorter duration, there was remarkable changes in the cropping system concept (Sharma *et al*, 2014). A large number of crops are now being grown after rice under different ecologies based on soil and prevailing agro- climatic conditions in major rice growing states of the country. Out of the major cropping systems identified by the Project Directorate for Farming Systems Research, rice based system occupies the largest area of about 28 m ha in India. Among the rice- based cropping systems, the major ones are rice- wheat (9.8 m ha), rice-rice (5.9 m ha), rice - fallow (4.4 m ha), rice-pulses (4.4 m ha), rice vegetables (1.2 m ha), rice groundnut (1.0 m ha), rice -mustard (0.5 m ha), rice-potato (0.5 m ha) and rice -sugarcane (0.4 m ha) reported by Yadav *et al*., 2013.

Growing rice continuously with unsuitable crops in the sequence and use of inputs in an imbalanced way has led to un-sustainability of rice based cropping systems of present day. Therefore , it is necessary to sustain the rice based cropping systems by adopting suitable technologies *viz*. crop diversification, tillage and crop establishment technologies, Site specific nutrient , water and weed management technologies through holistic approach to improve the productivity of system as well as soil and environmental health.

Technology intervention :

1. Crop diversification
2. Tillage and crop establishment
3. Site specific nutrient management
4. Water management
5. Weed management

Technological interventions through crop diversification

Diversification is growing a range of crops suited to different sowing and harvesting times, assists in achieving sustainable productivity by allowing farmers to employ biological cycles to minimize inputs, maximize yields, conserve the resource base, reduce risk due to both environmental and economic factors. The RCTs such as bed planting and zero tillage expand the windows of crop diversification. The farmers of rice-wheat belt have taken the initiative to diversify their agriculture by including short duration crops such as potato, soybean, blackgram, greengram, cowpea, pea, mustard, and maize into different combinations. Such diversification would not only improve income, employment and soil health but also reduce water use and GHGs emission and more adaptability to heat and water stress.

Singh *et al.* (2010) evaluated rice based cropping systems and results revealed that rice-potato- onion system produced higher rice equivalent yield (28.47 kg ha^{-1}) and system productivity (94.27 kg ha^{-1} day) as compared to rice-pea-green chilli (13.23 kg ha^{-1} and 38.91 kg ha^{-1} day, respectively). This is due to the higher unit value of vegetables crops like potato and onion and total duration of the system is also lesser than the other rice based cropping systems.

Alok kumar *et al*. (2008) noticed that rice-potato-greengram cropping system has recorded higher system profitability (Rs. 118.35 ha^{-1} day) because inclusion of potato as a vegetable crop which produce more biomass and turnover more economic condition of the farmer per unit area. Greengram as short duration pulse crop morever, being pulse crop it fixes atmosperic nitrogen which leads to reduce in cost of cultivation. The lowest system profitability was recorded in rice –oat (multicut) system (Rs. 65.47 ha^{-1} day).

Dinesh and Purushottam (2014) evaluated viable alternate efficient cropping systems for existing rice-wheat system. The higher crop equivalent yield (CEY) (t ha^{-1}), system productivity (kg ha^{-1} day) and relative production efficiency (RPE) (%) were higher in rice-potato-cowpea (22.02, 60.3 and57.49 respectively) over rice-wheat system. Where rice-wheat has least rice equivalent yield, system productivity and no relative production efficiency this indicates the capacity of the diversified system over existing system. But rice-wheat+Indian mustard has higher energy use efficiency followed by rice-wheat (traditional). Higher input in rice-potato-cowpea and rice-potato-greengram this is due to the rice and potato is the exhaustive crop required higher fertilizer and other input.

Singh *et al.* (2008) revealed that irrigate the rice crop at disappearance of ponded water (DP) and normal irrigate the other crops – wheat cropping system considered as traditional system others are improved or diversified cropping systems. Rice (DP)–potato- wheat has recorded higher relative production efficiency (108.07 %) because of this system consist of potato as vegetable crop it contribute more equivalent yield and also wheat as most suitable for north Indian climatic condition, hence, production efficiency is more.Irrigate the rice at appearance of hair line cracks in the field (HC), Rice (HC)- Potato – wheat system has recorded second higher relative production efficiency (107.55 %), while, compared to these two different irrigation situation to the rice crop, irrigation at hairline cracks saves the 20% irrigation water.

Sharma *et al*. (2014) evaluated total energy input and output of different rice based cropping system, the pooled data of three years reported that energy use efficiency of different cropping system ranges between 2.54 to 5.00. The energyuse efficiency is higher with respective to rice-maize-clusterbean and rice-maize+rajmash-maize+cowpea this due to maize is C4 plant with negligible photo respiration, utilize high solar radiation and high energy use efficiency.

Alokkumar *et al.* (2014) reported that the sustainable yield index of hybrid rice-potato-GM recorded higher sustainable yield index (0.95) compared to other cropping systems because rice and wheat has more demand and more market price crops. Lowest sustainable yield index was noticed in basmati rice –berseem (GF + Seed) (0.81).

Yadava *et al.* (2013) reported that higher relative employment generation efficiency (30.64%) in rice- potato-onion, due to the potato and onion as both are the vegetable crops it more employment opportunity (469 man days) and rice-maize as generate employment generation (359 man days).

Devkant Prasad *et al*. (2013) reported that among the cropping systems, rice–potato + wheat (1:1)–greengram cropping system recorded higher system productivity (20.39 t /ha), land use efficiency (95.9 %) with production efficiency (55.58 kg/ha/day) and employment generation (293 man days/ha) as compared to other cropping systems. The system also recorded maximum net profit, B:C ratio (1.61).

Technological interventions through site specific tillage and crop establishment techniques

ZERO TILLAGE -Conventional land preparation practices for wheat after rice involves as many as 10-12 tractor passess. Changing to a zero- till system on 1 ha of land would save 98 liters of diesel and approximately 1 million liters of irrigation water besides reducing about a quarter tonne less emission of carbon dioside (CO2), The principal contributor to global warming. However, impact or zero tillage on methane (CH4) and nitrous oxide (N20) emissions have showed contrasting results with lower, equal and higher compared to the conventional systems depending upon the soil type and water management. Zero tillage also allows rice - wheat farmers to so wheat sooner after rice harvest, so the crop heads and fill the grain before the onset of pre monsoon hot weather.

RAISED BED PLANTING -In raised bed planting a part of soil surface always 245 remains unsubmerged. Thus it not only reduces water use and improves drainage but also reduces methane emission. Crops on beds with residue retained on surface is less prone to lodging and more tolerant to water stress, thereby making it more adaptable to unfavorable climate.

Naresh *et al*. (2011) revealed that higher rice – wheat system yield recorded in ZTDSR+S (10.40 t ha^{-1}), CT-TPR (10.76 t ha^{-1}) and CT-TPR+S (11.08 t ha^{-1}) compared to CT-DSR (9.81 t ha^{-1}) and CT-TPR (9.70 t ha^{-1}). Wheat yield similar in all tillage treatments. This may be attributed to 10 days early maturity under DSR so, turn over period is more it ensures timely sowing in optimum moisture in soil leads to better wheat crop establishment. Inclusion of sesbania as ground cover as it fixes atm. Nitrogen and rice straw mulching. But ZTDSR+S recorded significantly higher net returns and benefit cost ratio. It was on par with ZTDSR and lower economics reported in CT-TPR.this may be due to less inputs used under ZTDSR with sesbania.

Thind *et al*. (2012) revealed that the higher mean grain yield of wheat was recorded in ZT+ rice straw mulch (5.17 t ha^{-1}). It was on par with Conventional tillage (5.09 t ha^{-1}) and lowest was recorded in ZT-rice straw removed (4.02 t ha^{-1}). The mean grain yield of wheat increased by 43 % with straw mulching compared to no mulch under zero tillage system. Increase in wheat yield is mainly due to rice straw mulching, crop residues are primary source of organic

matter and rice straw contains 5-8 kgN,0.7-1.2 kg P, 0.5-1 kg K and micronutrients.

Baldev Raj Kamboj *et al*. (2013) reported that rice cultivar perform better when grown in no-till MTR compared to CPTR . No-till MTR recorded higher grain yield (8.2 t ha^{-1}) compared to CPTR (7.7 t ha^{-1}) in PR 113 rice cultivar. Similar trend was observed in all the varieties except Basmati cultivar CSR 30 which produced similar yields in both establishment methods. In 2010, performance OF PUSA 44 better in no-till MTR than CPTR. They also reported that different rice and wheat cultivars recorded higher grain yield under no-till MTR compared to CPTR. This may due to mechanical transplanting ensures timely transplanting and maintains proper planting geometry as recommended and adoption of no-tillage in both the crops.

Technological interventions through Site Specific Nutrient Management (SSNM)

The concept of SSNM for rice was developed in the mid-1990s and then evaluated from 1997 to 2000 in about 200 irrigated rice farms at eight sites in six Asian countries. Site Specific Nutrient Management is defined as the dynamic, field-specific management of nutrients in a particular cropping season to optimize the supply and demand of nutrients according to their differences in cycling through soil-plant systems.

Gill *et al*. (2009) reported that in rice-wheat cropping system site specific nutrient management ($N_{180}P_{60}K_{90}S_{45}$ $Zn_{40}B_5$ kg ha^{-1}) recorded significantly higher rice equivalent yield (10,933 kg ha^{-1}) and Nutrient uptake (301, 101 and 363 kg ha^{-1}, respectively) when compared to farmers fertilizer practice ($N_{180}P_{60}S_{25}$ kg ha^{-1}) (8422 kg ha^{-1}, 203, 64 and 267 kg ha^{-1}, respectively).

Nagegowda *et al*. (2011) reported that adoption of site specific nutrient management (N_{150} $P_2O_{5\ 75}$ K_2O_{75} S_{39} $Mg_{45.6}$ Zn_6 Mn_6 Cu_2 Fe_5 $Mo_{0.5}$ $B_{0.6}$ kg ha^{-1}, respectively) in sole rice recorded significantly higher leaf area (954.5 cm^2 $hill^{-1}$), test weight (14.4 g), grain yield (56.7 q ha^{-1}) and harvest index (0.45) when compared to farmers fertilizer practice ($N_{282}P_2O_{5\ 77}K_2O_{56,}$ kg ha^{-1}, respectively) (687.3 cm^2 $hill^{-1}$, 13.2 g, 43.7 q ha^{-1} and 0.41, respectively).

In rice site specific nutrient management recorded higher grain yield (7.47 t ha^{-1}), agronomic N use efficiency (13.4 kg kg^{-1}) and partial factor productivity (56.2 kg kg^{-1}) when compared to farmers practices (195 kg ha^{-1}, 7.08 t ha^{-1}, 1.39 t ha^{-1}, 7.1 kg kg^{-1} and 36.3 kg kg^{-1}, respectively) (Peng *et al*., 2010).

Singh and Dobermann (2002) reported that site specific nutrient management in rice-wheat cropping system recorded higher grain yield of rice (6.09 t ha^{-1}), wheat (5.40 t ha^{-1}) compared to farmers' fertilizer practice (5.53 and 4.82 t ha^{-1}, respectively). This might be due to better nutrient uptake, agronomic efficiency, Partial productivity and Physiological efficiency.

In rice-maize cropping system site specific nutrient management recorded significantly higher rice equivalent yield (13500 kg ha^{-1}) when compared to State recommendation of fertilizer application (11230kg ha^{-1}) (Jat *et al*., 2009).

In rice-wheat cropping system SSNM (N_{150} P_{60} K_{120} S_{40} B_5 Mn_{20} Zn_{25} kg ha^{-1}, respectively) recorded higher cost of cultivation (42,072 Rs ha^{-1} $year^{-1}$), gross returns (1,04,250 Rs ha^{-1} $year^{-1}$) and B: C ratio (2.48) when compared to farmers practice ($N_{90}P_{30}$ kg ha^{-1}, respectively) (34,130 Rs ha^{-1} $year^{-1}$, 57, 000 Rs ha^{-1} $year^{-1}$ and 1.67, respectively), (Anon, 2008b).

Singh *et al*.(2013) revealed that the rice yield and agronomic S use efficiency was significantly higher in 30 or 45 kg S application .increasing S rates beyond 30 kg /ha couldn't bring any significant yield. Cereals require less of sulphur for satisfactory crop growth and also ensures the presence of optimum level of of S- containing amino-acids in the grain. But S use efficiency in residual wheat increased with increasing S rates as wheat contains highest protein among cereals because S actively involved in protein synthesis.

Technological interventions through water management

Mukherjee (2011) reported that rice-garlic-maize+cowpea has higher water use productivity (137.9 kg ha-cm^{-1}) due to higher consumptive of water followed by rice-potato-maize fodder (114.1 kg ha-cm^{-1}). Rice-garlic-maize+cowpea have significantly higher over all the treatments. Rice-wheat has least consumptive use of water (152.7 cm ha^{-1}), rice equivalent yield (11.73 t ha^{-1} year) and water use productivity (76.8 kg ha-cm^{-1}). This is due to rice require higher water application.

Anup Das *et al.* (2014) evaluated rice based cropping systems and data showed that productivity improved in cropping intensity and water productivity over existing system. Cereal-legume sequence cropping recorded higher water use efficiency (12.34 to 19.69 kg ha-cm^{-1}) and crop equivalent yield (1284 to 2143 kg ha^{-1}) over rice –fallow (5.99 kg ha-cm^{-1} and 652 kg ha^{-1}, respectively).

In Rice, WPET was highest in the three dry-seeded treatments kept around field capacity (all three statistically the same), intermediate in the raised beds irrigated at 20 kPa, and lowest in the two flooded treatments The water productivity with respect to combined irrigation and rain water input (WPIR) was about one-half of that of WPET in all treatments but had the same trends as of WPET across treatments. Like in rice, in wheat also the differences in WPET among the treatments were small, though the flat beds and the raised beds consistently had the lowest values. Unlike in rice,\ the WPIR was comparable to the WPET because nearly all evapotranspiration was met by irrigation and rainfall, and losses by deep percolation were small revealed by Choudhury *et al.*(2006).

Technological interventions through weed management

Climate change will also affect the weed communities in the rice based cropping system. A review on the effect of weed growth on yield suggested losses in the range 28-74% in rice and 15-80% in wheat 5,6. Improving weed control in farmers' field has shown to increase rice and wheat yield by 15 30%. Northwest India annually contributes more than 50-60% of rice and wheat to the central food grain reserve, making it the 'bread basket' of the country. Therefore, if productivity of these crops is affected, Indian food security is bound to be affected. Given that the demand for food is

projected to rapidly outpace increase in supply, effective weed control is a priority in this system. Important weeds of rice include *Echinochloa crusgalli, E. colona, E. glabrescens, Ammannia spp., Eragrostis spp., Ludwigia sp., Ischaemum rugosum, Leptochloa chinensis, Paspalum distichum, Cyperus iria, C.difformis, Fimbristylis miliacea, Scirpusmaritimus, Eleocharis spp., Eclipta prostrata, Sphenoclea zeylanica* and *Monochoriavaginalis*. Important weeds of wheat include *Phalaris minor, Avena ludoviciana, Poa annua, Loliumtemulentus, Chenopodium album, Rumex dentatus, R. spinosus, Medicago denticulata, Melilotus alba, Anagallis arvensis, Lathyrus aphaca, Fumaria parviflora, Vicia sativa, Coronopus didymus, Malvaparviflora* and *Cirsium arvense*. Common weed management practices in the rice based cropping system include soil tillage, flooding, summer ploughing, crop rotation and use of herbicides; these practices are often used in combination. Integrated weed management strategies need to be developed which target the prevention of weed invasion, recruitment and reproduction. Such strategies may include combination of optimal fertilizer schedule, summer ploughing, crop rotation, land preparation, modifying plant geometry, stale seedbed technique, planting time, seed rate and use of weed-competitive cultivars18. Knowledge of weed ecology and biology could be used as a tool for effective weed management in futuristic climate change.

Mishra and singh (2012) revealed that continuous ZT were recorded significantly higher higher system yield (7.39 t ha^{-1}) than with continuous CT (6.21 t ha^{-1}) or rotional tillage (5.78 to 6.21 t ha^{-1}) regardless of weed control methods. Further application of herbicide followed by one hand weeding recorded significantly higher system productivity (7.94 t ha^{-1}) compared to herbicide alone (7.29 t ha^{-1}). This may be due to improved moisture condition and better weed control efficiency.

They also reported that continuous ZT were recorded significantly higher total weed dry weight in rice and wheat (154 and 130 g m^{-2}) than with continuous CT or rotional tillage regardless of weed control methods. further application of herbicide followed by one hand weeding recorded significantly lower total weed dry weight in rice and wheat (61 and 39 g m^{-2}) compared to herbicide alone (155 and 41 g m^{-2}, respectively). This may be due to under conventional tillage puddling is done it is the one of the weed control method , in zero tillage major problem is weed because no disturbance to the soil.

CONCLUSION

From this it can be inferred that, Inclusion of commercial crops (potato, onion and vegetables), legumes (green gram, black gram and lentil) and adoption of no tillage either in rice or in both rice and succeeding crop, DSR crop establishment method, SSNM for nutrient management, improved weed and water management through zero tillage were found new technological interventions in rice based cropping systems. Further, adoption of these technologies in rice based cropping systems could be possible to obtain higher sustainable yield of rice, higher system productivity, nutrient use efficiency, water use efficiency and finally sustainability of cropping system with conserved resources.

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REVIEW PAPER

Rice Sheath Blight: A Review of The Unsung Fatal Disease

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ABSTRACT

Asia is the largest producer of rice, accounting for 20% of the total global rice production. Rice is the staple and pre-eminent food crop of Asia and its cultivation occupies 80% of the total cropped area. The production of rice should be enhanced to feed the increasing population of Asian countries and countries around the globe. Various biotic and abiotic stresses act as constraints on the rice production. Among them, Rice sheath Blight (ShB) disease is one of the major biotic stress cum constraint. The disease is prominent in the places where rice is intensively cultivated. *R. solani* is the major causal organism of this disease and the perfect stage is represented by *Thanetophorus cucumeris*. *R. solani* has a good survival and inoculums potential which also related to the incidence and severity of the disease. The commercially cultivated varieties of rice have very sufficient level resistant to ShB. Though there were many cultural and biological approaches, application of chemical fungicides is the only effective control measures for management of this disease. Still various research is going on to find genes which are responsible for sheath blight resistance in Rice. The role of plant growth-promoting rhizobacteria (PGPR) and various genera of PGPR in ShB suppression are discussed. The present mini review focused on various aspects relating to ShB suppression by cultural, chemical methods and PGPR such as antagonism and induction of systemic resistance and integrated management of ShB involving all the compatible combinations were mentioned in this review.

Key words *Sheath Blight Disease, Mode of infection, Antagonism, Disease management.*

The world's population is expected to surge from 6.1 billion in 2000 to 9.2 billion in 2050 (UN World Population prospects, 2005). A significant increase in predicted human population requires increasing crop yields to meet the requirements of the rising global demand for food. At current annual rate, the world population is expected to grow at 1.2% or approximately 77 million people per year (Fernando, 2006). Six countries, India, China, Pakistan, Bangladesh, Nigeria, and Indonesia, account for majority of the annual population growth. Of these, four Asian countries, India, China, Pakistan, and Bangladesh, are major consumers of rice cereal. Regardless of major advances in agriculture science over the past 50 years, a significant number of the world's population suffer from hunger and under nourishment. Agricultureis the culture that serves the nation. India being a developing country is densely populated and relies on agriculture. Apropos of an UN report, India will soon become the most populous nation by 2022. In this scenario, agricultural development is the only option. India needs to increase its production to feed such sky rocketing population. To increase production, we need to recover the crops from fatal epidemic diseases. Rice is the most stable food in the world which is a monocotyledonous annual grass of *Graminaceae* family. *Oryza* has included approximately 20 wild species and 2 cultivated species these are *Oryza sativa* which is grown around the world including India and *Oryza glaberrima* which is grown only in Africa (Parejaet al., 2011). In India Rice contribute 42% of the total food grain production and 45% of the total cereal production (Ramakrishnaet al., 2016). India is also the leading exporter of rice. But most of the rice yield is reduced by the disease infestation.

Sheath Blight of Rice

Rice is affected by a series of epidemic as well as devastating diseases. Rice Sheath Blight(ShB) is one of the detrimental diseases of rice.Rice sheath blight disease caused by *R. solani* is a destructive disease that leads to massive yield loss and degradation of rice. This disease was first reported by Miyake from Japan in 1910 referred as 'Oriental leaf and sheath blight'. Although from India it was first reported by Pancer and Chahal in 1963. Apropos of Lee and Rush (1983) yield loss occur between 20 to 50% when all the sheaths are infected. According to Roy (1979), it was estimated that there was yield loss of 10 to 36% in Assam depending of the growth stage of the plant when the fungus attacks. Sheath blight occurs in areas having high temperature and high humidity content and by application of excess nitrogenous fertilizer. However, there is no commercial variety which is resistant to this disease, but the land races can be used to achieve the novel genes for disease resistance as well as abiotic stress tolerance and source of yield enhancing traits (Shakiba and Eizenga, 2014). ShB disease management is difficult because of high genetic diversity of the causal organism and wide host range. Apart from the conventional breeding approaches and application of hazardous pesticides. In spite of successful adaptation of scientific developments and establishment of rice crop, pests and pathogens are inevitable and protective methods should be available to minimize the crop loss.

The Pathogen& its Biology

Previously the causal organisms were thought to be *Corticium sasakii* (Shirai), *C. vagum* (Berk& Curt, 1918 & 1926). *Schlerotium irregulrae* and *R. solani* Kuhn (1858). But, *R.solani* is accepted to be the causal organism and *T. cumuris* to represent the perfect stag (Chin, 1976; Kozaka, 1975). The pathogen is soil borne saprotrophic and facultative parasite (Ogoshi, 1996). It has a wide host range and worldwide distribution. The movement of the pathogen

is limited as there is lack of spores and survives in unfavorable conditions by formation of dormant hyphae and sclerotia (Regad, et al., 2001). *R. solani* is a basidiomycete fungus and it does not produce any asexual spores. Vegetative mycelium is produced which is colourless but becomes brown as it grows and mature. *R. solani* possess pale to dark brown rapidly growing mycelium. There is a formation of septum in the branch near the point of origin. *Sclerotia* formed varying in size but uniform in texture. The outer cells of the sclerotia were darker and thick walled. *T. cumuris* represents the sexual stage of *R. solani* (Parmeter, 2007).

Disease Symptoms

A plant disease symptom is the phenotypic or physiological manifestation of a successful invasion in the host by the pathogen. The visible or otherwise detectable abnormality arising from a disease or a disorder is called symptom. (Riley et al., 2002) Symptoms of this disease are generally observed from the milking stage to tillering stage of the rice crop. The symptoms are also seen in tillering to heading stage. Initially lesions occur on the sheaths withthe diameter of 0.5-3cm occurring below the leaf collar. Later, the lesions extent to 1cm in width and 2-3cm in length (Fleet and Rush, 1983). Oval or elliptical or irregular greenish grey coloured spots are formed. When the spots enlarge, the center of the spots becomes greyish white with blackish brown irregular border. Blightening occurs as formation of several lesions and they coalesce with each other. As the disease severity increases, the infection extends to the inner sheaths which cause death of the whole rice plant.

Cultural Measures

Cultural method means management of disease without application of any chemicals. Cultural methods do not have adverse environmental effects too. (Jaacov Katan, 2000) Breeding disease-resistant rice cultivars is believed to be one of the most promising approaches to control the disease. However, no rice cultivar has been found completely resistant to the soilborne fungus so far (Bonmann et al., 1992; Zou et al., 2000). Biocontrol of rice sheath blight has been reported and well documented. Biological control of sheath blight can be achieved by using antagonistic *Pseudomonas* spp. (Nagarajkumar et al., 2004; Nandakumar et al., 2001), *Bacillus* spp.(Chen et al., 2004; Li et al., 1993), *Trichoderma* spp. (Shanmugam et al., 2001; Tang et al., 2002), and antifungal metabolites produced by *Streptomyces* spp. (Liao et al., 2009; Prabavathy, 2005) (Yang et al., 2017). Several rhizobacteria are known to detoxify the toxins produced by fungal pathogens and they have been developed as biocontrol agents to control fungal diseases of crop plants (Toyoda et al., 1988; Kneusel et al., 1994; Dickman and Chet, 1998; Thangavelu et al., 2001) (Nagarajkumar et al., 2005).

Biological control using PGPR:

Antagonism between organisms is common in the ecosystem and is most prevalent among soil microorganisms. Natural interference between beneficial soil microorganisms and plant pathogens results inzone of buffer, thereby inhibiting or reducing disease development (Kohl et al., 2011). Various microbial defense mechanisms may work independently or together, depending on the rhizosphere or phyllosphere characteristics. Managing soil-abundant beneficial microbes for the improvement of plant root and shoot growth and plant health is an exciting field. Microbial interactions in the rhizosphere influence plant health and soil fertility (Jeffries et al., 2003). Advancements in biological control have led to identification and development of antagonistic bacteria with plant and root growth stimulating ability (Yellareddygari et al., 2014). Several strains of *P. fluorescens* have been successfully used for biological control of rice sheath blight (Mew and Rosales, 1986; Gnanamanickam et al., 1992; Rabindran and Vidhyasekaran, 1996; Krishnamurthy and Gnanamanickam, 1997; Vidhyasekaran and Muthamilan, 1999). Since the fungus *R. solani* survives in soil as sclerotia and produces Oxalic Acid (OA) it would be ideal to identify an antagonistic strain of *P. fluorescens* with a potential to detoxify the OA.

Chemical control

Basically, chemical control of any fungal plant disease consists of application of systemic or contact fungicide. The application of systemic fungicide is prevalent since 1960s and it is found that they provide better disease management than the non-systemic ones (Gullino et al., 2000). A vast range of fungicides differing in modes and formulations are available in the market for the management of sheath blight disease. The fungicides which come under the strobilurins group, are widely used to combat sheath blight disease. Among the strobilurins group fungicides, the azoxystrobin fungicide is widely used as it is very much effective in managing this lofty disease (Groth DE, Bond JA, 2006). This fungicide was the first registered fungicide being derived from â-methoxy acrylate. It is sold as various names by various companies (Syngenta, Bayer, Raleigh etc.) in the market (Gricahr and Besler,2004). Another effective chemical against sheath blight is validamycin which is used throughout Asia (Miyagi Y. 1990). Meanwhile two antifungal compounds are found from *Streptomyces* sp. PM5 which are antifungal and can be used against sheath blight disease. (Prabhavathy *et al.,* 2006). The foremost benefits of using fungicides are lower incidence of disease and reduction of inoculum and improved grains and quality (Groth DE, 2008). But chemical control has its drawbacks too. The pathogen has the chances to develop resistance to a chemical by regular continuous application of fungicide.(Zhang CQ, Liu YH, 2009). Although chemical methods are main measures taken against any disease, there stands the chance of developing resistance in the pathogen which makes the pathogen more virulent (Brent K J, Hollomon DW, 1998).

Future aspects:

Plant breeders and the plant pathologists will work together to combine same rice type with some different race-specific genes and genes which will confer quantitative resistance. (Channamallikarjuna, 2009). Identification of QTLs and the possible candidate genes having the sheath blight resistance is still going on. Backcrossing with the land races may give rise to resistance against this fatal disease. (Shailesh *et al.*, 2015). Allelic analysis along with

association mapping is also being done to figure out the resistant genes for this disease (Jia *et al*., 2012). There are also the ideas of Integrated Disease Management and ecological plant pathogen control which are broad-based. Integrated Disease Management helps in mitigating the disease the damage and helps in sustainable farming. (Kumar *et al.*, 2009). Using a diversified rice gene pool will also help developing host-pathogen resistance. (Imbe et al. 2000). Continuous search for new anti-fungal bacterial strains are also needed and there should be continuous trials of the formulations (Dongjing Yang et al, 2009).

CONCLUSION

Sheath blight being a crop ruinous disease, the management should be more effective and less time-consuming. Bio-safety should also be kept in mind while developing new fungicides. Besides, there should be reassessment and re-registration should be done with the changing guidelines of the fungicide residue level. The farmers should be educated well and the correct and relevant information about environment friendly and effective Integrated Disease Management of sheath blight disease. Though many challenges will come, there should be more extensive research on finding the candidate genes which are resistant to this detrimental pathogen. Both molecular breeding as well as conventional breeding will have to focus on identifying and developing the resistant genes (Yellareddygari et al., 2014).

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REVIEW PAPER

A Review on Effect of Integrated Nutrient Management on Soil Properties

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ABSTRACT

Indian agriculture has been successful in increasing crop yield production in the past. For increasing the yield, accompanied by the series of problems related to the natural resources. Application of chemical fertilizer with organic manure that can improve soil fertility, soil properties as well as productivity in a sustainable manner. Integrated nutrient management is practiced by applying the organic manures and fertilizers in combination after assessing what the soil can provide through soil testing, and the crop nutrient requirements to give certain amount of yield.

Key word: *Integrated Nutrient Management, Soil Properties and Yield.*

Integrated nutrient management (INM) is the maintenance of soil fertility and plant nutrient supply at an optimum level to sustain the desired crop productivity. INM has been considered a broad based remedy against soil fertility decline, the management practices advocated by scientists *viz*., FYM or bio compost, green manures like sun hemp or dhaincha as in situ application, bio-fertilizers, crop residue mulching, *etc*. Sufficient and balanced application of organic manures and fertilizers are the focus in INM. Improved methods of application along with proper timing of application are also considered to achieve the best efficiency of used organic manures and fertilizers.

MATERIALS AND METHODS

In August 2017, literature reviews were collected different aspects about effect integrated nutrient management on soil health (effect on physical properties, effect on chemical properties, effect on biological properties and effect on crop yield) were confined to internet searches using search engines provided by Google throughout the world. The literature review found some published like reports of about integrated nutrient management, research papers and thesis within the past years.

RESULT AND DISCUSSION

INM (100% RDF (40:20:00 NPK kg ha^{-1}) + FYM @ 10 t ha^{-1}) recorded significantly higher seed yield of Niger and organic carbon (OC) content in soil after harvest of Niger than fertilizer alone treatment (Anon., 2007).

Khanpara *et al.* (2008) found significantly higher available N and K in soil after groundnut and K in soil after wheat with 100% N through FYM. Pod yield of groundnut was recorded with 100% N through FYM but higher wheat grain and economic return was recorded with inorganic fertilizer (100% RDF as per soil test).

Kumar *et al.* (2012) observed that 100% RDF + FYM @ 5 t ha^{-1} + GM (*Sesbania* in situ) + S @ 40 kg ha^{-1} + Zn @ 15 kg ha^{-1} + Mn @ 10 kg ha^{-1} + Fe @ 10 kg ha^{-1} resulted into significantly higher water holding capacity (WHC), OC, available P, S, Zn, bacteria, fungi and *Actinomycetes* in soil, significantly lower soil BD and higher rice equivalent yield, whereas significantly higher available N and K with 100% RDF + FYM @ 5 t ha^{-1} + GM in rice – mustard cropping sequence.

All the INM treatments applied to garlic crop at Junagadh recorded significantly higher values of OC, available K, S and Fe contents in soil than control and RDF alone (Anon. 2012).

Chesti *et al.* (2013) found highest built-up of OC in soil after three year of continuous application of 100% NPK (100:60:30 NPK kg ha^{-1}) + FYM @ 10 t ha^{-1} which was statistically at par with 50% NPK + FYM @ 10 t ha^{-1} and 50% NPK + 10 kg Zn ha^{-1} + 10 t FYM ha^{-1} in soil. Similarly significantly higher available N, P, K in soil and wheat grain yield was recorded in 100% NPK (100:60:30 NPK kg ha^{-1}) + FYM @ 10 t ha^{-1}.

Pawar *et al.* (2013) application of 50% RDF + 50% N through FYM significantly increased hydraulic conductivity (HC), mean weight diameter (MWD), OC, available N, P, K, soil microbial biomass carbon (SMBC), soil microbial biomass nitrogen (SMBN), dehydrogenase activity (DHA). Whereas 100% RDF (80:40:40 NPK kg ha^{-1}) recorded significantly higher seed cotton yield. Significantly higher SMBC, SMBN, DHA were recorded with conservation tillage than conventional tillage.

Significantly lower pH and EC of soil and higher grain yield of sorghum was recorded in raised bed land configuration than flat bed. OC and ESP were not influenced significantly due to land configuration. The significantly lower EC, pH and higher OC after harvest of sorghum was recorded with INM treatment consisting of 75% RDF + FYM @ 10 t ha^{-1} (Anon., 2014).

Gharpinde *et al.* (2014) revealed that 100% RDF (30:75:00 NPK kg ha^{-1}) + 25 kg K_2O ha^{-1} + Biofertilizer (*Rhizobium* + PSB) recorded significantly higher OC, available N, P, K in soil after harvest of soybean and grain yield while it was statistically at par with 100% RDF + 25 kg K_2O ha^{-1} and 100% RDF + Biofertilizer.

Dutta and Sangtam (2014) found that significantly lower bulk density (BD) and higher WHC, OC, available K with application of ½ N + PK + ½ N forest litter than control and other INM treatments. Application of NPK + Poultry litter increased % aggregate (>0.25mm), MWD and available N. While NPK + FYM + Zn @ 10 kg ha^{-1} resulted into significantly increased CEC. Increased in soil pH with Forest litter burned + ½ FYM and available P with NPK +

FYM was recorded after harvest of upland rice under acid soils of Nagaland.

Application of organics (FYM @ 10 t ha^{-1} + N fixer-A, PSB and chopped crop residues of same plot) significantly increased WHC, OC and BD than INM treatments but remained statistically at par with organic (FYM @ 10 t ha^{-1} + N fixer-B, PSB and chopped crop residues of same plot) and integrated (FYM @ 5 t ha^{-1} + N fixer- B + ½ N + PSB + ½ P_2O_5) significantly increased available N, P, K, CEC in soil and green pod yield of French bean (Gaurav *et al.,* 2014).

Dubey *et al*. (2014) studied that nutrient management with 100% organics and INM treatment increased fungi, bacteria, *Azotobacter*, PSB and *Actinomycetes* population in soil after completion of crop sequences. In case of cropping sequences, Green manure (sunhemp) – Rice (basmati) - Durum Wheat recorded numerically higher *Azotobacter*, PSB, *Actinomycetes* counts in soil while higher fungi, bacteria count were recorded in Rice – Berseem (fodder and seed). The significantly higher rice equivalent yield was recorded with Rice – Potato – Okra cropping sequence.

Gudadhe *et al.* (2015) noted that application of FYM @ 10 t ha^{-1} + 100% RDF recorded significantly higher OC content, bacteria, fungi, *Actinomycetes* count and lower pH, EC values of soil. Higher available N, P, K in soil was recorded with application of 75 % RDF + 25 % RDN through vermicompost after harvest of cotton. Significantly higher values of available N, P, K, bacteria, fungi and lower pH, EC were recorded in no application of nutrient to chick pea crop treatment while higher OC, *Actinomycetes*, cotton equivalent yields were recorded with 100% RDF to chick pea.

Salvi *et al.* (2015) concluded that application of 100% RDF (100:50:50 NPK kg ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 5 kg ha^{-1} + FYM @ 10 t ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} to okra recorded significantly higher MWHC, OC, available N, P, K while OC and available P was statistically at par with RDF + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 5 kg ha^{-1} + FYM @ 10 t ha^{-1}.

Application of 50% RDF + MS (Maize stalk incorporation with cellulolytic culture) + BF (*Azospirillum* +PSB) + GM (sunhemp) recorded significantly higher HC, maximum water holding capacity (MWHC), percentage stable aggregate (PSA), MWD, OC and lower BD after six year experimentation with *kharif* maize. Whereas available N, P, K content in soil and grain yield of maize increased significantly with 100% RDF + BF (*Azospirillum* +PSB) + GM (sunhemp) (Gundlur *et al.*, 2015).

Significantly higher %WSA (0.5 to 1.0 mm and >1.0 mm), available N, P_2O_5, K_2O, S, in soil and cabbage head yield were recorded with 100% FYM, 100% Biocompost and 75% FYM + 25% Scutching waste which were applied FYM @ 10 t ha^{-1} carbon equivalent basis, common 100% RDF (100:50:50 kg NPK ha^{-1}) was also applied to all the treatments (Saini , 2016).

Application of 50% RDF + 50% N through FYM recorded significantly higher values of MWD, AWC, HC, OC, available N, P, K and lower values of soil pH, EC than inorganic application. Similarly under conservation tillage recorded significantly higher values of MWD, AWC, OC, available N and P than conventional tillage (Wagh *et al.,* 2016).

Indoria *et al.* (2016) recorded significantly higher values of MWD, HC, WUE, SOC, seed yield of soybean and lower BD with NPK + FYM @ 4 t ha^{-1} after harvest of soybean than control treatment.

At Waghai, application of vermicompost @ 2 t ha^{-1} + Biofertilizer @ 4 kg ha^{-1} (*Azotobacter*) recorded significantly higher soil OC which was statistically at par with 75% RDF + VC @ 1 t ha^{-1} + Biofertilizer @ 4 kg ha^{-1} (*Azotobacter*) and 75% RDF + VC @ 2 t ha^{-1} while significantly higher finger millet grain yield was recorded with 75% RDF + VC @ 2 t ha^{-1} (Anon. 2017)[a].

Aapplication of FYM/Compost @ 20 t ha^{-1} + 100% RDF (inorganic source) in sugarcane plant crop recorded significantly higher soil OC while application FYM/Compost @ 20 tonnes ha^{-1} + 50% RDF (inorganic source) significantly higher available P_2O_5, whereas application of FYM/ Compost @ 10 tonnes ha^{-1} + Biofertilizer (*Azotobacter / Acetobacter +PSB*) + soil test basis (NPK application) recorded significantly higher cane yield (Anon. 2017)[b].

CONCLUSION

Integrated or combined application of organic (Farm Yard Manure, Biocompost, Vermicompost *etc*.), inorganic (fertilizers like Urea, DAP, SSP, MOP *etc*.) source of nutrients along with biofertilizer (Rhizobium, Azospirillum, Azotobacter etc.) not only increase the yield of crops but also improve the soil physical (BD, MWHC, MWD, WUE, hydraulic conductivity, WSA, *etc*.), chemical (pH, EC, OC and available macro and micro nutrients) and biological (Bacteria, Fungus, Actinomycetes, *Azotobacter*, PSB *etc*.) properties in a sustainable manner.

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REVIEW PAPER

A Review on Effect of Liquid Organics on Soil Health and Crop Production

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ABSTRACT

Liquid organics are prepared from natural substances containing nutrients, growth promoter and microbes that improve the soil properties, growth and productivity of plants. Present review suggest that effect of liquid organics on physical (BD, WSA, MWD, IR, Porosity, WAC), chemical (EC, pH, OC, available macro and micronutrients in soil) and biological (population of bacteria, fungi and Actinomycetes) properties of soil as well as nutrient uptake, quality, pest resistanceand yield of different crops.

Key words *liquid organics, Soil physical property, Biological property, Chemical property, Crop production.*

The current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. It is worth noting that nutrient management through organics play a major role in maintaining soil health due to buildup of soil organic matter, beneficial microbes and enzymes, besides improving soil physical and chemical properties. To achieve sustainable soil fertility and productivity of a crop use of fermented liquid organics *viz*., Panchagavya, Jeevamrut, Beejamrut, Vermiwash etc., are becoming popular among farmers. They contain all nutrient, numerable microorganisms, vitamins, essential amino acids, growth promoting factors like IAA, GA and beneficial microorganisms (Palekar, 2006). Nowadays, liquid organics is the main component behind the biodynamic farming cultivation.

MATERIAL AND METHOD

In November 2107 reviews were collected on the different aspect about the effect of liquid organics on soil health and crop production.The purpose of this review was tostudy effect of liquid organics on physical, chemical and biological properties of soil as well as nutrient uptake and yield of different crops found from internet searches engines like google. I used credible and rich web pages. These web pages and my other sources are professional, credible and full of agricultural knowledge.

RESULT AND DISCUSSION

Physical properties

Tharmaraj *et al*. (2011) observed that mixture of vermicompost and vermiwash treated plots showed maximum water holding capacity, porosity and moisture content in soil at initial and final stage of rice compared to other treatments.

Bokare (2013) reported that application of enriched banana pseudostem sap @ 2% spray recorded lower bulk density with higher Infiltration rate and WSA (0.5-1.0 mm sized) (%). Whereas WSA (>1.0 mm sized) (%) found higher in application of Banana pseudostem sap @ 2% spray: Enriched banana pseudostem sap @ 2% spray (1:2) in soil after harvest of onion.

Laharia *et al.* (2013) reported that lower bulk density (BD) and significantly increased hydraulic conductivity (H.C.), mean weight diameter (MWD) and available water capacity (AWC) with application of 100%RDN through vermicompost +jeevamrut (30 &45 DAS) in soil after harvest of soybeanas compared to other treatments.

Parmar (2013) revealed that lower BD and significantly higher WSA (>1mm and 0.5-1.0 mm size) recorded with application of 50% NADEP compost + 50% castor cake in soil after harvest of maize and remained statistically at par with T_1 - NADEP compost 100%,T_9 -Jeevamrut 500 litha^{-1} + Panchagvaya 50 litha^{-1} (15 days interval), T_{10}Jeevamrut 500 litha^{-1} + Panchagvaya litha^{-1} (30 days interval).

Bag *et al*. (2015) reported that application of BC: VC: CC + enriched sap (1%) recorded lower bulk density and higher WSA (0.5-1.0 mm size) whereas, higher WSA (>1mm size) found higher in application of BC: VC: CC + panchagavya (2%) in soil after harvest of chickpea as compared to rest of the treatments.

Chemical properties

Lekshmi (2011) reported that application 75%N as biomineral compost + panchagavya recorded significantly higher available OC, N, P, K and micro nutrient except Cu which was found higher in application 75%N as effective microorganism compost + panchagavya in soil after harvest of chilli as compared to control.

Laharia *et al*. (2013) reported that application of 100%RDN through vermicompost +jeevamrut (30 &45 DAS) significantly decreased the pH, EC, $CaCO_3$ and increased organic carbon (OC) and available N, P, K content in soil after harvest of soybean as compared to control.

Gopakkali and Sharanappa (2014) observed that application of EBDLM (Enriched Bio-Digested Liquid Manure) at 125 kg N equivalent ha^{-1} + 3 sprays of panchagavya(3%) recorded significantly higher organic carbon, available N, P and K in soil after harvest of chilli as compared to other treatments.

Jondhale (2014) reported that the foliar application of1% banana pseudostem sap showed significantly higher available N,P,K and micro nutrients in soil after harvest of rice as compared to other treatments.

Kiran *et al*. (2015)observed that application of beejamrutha + jeevamrutha + vermicompost equivalent to 100% RDN)+ panchagavya (3%) recorded significantly higher available nitrogen and potassium whereas,

phosphorus found higher in application of beejamrutha + jeevamrutha + FYM equivalent to 100% RDNin soil after harvest of chickpea as compared to other treatments.

Akhila (2017) reported that foliar application of 2% seaweed sap recorded significantly higher organic carbon, N, P, K in soil after harvest of greengram as compared to other treatment.

Siddaram *et al.* (2017)observed that application of FYM 12.5 t + BDLME (Bio-Digested Liquid Manure Equivalent) to 150 Kg N ha^{-1} recorded significantly higher OC whereas, available N, P, K found higher in application of FYM 12.5 t + BDLME to 75 kg N ha^{-1} in soil after harvest of rice as compared to other treatments.

Biological properties

Ghodpage *et al.* (2009)reported that application of vermicompost @ 2.5 t ha^{-1}+ amrutpani+ biofertilizer @ 3 kg ha^{-1} recorded higher population of bacteria, whereas fungi found higher in application of vermicompost @ 2.5 t ha^{-1}+ amrutpani and actinomycetes found higher in application of RDF + Amrutpani in soil after harvest of cotton as compared to control.

Patil *et al.* (2012) reported that application of 100% RDN through vermicompost + jeevamrut recorded significantly higher population of bacteria, fungi and actinomycetes after harvest of soybean as compared to control.

Gopakkali and Sharanappa (2014) observed that application of EBDLM (enriched bio-digested liquid manure) at 125 kg N equivalentha^{-1} + 3 sprays of panchagavya(3%) recorded significantly higher bacteria, fungi and actinomycetes population in soil after harvest of chilli as compared to other treatments.

Patel (2014)reported that application 50% RDN each from BC &NADEP compost + jeevamrut @ 2000 l ha^{-1}recorded higher population of bacteria and fungi whereas, actinomycetes found higher in application of 100% RDN each fromNaC + jeevamrut@ 2000 l ha^{-1} after harvest of onion as compared to other treatment.

Siddaram *et al.* (2017) reported that application of FYM 10 t + BDLME to 35 kg N ha^{-1}showed significantly higher population of bacteria, fungi and actinomycetes after harvest of field bean as compared to control.

Siddaram *et al.* (2017) reported that application of FYM 12.5 t + BDLME to 150 kg N ha^{-1}recorded significantly higher population of bacteria, fungi and actinomycetes after harvest of rice as compared to control.

Crop production

Vennila and Jayanthi (2010) revealed that the significantly higher number of fruit $plant^{-1}$, fruit length, fruit weight and fruit yield of okra with the application of 100% RDF + panchagavya spray (2%) as compared to the control.

Gore and Sreenivasa(2011) observed that the content of nutrient (N,P,K), number of fruit $plant^{-1}$ and fruit yield of tomato significantly higher with the application of RDF + beejamruth + jeevamruth + panchagavya as compared to other organic treatments.

Patil *et al.* (2012) reported that application of 100% RDN through vermicompost + jeevamrut were recorded higher protein and oil content, similarly significantly higher grain and straw yield of soybean as compared to control.

Jadhav *et al.* (2014) revealed that the significantly higher root diameter, single root length, single root weight, yield ha^{-1} and B: C ratio of radish with the application of 1:3 (water: vermiwash) as compared to the control.

Patel (2014) revealed that the significantly higher bulb and leaves yield of onion with the application of 33% RDN each from BC, CC and VC + jeevamrut @ 2000 l ha^{-1} whereas significantly higher pyruvic acid found with application of 33% RDN each from BC,NaC and CC as compared to other organic treatments.

Bag *et al.* (2015) reported that application of BC: VC: CC + cow urine (2%) significantly improved the grain yields and straw yields of chickpea as compared to the control.

Saranraj and Thiruppathi (2015) revealed that the significantly higher nutrient uptake, straw yield and grain yield of rice with the application of vermiwash 5% at tillering and flowering as compared to the control.

Akhila (2017) reported that foliar application of 2% seaweed sap recorded significantly higher stover yield and seed yield after harvest of greengram as compared to other treatments. Highest B: C ratio was recorded with treatment EBPS 1%.

CONCLUSION

Use of liquid organics improve physical (BD, WSA, IR, Porosity, WAC), chemical (EC, pH, OC, available macro and micro nutrient in soil) and biological (population of bacteria, fungi and Actinomycetes) properties of soil as well as nutrient uptake and yield of different crops.

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REVIEW PAPER

Physiology of Cut Flowers and Senescence Regulation

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ABSTRACT

Flower senescence is the final developmental phase between the maturity and death of a flower or flower organ. The changes can be structural, biochemical and metabolic that can be observed by careful investigation. ROS generation, lipid peroxidation and lipoxygenase (LOX) activity are closely associated with petal senescence. Very efficient antioxidative enzyme system like superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), glutathione reductase (GR) is present in the developing flowers (including petals) to get rid of ROS activity. For a good cut flower it should have long vase life and must retain the colour for a long time. Besides antioxidant enzymes; carotenoids, flavonoids and anthocyanins of coloured floral organs also possess ROS-scavenging property. Important changes in sugars and degradation of nucleic acids, proteins, starch, fatty acids, etc. have been reported in petals during senescence of cut flowers. Ethylene and ABA act as promoters of senescence whereas PGRs like cytokinins, auxins, gibberellins, salicylic acid, polyamines and morphactin can delay the process. Lower concentration (2%) of ethanol and methanol are also effective in improving vase life of cut flowers. Senescence regulation can be achieved at the transcriptional, translational and post-translational stages.

Key words *Biochemical changes, Cut flowers, Growth regulators, Petal-senescence, Ultrastructural changes*.

Flower senescence is the final developmental phase between the maturity and death of a flower or flower part and it is an integral process that allows the removal of a metabolically costly tissue (i.e. petal), after it has attracted pollinators for sexual development, and signals the initiation of ovule development and seed production (Arora 2008). It is characterized by a number of catabolic processes such as degradation of proteins, lipids and nucleic acids; lipid peroxidation, disruption of cell membranes etc., but at the same time, it is connected with controlled degradation (break down of components), remobilization (selective degraded molecules of nutrient storage materials) and re-utilization of cell components (Tripathi and Tuteja 2007; Shahri 2011). Nutrients from the ageing floral organs (petals) are remobilized and transported to developing ovary in flowers. Physiological changes such as loss of water from the senescing tissues, leakage of ions and generation of reactive oxygen species (ROS) can also be witnessed during petal senescence. Moreover, the process of flower senescence has been shown to be a genetically programmed event (Hoeberichts et al. 2005; van Doorn and Woltering 2008; Rogers 2012).

Ultrastructural changes of organelles: The closure of plasmodesmata is one of the earliest changes in cell ultrastructure during senescence of *Iris* petals that halted the transport between neighbouring cells (van Doorn et al. 2003). Invaginations of the tonoplast and appearance of numerous vesicles in the vacuole have been noticed in *Ipomoea tricolor* petal cells. Remnants of mitochondria, loss of endoplasmic reticulum and attached ribosomes have been reported in senescent petal cells of *Ipomoea*, carnation (Smith et al. 1992), *Hemerocallis* (Stead and van Doorn 1994) and *Iris* (van Doorn et al. 2003). At late stage of senescence, alterations have been noticed in nucleus such as nuclear blebbing in tobacco petals, DNA condensation and decrease in nuclear diameter in *Petunia hybrida* and *Argyrantheum frutescens*, but not in petals of *Antirrhinum majus* (Yamada et al. 2006).

Reactive oxygen species (ROS): ROS includes both free radicals and hydrogen peroxide (van Doorn and Woltering 2008). Free radicals are relatively unstable while H_2O_2 is more stable, long lived (half life of 1 ms) and diffusible (Rogers 2012). All the free radicals are capable of oxidizing a range of organic compounds such as lipids, proteins and nucleic acids. H_2O_2 can diffuse across membranes and can translocate to other cellular organelles; being produced mainly in chloroplasts and peroxisomes.

Lipid peroxidation is commonly used as an indicator of prevalence of free radicals in tissues (Smirnoff 1993). Malondialdehyde (MDA) is a common product of this process that recorded significant increment during senescence as in tulips (Jones and Mc Conchie 1995), roses (Fukuchi-Mizutani et al. 2000) and gladiolus (Ezhilmathi et al. 2007). Increment in MDA has been noticed with the progress of senescence in inflorescences of *Salvia officinalis* (Kaur and Mukherjee 2010), *Matricaria parthenium* (Kaur and Mukherjee 2012) and *Chrysanthemum* (Khokhar et al. 2013).

Lipoxygenase is one of the important senescence associated enzymes which exhibited about 371 percent increase during 6-day in the untreated cut flowers of *Chrysanthemum sinense* (Khokhar et al. 2013). Elevated LOX activity is a common feature during flower senescence

in carnation (Rouet-Mayer et al. 1992), tulips (Jones and Mc Chonchie 1995) and fully open *Gladiolus* (Ezhilmathi et al. 2007). LOX oxidizes fatty acids liberated from the membrane as a result of peroxidation.

Superoxide dismutase (SOD), ascorbate peroxidase (APX) and catalase (CAT): SOD, a metal containing enzyme catalyzes the dismutation of superoxide radicals to oxygen and hydrogen peroxide. In carnation petals, specific activity of SOD decreased after full blooming (Drolliard et al. 1989) whereas in daylily, the activity increased with the onset of senescence (Panavas and Rubinstein 1998). All isoforms of SOD in carnation petals showed decline at different stages of senescence. In *Chrysanthemum morifolium,* petals showed a significant increase during early stage of senescence; however, a decline was observed at advanced stages (Bartoli et al. 1995). Rise in SOD levels with the maturation of flowers and decline at the onset of senescence have been observed in *Calendula officinalis* and *Aster novae belgii* (Kaur et al. 2014). Sharp decline in SOD activity has also been noticed in cut flowers of *Chrysanthemum sinense* during 0 to 6-day (Khokhar et al. 2013).

Ascorbate is a major metabolite in plants. Membrane bound ascorbate peroxidase is found to scavenge the H_2O_2 which was produced by the action of SOD on the superoxide radical (O_2^-). APX activity has been directly correlated with the reduction in free radical induced membrane damage. Another enzyme that can lower H_2O_2 levels is catalase (CAT). In carnation petals, APX and CAT activities increased during senescence (Bartoli et al. 1996).

Membrane permeability: Evidence for an increase in membrane permeability during senescence of several flower species suggests that there is disruption of membrane integrity and loss of intracellular compartmentation. Two types of membrane damage are possible: the first, senescent petals showed anthocyanins and electrolytes leakage as the anthocyanins are located in the vacuole, their release indicates loss of selective permeability of both the tonoplast and the plasma membrane (Matile 1997). Thompson et al. (1982) suggested the second possibility having a strong correlation between membrane leakiness and phospholipid breakdown in senescing flowers**.** The important changes at the membrane, which include the decrease in all classes of membrane phospholipids and increase in neutral lipids, are mainly due to increased action of phospholipases and acyl hydrolases.

Changes in Pigments: Like chlorophyll as the principle green foliage pigment, flavonoids (anthocyanins, flavonols and flavones) are coloured pigments that commonly occur in red, purple and blue flowers (Vaknin et al. 2005). These pigments accumulate in the epidermal or sub-epidermal cell vacuoles of flowers, fruits and foliage. In petunias the flower longevity was inversely correlated to anthocyanins content (Ferrante and Vernieri 2006). Carotenoids constitute many of the yellow, orange and red pigments. One of the senescence indicators in plant tissue is an increase in vacuolar pH. Most anthocyanins are reddish in acidic solution (pH, < 7) but become purple and blue as the pH is raised. During this process, sugars as respiratory substrate get depleted and protein degraded to release free amino groups resulting more alkaline pH in the cell (Estelle 2001). Peroxidases are more likely candidates *in Planta* anthocyanin degradation as they are located in the cytoplasm and in most cell organelles including the vacuoles.

Protein and nucleic acids: During the time course of senescence, targeted protein degradation is a critical part. Therefore, the activity of proteolytic enzymes is an essential element in these processes. Protease degrades proteins by hydrolyzing internal peptide bond and is one of the best characterized cell death proteins in plants (Beers et al. 2000). These proteolytic enzymes have been divided into different groups depending upon the specific site at which they cleave target proteins and the most common one is cysteine protease (CPase). Cysteine protease is probably responsible for the degradation of proteins leading to the decomposition of the cell components and resultant cell death during senescence of petals. The wilting of petals, however, is related to expression of genes for enzymes such as cysteine protease(CPase) and lipase, which are responsible for hydrolytic degradation of cell during petal senescence. The CPase genes upregulated during natural, pollination induced and exogenous ethylene induced senescence in the carnation petals (Jones et al. 1995). The CPases in flowers up regulated during petal senescence in daylily (Valupuesta et al. 1995), *Alstroemeria* (Wagstaff et al. 2002) and *Sandersonia* (Easton et al. 2002). CPase is the closest functional homologue to caspases in senescing plant tissue and commonly found during leaf and petal senescence (Wagstaff et al. 2002).

The upregulation of enzymes degrading RNA and DNA seems to be a common feature of the late stages of senescence in plants. Several RNases have been detected in senescing petals of morning glory (Lesham et al. 1986) and daylily (Panavas and Rubinstein 1998). RNase activity in *Hemerocallis* petals also increased during senescence whereas in *Ipomoea* the large increase in DNase activity was noticed. In petals of *Hemerocallis* (Panavas et al. 1999) and *Petunia* (Langston et al. 2005), the m-RNA abundance of DNase genes increased during senescence.

Carbohydrates: The active degradation of sucrose and starch occurred more intensively in stressed tissue where an enhanced induction of invertase and á -amylase has been observed (Koizuka et al. 1995). Cell requires more sugars to fulfill the energy and carbon needs for defensive response to stresses. Since cut flowers suffer from an energy deficiency and are susceptible to different stresses, the demand for hexoses in petals might be satisfied by the hydrolysis of disaccharides and starch. Moreover, it has been found that flower petals contained highly active invertase (Borochov and Woodson 1989). The activity of

á-amylase plays an important role in the mechanism of petal opening and regulate the appearance of senescence syndrome.

Role of plant growth regulators in petal senescence

A striking feature of senescence whether cellular or organismal is that it is a correlative phenomenon and controlled by phytohormones (Leopold and Nooden 1984). Both senescence-promoting and senescence-retarding phytohormones exist. In most of the flowers, it is an increase in ethylene following pollination that triggers the changes associated with petal senescence. The roles of individual phytohormones are discussed below.

Ethylene as a promoter of senescence: Ethylene is a plant hormone with endogenous production associated with the progress of senescence and a dramatic increase of its release has been well established in accordance with the wilting of a number of cut flowers (Woltering and van Doorn 1988). Petal senescence is linked to specific genes and ethylene plays a regulatory role in the transcription of these sensescence-controlling genes (Lincoln et al. 1987; Bartoli et al. 1996). Ethylene production is regulated by different inducers in each flower organ (Larson et al. 1993). The increased ethylene production may be due to higher amounts of mRNAs for enzymes responsible for ethylene synthesis. The petal senescence rate in cut flowers is strongly dependent on temperature and on environmental water parameters. Ethylene induces flower senescence and in hibiscus plants causes buds abscission, compromising the ornamental quality (Høyer 1996).

Compounds such as amino-vinyl glycine (AVG) and amino-oxy acetic acid (AOA) effectively delay senescence of climacteric flowers by inhibiting the action of ACC-synthetase (ACCS). Due to its heavy metal nature, silver acts as a non competitive inhibitor of enzyme activity and as such also inhibits the activity of the enzymes involved in ethylene synthesis. The addition of ethanol to the vase medium can also increase vase life by inhibiting the conversion of ACC to ethylene (Pun et al. 2001). High CO_2 levels suppress ethylene synthesis by inhibiting the activity of ACCS. In addition, chelators such as 8-hydroxyquinoline sulfate (8-HQS) or 8- hydroxyquinoline citrate (8 -HQC) that are commonly used as antimicrobial agents in preservatives also act by inhibiting ethylene synthesis.

Abscisic acid as a promoter of senescence: Another important plant hormone involved in flower senescence is ABA, which increases the senescence processes in many cut flowers (Ferrante and Vernieri 2006). ABA may act by increasing ethylene sensitivity as observed by exogenous applications of ABA in hibiscus flowers (Trivellini et al. 2007), suggesting that both hormones are involved in flower senescence. ABA is a natural regulator of perianth senescence and present in higher amounts in naturally senescing petals. ABA is considered the most promising growth regulator which promotes senescence. Exogenous applications of ABA accelerate the symptoms of flower senescence in carnation, rose and daylily flowers (Mayak and Halevy 1972; Panavas et al. 1998). Endogenous content of ABA increased during senescence in several flowers and this may be due to conversion of carotenoids to ABA (Milborrow 2001).

Role of other hormones

Cytokinins: In general, cytokinins appear to inhibit senescence of petals, perhaps by acting to prevent ethylene synthesis, or by decreasing the sensitivity of the cells to ethylene. Cytokinin content in carnation (van Staden and Dimalla, 1980) and *Cosmos sulfurous* (Saha et al. 1985) is greatest in young flowers and decreases during corolla opening and development. Enhanced cytokinin level in *Petunia* and tobacco delays flower senescence (Zubko et al. 2002). Increased cytokinin when applied exogenously or increased endogenously in transgenic plants, effectively postpone senescence. Petal senescence in carnation is delayed by cytokinin application. Higher levels of cytokinins delayed the rise in ethylene synthesis. Moreover, using 6-methylpurine, an inhibitor of cytokinin oxidase/ dehydrogenase, the longevity of carnation petals could be extended (Taverner et al. 2000). Accelerated cytokinin breakdown has been reported during carnation petal senescence due to increase in mRNA abundance of two genes encoding cytokinin oxidase/dehydrogenase (Hoeberichts et al 2007). The longevity of harvested *Grevillea* 'Sylvia' inflorescences was extended by about 2 days and various senescence parameters were suppressed by dipping treatments of 1 and 10 mM 6-benzylaminopurine (BA; Setyadjit et al. 2004). Application of BA has also reduced ethylene production and extended the vase life of cut *Eustoma* flowers (Asil and Karimi 2010). Early flowering and increased percentage of inflorescence by BA have been reported in *Dendrobium* orchids (Nambiar et al. 2012).

Recent study of petal senescence in cut flowers of *Matricaria parthenium* has revealed highly effective role of kinetin (individually and in combination with sucrose) in delaying senescence (Mukherjee and Mukherjee 2017). The combined application has not only made the flowers more turgid and fresh; but also reduced starch degradation, lipid peroxidation and lipoxygenase activity.

Auxins: Auxins have been found to delay the senescence of cut flowers like carnation and petunia (Halevy and Mayak 1981). 2, 4-Dinitrophenol (2, 4-DNP) has been found to inhibit ethylene evolution in carnation. But there are some contradictory result reported by Stead (1992) where auxins enhanced ethylene production and stimulated senescence in some ethylene-sensitive flowers. In cut carnation flowers, IAA-treatment has hastened the increase in ethylene production and petal wilting. Jones and Woodson (1999) have reported 2, 4-D induced expression of ACC synthase genes in the styles, ovaries and petals of carnation flowers. It was also noticed that the removal of gynoecium does not allow the production of ethylene even after the treatment with IAA.

Gibberellins: Gibberellins have been shown to improve vase life in lilium and promote corolla growth and pigmentations in petunia flowers (Izaki et al. 1996). Detached flowers last longer when they are held in solutions containing gibberellic acid (GA_3) (Ichimura and Goto 2000). Accel ($BA+GA_{4+7}$) has a potential to be used as a commercial cut flower preservative solution for delaying flower senescence, prolonging the vase life and enhancing post harvest quality of *Alstroemeria* cut flowers (Mutui et al. 2001). Application of GA_3 to cut caranation flowers delayed the rise in ethylene production and postponed wilting.

Polyamines (PAs): Polyamines are low molecular weight polycationic, biogenic amines that are universal to all living organisms and involved in the regulation of growth, development, senescence and stress probably by binding to negatively charged macromolecules (Kusano et al. 2008). Diamine putrescine (Put) is a major PA in plants and a precursor for triamine spermidine (Spmd) and tetramine spermine (Spm). Due to their positive charge, these compounds can bind various cellular macromolecules including DNA, RNA, chromatin and proteins. Some studies have been conducted with PAs in extending post-harvest shelf life of flowers. PA like putrescine improved fresh weight, solution uptake and vase life of cut *Dahlia pinnata* (Mahgoub et al. 2011) and *Narcissus* (Sardoei et al. 2013). Spermidine also increased vase life by improving fresh weight and solution uptake of cut spikes of *Gladiolus* (Dantuluri et al. 2008).

While working with *Calendula officinalis* cut flowers having individual treatments of sucrose, L-serine and spermine as well as a combination of sucrose + L-serine and sucrose + spermine, better results were obtained with L-serine and spermine in minimizing the reduction in flower diameter, moisture content of petals and membrane stability index (MSI) values (Kaur and Mukherjee 2015). They were able to maintain relatively higher values of antioxidant enzymes like ascorbate peroxidase and catalase. Spermine was very effective in combination with sucrose in extending the vase life of these cut flowers.

Salicylic acid: Salicylic acid (SA) is another endogenous growth regulator which is effective in other forms of acetyl salicylic acid and methyl salicylate in plants as well (Raskin 1992). SA participates in the regulation of physiological processes for improving all growth characters and due to its role in plant metabolism, is considered to be a potent plant hormone. SA is not only effective in obtaining maximal flowering but also suppresses ACC synthase and ACC oxidase activities; and ethylene biosynthesis.

Salicylic acid can be used to increase the longevity of *Matricaria parthenium* cut flowers (Mukherjee and Mukherjee 2017). It could delay the appearance of senescence symptoms on flower petals and partly reduce the membrane damage. However, the degree of effectiveness was slightly lower than kinetin.

The vase solution having 5-SSA (5-Sulfosalicylic acid) increased cut flower vase life of *Gladiolus* (Ezhilmathi et al. 2007) and *Narcissus* (Sardoei et al. 2013) by increasing their water uptake and fresh weight. In *Gladiolus* flowers, 5-SSA also increased significantly cumulative uptake of solution and number of opened florets; and lowered lipid peroxidation and lipoxygenase activity. It also increased membrane stability, soluble protein content and activities of SOD and catalase in comparison to controls (Ezhilmathi et al. 2007).

Morphactins: Morphactins are novel group of compounds highly active in plant morphogenesis. They inhibit and/or otherwise modify development and growth of plants (Schneider et al. 1965). Sankhla (1969) was the first to show that morphactins in the bisexual flowers of *Nicotiana paniculata* suppress the anthers and stimulate the female character. In tomato and cucumber, the application of morphactin in low concentration during flowering may lead to the development of parthenocarpic seedless fruits. Mukherjee (1980) also observed in tomatoes that single morphactin treatment significantly checked the abscission and shedding of flowers thereby increasing the number of fruits per plant.

Role of PGRs on petal senescence has been studied in a number of plants in our laboratory including *Calendula officinalis, Coreopsis lanceolata* and *Arctotis grandis* (Khokhar and Mukherjee 2010a, b). MOR at a concentration of 3.64 and 36.4 µM was able to minimize protein degradation, reduce activities of protease and guaiacol peroxidase; and lower the amount of MDA and reducing as well as non-reducing sugars in comparison to controls. Flower petals of above mentioned untreated plants are characterized by a marked decline in protein, accelerated activities of protease and other degrading enzymes; and sharp rise in sugar content during senescence.

Ethanol and other alcohols

Exogenous application of ethanol has been shown to delay senescence of carnation flowers (Podd and Staden 2004). Pun et al. (1999) reported that ethanol (4% and 6%) increased the vase life of carnation flowers and cultivars showed variable response to ethanol treatment with regard to vase life increment. Two percent ethanol along with 2.5% sucrose delay senescence in *Lisianthus* cut flowers (Farokhzad et al. 2005). Continuous treatment with 8% ethanol doubled the vase life of 'White Sim' carnation (*Dianthus caryophyllus* L.) flowers (Wu et al. 1992). Eight and 10 percent ethanol were found to be effective in delaying senescence in bougainvillea flower (Hossain et al. 2007). Podd and Staden (2004) stated that low concentration of either ethanol or acetaldehyde apparently decreased the formation of ethylene by inhibiting the action of ACC synthase. Lower concentration of ethanol and methanol (2 %) was highly effective in lowering starch and protein breakdown and arresting the increment in sugars and protease activity in cut flowers of *Matricaria parthenium* and *Chrysanthemum* (Kaur and Mukherjee

2012; Khokhar et al 2013). Significant increments in solution uptake and flower diameter; and higher level of SOD activity after ethanol treatment was noticed in cut flowers of *Calendula officinalis* (Kaur and Mukherjee 2013). Further it was also noticed that n-butanol even at a lower concentration was not able to extend the vase life of *C. officinalis*.

CONCLUSION

Only limited number of flowers have been extensively studied to know about regulation of petal senescence. Studies are needed at the cellular and organelle level to understand more about the role of ROS, antioxidant enzymes and metabolites; as well as the expression of certain genes putatively specific to any stress or regulated by PGRs.

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REVIEW PAPER

Dissolved Organic Matter in Soil : A Review Study

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ABSTRACT

Dissolved organic matter (DOM) comprises only a small part of soil organic matter (< 1%); nevertheless, it is an important fraction of the soil organic matter (SOM) because of its solubility, mobility and the fact that it often contains labile organic molecules which may serve as a nutrient and energy source for microorganisms. It is considered to have a major role in the transport and supply of carbon and nitrogen to microbial populations. Accumulation of DOM in soil helps mineralization of nutrients and their cycling in ecosystem. Adsorption of DOM is the main process determining the retention of DOM in soils. However, there are indications that the microbial degradation of DOM (both in soil solution and that adsorbed on soil minerals) is underestimated in subsoil horizons and it is generally assumed that adsorption diminishes the biodegradability of DOM. Control on DOM dynamics from laboratory experiments are often not supported in field studies on the scale of experimental plots, catchments, or watersheds or on temporal scales of month to years.

Key words *dissolved organic matter, soil, dissolved organic carbon, labile, SOM*

Organic materials are intrinsic and essential components of all soils. The organic fraction of the soil is determined by continuous admission of organic residues of plant and animal origin into the soil and their continual transformation under the action chiefly of biological factors but to some extent of chemical and physical factors. Among the different forms of soil organic matter (SOM) [labile, slow and recalcitrant], labile soil organic matter pools (LSOMs) can be considered as fine indicators of soil quality which influence soil function in specific ways and are much more sensitive to change in soil management practices. It is important as energy source for the soil food web and thus influences nutrient cycling for maintaining soil quality and its productivity (Chan *et al.,* 2001). The labile soil organic matter pool consists of: 1) Dissolved organic matter (DOM) which is a major controlling factor in soil forming processes and plays a role in many chemical and biological processes in soils. 2) Microbial biomass which provides a sensitive indication of changes in total SOM content as they respond more readily to changes in management or land use in the tropics and subtropics. 3) Light fraction carbon which acts as a transitory pool between fresh residues and humified soil organic matter, plays an important role in determining the structure and function of the soil ecosystem by acting as an energy source for heterotrophic organisms and as a reservoir of relatively labile carbon and plant nutrients. The three LSOMs seem to have a close association with one another and have important impact on soil quality (Laik *et al.*, 2009).

DOM (which includes C, N and other organically bound nutrients) is the most mobile and dynamic non-living organic matter fraction. It is often defined operationally as that organic matter, which passes through a 0.45 ìm filter (Zsolnay, 2003). DOM in soils is a small but is the reactive fraction of the SOM. It comprises only a small part of SOM (< 1%); nevertheless, it is an important fraction of the SOM because of its solubility, mobility and the fact that it often contains labile organic molecules which may serve as a nutrient and energy source for microorganisms.Only small proportions of DOM, mostly low molecular weight substances such as organic acids, sugars, amino acids, can be identified of chemical origin. Most of what is collectively termed 'dissolved organic matter' in soils is complex molecules of high molecular weight, namely, humic substances. A general chemical definition of DOM is impossible. DOM is often defined operationally as a continuum of organic molecules of different sizes and structures that pass through a filter of 0.45 µm pore size.

Sources of dissolved organic matter

The DOM concentration in soil solution is determined by the net result of its production, degradation, immobilisation and leaching. The contribution of these different processes to the DOM concentration is relatively unexplored (Kalbitz *et al.,* 2000). Different methods have been used to identify the sources and sinks of DOM in soil. Seasonal and spatial variability in DOM concentration and composition indirectly suggests relative importance of different DOM sources such as litter decomposition and dissolution of humic substances.

Ultimately, the source of virtually all DOM in soils is photosynthesis. This includes both recent photosynthates (through-fall, leaf litter, root exudates, decaying fine roots) as well as the leaching or decomposition of older, microbial processed SOM (Mc Dowell *et al.,* 1998). Chemical composition of DOM suggests that most DOM is an end product of microbial metabolism (Guggenberger *et al.,* 1994), yet short-term experimental manipulations of organic matter sources show that fresh litter also contributes significantly to the production of DOC *(*dissolved organic carbon). DOM consists of small defined molecules with sizes <1000 Da (Dalton) such as organic acids, sugars, amino acids, etc, colloidal substances with sizes >10000 Da such as cyclic nitrogen forms, aliphatic and peptide residues and aromatic

compounds such as soluble phenolics (Tian *et al.,* 2010).

In agricultural soils, DOM accounts for 0.05 to 0.4 % of SOM, whereas in forest soils, DOM accounts for 0.25 to 2% of SOM (Sollinger *et al.,* 2001). It has been found that 10 to 40% of DOM is readily degradable. DOM contains aromatic compounds which are microbiologically modified from the parent materials (Rumpell and Ingrid, 2011). The stability of DOM obtained from fresh litter is low resulting in less turn over times. DOM derived from strongly humified materials and mineral soil horizons are stable with turnover times of decades. It was reported that in acidic soils, interaction with amorphous Fe and Al oxides was the main stabilization mechanism (Rumpell and Ingrid, 2011). Complexation of Al and Fe with DOM in acidic forest soils is influenced by several soil solution variables, including the solution pH value, the redox potential that determines the Fe (II)/Fe (III) speciation and the molar ratio of metals to organic carbon (M/C). Furthermore, competition effects between different metal cations for binding on DOM can have a significant influence on the complexation with DOM. (Sollinger *et al*., 2001). In forest ecosystems, the flux of DOC from the forest floor into the mineral subsoil has been estimated at 115–500 kg C ha^{-1} $year^{-1}$. Concentrations of DOC in deep soil horizons and its export from mineral subsoil are usually small. Typically, 40–370 kg DOC ha^{-1} $year^{-1}$ are retained in the mineral subsoil. Sorptive stabilization of DOC is likely the main process for this retention (Kaiser and Guggenberger, 2003). Precipitation of DOM may also contribute to the formation of stable organic matter (OM) but this process has not been investigated so far. DOM is also involved in podzolisation of soil (Sollinger *et al.,* 2001).

Specific functions of dissolved organic matter

DOM in soil may be the most important C source, since most microbial metabolism depends on water transport of resources. Approximate 10–20% of the above ground C input from litter is released as dissolved organic carbon (Currie *et al.,* 1996; Michalzik *et al.,* 2001). Some of this C is utilized by microbes, some is retained in the soil by abiotic mechanisms, and some is transported into aquatic systems. DOM may be the most important carbon source since microorganisms are basically aquatic and all microbial uptake requires a water environment (Marschner and Kalbitz, 2003). About 2-69 kg C/ha/yr is available in between 0.2-1 m depth in forest soils (Neff and Asner, 2001). DOM stored in the first meter of the world soils usually below 30 cm depth ranges between 46-63%. Therefore, subsoil C may be even more important in terms of source or sink for CO_2 than topsoil carbon. DOM flows into subsoil along root channels and/or through bioturbation and becomes less bioavailable. Sorption reactions with the mineral surface further reduces DOM bioavailability. Occlusions with soil aggregates account for a great proportion of DOM preserved in subsoil (Kalbitz and Kaiser, 2008). In forest ecosystems, the flux of DOC from the forest floor into the mineral subsoil has been estimated at 115–500 kg C ha^{-1} $year^{-1}$ (Currie *et al.,* 1996). Concentrations of DOC in deep soil horizons and its export from mineral subsoil are usually small (Solinger *et al.,* 2001). Typically, 40–370 kg DOC ha^{-1} $year^{-1}$ is retained in the mineral subsoil (Currie *et al.,* 1996; Guggenberger and Kaiser, 2003). Sorptive stabilization of DOC is likely the main process for this retention.(Kalbitz *et al.,* 2000; Kaiser and Guggenberger, 2000). SOM mineralization is a microbial process and affected by temperature, moisture, soil physical and chemical properties and agricultural practices. In addition, chemical composition and nature of SOM is a critical factor for decomposition. SOM consists of different biologically-available compounds or fractions. Solid phase is expected to be less susceptible to decomposition while DOM is easily decomposable. Generally, depolymerization and solubilization of SOM are considered to be a prerequisite to mineralization (Marschner and Kalbitz, 2003). The soil solution is a bottleneck in the mineralization conversion of solid-phase organic matter to CO_2 and CH_4. Therefore, dynamics of DOM play an important role in mineralization of SOM. Reducing sugars and amino acids in DOM controls soil microbial peroxidase activity which assist in soil C and N mineralization in the ecosystems (Tian *et al*., 2010)

DOM plays a key role in the fate of metals in soil via modulating the complexation of metals in soil solution. DOM impacts on the mobilization of metals from the solid phase and on the transfer of metals to other compartments of the environment. Amery *et al.,* (2007) showed that the aromaticity of DOM modulates its affinity and its ability to mobilize Cu from the solid phase and thus affects Cu leaching to ground waters. Polyvalent metals like Fe and Al are hard Lewis acids, capable of strong and specific bonding to hard Lewis base functional groups on DOM molecules (Stevenson, 1994). Al and Fe can occupy the same functional groups on DOM molecules that are also involved in sorption of DOM to solid soil components (Kaiser *et al.,* 1997). When this results in a reduced negative charge on the DOM molecules, it could increase the mobility of DOM through the soil system by partially preventing sorption, especially since a large portion of DOM sorption is believed to be irreversible (Gu *et al.,* 1994, Jansen *et al*., 2003). This would also increase the mobility of Fe and Al themselves because binding to DOM alters precipitation equilibria with sparingly soluble inorganic Al and Fe salts and competes with immobilization of Al and Fe by adsorption to solid soil components (Stevenson, 1994).

DOM is an important contributor to transport of nutrients in the soil system (Guggenberger and Kaiser, 2003). Long-term DOC leaching may have wide-ranging impacts on freshwater biota, drinking water quality, coastal marine ecosystems and upland carbon balances (Evans *et al*., 2005). Evidence from studies in soil systems indicates that sorptive protection of DOM may be of particular importance. According to Guggenberger and Zech (1992) the change in concentration of DOM during transport through the mineral soil is caused by sorption of DOM on to the mineral phase. Iron and aluminium oxides are important sorbents of DOM with sorption usually described as surface complexation of DOM carboxylic acid groups (Kaiser *et al.,* 1997). Additionally, it is often found that soil is able to release DOM when exposed to aqueous solution containing no or very low concentrations of DOM. Thus, the soil solid phase may not only sorb DOM but may also release it.

Factors controlling dissolved organic matter dynamics in soil

Litter-fall represents the most important source of C inputs to the forest floor. Terrestrial total litter production is almost equivalent to net terrestrial primary production of about 60 Pg C yr^{-1}. Considering that the largest ecosystem internal flux of DOC occurs as percolate from the forest floor (Michalzik and Matzner, 1999), the rate of litter incorporation in the forest floor and its rate of degradation into products with varying degrees of humification may ultimately determine the rate of DOM production. Currie and Aber (1996) found that relatively high fluxes of DOC and CO_2 were caused by either high relative rates of decay or by high litter-fall fluxes. It was found that DOC leaching and CO_2 mineralization were correlated positively with the organic matter mass of the forest floors. In conclusion, increasing litter production and humus content presumably results in increasing DOM concentration and fluxes.

The quality of litter is determined largely by the dominant vegetation, which thus plays an essential part in controlling DOM concentrations in soil solutions. Soil solutions from mixed and coniferous stands often contain significantly more dissolved organic carbon and dissolved organic nitrogen (DON) than those from hardwood stands. Cronan (1990) pointed out that DOC export from coniferous forests was 50% higher than from hardwood stands. DOC and DON fluxes are higher in coniferous forests despite slower rates of litter decomposition. Until now, the reason for this difference has been poorly understood. Moreover, Kuiters (1993) showed in a laboratory leaching experiment that much more DOC was released from deciduous leaves (10-25 mg C g^{-1} dry matter) than from coniferous needles (<5 mg C g^{-1} dry matter), possibly as a result of differences in the water permeability of the leaves.

However, few attempts have been made to relate DOM production rates in the soil to the substrate quality of litter and humus. Northup *et al.,* (1995) showed that in a *Pinus muricata* forest ecosystem, characterized by extremely acidic and infertile soil, the polyphenol concentration of needle litter controls the release rate of DON. The DON released is assumed to be directly utilized by mycorrhizae, minimizing nitrogen loss to competing organisms. The potential decomposition rate of organic soil is conventionally characterized by its C/N ratio. There is little information about the effect of substrate quality on *in-situ* DOM dynamics in soils. Parameters such as the content of carbon or nutrients (N, P) in soil, or ratios between carbon and nutrients (e.g. C/N, C/P) are often not significantly related to DOM release rates (Cortina *et al.,* 1995). Microorganisms play dual roles as a pool of labile nutrients and the agent of decomposition of organic materials. Moller *et al.,* (1999) suggested that fungi are the most important agents in the process of DOM production, probably because of incomplete degradation of organic matter by fungi. So microbial metabolites constitute a significant portion of DOM released from the forest floor. In addition, microbial biomass itself provides an important pool of potential DOM mainly through cell death and lysis, the soil fauna also influences the rate of DOM release by enhancing the rate of turnover of microbial biomass and through the release of organic compounds at death (Whalen *et al.,* 1999). Faunal grazing also causes microbial immobilization.

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REVIEW PAPER

Banana Tissue Culture in India; Status, Opportunities and Challenges.

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ABSTRACT

India is one of the largest producers of banana and plantains as a major staple food crop in the world. The crop productivity has increased considerably with appreciable area expansion due to growing awareness of its nutrition value, high economic returns and export potential. To meet the large demand of good planting material, tissue culture techniques became popular and lots of private companies flourished as main players in this field in India. But the tissue culture companies face major constraints in production and marketing of tissue cultured raised banana plantlets. This is mainly due to rigidity of the farmers to adopt the technology-raised plantlets and issues concerning the genetic fidelity, quality, and disease freeness. Further due to inadequate development of this industry that too in particular area of the country, tremendous annual demand of more than 2000 million banana plantlets remains unfulfilled. There should be strategies to meet the gap between demand and supply with well-developed retail marketing policies with better outlets to reduce post hardening losses and the timely availability of certified quality banana plants to the farmers throughout the country.

Key words *Banana Tissue Culture in India; Status, Opportunities and Challenges.*

The scale and pace of technology revolution has begun to impact our lives in so many ways that it appears that civilization is moving into the age of biotechnology.Plant cell biotechnology has evolved as a new era in the 21st century merging the area of genetic engineering and molecular biology with conventional methods of crop breeding. It has been globally accepted as one of the important tools for crop improvement and has allows the appearance of new agricultural products with improved food, feed, fiber and fuel.These have occupied an increasing demand in the productive systems of several countries worldwide.In 1902, German Botanist Gottilieb Haberlandt conceived the concept of cell culture and laid the foundation of Plant Tissue Culture as a refined tool for botanical investigations (Suhasini *et al.,* 2017, Sumalatha, 2016; Razdan *et al*., 2003; Murashige and Skoog, 1962). After extensive research carried out by scientists worldwide, Plant Tissue Culture has made a great impact on both agriculture and related industry, through providing plants needed to meet the ever increasing world demand. It represents the most promising area of application at present time and giving an out look into the future. Its avenues range from Genetic engineering, Micropropagation, Haploid induction, Somaclonal variation, Molecular farming to Cryopreservation of valuable germplasm. Micropropagation known as Plant tissue culture as a practice used to propagate genetically identical plants under *in vitro* condition. In these processes, tissues or cells, either as suspensions or as solids is maintained under conditions conducive for their growth and multiplication (Suhasini *et al.,* 2017, Suman *et al*., 1997; Razdan *et al*., 2003; Murashige and Skoog, 1962). It is a achieved by following step by step procedure -

Stage 1: Selection of suitable explants, their sterilization and transfer to nutrient media for establishment, i.e. initiation of a sterile culture of the explant.

Stage 2: Proliferation of shoots from the explant on medium.

Stage 3: Transfer of shoots to a rooting medium followed by acclimatization.

Micropropagation has been extensively exploited to meet the growing demands for elite planting material in the current century. There exists a large demand of superior quality disease free plants in ornamental, horticultural, floricultural and agro-forestry sectors, which form the core sectors of agriculture. This need has been successfully tapped through micropropagation of economic viable plants there by effectively translating the concept of technology for the commercial needs. During the past 3-4 decades, an entirely new industry based on this technology has come up worldwide, and more so in India and has grown into a multi-million dollar business. In India, there are about 100 commercial plant tissue culture units with a minimum production capacity of about 1 million prioritized plants per unit per year under various consumer segments like Banana, Grapes, Pineapple, Strawberry, Sapota, Sugarcane, Potato, Turmeric, ginger, Vanilla, Cardamom,Aloevera, Geranium, Stevia, Patchouli, Neem,Gerbera, Carnation, Anthurium, Lily, Syngonium,Cymbidium,Teak, Teak, Bamboo, Eucalyptus and Populus. Among these, at least20 of the units have larger production capacities, with 5 to 10 million plants/year. In addition, thereare more than a dozen smaller units with 0.2 to 0.5 million plant production capacities where singlecrop like Banana,Gerbera, Bamboo are being produced.

The demand for micropropagated plants is growing by the day, since the conventional methods of propagation do not yield sufficient quantity and in some cases they are cumbersome.In India the aggregate production capacity of the established commercial tissue culture units is estimated at about thousand million plants per annum. The major consumers of tissue culture plants are the State Agriculture and Horticulture Departments, Agri Export Zones (AEZs), floriculturists and farmers. It has seen that the installed production capacity is not always utilized completely and only 50-60% utilization is generally best utilized. So apart from the technological development at industrial scale, a further investigation is required to fill the gap for adoption of technology among the farmers and need to develop

Table 1. State wise area of cultivation of Banana plants with their number and percentage contribution of both sucker and tissue culture raised plantlets in India.

State	Area of Cultivation (M. Hectares)	No. of Plants (In Million)	70% Suckers (In Million)	30% T C Raised Plantlets (In Million)
Andhra Pradesh	0.08	240	157	67
Arunachal Pradesh	0.0054	16	11	5
Assam	0.05	150	105	45
Bihar	0.03	90	63	27
Chhattisgarh	0.01	30	21	9
Goa	0.002	6	4	2
Gujrat	0.06	180	126	54
Karnataka	0.11	330	231	99
Kerala	0.06	180	126	54
Madhya Pradesh	0.04	120	84	36
Maharashtra	0.08	240	168	72
Orissa	0.03	90	63	27
Tamil Naidu	0.13	390	273	117
Uttar Pradesh	0.03	90	63	27
West Bengal	0.04	120	84	36
Total	0.7574	2272	1590	682

marketing strategies with broader reach to reduce the hardening and post hardening losses of plants (Yadav *et al*., 2005; Takle *et al.*, 2011). In India, major tissue culture industries are producing banana plants, so in this context it is important to study the current consumption pattern between farmer and Industries at a pilot level (Raman and Umanath, 2016; Takle *et al*. , 2011) . Hence, the main objective of writing this chapter is to identify the challenges of banana tissue culture industries and their marketing channels.

RESULT AND DISCUSSION

Banana is the fifth largest agricultural commodity in world trade after cereals, sugar, coffee and cocoa. India, Ecuador, Brazil and China alone produce half of total bananas of the world. According to FAO estimates, India occupies the highest area under banana cultivation in the world. It may be noted that 11 percent of the total global area under banana production belongs to India. It ranks first in production and contributes about 23% in world pool of banana production (Ali S, *et al.,* 2017, Sumalatha, 2016: Alagumani, 2002; 2005; Biswas and Kumar, 2010; Kumar *et al.,* 2005; FAO 2014). The advantage of wide range of Musa cultivars with varying genomic status is its wide cultivation in varying agro climatic (geographical) regions throughout the year and it has seen a spectacular growth worldwide in recent years. It is envisaged that the demand is ever increasing and 50 million tons of banana will be needed to meet the domestic demand by the year 2050 (Raman and Umanath, 2016; Ahmed *et al.,* 2014; Mustaffa, 2011). There is also a considerable scope for the export of banana and its products, which further enhances the demand. With a production target of 50 million tons in the year 2050,the major production constraints are good quality planting material, increasing input costs of fertilizers, irrigation and management of insect pests and diseases which need to be solved for maximizing the production (Guledgudda and Olekar, 2002; Padma Rani and Mani, 2016; Ahmed *et al*., 2014; Hanumantharaya *et al*., 2009; Karule *et al.,* 2016). Tissue culture raised plantlets will play an important role in minimizing the constrain of production targets as these are superior than conventional suckers with respect to high field establishment rate, uniformity in growth, synchronized harvesting, early maturity, better-quality fruits, high production and other yield related parameters. Tissue culture based plantlets yielded 63.44 t/ha, which was 39.43% higher than the conventional sucker grown crop (45.50 t/ ha) and as a result crop grown with tissue culture plantlets had a benefit cost ratio of 2.25 as compared to 1.65 of crop grown with conventional suckers (Raman and Umanath, 2016; Sudharshan, 1998; Saxena, 2014; Alagumani, 2005; Mustaffa 2011; Biswas and Kumar, 2010; Yadav *et al*., 2005).

India is a country of great geographical diversity and has been divided into 15 geographical regions and 29 political states. The variations in its terrain, temperature, rainfall and soils have closely influenced the cropping patterns and other agricultural activities and encouraged the development and sustenance of large number of agricultural produce including banana (Robinson, 1990; 1996; Saxena, 2014). Though, more than 20 varieties are grown by farmers, Cavendish groups form the main stay of Indian farmers, owing to its high yield, wide market acceptability, short crop duration and high economic returns per unit area (Pradeep *et al.,* 1992). In India 0.757 million hectares of land is utilized by farmers for Banana cultivation in 15 States and due to geographical barrier its cultivation is not profitable in other 14 states of the country including North Eastern states. It has been observed that more than 50% of banana cultivation occurs only in four states like Tamil Naidu ranks first with 0.13m. hectares followed by

Table 2. Production of Banana plants from Recognized tissue culture laboratory in India.

States	Number of recognized lab*	Production of Banana** (In Millions)
Andhra Pradesh	9	12
Assam	1	0
Bihar	1	0
Chhattisgarh	5	14
Gujarat	14	30
Haryana	2	7
Himachal Pradesh	1	0
Karnataka	9	20
Kerala	0	20
Madhya Pradesh	2	5
Maharashtra	25	55
Orissa	1	5
Punjab	2	0
Rajasthan	1	0
Tamil Nadu	10	18
Telangana	5	30
Uttar Pradesh	3	9
West Bengal	4	15
Total	95	240

* http://dbtncstcp.nic.in/html/content/certified_TCUs.html

** Production per year has been calculated on the basis of the information available on individual company production data.

Karnataka with 0.11 m. hectares whereas Andhra Pradesh and Maharashtra ranks third with 0.08 m.hectares each (Mustaffa, 2011; Biswas and Kumar, 2010; Saxena, 2014). With 3000 recommended planting material of Banana per hectare it has been estimated that about 2272 million plants are grown annually (Takle *et al*., 2011; Yadav *et al.,* 2005; Kodym and Zapata-Arias 2001; Anonymous 2002). In India the present requirement of banana plants is approximately 2272 million plants/year and Indian farmer's uses 70% conventional planting materials ie, sucker and only 30% tissue culture raised plantlets indifferent states of the country (Tab. 1) which indicates clearly that the use of tissue-cultured plantlets is very low. With vast potential of 2272 million of tissue culture raised Banana plantlets in India, there is a need to encourage the Indian farmers to adopt the technology which is in tern dependent on sufficient infrastructural equipped Tissue culture industry along with certification program to meet the requirement of healthy planting material (Ali S, *et al.,* 2017, Sumalatha, 2016; Saxena, 2014; Badgujar *et al.,* 2005).

India entered the field of commercial tissue culture in 1987, when a modern export oriented commercial plant tissue culture unit was set up by A.V. Thomas and Co; a well-known plantation company of Kerala in Cochin. At present estimated number of 95 tissue culture units have been recognized by government of India with aggregate capacity of 240 million banana plants per annum which are operational (Tab. 2). Besides these recognized labs at least 20 smaller units are also functional for production to cater the huge demands. 60 percent of the total tissue culture unit in the country, cater the domestic as well as interstate market is confined to only four states like Maharashtra, Gujrat, Telangana and Karnataka, other state are still untapped for these potential of banana, as they are faced with problem

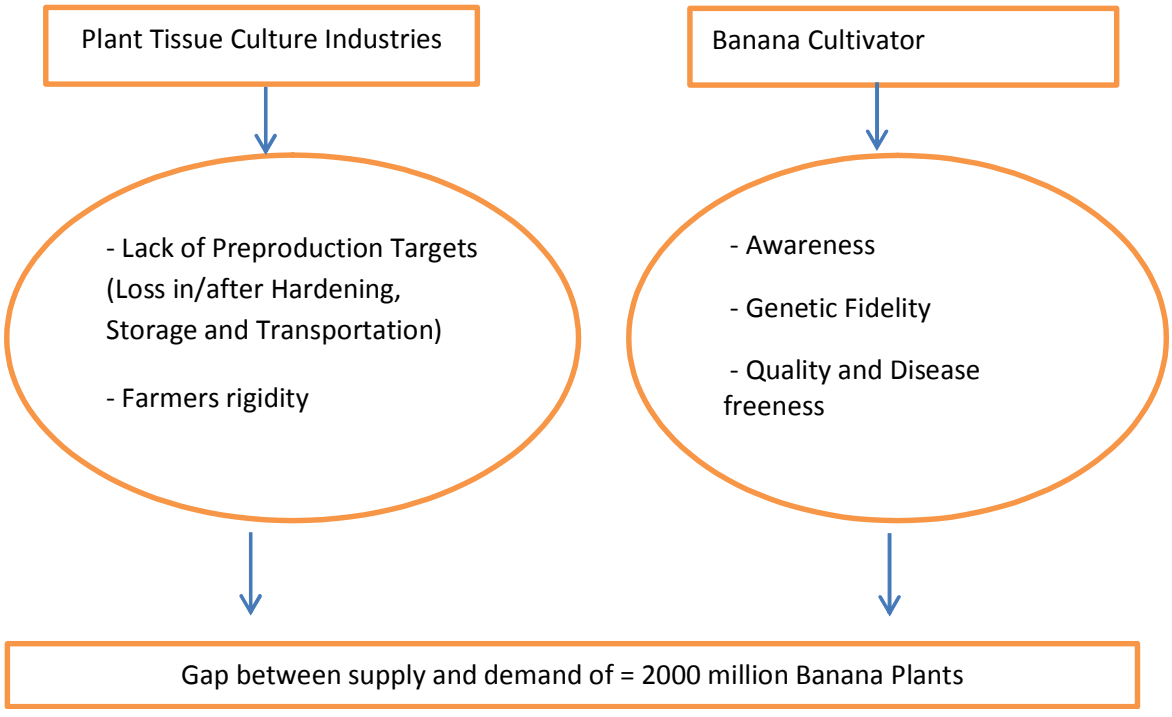

Fig. 1. Challenges faced by industry and farmer as major hurdles in achieving the true market potential.

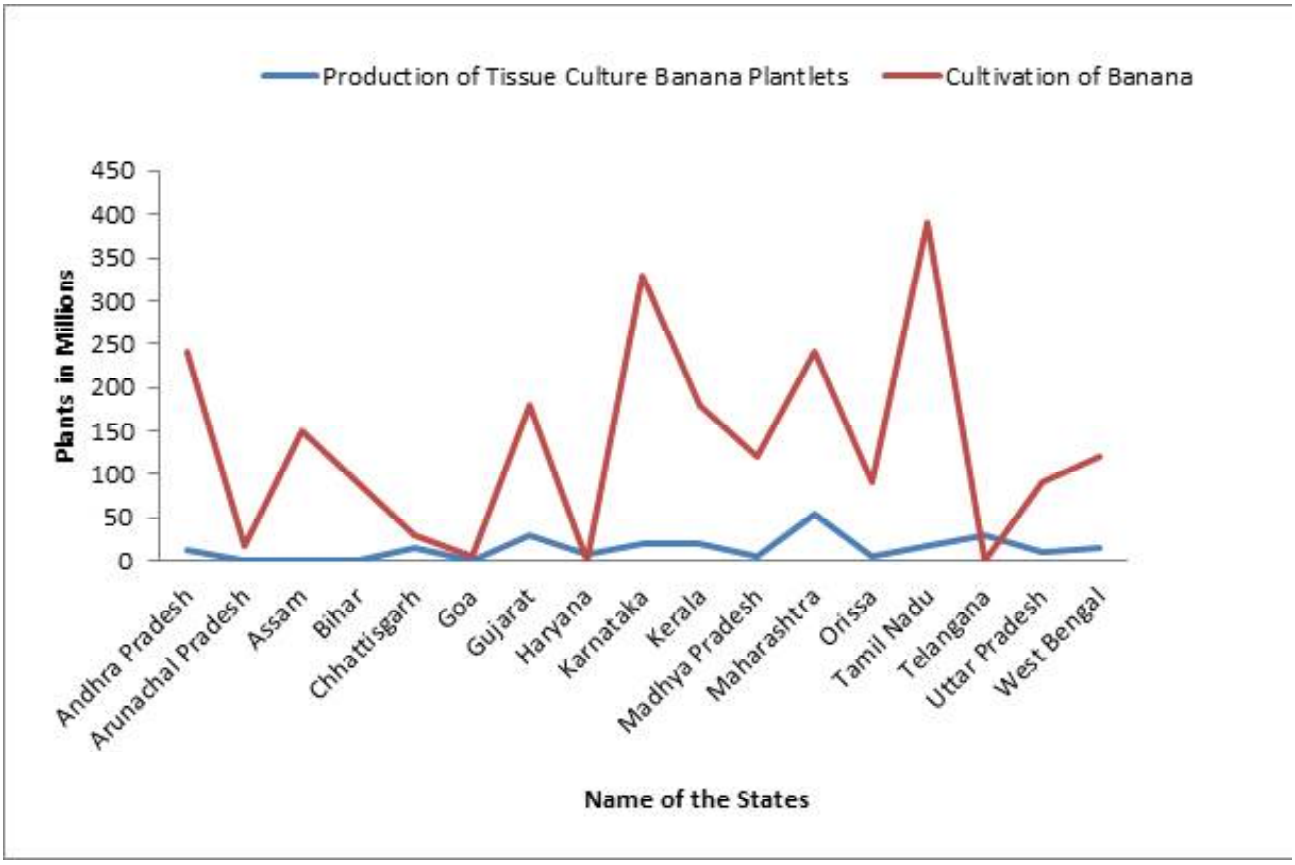

Fig. 2. State wise cultivation of banana plants and production of tissue culture Banana plantlets

ranging from climatic disadvantage, non-availability of infrastructure and conducive policies (Sudharshan, 1998; Anonymous, 2008; BCIL, 2005). States like Bihar, Assam and Goa which produce banana by traditional farming methods lack well developed infrastructural support of tissue culture based industry creates a wide gap between farmers and industry (Fig. 2). Indian Industries today do not have sufficient access to primary markets and it has been experienced by the firms that the market estimation exercises done prior to business establishment lose their relevance at the time when the product is ready after post harvesting, transportation and storage. In the market long term orders are not placed by farmers therefor production planning for the lab becomes uncertain for industry. The post hardening loss is a major constrain of the sector which may be minimized by the uniform establishment of tissue culture industries as per demand of the different states of the country(Fig. 1).In some states like Assam, Bihar and Goa the market potential still remains untapped and there should be targeted in a more planned way(Fig.2). Rigidity and illiteracy of Indian farmers is another resistance faced by the industry to convince them for economic advantages and genetic fidelity of tissue culture raised plants (Daniells, 1997). Other challenge of the industries is the middleman who largely benefited in marketing of the plants (Bapat and Iqbal 1998;1998). To tap the vast potential market size of more than 2000 million of plant per annum there is need for extensive networking of channels, market development and improved post-harvest handling, storage, transport and seed certification throughout the country (Anonymous 2002; Mehnaz *et al.,* 2015). Tissue culture industry, to a certain extent, represents the transformation of traditional economy into modern by the application of plant biotechnology so there is a need to educate Indian farmers through extension activities for optimum utilization of the land available with them, getting the best possible rates through subsidies given by Government for overall prosperity of the farmer using modern technology (BCIL, 2005; Bapat and Iqbal 1998; 1998). Upon interaction with individual and contact farmers at village and district level and financial managers and industry personnel's involved in commercial production of Banana plantlets we have try to recognize the barriers faced at farmer industry interface and to device possible solutions for mutual benefit.

CONCLUSION

On the basis of present study it can be concluded that there is a need to motivate the Indian farmers throughout the country about product diversity, quality and economic importance of tissue culture raised plants for adaptation from traditional modes of farming to the modern technology. It is also proposed that the development of regional translational collaborative center to carry out preproduction target analysis to minimize the post-hardening losses of Indian tissue culture industries should be promoted to meet the challenges for lab to land programs.

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Influence of Weather Parameters on Fungal Fruit Drop of Nagpur Mandarin in Ambia Bahar

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ABSTRACT

Maximum fruit drop of Nagpur mandarin caused by *Colletotrichum gloeosporioides* was recorded in the second fortnight of December (8.5%) during 2009 and first fortnight of December (8.86%) in 2010. Minimum fruit drop incidence (3.25% and 2.22%) was observed during the of first fortnight of June 2009 and 2010 respectively. Thus, maximum fruit drop were noticed in the month of December when the ambia bahar nearing to the harvesting stage. Significant correlation of fruit drop was recorded with minimum temperature (r= -0.771) during 2009 whereas, in 2010 negative and significant correlation was observed with maximum and minimum temperature (r= -0.582 and r= - 0.704) respectively. Pooled correlation coefficient for both the year also showed negatively significant correlation with minimum temperature (r= -0.730) and fruit drop incidence.

Key words *Weather parameters, fruit drop, Nagpur mandarin*

Citrus is the major fruit crop grown in tropical and subtropical region of the India. China rank first in production followed by USA and Spain. India rank forth in the production of citrus fruits in the world. The citrus fruits are attacked by number of pathogens from bloom to harvesting stage and subsequently by post-harvest pathogens that affects the production of crop and considerably deteriorate the fruit quality. The pre-harvest pathogens like *Colletotrichum gloeosporioides, C. acutatum, Botryodiplodia theobrome, Alternaria citri, Phomopsis citri* etc. infect the fruit from fruit set till harvest and caused considerable damage to its production and quality (Naqvi, 2004).

Post bloom fruit drop of citrus results from blossom infection by the fungus *Colletotrichum gloeosporioides*. About 10 to 20 per cent fruit drop in citrus observed due to fungal infection (Randhawa and Singh, 1967, Tayade and Ingle, 1997). *Colletotrichum gloeosporioides* cause anthracnose diseases in tropical fruit crops resulting in to low yield and quality of fruits (Prapassorn Bussaman *et al*; 2012). The losses (24.00%) have been observed by pre-harvest quiescent infection of *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae* in the form of stem end rot and anthracnose in citrus (Naqvi, 1993). Under congenial humid conditions, *C. gloeosporioides* infect the tender twigs resulting in drying of twigs starting from the tip and dieback. The fungus manifests on the dead tissues of the twigs. The blighted trees on bearing suffers heavy fruit drop and fruits harvested from such trees developed stem end rot during storage. The present investigation was aimed to study the effect of environmental parameters in relation to fruit drop incidence in ambia bahar.

MATERIAL AND METHODS

Citrus is a perennial crop and there are two main fruiting seasons such as mrig bahar and ambia bahar. As per the earlier literature, it is known that fungal infection in citrus gets aggravated with the prevalence of high temperature, humidity, coupled with rainfall. The prevailing weather parameters during standard meteorological weeks such as maximum and minimum temperature, rainfall and relative humidity, rain fall and rainy days were also recorded for simple correlation studies with the fruit drop incidence.

RESULT AND DISCUSSION

The data given in table 1(a) revealed the relationship between premature fruit drop and prevailing temperature, relative humidity and rainfall recorded during June to December 2009-2010. The maximum fruit drop of Nagpur mandarin were recorded in the second fortnight of December (8.5%) and minimum was observed during first fortnight of June (3.25%) in 2009 when weather variable *viz*. average temperature maximum (30.22 and 41.5^{o}C), minimum temperature (14.27^{o}C and 26.28^{o} C), morning relative humidity (68 and 62%), evening relative humidity (49 and 46%) respectively.

The similar trend of fruit drop was recorded during first fortnight of December (8.86%) in 2010 while the minimum was observed during first fortnight of June (2.22%) and weather variable were average temperature maximum (31.00 and 45.2^{o}C), minimum temperature (20.05 and 27.5^{o}C), morning relative humidity (78 and 54%), evening relative humidity (62 and 44%) respectively.

Significant and negative correlation of fruit drop observed with minimum temperature (r= -0.771) during 2009, whereas in 2010 significant correlation was recorded with maximum and minimum temperature (r= -0.582 and r= -0.704) respectively (Table 2). Pooled correlation coefficient for both the year showed significant negative correlation with minimum temperature (r= -0.730) and fruit drop incidence. In present investigation significant negative correlation of Nagpur mandarin fruit drop was observed with maximum and minimum temperature and positive with morning and evening relative humidity.

Kumar and Garg (2012) reported significant correlation between premature fruit drop of Kinnow mandarin with prevailing temperature and relative humidity. Singh *et al*. (2009) also standardized the positive correlation between disease and maximum temperature in guava anthracnose caused by *C. gloeosporioides*.

Table 1(a). Effect of weather parameters on fruit drop incidence of Nagpur mandarin in ambia bahar (2009)

Sr No.	Month	Fort-night	Fruit drop Incidence %	Temp. ^{0}C		Relative Humidity %		Rainfall mm	Rainy Days
				Max	Min	Morning	Evening		
1	June	Ist	3.25	41.50	26.28	62	46	07.20	03
2	June	IInd	3.86	41.14	28.38	58	47	00.00	00
3	July	Ist	3.63	39.00	25.45	63	56	25.80	05
4	July	IInd	3.77	29.16	24.08	80	74	23.10	13
5	Aug.	Ist	4.90	25.36	24.04	76	76	09.80	08
6	Aug.	IInd	5.15	30.06	24.94	70	65	01.80	01
7	Sept.	Ist	6.81	31.01	24.00	68	60	08.40	08
8	Sept.	IInd	7.31	30.00	24.26	66	52	12.84	05
9	Oct.	Ist	7.89	34.00	24.10	65	55	00.00	00
10	Oct.	IInd	7.57	34.30	22.22	66	56	06.40	01
11	Nov.	Ist	7.85	34.68	15.90	60	45	00.00	00
12	Nov.	IInd	8.06	32.50	17.70	71	49	12.26	03
13	Dec.	Ist	8.35	29.14	15.12	67	52	16.00	01
14	Dec.	IInd	8.50	30.22	14.27	68	49	00.00	00

Table 1(b). Effect of weather parameters on fruit drop incidence of Nagpur mandarin in ambia bahar (2010)

Sr No.	Month	Fortnight	Fruit drop Incidence %	Temp. ^{0}C		RH %	RH %	Rainfall mm	Rainy Days
				Max	Min	Morning	Evening		
1	June	Ist	2.22	45.20	27.50	54	44	0.00	0
2	June	IInd	3.25	41.34	29.44	56	35	5.00	1
3	July	Ist	3.33	35.64	25.38	82	61	43.03	6
4	July	IInd	3.43	30.47	22.67	84	68	12.63	12
5	Aug.	Ist	4.76	30.03	24.75	84	65	25.76	12
6	Aug.	IInd	6.25	28.52	23.70	83	70	18.47	8
7	Sept.	Ist	6.66	32.30	24.41	78	66	24.12	8
8	Sept.	IInd	7.14	30.02	24.62	83	73	20.52	8
9	Oct.	Ist	7.69	31.89	23.10	74	68	10.70	2
10	Oct.	IInd	8.15	33.73	20.91	67	63	23.00	1
11	Nov.	Ist	8.45	33.10	20.08	74	59	27.00	4
12	Nov.	IInd	8.66	33.48	18.18	80	66	4.00	2
13	Dec.	Ist	8.86	31.00	20.05	78	62	11.40	1
14	Dec.	IInd	7.75	28.30	12.40	68	52	1.00	1

Table 2. Simple correlation of fruit drop incidence with weather parameters

Weather parameters	Correlation coefficient (r)		Pooled Correlation coefficient (r)
	2009	2010	2009 and 2010
Temperature			
Maximum	-0.411	-0. 582*	-0.499
Minimum	-0.771**	-0.704**	-0.730**
Relative Humidity			
Morning	-0.048	0.268	0.139
Evening	-0.345	0.452	0.094
Rainfall	-0.333	-0.034	-0.136.
Rainy days	-0.443	-0.274	-0.346

r = 0.05- 0.532* r = 0.01- 0.661**

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Integrated Nutrient Management on Growth and Yield of Pigeonpea *(Cajanus cajan* (L.) Millsp.)

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ABSTRACT

A field experiment was carried out during kharif under rainfed condition at Gandhi Krishi Vigyan Kendra, Bangalore with factorial treatment combination of three levels of recommended dose of fertilizers (100, 75 and 50%), two levels of FYM (0 and 7.5 t/ha) and with and without composite biofertilizer (Rhizobium +PSB) seed inoculation to study the effect of inorganic, organic and biofertilizers and their combined application on growth and yield of pigeonpea. The results revealed that application of 100% recommended dose of fertilizers (25:50:25 kg N, P2O5 and K2O/ha) recorded significantly higher grain yield (1043 kg /ha) than 75 and 50 % RDF (938 and 884 kg /ha), respectively). FYM application at 7.5 t/ha resulted in significantly 21.2 percent higher grain yield (1047 kg/ha) than no FYM (864 kg/ha). Inoculation of pigeon pea seed with composite biofertilizer produced significantly 7.7% higher grain yield (991 kg/ha) than no seed inoculation (920 kg/ha). Application of 100% RDF, FYM @ 7.5 t/ha and seed inoculation with composite biofertilizer significantly increased the growth and yield components of pigeon pea. The interactions between organic, inorganic and composite biofertilizer were not significant on growth and yield of pigeon pea. The maximum net returns/ha was obtained with combined application of 100% RDF, FYM at 7.5 t/ha and seed inoculation with composite biofertilizer.

Key words *Biofertilizers, Fertilizers, FYM, Pigeonpea*

In Karnataka pigeon pea (*Cajanus cajan* (L.) Millsp.) ranks first both in area (3.63 lakh hectares) and production (1.57 lakh tones). Its productivity in the state (463 kg/ha) (Anon., 1997) is far below than national average of 584 kg/ha. The productivity of pigeon pea in India is far below that the agriculturally advanced countries (852 kg/ha) (Anon., 1994) and will be difficult to meet the demand of increasing population unless and until the productivity as well as production of pigeon pea in India is increased significantly. Continuous use of NPK fertilizers under intensive cropping system has caused widespread deficiency of secondary and micronutrients in soil (Takkar *et al.,* 1996) and has adverse effect on soil physical, chemical and biological properties thereby affecting the sustainability of crop production, besides causing environmental pollution (Virmani, 1994). Further, the chemical fertilizers are costly. Therefore, there is an urgent necessity for exploring the alternate plant sources which can supplement the use of chemical fertilizers without affecting the soil health and sustainable productivity. Pigeonpea is rich in protein, hence the requirement of nutrients including secondary and micronutrients is high. For achieving sustainable productivity of pigeon pea the supply of nutrients in balanced and integrated manner is important. But the information on integrated use of FYM, fertilizers and biofertilizers on pigeonpea is scanty. Keeping these points in view, a field experiment was conducted to study the effect of individual and combined application of FYM, chemicalfertilizers and composite biofertilizers on growth and yield of pigeonpea.

MATERIAL AND METHODS

A field experiment was conducted at Gandhi Krishi Vigyan Kendra, Bangalore during kharif under rain fed condition on red sandy clay loam soil. The experimental soil was medium in organic carbon (0.60%), low in available N (215 kg/ha), high in available P (43 kg/ha) and medium in available K (150 kg/ha). The experiment was laid out with factorial concept in randomized complete block design with three replications. There were twelve treatment combination comprising of three levels of recommended dose of fertilizers (100, 75 and 50%), two levels of FYM (0 and 7.5 t/ha) and with and without composite biofertilizer (Rhizobium + Phosphate solubilising bacteria) as seed inoculation. The gross plot size was 5.4 x 4.0 m. the recommended dose of fertilizers for pigeon pea was (25:50:25 kg NPK/ha). Pigeon pea Cv. TTB-7 was sown at spacing of 60 x20 cm. The rainfall received during the crop growth period was 742.6mm.

RESULTS AND DISCUSSION

Effect of fertilizers on pigeonpea

Application of 100% recommended dose of fertilizers, irrespective of levels of FYM and composite biofertilizer produced significantly 11.2 per cent higher grain yield of pigeon pea (1043 kg/ha) than 75% RDF (938 kg/ha)which was on par with 50% RDF (884 kg/ha) (table 1). Gupta and Namdeo (1999) also reported that application of 100% RDF significantly increased the grain yield of pigeonpea compared to 75% and 50% RDF. Significantly maximum grain yield of pigeon pea with application of 100% RDF over 75% and 50% RDF was mainly due to significantly 9.2% more number of primary branches per plant and more number of pods per plant resulting in higher grain yield per plant (Table 1).

Application of 100% RDF produced significantly more dry matter at 90, 120, 150 DAS and at harvest than 75 and 50% RDF. Application of 100% RDF recorded significantly higher dry matter distribution in to pods and also significantly increased the leaf area index at 120 DAS from 2.60 in 75% RDF to 2.712 (Table II) significantly better plant

Table 1. Effect of levels of RDF, FYM and composite biofertilizer on grain yield and yield components of pigeonpea

Treatments	Primary branches per plant	Pods per plant	100 grains weight (g)	Grain yield per plant (g)	Grain yield (kg/ha)
Levels of RDF (A)					
100 % RDF	27.3	41.4	12.2	13.4	1043
75 % RDF	25.0	38.8	12.0	12.1	938
50 % RDF	22.4	36.5	11.8	11.2	884
SE m±	0.72	1.03	0.15	0.28	29.3
CD at 5%	2.12	3.90	NS	0.84	86.0
Farmyard manure (B)					
0	21.8	35.2	11.8	11.3	864
7.5 t ha^{-1}	28.0	42.2	12.2	13.2	1047
SE m±	0.59	1.09	0.12	0.23	23.9
CD at 5%	1.73	3.20	0.36	0.70	70.2
Composite bio fertilizer (C)					
Without composite biofertilizer	22.8	35.3	11.9	11.6	920
With composite biofertilizer	27.0	42.4	12.2	12.9	991
SE m±	0.59	1.09	0.12	0.23	23.9
CD at 5%	1.73	3.20	NS	0.70	70.2
Interactions					
AXB SE m±	1.02	1.89	0.21	0.40	41.5
CD at 5%	NS	NS	NS	NS	NS
AXC SE m±	1.02	1.89	0.21	0.40	41.5
CD at 5%	NS	NS	NS	NS	NS
BXC SE m±	0.83	1.54	0.17	0.33	33.9
CD at 5%	NS	NS	NS	NS	NS
AXBXC SE m±	1.45	2.67	0.30	0.57	58.8
CD at 5%	NS	NS	NS	NS	NS

RDF= Recommended dose of fertilizers (25:50:25 Kg N, $P_2O_5$and K_2O/ha)

NS= Non Significant

growth with 100% RDF over 75 and 50% RDF could be related to significantly more number of nodules and nodule dry weight per plant (Table II).

Effect of FYM on pigeonpea: Application of farm yard manure @ 7.5 t/ha, irrespective of levels of RDF and composite biofertilizer resulted in significantly 21.2 per cent higher grain yield of pigeon pea (1047 kg/ha) than no FYM application (864 kg/ha) (Table 1). These results are in accordance with the findings of Prabhakaran (1998). The increase in grain yield with FYM application might be attributed to beneficial effect of FYM on physical, chemical and biological properties of soil, besides supplying all essential nutrients to plant growth. Significantly higher grain yield of pigeonpea with application of FYM at 7.5 t/ha over no FYM was mainly due to significantly more number of primary branches per plant, more number of pods per plant and higher 100 grain weight resulting in higher grain yield per plant (Table I).

Application of FYM at 7.5 t/ha produced significantly higher dry matter production at 90, 120, 150 DAS and at harvest than no FYM and also significantly increased the leaf area index at 120 DAS from 2.468 to 2.736 over no FYM and this increased leaf area index was the reason for increased dry matter production. Higher dry matter per plant due to application of FYM at 7.5 t/ha over no FYM could be related to significant improvement in plant height and number of primary branches per plant. Application of FYM @ 7.5 t/ha also produced significantly more number of nodule and nodule dry weight per plant than no FYM.

Effect of Composite biofertilizer on pigeonpea: Inoculation of pigeon pea with composite biofertilizer, irrespective levels of RDF and FYM produced significantly 7.7 higher

Table 2. Effect of levels of RDF, FYM and composite biofertilizer on plant height, nodulation and leaf area index in pigeonpea

Treatments	Plant height (cm)	Nodule number per plant	Nodule dry weight (mg/plant)	Leaf area index at 120 DAS
Levels of RDF (A)				
100 % RDF	155.7	20.4	41.2	2.71
75 % RDF	153.0	19.3	39.2	2.60
50 % RDF	148.2	15.3	31.5	2.49
SE m±	3.3	0.46	6.77	0.03
CD at 5%	NS	1.3	2.3	0.10
Farmyard manure (B)				
0	146.8	13.0	25.6	2.46
7.5 t ha^{-1}	158.8	23.6	48.9	2.73
SE m±	2.7	0.38	0.63	0.0.3
CD at 5%	8.1	3.8	1.9	0.08
Composite bio fertilizer (C)				
Without composite biofertilizer	147.8	14.1	30.2	2.49
With composite biofertilizer	156.8	22.5	44.4	2.71
SE m±	2.7	0.38	0.63	0.03
CD at 5%	8.1	1.0	1.9	0.08
Interactions				
AXB SE m±	4.8	0.66	1.09	0.05
CD at 5%	NS	NS	NS	NS
AXC SE m±	4.8	0.66	1.09	0.05
CD at 5%	NS	NS	NS	NS
BXC SE m±	3.9	0.54	0.89	0.04
CD at 5%	NS	1.57	2.61	NS
AXBXC SE m±	6.7	0.92	1.54	0.07
CD at 5%	NS	2.72	4.53	NS

RDF= Recommended dose of fertilizers (25:50:25 Kg N, $P_2O_5$and K_2O/ha)

NS= Non Significant

grain yield of pigeonpea (991 kg/ha) than no inoculation (920 kg/ha) (Table I). significantly higher grain yield of pigeonpea with seed inoculation with composite biofertilizer might be attributed to increased biological nitrogen fixation by rhizobium (Prabhakaran 19998) and increased availability of P by phosphate solublising bacteria through solublising process by producing organic acid (Gupta and Namedo, 1999). Significantly maximum grain yield of pigeonpea due to inoculation with composite biofertilizer over no seed inoculation was mainly due to more number of primary branches per plant and significantly more number of pods per plant resulting in higher grain yield per plant (Table I). A significant increase in the grain yield and components of pigeonpea due to seed inoculation with composite biofertilizer was attributed to significantly higher dry matter production at 90, 120, 150 DAS and at harvest and higher dry matter distribution in to pod. Seed inoculation with composite biofertilizer significantly increased the LAI at 120 DAS from 2.494 to 2.710 over no seed inoculation resulting in significantly maximum dry matter production. Better plant growth due to composite biofertilizer could be related to increased nodulation (Table II).

Interaction between fertilizers, FYM and composite biofertilizer on pigeonpea: Difference in grain yield of pigeonpea due to interaction between fertilizers and FYM, fertilizer and composite biofertilizer, FYM and composite biofertilizer, and fertilizers, FYM and composite biofertilizer were not significant (Table 1). These non-significant difference in grain yield due to these interactions can be traced back to the non-significant differences in plant

height, number of primary branches per plant, LAI, dry matter production and its distribution, number of pods per plant, 100 grain weight, grain yield per plant (Table 1).

Economics of integrated nutrient management in pigeon pea: The highest gross returns (Rs. 14736/ha) and net returns (Rs. 5360/ha) was realized with combined application of FYM at 7.5 t/ha and 100% RDF with composite biofertilizer seed inoculation (Table III). Although there was no significant interaction on grain yield of pigeon pea. The maximum gross as well as net return with combined application of FYM and 100% RDF with composite biofertilizer seed inoculation over application of 100% RDF alone was a result of increase in the grain yield of pigeonpea by 210 kg/ha. The next highest gross return of Rs. 13911/ha and net return Rs.4880/ha were obtained with 100% RDF and 75 % RDF and it was due to increase in grain yield of pigeonpea by 144 kg/ha over 100% RDF.

CONCLUSION

From the above findings it can be concluded that application of FYM at 7.5 t/ha, 100% RDF and seed inoculation with composite biofertilizer is required to realize higher grain yield and net returns in pigeonpea.

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Effect of Variety and Bio-fertilizer on Yield and Bio-chemical Constituents of Pineapple fruit [*Ananas comosus* (L.) Merr.]

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ABSTRACT

A field experiment entitled "Effect of variety and bio-fertilizer on yield and bio-chemical constituents of pineapple fruit [*Ananas comosus* (L. Merr.)]" was conducted at Horticulture Research Farm (HRF), Andro, Imphal- East during 2011-2013 to study the effect of different varieties (V_1 =Kew, Queen and Mauritius) and different concentrations of bio-fertilizers (B_1 = Biomix-1 @ 290.37 g + Biomix-5 @ 313.37 ml/40plants, B_2 = Biomix-1 @ 290.375 g/40 plants and B_3 = Biomix-5 @ 313.373 ml/40 plants) on the bio-chemical constituents of pineapple fruit. It revealed that there was a profound impact on the leaf NPK content, bio-chemical constituents and yield of pineapple fruit.Kew performed better in respect of leaf NPK content. A significant difference was found in P content while N & K was not significant. The highest leaf NPK content was found in V_1B_1 (1.35 %, 0.18 % and 1.97 %, respectively). The specific gravity, fruit TSS and Vitamin C content were found significant. The specific gravity value ranges from 1.14 to 1.78. The value of acidity of fruits ranged from 0.599 to 0.674. Acidity was not influenced by the application of bio-fertilizer on the varieties tested. However, a negative correlation was noticed with the TSS content of the fruit. The value of vitamin C content ranged from 18.08 mg/100 ml to 22.64 mg/100 ml. Subsequently, the highest fruit yield was recorded with the application of Biomix-1 + Biomix-5 in Kew variety i.e. V_1B_1 (31.02 tonnes/ha) and the lowest was with the application of control treatment in Mauritius variety i.e. V_3B_3 (14.44 tonnes/ha).

Key words *Ananas comosus, Kew, Queen, Mauritius, bio-fertilizers, bio-chemical constituents*

Pineapple [*Ananas comosus* (L.) Merr.] belongs to family Bromeliaceae, subfamily Bromelioideae, order Bromeliales, genus *Ananas* and species *comosus* (Brotholomew *et al.* 2003). Pineapple is one of the most important commercial fruit crops of the tropical and sub-tropical regions of the world. It is highly valued because of its excellence in canning and other processing industries for the production of nutritious and value added products like jam, jelly, candy, canned pineapple, squash, etc. Pineapple fruit is a good source of vitamin A, B, C and minerals.

Pineapple can grow in moist to extremely dry situation and at varying altitudes from sea level to alpine conditions. (Brotholomew *et al*., 2003). Such agro-climatic conditions prevailed in the North-Eastern region is ideal for its expansion and also it can be grown in all types of soils provided the soil is well drained and pH ranged from 4.5 to 6.5. For quality production of pineapple and increasing crop yield, use of organic nutrient is very essential.Moreover, Bio-fertilizers offer an economically alternative and ecologically sound means of reducing external inputs and improving the quality and quantity of internal resources. *Azotobacter* and *Azospirillum* are used extensively to substitute nitrogenous fertilizers in nutrient management programmes(Wani, 1990).

In the North Eastern region of India, particularly Manipur no work has yet been done about the use of bio-fertilizers on pineapple cultivation. Moreover, Biomix is a product of M/s Care Pro Science Ltd., certified by INDOCERT and recommended by NCOF (National centre for organic farming). Biomix-1 (*Azotobacter, Azospirillium, Rhizobium, Bacillus, Pseudomonas* and *Trichoderma*)is applied at the time of planting in soil which is very useful in growth and development of plants. Biomix-5 (*Azotobacter, Trichoderma* and *Pseudomonas*)is applied at the root zone of the plant as a liquid form which acts as an insect-pest and disease protectant. Therefore, an experiment was carried out on "Effect of variety and bio-fertilizer on the yield and bio-chemical constituents of pineapple fruit [*Ananas comosus* (L.) Merr.]" using three important varieties of pineapple widely grown in Manipur *viz*., Kew (Cayenne), Queen and Mauritius.

MATERIALS AND METHODS

The present investigation on "Effect of variety and bio-fertilizer on yield and bio-chemical constituents of pineapple fruit (*Ananas comosus*)" was undertaken at Horticulture Research Farm (HRF), Andro, Imphal-East located within a latitude and longitude of 24°45.89´and 94°03.46´ respectively with an altitude of 880 m above mean sea level during November, 2011 to June, 2013. In this experiment, three varieties (V_1=Kew, V_2=Queen and V_3=Mauritius) and bio-fertilizer sources {B_1= Biomix-1 (5 Kg/ha) +Biomix-5 (5 Kg/ha), B_2=Biomix-1 (5 Kg/ha) andB_3=Biomix-5 (5 Kg/ha)} were used, laid out in a Factorial Randomised Block Design with 3 replications accommodating 9 treatments in each replication. The details of the treatment were V_1B_1, V_1B_2, V_1B_3, V_2B_1, V_2B_2, V_2B_3, V_3B_1, V_3B_2 and V_3B_3.Fruits were harvestedand its yield was calculated andfurther bio-chemical analysis was carried out.

Parameters recorded:

Fruit yield: Fruit yield was calculated by multiplying the total number of fruiting plant per treatment with the average fruit weight harvested. It was then calculated into tonnes / ha.

Specific gravity: Specific gravity of the fruit was measured by water displacement method. The displaced water was collected in the container and measured in the measuring

Table 1. Effect of variety and bio-fertilizer on the leaf NPK status of pineapple

	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
V_1	1.33	0.16	1.96
V_2	1.32	0.15	1.94
V_3	1.31	0.14	1.93
S.Ed(±)	0.02	0.002	0.03
$CD_{(0.05)}$	NS	0.004	NS
B_1	1.34	0.17	1.96
B_2	1.32	0.15	1.94
B_3	1.30	0.13	1.92
S.Ed(±)	0.02	0.002	0.03
$CD_{(0.05)}$	NS	0.004	NS
V_1B_1	1.35	0.18	1.97
V_1B_2	1.33	0.16	1.96
V_1B_3	1.32	0.15	1.94
V_2B_1	1.34	0.16	1.95
V_2B_2	1.32	0.15	1.94
V_2B_3	1.30	0.13	1.92
V_3B_1	1.34	0.16	1.96
V_3B_2	1.31	0.14	1.93
V_3B_3	1.29	0.12	1.91
S.Ed(±)	0.03	0.003	0.05
$CD_{(0.05)}$	NS	0.005	NS

cylinder (W_2) and the specific gravity was determined as:

$$\text{Specific gravity} = \frac{\text{weight of the fruit } (W_1)}{\text{quantity of displaced water } (W_2)}$$

TSS: TSS of the juice was measured by Erma hand Refractometer (Japanese made) and average was recorded.

Ascorbic acid: Ascorbic acid was estimated by the visual titration method as described by Ranganna (1977).

Titratable acidity: The acidity of juice as anhydrous citric acid was estimated by indicator method (AOAC, 1975) by titrating the juice against standard alkali solution (N/10 NaOH), using phenolphthalein indicator till end point which was indicated by percentage was calculated by using the relationship: 1ml of 0.1N sodium hydroxide is equivalent to 0.0064g of anhydrous citric acid.

Statistical analysis: The analysis of variance method as suggested by Gomez and Gomez (1984) was followed to statistically analyse the various data recorded and interpretation of the results. The significant of the different sources of variation was tested with the help of 'F' test at 5% level of probability.

Leaf nutrient analysis: The 'D' leaf of the pineapple was taken for N, P_2O_5 and K_2O analysis.

Estimation of nitrogen: Total nitrogen was estimated as per the Micro kjeldhal method as described by Humphries (1956). The amount of nitrogen was expressed as percentage on dry weight basis.

Estimation of Phosphorus: The estimation of phosphorus from leaf samples was done by colorimetric method as described by Jackson (1973).

Estimation of Potassium: The estimation of potassium from leaf samples was done by Flame photometric method as described by Jackson (1973).

RESULTS AND DISCUSSION

Leaf NPK content

NPK contents of leaf were analysed at 12 MAP i.e. at the flowering initiation period which indicated leaf nitrogen, leaf phosphorus and leaf potassium content (Table 1). A significant difference was found in P with respect to varietal effect, bio-fertilizers used and their interaction effect whereas N & K was not significant. The highest leaf NPK content was found in V_1B_1 (1.35%, 0.18% and 1.97%, respectively). Proper growth and development as influenced by bio-fertilizer was one of the factors for having higher NPK of D-leaf. Moreover, Vessy (2003) indicated that biofertilizer increased the supply or availability of essential nutrients and promote plant growth. This is in agreement with the findings of Singh and Sharma (1993), Mahendra*et al*. (1996), Suchorska (1996), Sukhanda (1996), Verma (1998), Tiwary *etal*. (1999), Vasanthi and Kamaraswamy (2000).

Fruit yield (tonnes/ha)

The fruit yields presented in Table 2indicated significant effect on the fruit yields. The highest yield was recorded in V_1 (26.69 tonnes/ha) while V_3 (15.87 tonnes/ha) recorded the lowest yield. This could be due to the varietal characteristic of the pineapple. This is in agreement with the findings of Dass *et al.* (1978); Gopimany *et al.* (1978) and Nayar *et al.* (1981) who found the variety "Kew" to be superior in all respects of yield and quality. Similarly, bio-fertilizer effect on fruit yield was observed wherein the

Table 2. Effect of Variety and Bio-fertilizer on yield and bio-chemical constituents of Pineapple fruit

	Yield (t/ha)	Specific gravity	Acidity(%)	TSS(°Bix)	Vit C(mg/100 ml)
V_1	26.69	1.54	0.610	16.18	21.77
V_2	18.78	1.16	0.620	15.40	20.60
V_3	15.87	1.23	0.661	13.59	18.90
S.Ed(±)	0.27	0.02	0.002	0.13	0.10
$CD_{(0.05)}$	0.58	0.04	0.005	0.27	0.21
B_1	22.76	1.42	0.617	15.75	21.12
B_2	20.45	1.28	0.632	14.95	20.52
B_3	18.13	1.24	0.641	14.48	19.62
S.Ed(±)	0.27	0.02	0.002	0.13	0.10
$CD_{(0.05)}$	0.58	0.04	0.005	0.27	0.21
V_1B_1	31.02	1.78	0.599	17.00	22.64
V_1B_2	26.35	1.46	0.610	16.32	21.95
V_1B_3	22.70	1.39	0.620	15.22	20.71
V_2B_1	20.14	1.20	0.609	16.02	21.21
V_2B_2	18.95	1.15	0.620	15.18	20.51
V_2B_3	17.25	1.14	0.630	15.00	20.08
V_3B_1	17.11	1.28	0.642	14.23	19.51
V_3B_2	16.06	1.24	0.667	13.34	19.11
V_3B_3	14.44	1.18	0.674	13.21	18.08
S.Ed(±)	0.47	0.03	0.004	0.22	0.18
$CD_{(0.05)}$	1.00	0.07	NS	0.47	0.37

highest yield was recorded in B_1 (22.76 tonnes/ha) and the lowest yield in B_3 (18.13 tonnes/ha). This is attributed to combined effect of Biomix-1 + Biomix-5. Interaction effect also showed thatV_1B_1 the highest fruit yield (31.02 tonnes/ ha) while the lowest yield was in V_3B_3 (14.44 tonnes/ha). This could be due to varietal growth characteristics which exhibited maximum Leaf Size Index during the growing period coupled with bio-fertilizer mixture. This supported the finding of Wu and Su (1965) as they stated that the larger the leaf size index the greater the fruit weight and yield. Thamsurakul *et al.* (2000) also recorded the efficiency of *VAM* in increasing yield of pineapple. Balakrishnan *et al*. (2001) obtained highest fruit yield with the application of *Azotobacter* and *Azospirillum* in custard apple.

Bio-chemical contents on pineapple fruit

The specific gravity, fruit TSS and Vitamin C content were found significant with respect to varietal effect, bio-fertilizers used and their interaction effects (Table 2). The specific gravity value ranges from 1.14 to 1.78. According to Morton *et al.* (1987) highest quality of pineapple was obtained when the specific gravity value attained 1.02 and above. The value of acidity of fruits ranged from 0.599 to 0.674. Acidity was not influenced by the application of bio-fertilizer on the varieties tested. However, a negative correlation was noticed with the TSS content of the fruit. The highest TSS content was registered in V1B1 which could be due to combined use of bio-fertilizer and varietal features leading to the accumulation of more sugars and other soluble components from the hydrolysis of proteins and oxidation of ascorbic acid. The findings corroborated the findings of Rathi and Bist (2004) and Dey *et al*. (2005). The increase in TSS could be attributed to quick metabolic transformation of soluble compounds and more conversion of organic acids to sugars. The increase in sugar content might also be due to degradation of polysaccharides into monosaccharides. The value of vitamin C content ranged from 18.08 mg/100 ml to 22.64 mg/100 ml. and was found to be significant with respect to varietal effect, bio-fertilizers used and their interaction effects. The improved fruit quality may be attributed to better vegetative growth which resulted in higher quantity of photosynthates and the translocation to the fruits thus increasing the contents of various fruit quality parameters. Similar results have been reported by Pathak and Ram (2004), Naik and Haribabu (2007) in guava, Dutta and Kundu (2012) in Himsagar mango.

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Eco-Friendly Management of Castor (*Ricinuscommunis* L.) Wilt Caused by *Fusarium oxysporum* f. sp. *ricini* by Organic Manure/Cakes *in Vitro*

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ABSTRACT

Castor (*Ricinuscommunis* L.) is a most important non-edible oilseed crop of arid and semi-arid region of India. Wilt of castor caused by *Fusarium oxysporum* f. sp. *ricini* Nanda and Prasad is a serious problem in Gujarat state. Considering, the importance of disease present studies were conducted to test the effect of organic manures/cakes on the growth of wilt pathogen under *in vitro* conditions. The extracts of different oil cakes/organic manures were tested against *F. oxysporum* f. sp. ricini by poisoned food technique in *in vitro*. Least growth of pathogen was recorded in extracts of neem cake showing excellent inhibitory effect of 51.11 per cent reduction over control followed Poultry manure (48.15%).

Key words *Castor*, *Fusarium oxysporum* f. sp. *ricini, Organic manure/cakes, in vitro*

Castor wilt caused by *Fusarium oxysporum* f. sp. *ricini* Nanda and Prasad is most common disease of castor.It belongs to genus *Ricinus*of *Euphorbiaceae*family and its common name is castor bean. Castor is indigenous to Eastern Africa and most probably originated in Ethiopia. The castor plant has been cultivated for centuries for the oil produced by its seeds. Among the non-edible annual group of oilseed crops, castor constitutes very important position in the oil seed economy throughout the world. Castor is affected by many diseases and among them, wilt caused by *Fusarium oxysporum* f. sp. *ricini* is an important disease and responsible for lethal damage to crop. Management of wilt by use of fungicide in soil is difficult and economically non-viable. The use of organic amendments is one of the successful methods for management of soil borne pathogens in general and wilts in particular. Incorporation of organic amendments to soil is well known practice for better plant vigour and yield. Organic amendments when applied to soil release some toxic substances which prevent the growth of soil borne plant pathogens. The present study was undertaken with an object to access the efficacy of organic amendments in suppressing the growth of *Fusarium oxysporum* f. sp. *ricini in vitro* for managing wilt of castor.

MATERIALS AND METHODS

Experimental location

This work was conducted in Department of Plant Pathology, N. M. College of Agriculture, Navsari agricultural University, Navsari during 2015-16. Determine the antifungal activity of FYM, Neem cake, Castor cake, Groundnut cake, Coconut cake, Vermicompost and Poultry manure against *Fusarium oxysporum* f. sp. *ricini* by Poison food technique.

Isolation of pathogen

Castor plants with typical wilt symptoms were collected from wilt affected field in Navsari district of Gujarat. The roots of such diseased plants were washed with running tap water to remove all adhered soil particles and they were subjected to tissue isolation. Isolation of the pathogen from diseased specimen was made by tissue isolation technique. The typically infected roots and stem portions from the collar region were cut in to small pieces with the help of sterilized knife and again washed with the sterilized water. These pieces were then disinfected for one minute in 0.1 per cent mercuric chloride solution. To remove residue of mercuric chloride, the pieces were washed thrice in sterilized distilled water for one minute each time and pieces were then transferred aseptically on to potato dextrose agar (PDA) medium in Petri plates. The Petri plates were incubated for five days at 27 ± 2°C temperature. The growth of pathogen obtained from the pieces was transferred on PDA slants and incubated for further growth at 27 ± 2°C temperature. These cultures were further purified by single spore isolation method. These pure culture isolates were maintained on PDA slants in refrigerator at 5 ± 2°C temperature. The streptomycin was added after autoclaving the media to avoid bacterial contamination.

Efficacy of organic manure/cakes against *Fusarium oxysporum* f. sp. *ricini in vitro*

The following materials were used during the present investigations:

Organic manure/cakes:

Various oilseed cakes were obtained from the local market, NAU, Navsari farm viz., FYM, neem cake, castor cake, groundnut cake, coconutcake, vermicompost and poultry manure

Methods:

The aqueous extract of different organic materials was prepared by suspending 30g of each organic material in150 ml sterilized distilled water in flask and left for 25 days. The flasks were shaken on alternate day for thoroughly mixing

Table 1. Effect of different organic manure/cakes against *Fusarium oxysporum* f. sp. *ricini*

Sr. No.	Name of extract	Average colony diameter of pathogen (mm)	Growth inhibition over control (%)
1	FYM	63.33	29.62
2	Neem cake	44.00	51.11
3	Castor cake	53.33	40.74
4	Groundnut cake	74.33	17.41
5	Coconut cake	51.33	42.96
6	Vermicompost	57.67	35.93
7	Poultry manure	46.67	48.15
8	Control	90.00	0.00
	S.Em.±	1.62	
	C.D. at 5%	4.86	
	C.V.%	4.67	

and dissolution of the content. After 25 days, the flasks were thoroughly shaken and content was filtered through double layered muslin cloth and autoclaved at 1.2 kg cm-2 pressure for 20 minute. The sterilized extract was used for testing their inhibitory effect on *Fusarium oxysporum* f. sp. *ricini in vitro* by poisoned food technique. The autoclaved extract were individually added in previously sterilized melted and cooled potato dextrose agar medium@ 10 per cent v/v at the time of pouring in petriplates and mixed thoroughly. All the plates were incubated at room temp. (27±2ÚC) after placing the 4 mm disc of actively growing 7 days old pure culture of *Fusarium oxysporum* f. sp. *ricini* for experiment were kept for each treatment. Medium without organic extract served as control.

Per cent growth inhibition of the fungus in each treatment in comparison to control was calculated by the following equation (Bliss, 1934):

$$PGI = \frac{X\ 100}{C} C - T$$

Where,

PGI = Per cent growth inhibition

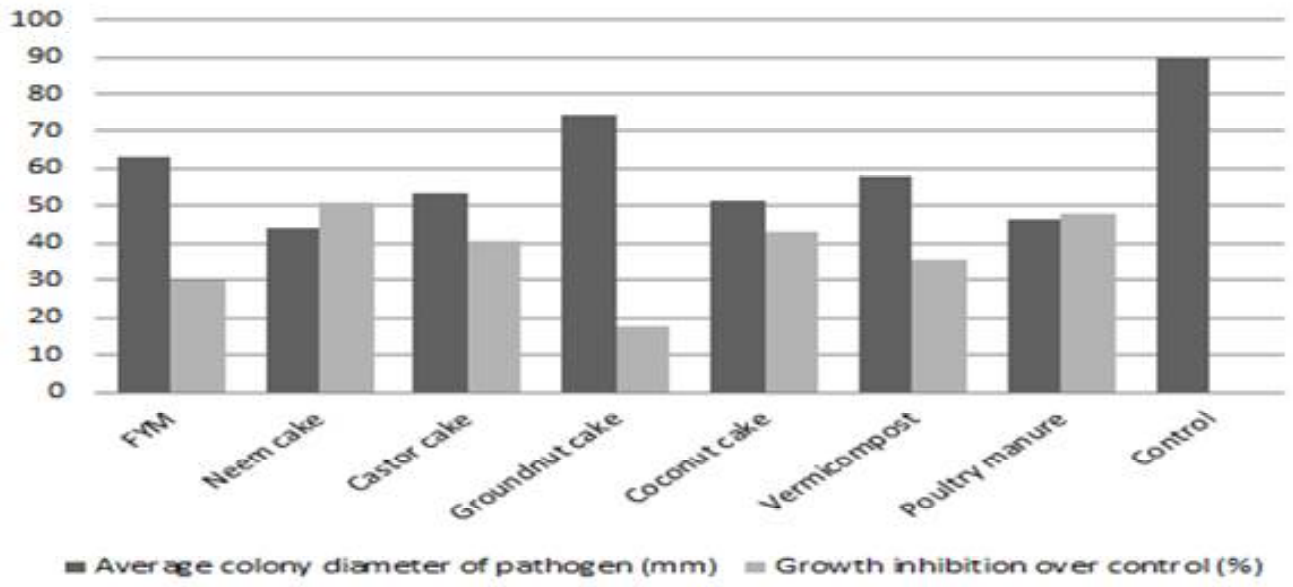
C = Colony diameter in control (mm)

T = Colony diameter in treatment (mm)

RESULTS AND DISCUSSION

In vitro testing of organic manure/cakes:

The results presented in (Table-1& Graph-1) indicated that out of seven organic manure/cakes tested, all showed significantly inhibitory effect against the fungus. Among all the organic manure/cakes, significantly lower growth



Graph 1. Effect of different organic manure/cakes against *Fusarium oxysporum* f. sp. *ricini*

was revealed in the extract of neem cake (44.00 mm). Next best in order of merit was poultry manure (46.67 mm) followed by coconut cake (51.33 mm), castor cake (53.33 mm), vermicompost (57.66 mm), FYM (63.33 mm) and groundnut cake (74.33 mm).

Maximum per cent growth inhibition of *Fusarium oxysporum* f. sp. *ricini* was recorded in neem cake (51.11%) followed by Poultry manure (48.15%), Coconut cake (42.96%), Castor cake (40.74%). Whereas, Vermicompost (35.93%), FYM (29.63%) and Groundnut cake (17.41%) were least effective in inhibiting the growth of *Fusarium oxysporum* f. sp. *ricini.*

From this study, it is clear that neem cake and Poultry manure were found effective in reducing the growth of *Fusarium oxysporum* f. sp. *ricini* causing wilt in castor. Our result are harmony with earlier worker Yelmame*et al.* (2010) reported that extracts of neem cake inhibited the growth of *Fusarium oxysporum* f. sp. *capsici*by 59.23 per cent in laboratory condition. Effect of neem cake, castor cake, coconut cake, groundnut cake. FYM, vermicompost and poultry manure @ 10 per cent recorded inhibite the mycelial growth (80.44%), (17.78%), (5.11%), (8.67%), (25.89%), (37.56%) and (16.33%), respectively against *Fusarium oxysporum* f. sp. *dianthii*(Mahalakshmi and Yesuraja, 2013).

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Effect of Different Levels of KMS on Storage Behaviour of Cashew Apple *(Anacardium occidentale* L.*)* Juice

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ABSTRACT

An investigation was carried out to study the storage behaviour of the cashew apple juice preserved with different levels of KMS such as 1000, 1500, 2000 and 140 ppm with pasteurization as a control at ambient conditions. It was observed that the TSS, acidity, reducing and total sugars increased in the cashew apple juice during storage at ambient condition, while ascorbic acid content of cashew apple juice exhibited a deceasing trend during storage. The cashew apple juice from all treatments was found organoleptically acceptable up to 4 days. The cashew apple juice could be stored for a period of 4 days at ambient conditions without pasteurization by adding as minimum as1000 ppm KMS as a preservative.

Key words *Cashew apple juice, KMS, Storage behaviour*

Cashew (*Anacardium occidentale* L.) belonging to family anacardiaceae, is one of the most important commercial plantation crops in coastal parts of our country, which is known as a dollar earning crop. Cashew apple is a by-product of the cashew industry having tremendous potential for its utilization in the food processing sector. Cashew apple is a valuable source of minerals and vitamins and more fructose, the honey sugar. The cashew apple juice is reported to contain 5 times as much vitamin C as in citrus juice (Akinwale, 2000, Azam-Ali and Judge, 2001) and 10 times as in pineapple juice (Ohler, 1988). The cashew apple production is supposed to be three times higher than that of nut which is estimated to be 6.24 lakh tonnes in Maharashtra. Due to perishable nature of cashew apple as well as higher content of acrid principle, the commercial utilization of cashew apple for processing is still lacking in India. However, the juice extracted from the cashew apple could be utilized for preparation of value added products such as nectar, squash, syrup, *feni*, cashew apple powder, etc. Hence, it is important to preserve juice at farm level with minimum processing. Keeping this in view, the present investigation was carried out to study the the storage behaviour of the cashew apple juice preserved with different levels of KMS at ambient conditions.

MATERIAL AND METHODS

Freshly harvested cashew apples were washed and blanched in 2 per cent brine solution at 85^{0}C for 10 min. The juice was then extracted by using basket press. The extracted juice was further strained through four folds of muslin cloth to obtain clear cashew apple juice. It was then heated at 85^{0}C for 10 minutes for reducing superficial microbial load and clear juice was obtained. The cashew apple juice was heated to 85^{0}C temperature for five minutes and the preservative, potassium meta bisulphite (KMS) was added to the juice @ 1000 ppm, 1500 ppm and 2000 ppm as per treatment. After addition of preservative, the juice was filled in sterilized glass bottles and stored at ambient conditions. In control treatment, the juice was heated for 5 minutes and 140 ppm KMS was added which was then filled in sterilized glass bottles. After hot filling, the bottles were pasteurized at 85^{0}C temperature for 20 minutes, sealed air tight and stored as per the treatment for further investigation. The experimental data were analyzed statistically using Factorial Completely Randomized Design (FCRD). The observations on the changes in physical, chemical and sensory quality parameters of cashew apple juice during storage were recorded at 0, 1, 2, 3 and 4 days of storage at ambient condition. The chemical parameters such as TSS, titratable acidity, reducing sugars, total sugars and ascorbic acid content were estimated by using the methods described by Ranganna, (1997). The product was evaluated for its organoleptic qualities like colour, flavour and overall acceptability on a hedonic scale (Amerine *et al*., 1965). The data was analyzed for the statistical significance according to the procedure reported by Panse and Sukhante (1967).

RESULTS AND DISCUSSION

The data regarding the effect of preservative on TSS content of cashew apple juice are presented in Table 1 indicate that the treatment "1000 ppm KMS" (T_1) recorded maximum (9.85^{0}B) TSS irrespective of KMS levels, however, it was at par (9.80^{0}B) with the treatment "2000 ppm KMS" (T_3). The KMS level of 2000 ppm (T3) and 1500 ppm (T2) did not exhibit any effect on TSS content of the cashew apple juice and were at par with each other. The minimum (9.25^{0}B) TSS was observed in cashew apple juice preserved with 140 ppm KMS + pasteurization (T4). This clearly indicated that the process of pasteurization had significantly lowered the biochemical changes with respect to TSS during storage. An increase in TSS of cashew apple juice irrespective of the treatment was also noticed during the very limited storage period of 4 days. The increase in TSS during storage was also reported by Ayub (2010) in strawberry juice. An increasing trend with respect to titratable acidity of cashew apple was noticed irrespective of the treatments and it was increased from initial low of 0.19 per cent to 0.29 per cent after 4 days of storage at ambient conditions. Similar trend was also observed by Singh (2006) in kinnow juice.

It was observed that there was significant difference among the treatments with respect to the changes in reducing sugar content of cashew apple juice (Table 2). Maximum reducing sugars were observed in the treatment

Table 1. Changes in the TSS and titratable acidity (%) of cashew apple juice during storage

	TSS (°B)						Titratable acidity (%)					
Treatment	**Storage period (days)**						**Storage period (days)**					
	0	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**
T1	9.50	9.53	9.66	10.00	10.57	9.85	0.19	0.23	0.24	0.25	0.29	0.24
T2	9.50	9.50	9.60	9.93	9.40	9.79	0.20	0.24	0.25	0.27	0.30	0.25
T3	9.56	9.50	9.60	9.86	10.50	9.81	0.19	0.24	0.25	0.28	0.30	0.25
T4	8.90	8.97	9.10	9.30	10.00	9.25	0.19	0.20	0.26	0.27	0.28	0.24
Mean	9.37	9.38	9.49	9.77	10.12		0.19	0.23	0.25	0.27	0.29	
	S.Em. ±	C.D. at 5 %					S.Em. ±	C.D. at 5 %				
KMS levels (T)	0.017	0.048					0.002	0.007				
Storage (S)	0.019	0.053					0.003	0.007				
Interaction (T X S)	N.S.	N.S.					0.005	0.015				

Table 2. Changes in the reducing (%) and total sugar (%) content of cashew apple juice during storage

	Reducing sugars (%)						Total sugars (%)					
Treatment	**Storage period (days)**						**Storage period (days)**					
	0	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**
T1	6.92	6.93	6.96	7.13	7.25	7.04	7.15	7.18	7.18	7.30	7.36	7.23
T2	6.80	6.81	6.81	7.02	7.16	6.92	7.00	7.01	7.07	7.18	7.25	7.10
T3	6.75	6.78	6.81	6.92	7.14	6.88	7.03	7.02	7.05	7.08	7.24	7.08
T4	6.46	6.45	6.50	6.75	7.04	6.63	6.62	6.66	6.75	6.88	7.15	6.81
Mean	6.73	6.74	6.77	6.96	7.15		6.95	6.97	7.01	7.11	7.25	
	S.Em. ±	C.D. at 5 %					S.Em. ±	C.D. at 5 %				
KMS levels (T)	0.009	0.027					0.013	0.037				
Storage (S)	0.01	0.03					0.014	0.041				
Interaction (T X S)	0.021	0.061					0.029	0.082				

Table 3. Changes in the ascorbic acid (mg/100g) content of cashew apple juice during storage

	Ascorbic acid (mg/100g)					
Treatment	**Storage period**					
	0	**1**	**2**	**3**	**4**	**Mean**
T1	246.33	240.67	235.67	234.33	231.67	237.73
T2	241.33	237.00	233.00	229.67	223.33	232.87
T3	244.61	241.00	231.00	228.00	222.00	233.33
T4	233.67	232.67	229.67	227.33	223.00	229.27
Mean	241.49	237.84	232.34	229.83	225.00	
	S.Em. ±	C.D. at 5 %				
KMS levels (T)	0.484	1.384				
Storage (S)	0.484	1.547				
Interaction (T X S)	1.083	3.095				

T_1 (7.04%) which was statistically different to the rest of the treatments. Significantly lowest (6.63%) reducing sugar content was recorded in T_4 i.e. 140 ppm KMS + pasteurization irrespective of KMS levels. The reducing sugar content increased from 6.73 to 7.15 per cent up to 4 days of storage at ambient conditions. The acid hydrolysis

Table 4. Changes in sensory score for colour and flavour of cashew apple juice stored at ambient temperature

	Sensory score for colour						Sensory score for flavour					
Treatment	**Storage period (days)**						**Storage period (days)**					
	0	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**
T1	8.00	7.50	7.50	7.60	7.50	7.62	8.00	7.40	7.40	7.40	7.40	7.52
T2	8.00	7.50	7.30	7.40	7.40	7.52	8.00	7.10	7.00	7.20	7.00	7.26
T3	8.00	7.40	7.20	7.40	7.40	7.48	8.00	7.10	6.80	7.00	7.00	7.18
T4	8.00	7.00	6.90	6.70	6.70	7.06	8.00	6.40	6.40	6.40	6.40	6.72
Mean	8.00	7.35	7.23	7.28	7.25		8.00	7.00	6.90	7.00	6.95	
	S.Em. ±	C.D. at 5 %					S.Em. ±	C.D. at 5 %				
KMS levels (T)	0.049	0.138					0.058	0.164				
Storage (S)	0.055	0.154					0.065	0.184				
Interaction (T X S)	0.109	0.309					0.108	0.304				

Table 5. Changes in sensory score for taste and overall acceptability of cashew apple juice stored at ambient temperature

	Sensory score for taste						Sensory score for overall acceptability					
Treatment	**Storage period (days)**						**Storage period (days)**					
	0	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**
T1	8.00	8.20	8.20	8.20	8.20	8.16	8.00	7.70	7.70	7.73	7.70	7.77
T2	8.00	7.20	6.90	6.70	6.50	7.06	8.00	7.27	7.07	7.10	6.87	7.26
T3	8.00	7.10	6.40	6.60	6.20	6.86	8.00	7.20	6.80	7.00	6.87	7.17
T4	8.00	6.10	5.80	5.80	5.70	6.28	8.00	6.50	6.37	6.30	6.27	6.69
Mean	8.00	7.15	6.83	6.83	6.65		8.00	7.17	6.99	7.03	6.93	
	S.Em. ±	C.D. at 5 %					S.Em. ±	C.D. at 5 %				
KMS levels (T)	0.054	0.151					0.033	0.094				
Storage (S)	0.059	0.168					0.037	0.105				
Interaction (T X S)	0.119	0.338					0.075	0.210				

of non-reducing sugars resulted into increase in the reducing sugars of cashew apple juice during storage at ambient conditions. The similar results were also reported by Bharwal (2009) in hill lemon juice

Highest (7.23%) total sugars were observed in the cashew apple juice with 1000 ppm KMS level i.e. T_1 which was statistically different from all other treatments (Table 2) while significantly lowest (6.81%) total sugars were recorded in the treatment (T_4) i.e. 140 ppm KMS + pasteurization. A significant increase in total sugar content was observed from 2 days up to 4 days of storage. This could be due to the conversion of complex polysaccharides into soluble sugars during storage. The results obtained were similar to the findings of Patil (2004) in grape juice

Higher ascorbic acid content retention was noticed in the cashew apple juice preserved with different levels of preservative than that of preserved by pasteurization with 140 ppm KMS upto 4 days of storage (T3). A significant decline in the levels of ascorbic acid from 241.49 to 225.00 mg per 100 g was observed up to a storage period of four days. Loss of the ascorbic acid might be due to the oxidative reactions during storage at ambient conditions. These findings are also supported by Bharwal (2009) who observed a decreasing trend in ascorbic acid content of hill lemon juice treated with KMS @ 1400 ppm.

The colour, flavour and taste of the cashew apple juice under the treatment T_1 was liked by the judges the most while the lowest sensory score was obtained by the treatmentT_4 (7.06) i.e. 140 ppm KMS + pasteurization. The maximum mean score (7.77) for overall acceptability was recorded by the cashew apple juice with 1000 ppm KMS which was superior to all other treatments. The sensory score for colour, flavour, taste and overall acceptability declined significantly during storage period of 4 days at ambient conditions (Table 4 to 5). The present results are compared well with those of Ranote and Bains (1982) in kinnow juice, Masoodi *et al*. (1992) in Perlette grape juice and Hiremath (2012) in sapota juice. The cashew apple juice treated with different levels of KMS and stored at ambient condition was found acceptable with respect to

organoleptic qualities up to 4 days of storage. On the fifth day of storage, the fermentation of cashew apple juice was noticed while fungal growth was observed on sixth day.

CONSLUSION

The results from the present investigation indicated that the cashew apple juice without pasteurization could be stored for a period of 4 days at ambient conditions by adding 1000 ppm KMS as a preservative in the cashew apple juice.

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Assessment of Farmer's Perception on Pesticides Usage Pattern and Knowledge of Pest Management in Pomegranate Under High Density Planting at Major Pomegranate Growing Districts of Tamil Nadu

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ABSTRACT

Pesticides are widely used in both agricultural and horticultural production to prevent or control pests, diseases, weeds and other plant pathogens in an effort to reduce or eliminate yield losses and maintain high product quality. Especially in pomegranate various types of pests were attacking and reducing the yield. There are 91 insects, 6 mites and 1 snail pest feeding on pomegranate crop has been reported in India. Increase the production and productivity farmers are growing pomegranate under high density planting. Almost all the farmers depended on chemical pesticides for the management of pests of pomegranate. A field survey was carried out on pesticide usage pattern in pomegranate under high density planting was undertaken in four major pomegranate growing districts of Tamil Nadu *viz.*, Coimbatore, Erode, Tiruppur and Karur. Majority of the farmers (76.6 per cent) used imidacloprid for managing the pests. Sixty six per cent of farmers used monocrotophos as next option to imidacloprid. The farmers using chlorantraniliprole, fipronil and dimethoate represents 60, 46.6 and 40 per cent respectively

Key words *Pomegranate, Pesticides, Imidacloprid, Monocrotophos, Tamil Nadu*

Pomegranate (*Punica granatum*) is a favourite table fruit in tropical and subtropical regions of the world. It is one of the important semi- arid fruit crops grown in India. India is the largest producer of pomegranates in the world. Pomegranate is one of the important fruit crop in India cultivated in arid and semiarid regions of Gujarat, Maharashtra, Karnataka, Uttar Pradesh, Andhra Pradesh and Tamil Nadu (Balikai *et al.,* 2011). The total area under cultivation of pomegranate in India is 107.00 thousand ha and production is around 743.00 thousands tons. Some of the finest varieties of pomegranate having soft seeds, very less acids and very attractive colour of the fruits and grains are found in India (Verghese and Reshmi, 2014). The yield in pomegranate is decreasing in certain area due to several reasons among them insect pest problem is major one. Pomegranate is attacked by more than 50 species of insects in India (Biradar and Navi, 2006). Further, in order to increase the production and productivity, farmers are growing pomegranate under high density planting which accommodates 1000 plants per hectare as compare to 750 plants per hectare in the normal planting. Comparing to the normal planting, under high density planting of pomegranate will create microclimate and also increasing the pest populations.In recent years, the use of organic synthetic pesticides has become widespread practice for preventing, controlling and destroying pests. Usually sucking and defoliating pests were managed by spraying of systemic and contact pesticides (Deviprasad *et al.,* 2015). Therefore, the aim of the present study was to investigate the various pattern of a few pesticide's usage and farmers knowledge about pest management in pomegranate under high density planting from major pomegranate growing districts of Tamil Nadu.

MATERIALS AND METHODS

Intensive field studies was conducted during the year 2015 to 2016 for understand the actual situation of pesticide usage pattern adopted by farmers in commercially grown pomegranate farms, a survey on pesticide usage pattern on pomegranate under high density planting was undertaken in four major pomegranate growing districts of Tamil Nadu *viz.,* Coimbatore, Erode, Tiruppur and Karur (Table.1). During survey thirty pomegranate growing farmers were randomly selected in each village and the data on pesticides usage pattern were collected by means of a structured questionnaire administered via personal interviews. Thus, a total of 30 farmers that spread over the

Table 1. List of villages selected for survey in pomegranate growing districts of Tamil Nadu

S.No	District	Name of the village
1	Coimbatore	Theethipalayam
		Thondamuthur
		Narasipuram
2	Erode	Pazhamangalam
		Kalathuminra palayam
		Korakaatu pudhur
		Chetti thottam
		Unjalur
		Sivagiri
		Kaara valasu
		Kodumudi
3	Tiruppur	Manupatty
		Elaiyamuthur
		Pallapalayam
		Thumbalapatti
		Kallapuram
4	Karur	Kolathupalayam
		Pallapatti
		Vellapatti
		Keeranur
		Thennilai

Table 2. Pesticides commonly used in pomegranate under high density planting

Name of pesticides	Chemical group	Toxicity class*	Status	Number of farmers using it $	User farmers (%)
Insecticides					
Imidacloprid	Neonicotinoid	II	Registered	23	76.66
Monocrotophos	Organophosphate	Ib	Registered	20	66.66
Dimethoate	Organophosphate	II	Registered	12	40
Dichlorvas	Organophosphate	II	Registered	11	36.66
Chlorantraniliprole	Anthranilic diamide	Ib	Registered	18	60
Fipronil	Phenylpyrazole	II	Registered	14	46.66
Propargite	Sulfite ester	III	Registered	9	30
Indoxocarb	Carbamate	Ib	Registered	6	20
Neem oil		Unknown		4	13.33

*Toxicity class as classified by the anonymous (2011) Where Ia – Extremely hazardous; Ib – Highly hazardous; II – Moderately hazardous; III – Slightly hazardous; U- Unlikely to present acute hazard in normal use. $ - Multiple answer possible

major pomegranate growing districts of Tamil Nadu formed the sample of this study. The data collected include the farmer's demographic information, literacy rate, cultivation practices, information on major pests, major pesticides, spray intervals, dosage of insecticides, number of sprays, reason for number of sprays at each harvest interval period and knowledge on eco-friendly pest management practices. The objective and scope of the study was first explained to them to win their co-operation. Even though the farmers of the study region did not maintain any farm records, they were able to furnish necessary information by memory recall and by virtue of their experience. The information gathered on pesticides usage was processed. The collected data were entered in the MS-Excel worksheet, classified and used in for further analysis. The analysed data were used to preapare result graphs and tables.

Table 3. Seasonal abundance of Pomegranate pests under high density planting

S.No	Month	Farmer's perception level of incidence	Farmer's responses* (%)
1.	September - October	High	13.3
2.	October – November	High	23.4
3.	November - December	High	60.0
4.	December – January	High	3.3
5.	January - February	Low	56.6
6.	February – March	Low	20.0
7.	March -April	Low	6.7
8.	April - May	Low	16.7

*Multiple answers possible

Table 4. Number of insecticide spray given to pomegranate under high density planting

S.No	Number of insecticide spray given to pomegranate / crop (6 months)	Farmer's responses (%)
1.	15-20	13.3
2.	20-25	70
3.	25-30	10
4.	>30	6.7

Table 5. Knowledge updates of pomegranate growers on eco-friendly pest management practices

S.No	Knowledge on eco-friendly pest management	Farmer's responses # (%)	
		Yes	No
1.	Yellow sticky traps	83.3	16.7
2.	Light traps	76.6	23.4
3.	Predators	86.7	13.3
4.	Parasitoids	93.3	6.7
5.	Entomopathogens	16.7	83.33
6.	Plant products	56.7	43.3
7.	IPM*adoption	13.3	86.7

*IPM- Integrated pest management, # - Multiple answers possible

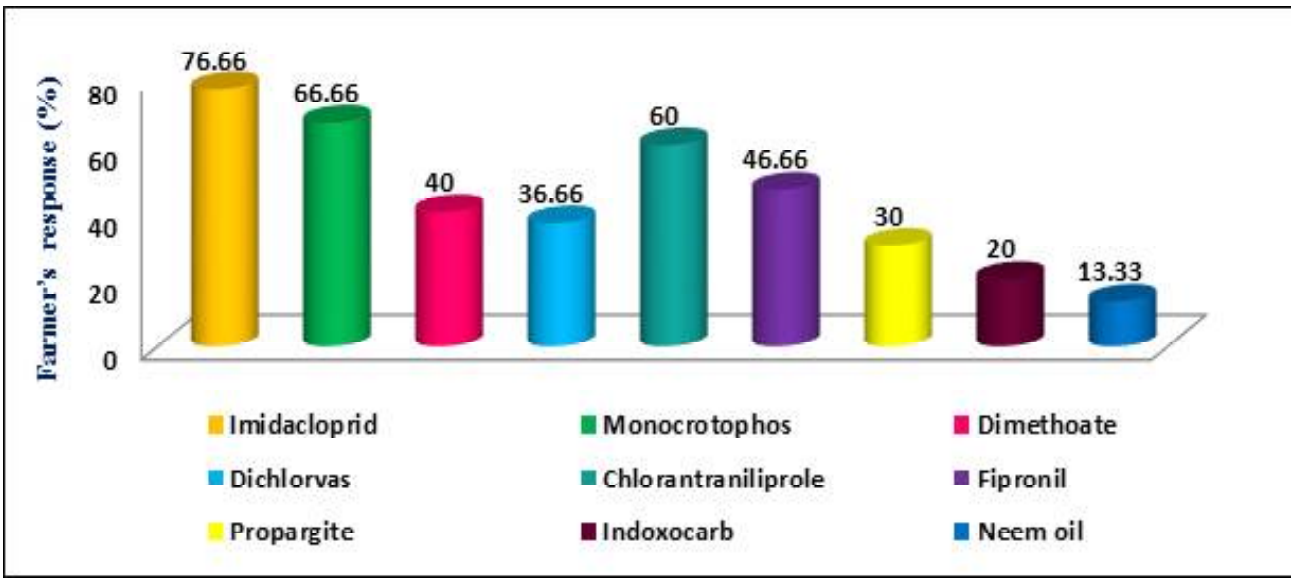

Fig. 1. Commonly used pesticides in pomegranate under high density planting

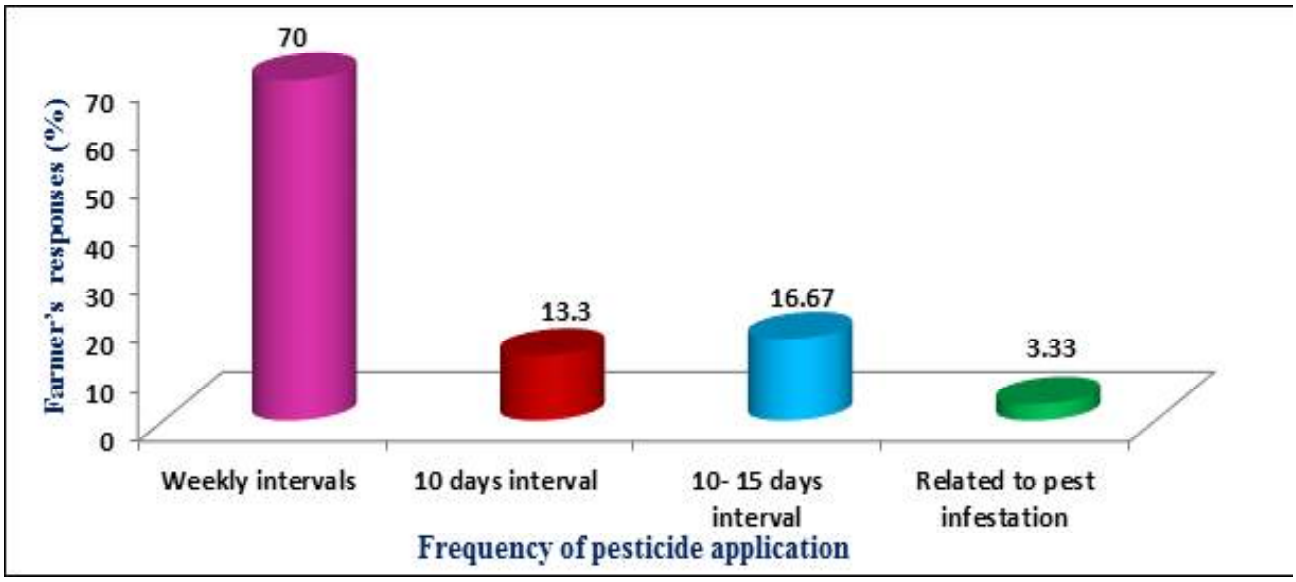

Fig. 2. Frequency of pesticide usage in pomegranate

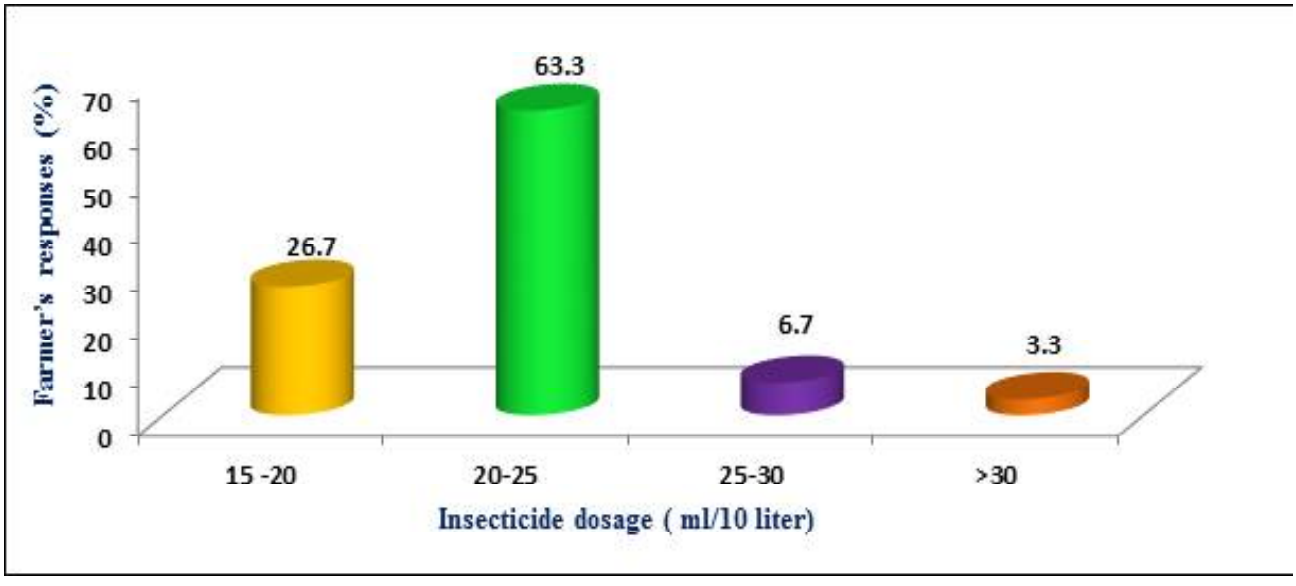

Fig. 3. Dosage of insecticide used by farmers in pomegranate

Table 6. Sourcing of information on pesticide usage

S.No	Information on Pesticide usage	Farmer's responses (%)
1.	Pesticide dealers	6.67
2.	Pomegranate growers association (Sivagiri, Erode district)	83.3
3.	AO*/ Scientist	10

*AO – Agricultural officer

RESULTS AND DISCUSSION

The commonly used pesticides by farmers in pomegranate were listed in table 2. Many of the farmers interviewed used neonicotinoid imidacloprid (76.6 per cent farmer response) followed by the use of organophosphate monocrotophos (66.6 per cent farmer response) and chlorantraniliprole (60 per cent farmer response). The others used dimethoate (40 per cent), dichlorvas (36.66 per cent), fipronil (46.66 per cent), propargite (30 per cent) and indoxocarb (20 per cent). Only 13.33 per cent of farmers used neem oil for managing the pests (Fig.1). Farmer's perception on seasonal abundance of pomegranate pests under high density planting recorded during the survey in four districts of Tamil Nadu was presented in table 3. The abundance of pest population was high in the month of November – December (60 per cent farmer response) followed by October –November (23.3 per cent farmer response). Pest population abundance was low in the period of January – February (56.6 per cent) followed by February –March (20 per cent farmer response). Most of the farmers used power sprayers for pesticide application in all the four districts. Farmer's responses on the frequency of pesticides usage indicated that seventy per cent farmers applied pesticides at weekly interval, whereas 13.33% at 10 days interval and 16.66 % at 10-15 days interval. Remaining farmers use the pesticide application based on the pest infestation (3.3 %) (Fig. 2). Majority of the farmers use insecticide dosage at 20-25 ml per 10 liter of water (63.3 per cent) followed by 15-20 ml per 10 liter of water (26.7 per cent) and 25-30 ml per 10 liter of water (6.7 per cent). Farmers who use more than 30 ml per 10 liter of water was 3.3 per cent (Fig. 3). Seventy per cent of farmers sprayed insecticides 20 – 25 time followed by 15-20 spray (13.3 per cent) and 25-30 spray (10 per cent) during the cropping period of 6 months. More than 30 sprays per crop was expressed by 6.7 per cent of farmers (Table 4). Except entomopathogens and IPM adoption, farmer's responses on awareness of eco-friendly pest management practices like yellow sticky traps, light traps, predators, parasitoids, plant products were relatively high in all the three major pomegranate growing districts of Tamil Nadu (Table 5). Strategies for the management of pomegranate pests under high density planting is obtained by farmers from Pomegranate growers association (PGA) Sivagiri, Erode district, Tamil Nadu (83.3 per cent farmers response), whereas a minimum respondents depend on Agricultural officer or scientist (10 per cent), followed by pesticide dealers (6 per cent) respectively (Table 6).More common usage of imidacloprid and monocrotophos by maximum number of farmers can be reasoned out by the fact that, the national institute (NRC, Solapur commonly attending pomegranate research) recommended the use of imidacloprid and monocrotophos in the packaging practices to pomegranate cultivation. During survey it was observed that for a single crop multiple formulations of pesticides were used. Farmers reported that most of the pesticides were obtained from more than one sources and they were readily available for purchase by farmers. The primary source of pesticides for purchase by formers in the study area were the Agro-chemical shops in the local markets.The major sources of information for use of pesticides by formers were based on notifications from agrochemical shops and also through agricultural government employed officers, sales representatives from various agro chemical companies.

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Occurrence, Virulence, and Cultural Characteristics of *Macrophomina phaseolina* Causing Root rot of Sesame from Cuddalore District of Tamil Nadu

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ABSTRACT

Sesame (*Sesamum indicum* L.) is grown as an oilseed crop in tropical and subtropical parts of the world it is known as a queen of oil seeds. Sesame crop is affected by many diseases caused by viruses, bacteria and fungi. Among the fungal diseases, the dry root rot caused by *Macrophomina phaseolina* (Tassi.)Goid causes significant yield losses in sesame growing areas of Cuddalore district of Tamil Nadu. Hence, the present study was conducted with an objective to assess the prevalence and incidence of dry root rot of sesame in Cuddalore district of Tamil nadu, India during 2015-16 and assess the cultural characters and pathogenic variability among the isolates of *M. phaseolina.* The survey was conducted in different locations of Cuddalore district revealed the endemic nature of the root rot disease incidence.Among the different locations of Cuddalore district surveyed for sesame dry root rot incidence the maximum incidence of the disease (34.65%) registered in Kothattai (MP_4) followed by Virudachalam,Parangipatti and Bhuvanagiri the other locations *viz*., Pattampakkam and Kurinjipadi had a moderate disease incidence while the minimum root rot incidence was recorded in Annamalainagar. The survey revealed that higher levels of disease incidence in rain fed crop than that of irrigated crop. The dry condition prevalent in the rain fed conditions might have favored the pathogen which could be attributed as the reason for the higher level of disease incidence.

Key words *Sesame, Root rot, Survey, Pathogenicity, Disease incidence*

Sesame (*Sesamum indicum L.*) is the "Queen of oilseeds" is one of the important oilseed crops being cultivated in many countries and is the highest oil bearing oilseed used for the extraction of oil (Thiruppathi *et al.*, 2001) percentage of oil ranges from 46-52 per cent and is widely used in Southern India for cooking purpose (Ninan,1989)Sesame oil is also a raw material for the production of industrial materials such as paints, varnishes, soaps, perfumes, pharmaceuticals and insecticides (Barut and Cagirgan, 2006).

Globally the crop is grown in area of 11.25 million hectares with production of 6235.53 thousand tones and productivity of 576.3 kg/ha (FAO, 2014), India is the largest producer, consumer and exporter of sesame as per the Solvent Extractions Association of India (SEAI), the area under sesame crop is 19.81 lakh hectares with production of 8.87 lakh tones during 2015 -2016.In Tamilnadu, sesame was cultivated in 0.66 lakh hectares with production of 0.36 lakh tones and yield 596kg/ha respectively during 2014-2015 and the major sesame producing districts are Erode, Villupuram, Thanjavur, Karur, Cuddalore, Thoothukudi and Salem. (Agriculture Statistics at a glance, 2015)

The crop is affected by various diseases caused by fungi, bacteria and viruses of these pathogens, among the diseases the *Macrophomina phaseolina* (Tassi) Goid is an important fungal pathogen, distributed worldwide and *M. phaseolina* attacks crop plants at different stages of plant growth and causes complex disease syndromes like root rot, seedling blight, charcoal rot, ashy stem blight, wilt, collar rot, dry rot, pod rot and seed rot in several crops(Ma *et al.,* 2010).The disease is both seed and soil borne and usually infects the crop under dry and warm condition. sesame is mostly grown as a rain fed crop and under this situation the crop exposed to sufficient soil moisture during its initial growth stages (up to 30-35 days), the dry condition prevalent during the later stage of the crop is a predisposing factor for infection of the root rot pathogen (Balabaskar, 2006).Its micro sclerotia, formed in senescing shoot tissues, survive well in soil (Mayek-Perez *et al*., 2002). The fungus is soil-borne and possess great problem in managing the disease. During the recent years this disease causes significant losses in sesame growing areas of Cuddalore District of Tamil Nadu.

Hence, the present study was conducted with an objective toassess the prevalence and incidence of dry root rot of sesame in Cuddalore district of TamilNadu, India during2015-16 and assess the cultural characters and pathogenicvariability among the isolates of *M. phaseolina.*

MATERIALS AND METHODS

Survey on the root rot incidence of sesame in Cuddalore district

A field survey was conducted by during 2015-2016 to assess the extent of root rot occurrence of sesame in Cuddalore district of Tamil Nadu State. The villages where sesame is traditionally grown are selected for assessing the prevalence of root rot disease caused

Table 1. Survey on the incidence of sesame root rot in Cuddalore district of Tamil Nadu

Sl. No.	Isolated place	Isolates	Variety	Soil type	Situation	Root rot incidence (%)
1.	Annamalainagar	(MP_1)	TMV4	Clay	Irrigated	13.60
2.	Parangipatti	(MP_2)	Local	Sandy loam	Rainfed	28.50
3.	Kurinjipadi	(MP_3)	TMV4	Red sandy	Irrigated	15.00
4.	Kothattai	(MP_4)	TMV3	Sandy loam	Rainfed	34.65
5.	Pattampakkam	(MP_5)	TMV4	Clay loam	Rainfed	21.46
6.	Bhuvanagiri	(MP_6)	Local	sandy loam	Rainfed	23.75
7.	Virudachalam	(MP_7)	TMV3	sandy loam	Rainfed	32.17

M. phaseolina seven locations representing both rain fed and irrigated situations were selected for the survey. Per cent disease incidence was worked out as per phytopathometry (Mayee and Datar, 1986).

Per cent Disease Incidence (PDI) =

$$\frac{\text{No.of Diseased Plants}}{\text{No.of Plants Observed}} \times 100$$

Also, the infected plants showing the typical symptoms of root rot due to infection with *M. phaseolina* were collected along with rhizosphere soil for isolation of the pathogen. The other information's regarding the soil type in which the crop is grown and the variety of Sesame cultivated were also recorded in the respective survey fields.

Isolation of the pathogen

The pathogen *M. phaseolina* was isolated from the diseased roots of sesame plants showing the typical root rotsymptoms by tissue segment method onpotato dextrose agar (PDA) medium. The axenic cultures of thedifferent isolates of the pathogen were obtained by single hyphal tip method (Rangaswami, 1972) and these weremaintained on PDA slants.

Mass multiplication of *M. phaseolina* inoculum for soil application

The isolates of the pathogen were multiplied in sand maizemedium (Riker and Riker, 1936). Sand and ground maize seedswere mixed in the ratio of 19:1, moistened to 50 per cent level,filled in 500ml conical flask and autoclaved at 20 psi for two hours. Four actively growing mycelial discs (9 mm) of the *M. phaseolina* collected from different locations wereinoculated into each flask under aseptic condition and theflasks were incubated at room temp.(28 ± 2º C) for 15 days. Theinoculum thus obtained was used for the experiments.

Table 2. Cultural characteristics of *M. phaseolina* isolates

SI. No.	Isolates	Colony character	Mycelial growth(mm)	Number of sclerotia (9mm disc)	Sclerotial size(µ)
1.	MP_1	Light grey scanty aerial growth	81.39^{g}	152.49^{g}	72.37^{g}
2.	MP_2	grey profusely aerial growth	87.43^{c}	175.69^{c}	92.38^{c}
3.	MP_3	Light grey scanty aerial growth	82.51^{f}	158.41^{f}	77.11^{f}
4.	MP_4	Black profusely aerial growth	90.00^{a}	188.46^{a}	104.18^{a}
5.	MP_5	Light grey scanty aerial growth	83.76^{e}	164.72^{e}	81.32^{e}
6.	MP_6	Light grey scanty aerial growth	85.24^{d}	171.74^{d}	87.17^{d}
7.	MP_7	grey profusely aerial growth	88.88^{b}	179.51^{b}	99.97^{b}

Values not sharing a common superscript differ significantly at $P < 0.05$ (DMRT)

Table 3. Pathogenicity of *M. phaseolina* isolates

SI. No.	Isolates	Root rot incidence (%)			Mean
		45 DAS	60 DAS	75 DAS	
1.	MP_1	12.25^{f}	22.74^{g}	24.34^{g}	19.77
2.	MP_2	18.39^{c}	34.61^{c}	52.42^{c}	35.14
3.	MP_3	15.10^{d}	28.16^{e}	33.12^{e}	25.46
4.	MP_4	25.80^{a}	49.39^{a}	64.76^{a}	46.65
5.	MP_5	13.75^{e}	24.72^{f}	28.76^{f}	22.41
6.	MP_6	13.75^{b}	30.82^{d}	39.72^{d}	28.09
7.	MP_7	24.59^{b}	47.24^{b}	62.56^{b}	44.76

Values not sharing a common superscript differ significantly at $P < 0.05$ (DMRT)

Pathogenicity test

The potting mixture was prepared thoroughly mixing clay loam soil, sand and farm yard manure at 1:1:1 ratio. The inoculum of each isolate of *M. phaseolina* collected from different locations were separately mixed at five per cent level (w/w) with the sterilized soil filled in 30cm earthen pots ten days before sowing (Sanker, 1994).Sesame seeds were sown @ 5 seeds pot^{-1}. Three replications were maintained in a randomized block design and the sesame cultivar TMV 3 was used in this study. The pots were maintained in glass house with regular, judicious and uniform watering. The root rot incidence was recorded at 45, 60 and 75DAS and record,also the plants showing the typical root rot symptom were pulled out and the pathogen was re-isolated on PDA slants. The culture thus obtained was compared with that of the original culture and the pathogenicity (Koch postulates) was proved.

Cultural characteristics of the isolates

Morphological characters on PDA

Fifteen ml of the medium was poured into each of the 90 mm Petri dishes. One ml of streptomycin sulphate of 100 ppm strength was added to the medium just before pouring into the plates. Inoculation was made by transferring 9mm growth disc of *M. phaseolina* taken from the periphery of seven day old culture. The plates were incubated at (28 ± 2º C) differences in topography, type of margin, rate of growth and days to form sclerotia were recorded.

Mycelial growth

Fifteenml of the sterilized PDA medium was poured into sterile Petri dishes and allowed to solidify. A nine mm culture disc of *M. phaseolina* obtained from actively growing region was aseptically placed at the center of the Petri dish and incubated at room temperature (28 ± 2º C) The radial growth of the isolates (in mm) was measured four days after inoculation.

Sclerotial number

From seven day old culture of the isolates, four culture discs (9mm) were cut and placed into 50 ml beakers containing 10 ml of sterile water. These beakers were kept on a mechanicalshaker at 1000 rpm for 30 min. to separate the sclerotia from the medium; then squeezed through cheese cloth; washed several times with distilled water and the sclerotia were transferred to a glass vial containing 2.5 ml of 2.5 per cent ammonium sulphate. After 10 min. the floating sclerotia were filtered through whatman No. 1 filter paper; rinsed with dist. Waterand the number of sclerotia was counted using stereo zoom microscope (Dhingra and Sinclair, 1978). The time taken by the isolates to form sclerotia was also recorded. The number of sclerotia per microscopic field and per nine mm disc were assessed and recorded.

Sclerotial size

For each isolate 100 sclerotia were collected at random. These were dried under shade for two hours and their size was measured using an ocular micrometer in a calibrated microscope.

RESULTS AND DISCUSSION

Survey on the root rot incidence of sesame in Cuddalore district

The data presented in (Table 1) on the survey in different locations of Cuddalore district revealed the endemic nature ofthe root rot disease incidence. Among the different locations of Cuddalore district surveyed for sesame root rot incidence, Kothattai (MP_4) registered the maximum incidence of the disease (34.65%) followed by Vridhachalam (MP_7) with (32.17) per cent, Parangipatti (28.50), Bhuvanagiri (23.75) and Pattampakam (21.46) had moderate disease incidence while the minimum root rot incidence of (13.60) per cent was recorded in Annamalainagar. In general, the crop grown under rain fed conditions showed more root rot incidence when compared

with the crops grown under irrigated conditions. In respect of soil type, sandyloam soil had more root rot incidence (15.00 to 34.65%) than and clay loam (13.60 to 23.75%) soil.The variation in the extent of the disease incidence might be due to the prevalence of the isolates of the pathogen differing in their virulence as observed in the present study. Similar such endemic nature of root rot disease of sesame in Tamil Nadu was earlier reported by Karunanithi (1996).The survey revealed higher levels of disease incidence in rain fed crop than that of irrigated crop. The dry condition prevalent in the rain fed conditions might have favored the pathogen whichcould be attributed as the reason for the higher level of disease incidence. Soil texture also had a significant impact on root infections. In the present survey more root rot disease incidence was observed in sandy loam as compared to clay or clay loam (Table 1). Similar to the present results, the crop grown in sandy loam soil registered higher per cent of root rot incidence than that of clay soil (Rettinasababady and Ramdoss, 2000). Higher incidence ofthe disease in sandy soils might be attributed to the lesscompetitive saprophytic ability (CSA) of the pathogen at highmoisture holding capacity (MHC) associated with heavy soils like clay (Umamaheswari, 1991 and Cruz Jimenez 2011) observed highest *M. phaseolina* root populations in sandy soils, followed by loamy sand and loam soil textures. These earlier reports lend support to the present findings.

Cultural characteristics

Mycelial growth isolates

All the seven isolates of the root rot pathogen *M. phaseolina* produced black grey profusely aerial mycelial growth on Potato Dextrose Agar (PDA) medium.The isolate MP_4recorded the maximum (90 mm) mycelia growth,while it was the minimum (81.39 mm) in the case of MP_1. The other isolates showed moderate mycelial growth (82.51 to 88.88 mm)(Table 2).Similar such variation in the cultural characteristics of *M. phaseolina*on PDA was reported by Tandel*et al.,* (2012). Also, several earlier workers have reported about the variations in the mycelial growth among the isolates of *M. phaseolina* (Edraki and Banihashemi, 2010; Ijaz*et al.,* 2012). *M. phaseolina* isolates from pearl millet, sesame, horsegram and mothbean differed in their mycelial growth and showed marked variation in cultural characters (Sharma and Dureja, 2004). Shekhar*et al*., (2006) on the basis of colony color divided seven isolates into four groups namely grayish white, blackish gray, dark black and cottony white colonies while working withthat the isolates of *M. phaseolina* with faster mycelial growth were more pathogenic and produced higher root rot incidence. The virulence of the isolates of *M. phaseolina*was positively correlated with their growth rate (Ghosh and Sen, 1973) and Sharmishha*et al*., (2004) reported that the isolates of *M. phaseolina* with faster mycelial growth were found more pathogenic to cluster beans. These earlier reports corroborate with the present findings.

Sclerotial number

Allthe seven isolates of *M. phaseolina* varied in their ability to produce sclerotia on PDA medium. The maximum sclerotial number of 188.46 per nine mm culture disc was obtained from MP_4 which was also the most virulent isolate. The isolates (MP_7, MP_2, MP_6, MP_5 and MP_3) produced 179.51, 175.69, 171.74, 164.72 and 158.41numbers of sclerotia, respectively. The minimum number of sclerotia of 152.49 was recorded by $MP_1$the least virulent isolate(Table 2) It is evident from the observations that sclerotia are the primary means of survivial (Mirza, 1984) and sufficient build up of the growth is absolutely necessary for the aggressiveness of the pathogen. Generally isolates producing more sclerotia are more pathogenic and caused higher seedling mortality (Sharmishha *et al*., 2004). Hooda and Grover (1982) observed a positive correlation between the disease intensity and the inoculum density. Similarly, the correlation between inoculum density and disease development was reported in sesame (Sankar, 1994) and in other crops (Umamaheswari, 1991; Rettinasababady, 1996) in respect of *M. phaseolina*. Generally isolates producing more sclerotia are more pathogenic and caused higher seedling mortality as reported by Sharmishha *et al*., (2004). Also, the severity of the disease is directly related to the population of viable sclerotia in the soil (Sundravadana *et al.,* 2012). In line with these earlier reports, in the present observation also the isolate which produced the maximum sclerotia happens to be the most virulent isolate.

Sclerotial size

The isolates of *M. phaseolina* produced varying sizes of sclerotia on PDA. The most virulent isolate MP_4 produced the biggest sclerotia with a size of 104.18µm (Table 2) and the smallest sclerotial size of 72.37µm was recorded with MP_1, which was the least virulent isolate. The other isolates *viz.,* MP_7, MP_2, MP_6, MP_5, and MP_3 produced sclerotia with the size 99.97, 92.38, 87.17, 81.32, and 77.11respectively.Similar variation in the sclerotial size of *M. phaseolina*was observed by several workers (Suriachandraselvan and Seetharaman, 2003; Tandel*et al.,* 2012). Significant differences in mycelia development, size of sclerotia and pathogenicity of different isolates of *M. phaseolina* from cotton was observed by Vilela *et al.,* (1987). All these above reports corroborate with the present findings. The isolates producing bigger sclerotia caused more root rot incidence in cotton even at low inoculums level (Monga and Sheo Raj, 1994). In the present study also the isolate (MP10), which produced the biggest sclerotia caused the maximum root rot incidence. The possibility of containing more food materials and subsequent production of more germ tubes by bigger sclerotia might have resulted in more aggressiveness of the isolate.

Virulence of different isolates of *M. phaseolina* on sesame

The results of the pot culture experiment conducted

by artificial inoculation of the pathogen revealed varied levels of pathogenicity with different isolates. Among the thirteen isolates of *M. phaseolina* collected from different conventionally sesame growing areas of Cuddalore district, the isolate from Kothattai (MP_4) was found to be the most virulent, recording the highest incidence of 64.76 per cent (75 DAS) and the isolate MP_1 collected from Annamalainagar was the least virulent which recorded the lowest incidence of 24.34 per cent (Table 3). Therefore, MP_4 the most virulent isolate of *M. phaseolina* was used throughout the study. The variations in root rot incidence in different locations could be well attributed to the difference in virulence of the *M. phaseolina* isolates prevalent in the respective areas. The variability in the pathogenicity among the isolates of *M. phaseolina* was reported by several workers (Byadgi and Hegde, 1985; Karunanithi, 1996). *M. phaseolina* isolated from different host species differ in their morphological and cultural characters and even differences occur in the isolates from various parts of same host (Sundravadana *et al.,* 2012). The above reports are in agreement with the present investigation Similar observations were made by Shanmugasundaram (1992) in sunflower, Sankar (1994) in sesame and Rettinasababady and Ramadoss (2000) in rice fallow blackgram. Thus, the observations of the present survey indicated the endemic nature sesame root rot disease in cuddalore district of Tamilnadu, India.

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Bio-Efficacy of Different Insecticides Against Pearl Millet Earhead Worm, *Helicoverpa armigera* (Hub.) in Summer Pearl Millet: *Pennisetum glaucm* (L)

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ABSTRACT

The field experiment was carried out bio-efficacy of different insecticides against pearl millet Earhead worm, *Helicoverpa armigera* (Hub.) in Summer Pearl millet at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during the year 2011. Among various insecticides tested, Endosulfan + dichlorvos recorded minimum larval population and highest grain yield (2357 kg/ha) and was at par with spinosad (2306 kg/ha), indoxacarb (2263 kg/ha) and profenophos (2081 kg/ha). Based on overall efficacy and cost of treatment, the treatment of spinosad (1:30.00) was most effective and economical followed by indoxacarb (1:27.95), endosulfan + dichlorvos (1:27.40), profenophos (1:16.58), dichlorvos (1:16.38), quinalphos (1:11.46) and endosulfan (1:9.71) to manage ear head worm in pearl millet crop. The lowest avoidable loss due to incidence of *H. armigera* in pearl millet yield was observed in plots treated with spinosad (2.14%) and it was followed by indoxacarb (3.97%) and profenophos (11.70%), however, such loss was highest in untreated plots (60.24%).

Key words *Pearl Millet, Bio-efficacy, H armigera, Neonicotinoids, Biopesticides & earhead worm*

Pearl millet {*Pennisetum glaucum* (L.) R. Br.}, commonly known as pearl, cat tail, spiked or bulrush millet in english is world's sixth important and widely grown potential cereal food crop. In United States of America, Australia and South Africa, it is primarily grown as forage crop. The pearl millet is an annual tillering diploid (2n=14) belongs to family Gramineae, sub-family Peniceidae. In our country, it is known by many names in different languages, Bajri in Rajasthani, Gujarati and Marathi, Sajje in Kannada, Kambu in Tamil, Bajra in Hindi, Urdu and Panjabi and Sajjalu in Telugu.

In India, pearl millet is the fourth most important food grain crop after rice, wheat and sorghum. As an arid and semi-arid crop, pearl millet is the component of dry land eco-system which receives 15 to 175 cm rainfall per annum. The share of pearl millet in total food grain production of the country is to the tune of 10.7 per cent. It occupies an area of 8.73 million hectares having 8.89 million tones production. Traditionally, it is used as porridge. Now a days, bakery products like cakes, muffins, cookies and biscuits are enhanced with pearl millet flour. In Gujarat, it occupied an area of 7.03 lakh hectare having 9.61 lakh tones production with 1370 kg / ha productivity as kharif grown crop (Anon., 2009) while, in summer it occupied 1.74 lakh hectare having 4261 tones production with 2440 kg / ha productivity (Anon., 2010).

Pearl millet grains contain protein (9-15%), fat (5%) and mineral matters (2-7%). It is also rich in vitamins A and B, thiamin and riboflavin contents and imparts substantial energy to the body with easy digestibility. Apart from grain, the fodder and straw at harvest are important secondary products in low resource agriculture for animal feed and fuel. Due to low yield potential as well as fluctuating grain prices plant protection measures are hardly applied. However, potentiality of high yielding hybrid varieties attract heavy incidence of pests. Crop is attacked by a number of insect pests, *viz*., Ear head worm, *Helicoverpa armigera* Hubner; Gujarat hairy caterpillar, *Amsacta moorei*; Army worm, *Cirphis unipuncta* H.; Stem borer, *Chilo zonellus*; Blister beetle, *Cylindrothorax ruficolis* F.; Shoot fly, *Atherigona varia socata* M.; Surface grasshopper, *Chrotogonus brachypterous* B. and White grub, *Holotrichia consanguinea* B. (Patel *et al*., 1970).

Over last few years a pest known as pearl millet ear head worm, *H. aremigera* Hub. is appearing in the summer sown crop. It is most probable due to the bio-diversity of the pest. Adoption of Bt. cotton varieties in large area of the state, the pest diverted towards the available hosts for its existence. Considerable research work has been done on this international pest on its preferred host, like pulses, oil seeds, fruit and vegetable crops, but very scanty information is available in respect to pearl millet. For developing suitable pest management strategies, it is essential to work out its damage intensity, population fluctuation and effect of various abiotic and biotic factors on the pest occurrence in view of growing need for increasing yield and quality of the crop. Therefore, it was though worthwhile to undertake the study on various aspects on this pest in pearl millet crop. Keeping these facts in mind, the present investigation was planned with following aspects.

Bio-efficacy of different insecticides against pearl millet ear head worm, *H. armigera* in summer season.

MATERIALS AND METHODS

The investigation on bio-efficacy of pearl millet ear head worm, *Helicoverpa armigera* (Hubner) was carried out by adopting following materials and methodology for various aspects of field investigation.

Location	:	Farmer's field Village : Nadotra
Taluka	:	Dantiwada, District: Banaskantha.
Crop	:	Pearl millet
Variety	:	Dhanya-7792
Spacing	:	45 x 15 cm
Plot size	:	Gross : 4.20 m × 2.70 m (6 row)
		Net : 3.40 m × 1.80 m (4 row)

Table A. Details of treatment used for management of ear head worm on pearl millet

Sr. No.	Treatments	Concentration (%)	Formulation	Trade Name
1	Endosulfan	0.07 %	35 EC	Thiodan
2	Quinalphos	0.05 %	25 EC	Ekalux
3	Spinosad	73g a.i./ha	45 SC	Tracer
4	DDVP	0.05 %	76 EC	Nuvan
5	Indoxacarb	50g a.i./ha	14.5 SC	Avaunt
6.	Profenophos	0.05 %	50 EC	Curacron
7	Endosulfan + DDVP	0.07 % + 0.05 %	--	--
8	NSKE	5 %	45 EC	Neem seed
9	Neem Oil 1500 ppm	0. 50 %	100 EC	Neem guard
10	Control	---	---	---

*Figures in parentheses are retransformed value

Design : Randomized Block Design (RBD)

Replication : 3 (Three)

Treatment : 10 (Ten); Details are given in table A.

The crop was raised during summer, 2011 following the normal recommended cultivation practices except plant protection. Uniform plant population was maintained in all the experimental plots. The first application of insecticidal treatment was made at emergence of ear head. Total two sprays were given at weekly interval. The treatment fluid was sprayed with the help of knapsack sprayer (ASPEE HI-TECH) provided with hollow cone nozzle. The sprayer was washed thoroughly prior to the application of subsequent treatments.

Observations recorded

The observations were recorded from net plot from five randomly selected ear head before application of insecticides and after 3 and 7 days of spraying. Number of ear head worm per ear head were recorded from net plot in each treatment. The data, obtained were subjected to

Table 1. Efficacy of different insecticides against *H. armigera* in pearl millet

Treatments	Mean larval population/ ear head				
	Before spray	Days after spray			
		1st spray		2nd spray	
		3	7	3	7
Endosulfan 0.07 %	1.43 (1.54) *	1.33 (1.27)	1.30 (1.19)	1.22 (0.99)	1.19 (0.92)
Quinalphos 0.05 %	1.38 (1.40)	1.33 (1.27)	1.25 (1.06)	1.25 (1.06)	1.14 (0.80)
Spinosad 73g a.i. / ha	1.47 (1.66)	1.27 (1.11)	1.19 (0.92)	1.11 (0.73)	1.08 (0.67)
DDVP 0.05 %	1.42 (1.52)	1.40 (1.46)	1.35 (1.32)	1.25 (1.06)	1.30 (1.19)
Indoxacarb 50g a.i / ha	1.44 (1.57)	1.30 (1.19)	1.22 (0.99)	1.19 (0.92)	1.13 (0.78)
Profenafos 0.05%	1.38 (1.40)	1.33 (1.27)	1.22 (0.99)	1.30 (1.19)	1.14 (0.80)
Endosulfan 0.07 % + dichlorvos 0.05 %	1.35 (1.32)	1.11 (0.73)	1.08 (0.66)	1.02 (0.54)	1.05 (0.60)
NSKE 5 %	1.53 (1.84)	1.52 (1.81)	1.47 (1.66)	1.40 (1.46)	1.47 (1.66)
Neem Oil 1500 ppm	1.47 (1.66)	1.45 (1.60)	1.43 (1.54)	1.43 (1.54)	1.30 (1.19)
Control	1.60 (2.06)	1.55 (1.90)	1.68 (2.32)	1.62 (2.12)	1.66 (2.25)
S.Em.±	0.06	0.05	1.45	0.06	1.39
C.D. at 5%	NS	0.16	0.15	0.17	0.16
C.V. %	7.24	6.90	6.70	8.14	7.52

Table 2. Yield and avoidable losses in pearl millet

Sr. No.	Treatment	Grain yield (kg/ha)	Increase in yield over control (%)	Avoidable losses (%)
1	Endosulfan	1575.46	68.13	33.15
2	Quinalphos	1861.57	98.66	21.02
3	Spinosad	2306.48	146.14	2.14
4	Dichlorvos	1638.63	74.87	30.47
5	Indoxacarb	2263.34	141.54	3.97
6	Profenafos	2081.01	122.08	11.70
7	Endosulfan + Dichlorvos	2356.94	151.53	0.0
8	NSKE	1235.18	31.81	47.59
9	Neem Oil	1240.73	32.41	47.36
10	Control	937.03	00.00	60.24
S. Em.±		103.61	--	--
C.D. at 5%		307.69		
C.V. %		10.26		

statistical analysis for drawing meaningful conclusion.

Yield and economics

Grain yield from each treatment was recorded separately. Protection Cost Benefit Ratio (PCBR) was worked out to compare the economics of insecticidal treatment. From the yield data, per cent increase in yield over control and avoidable loss were calculated for each treatment by applying formula suggested by Khosla (1977) considering mean yield of pearl millet in each treatment.

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield in treatment - Yield in control}}{\text{Yield in control}} \times 100$$

$$\text{Avoidable loss (\%)} = \frac{\text{Highest yield in plot - Yield in treatment}}{\text{Highest yield in treated plot}} \times 100$$

RESULTS AND DISCUSSION

Field experiment was conducted to study the efficacy of various insecticides for the management of ear head worm in pear millet crop during summer- 2011. Results obtained on efficacy of different treatments against ear head worm are presented here under.

Larval population

Before spray

The results on larval population/ ear head before spraying of insecticides are summarized in Table 1. The result revealed that the difference in larval population/ ear head among different treatments before spray was non-significant, which indicated that larval population/ ear head was uniform in all the treatments.

First spray

The treatment differences were significant three days after first spray with regards to larval population in pearl millet (Table 1). The treatment of endosulfan + dichlorvos registered the lowest larval population (0.73 larva/ ear head); however it was at par with the treatment of spinosad (1.11 larvae / ear head). All other treatments recorded higher larval population which varied from 1.19 to 1.81 larvae/ ear head, while untreated control recorded the highest population (1.90 larvae/ ear head). The results pertaining to larval population seven days after first spray revealed significantly low larval population in the treatment of endosulfan + dichlorvos (0.66 larva / ear head), however, it was at par with spinosad, indoxacarb and profenophos. The larval population in these treatments varied from 0.92 to 0.99 larva/ ear head. The rest of treatments proved the next effective treatments against ear head worm and recorded lower larval population (1.06 to 1.66 larvae/ear head) than untreated crop (2.32 larvae/ear head).

Second spray

All the treatments were significantly superior in reducing the larval population over control three days after second spray. The lowest larval population was recorded in the treatment of endosulfan + dichlorvos (0.54 larva /ear head); however it was at par with the treatment of spinosad and indoxacarb, where the larval population ranged between 0.73 and 0.92 larva/ ear head. The rest of treatments formed the second group of effective treatments against ear head worm registering 0.99 to 1.54 larvae / ear head; Whereas, highest larval population was observed in untreated control (2.12 larvae/ear head).

The results pertaining to larval population seven days after second spray revealed significantly low larval population in the treatment of endosulfan + dichlorvos (0.60 larva / ear head), however it was at par with the treatment of endosulfan, quinalphos, spinosad, indoxacarb and profenophos where the larval population ranged between 0.67 to 0.92 larva / ear head. Dichlorvos, NSKE and Neem oil formed the second group of effective treatments against ear head worm recording the larval population between 1.19 to 1.66 larvae / ear head, whereas, the highest larval population was recorded in the untreated plot (2.25 larvae/ ear head). It can be inferred from the overall results that endosulfan + dichlorvos and spinosad proved highly effective, whereas, rest of the treatments proved

Table 3. Economics of different treatments for the control of ear head worm in pearl millet crop

Sr. No.	Treatment	Material required (Kg or L/ha)	Cost of material (Rs.)	Total cost of treatment (Rs.)	Yield (kg/ha)	Total realization (Rs.)	Net realization over control (Rs.)	Net gain (Rs.)	PCBR
1	Endosulfan	2.000	440	656	1575.46	17330	7023	6367	1:09.71
2	Quinalphos	2.000	600	816	1861.57	20477	10170	9354	1:11.46
3	Spinosad	0.300	270	486	2306.48	25371	15064	14578	1:30.00
4	Dichlorvos	0.650	228	444	1638.63	18025	7718	7274	1:16.38
5	Indoxacarb	0.900	288	504	2263.34	24897	14590	14086	1:27.95
6	Profenafos	1.000	500	716	2081.01	22891	12584	11868	1:16.58
7	Endosulfan+ Dichlorvos	1.330	334	550	2356.94	25926	15619	15063	1:27.40
8	NSKE	50	300	516	1235.18	13567	3280	2764	1:05.36
9	Neem Oil	5.000	500	716	1240.73	13648	3341	2625	1:03.67
10	Control	--	--	--	937.03	10307	--	--	--

Labour charges: Rs. 108/day, price of pearl millet grain Rs. 11/kg

more effective than untreated control to reduce the ear head worm population in pearl millet crop.

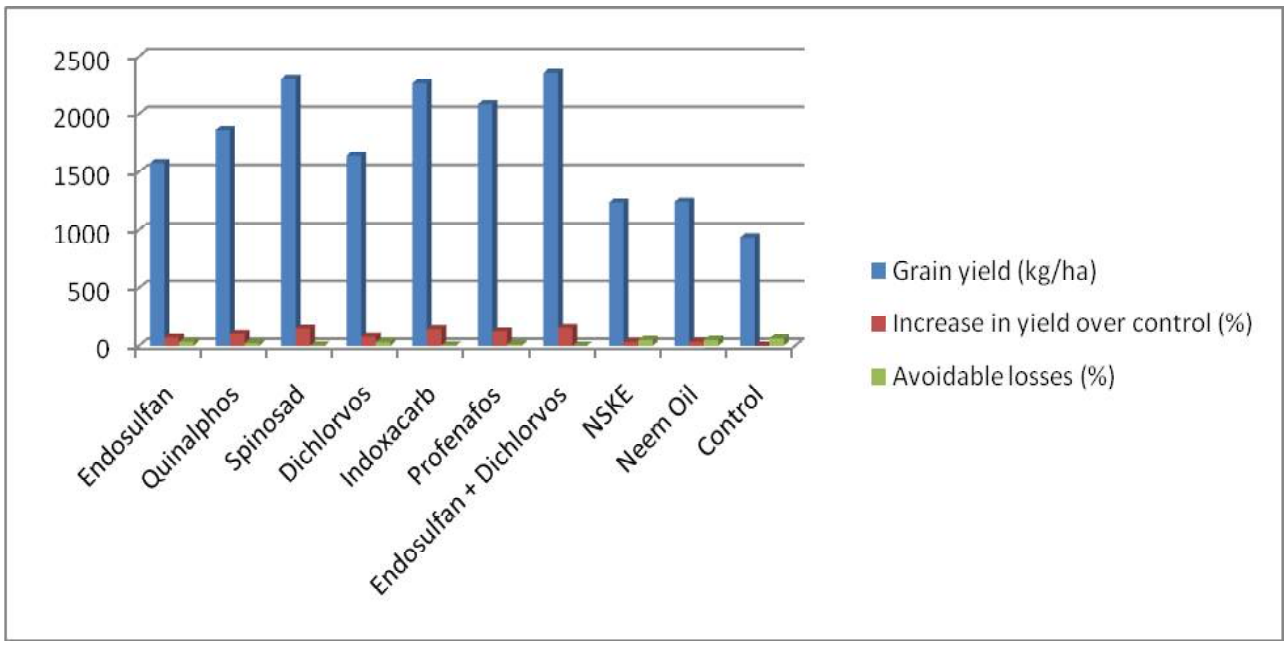
The order of effectiveness of various treatments against pearl millet ear head worm was endosulfan + dichlorvos > spinosad > indoxacarb > quinalphos = profenophos > endosulfan > dichlorvos = neem oil > NSKE. Thus, the combination of endosulfan and dichlorvos proved highly effective to control the ear head worm in pearl millet.Spinosad (0.009 %) and indoxacarb (0.0075 %) were found most effective in reducing the damage of Helicoverpa in pigeon pea at Junagadh (Babariya, et al., 2010).

Yield

The data on grain yield of pearl millet obtained in various insecticidal treatments are summarized in Table 2 and depicted in Graph 1. The grain yield of pearl millet in different treatments varied from 1235.18 to 2356.94 kg/ha. The highest grain yield of pearl millet was recorded in the treatment of endosulfan + dichlorvos (2356.94 kg/ha). However, it was found statistically at par with spinosad (2306.48 kg/ha). The treatments of indoxacarb (2263.34 kg/ha), profenophos (2081.01 kg/ha) and quinalphos (1861.57 kg/ha) formed next group of effective treatments in grain yield over control and were at par with each other. The treatment of endosulfan + dichlorvos (2356.94 kg/ha) was found moderately effective in grain yield over control. The remaining treatments neem oil (1240.73 kg/ha) and NSKE (1235.18 kg/ha) failed to increase significantly yield of pearl millet over control.

Increase in yield over control

Per cent increases in pearl millet grain yield over control due to various treatments were worked out on basis of the yield recorded in individual treatments including



Graph 1. Yield and avoidable losses in pearl millet

control The results revealed in Table-2 showed that the per cent increase in yield over control was maximum in the treatment of endosulfan + dichlorvos (151.53 %) and was followed by spinosad (146.17 %), indoxacarb (141.54 %) and profenophos (122.08 %). However, the lowest increase in yield over control was obtained in the treatment of NSKE (31.81 %). Percentage of avoidable losses in pearl millet yield due to ear head worm after applying various treatments were worked out and presented in Table 2. It can be seen from the results that the maximum grain yield was obtained in the treatment of endosulfan + dichlorvos and proved as the best treatment. The avoidable grain yield loss in pearl millet due to ear head worm varied from 2.14 to 60.24 per cent. The avoidable losses in pearl millet were minimum in the plots treated with spinosad (2.14 %) followed by indoxacarb (3.97 %) and profenophos (11.70 %) on the other hand, the highest percentage of avoidable losses in pearl millet grain yield was observed in untreated plot (60.24 %).

Economics

Economics of different treatments against ear head worm on pearl millet was worked out considering prevailing market price of grain, cost of insecticidal treatments including labour charges. The total realization, net gain and Protection Cost Benefit Ratio (PCBR) were also worked out for all the treatments and presented in Table 3. The results revealed that the total cost of treatments was minimum in the treatment of dichlorvos (444/ha) followed by spinosad (486/ha) and indoxacarb (504/ha), however quinalphos was the costliest treatment (816/ha). The total realization was highest in the treatment of endosulfan + dichlorvos (25926/ ha) followed by spinosad (25371/ha) and indoxacarb (24897/ ha), however, it was lowest in untreated control (10307/ha).

The highest net realization over control was registered in the treatment of endosulfan + dichlorvos (15619/ha). It was followed by spinosad (15064/ha), indoxacarb (14590/ ha), profenophos (2584/ha) and quinalphos (10170/ha). The lowest net realization over control was observed in the treatment of dichlorvos (7718/ha), endosulfan (7023/ha), neem oil (3341/ha) and NSKE (3280/ha), which was due to lower grain yield. The esults further revealed maximum net gain in the treatment of endosulfan + dichlorvos (15068 ha) followed by spinosad (15064 / ha), indoxacarb (‘ 14086 / ha) and profenophos (11868 / ha). Moreover, the highest Protection Cost Benefit Ratio (PCBR) was recorded in the treatment of spinosad (1:30.00). It was followed by indoxacarb (1:27.95), endosulfan + dichlorvos (1:27.40), profenophos (1:16.58), dichlorvos (1:16.38), quinalphos (1: 11.46) and endosulfan (1:9.71). The treatment of NSKE (1:5.36) and neem oil (1:3.67) recorded very low PCBR. Thus it can be inferred from the overall results that endosulfan + dichlorvos was the most effective treatment against the ear head worm of pearl millet, but from the view point of cost spinosad and indoxacarb may be preferred and can be advocated to the summer pearl millet growers.

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Exploring the Competence of Fungicides for Targeting Endopolygalacturonase Responsible for Alternaria Leaf Spot a Foliar Disease in Cotton - An *In Silico* Approach

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ABSTRACT

Alternaria leaf spot or alternaria blight is a common foliar disease of cotton occurring in most regions of the world. Alternaria leaf spot is one of major foliar disease caused by *A. macrospora, A. alternata*. This disease occurs in almost all the cotton growing countries of the world. Hybrids are more susceptible to this disease. Disease infect on leaves resulting in suppression of plant growth and reduction of yield. High severity of the infection causes strong defoliation of cotton, sharp decrease of yield and crude fiber quality. The disease symptoms are identified and on going through the disease cycle it was identified that Endopolygalacturonase plays an important role in it and hence it was considered to be a suitable target. Endopolygalacturonases (endoPGs) play major roles in pathogen penetration into plants at the initial phase of invasion. In this phase, the pectic polysaccharides in the plant primary cell walls used as potential barriers against pathogens are digested. The present study aimed to target Endopolygalacturonase through *Insilico* docking methods. The target Endopolygalacturonase was modeled and validated. The selected fungicidal compounds are targeted towards Endopolygalacturonase. It was identified through docking methods that the compound Carbendazim as potential compound for targeting endopolygalacturonase.

Key words *Alternaria leaf spot, Endopolygalacturonase, Modeling, Docking, Carbendazim*

Alternaria leaf spot is primarily a leaf disease but symptoms may also develop on cotyledons and bolls. It is a common foliar disease occur in most regions of the world. The fungus survives on undecomposed trash from previous cotton crops and is spread by air-borne spores. Infection is favoured by wet weather and temperatures of about 27°C. Plants are most susceptible at the seedling stage and late in the season when the crop begins to 'cut out'. Symptom development is favoured by any physiological or nutritional stress, e.g. heavy fruit load or premature senescence. Failure of the stomata to close makes the plant more prone to invasion and the leaves are brown, grey brown .The environment is most favorable within the crop canopy and therefore Alternaria leaf spot should be most severe on lower leaves and least severe on the upper .Plants with a high fruit load are more susceptible than plants with a low fruit load. When a susceptible crop is exposed to a favorable environment then defoliation occurs rapidly. Affected leaves develop an abscission layer, senesce and drop to the ground.(Hillocks, 1972)

To invade a plant tissue, phytopathogenic fungi produce several cell wall-degrading enzymes; among them, *endo*polygalacturonase (PG) catalyzes the fragmentation and solubilization of homogalacturonan. Polygalacturonase- inhibiting proteins (PGIPs), found in the cell wall of many plants, counteract fungal PGs by forming specific complexes with them. E*ndo*polygalacturonases (PGs), produced by a large variety of organisms such as bacteria, fungi, and plants, are involved in many physiological and pathological processes characterized by degradation and remodeling of the plant cell wall. Phytopathogenic microorganisms utilize PG as a component of their offensive arsenal to penetrate and colonize the plant tissues. It catalyzes the fragmentation and solubilization of pectic polymers by cleaving the internal bonds of homogalacturonan (constituent of the ''smooth region'' of pectin).As polygalacturonases(PGs) play an important role in the infection cycle ,they can be targeted to treat the disease. (Federici *et al*.., 2001)

MATERIALS AND METHODS

Homology Modeling

The sequence of Endopolygalacturonase of sequence length 379 and molecular weight Molecular weight: 38812.11 Da was retrieved from NCBI and subjected to Homology modeling. Discovery Studio v 2.0 was used for homology model construction. The homologous structures in the target were searched through NCBI –Blast (The National Center for Biotechnology Information). The parameters of the applied algorithm are (BLOSUM62; E-threshold, 10) using pdbaa server (Berman *et al.,* 2000). The template structures were selected for the model building with PDB ID: 11A5. Multiple sequence alignment was carried out to identify the conserved regions by aligning the target with the template structure. The aligned sequences were used for the model construction was built using "Build homology model" protocol in DS. (Fiser A and Sali., 2003)

Model validation

The spatial features of the residues should comply with empirically characterized constraints on torsional angles captured in Ramachandran plots (Ramachandran *et al* 1963) . Hydrophobic side chains of the protein are buried to reduce unfavourable contacts with water molecules. Hydrogen bonds, disulfide bridges, salt bridges and covalent bonds should be present, as these facilitate the folding and packing of the polypeptide chain. The methods typically used by structural biologists to check whether their crystal structures are well determined include PROCHECK (Laskowski *et al..,* 1993) which determine whether a protein structure has native-like features. The server RAMPAGE is used for calculating protein structure with unfavourable stereochemical properties such as Ramachandran outliers, steric clashes, incorrect hydrogen bonds and distorted bond angles.(C.Colovos and T. O. Yeates, 1993)

Active site prediction

The active sites of the protein were predicted using DS 2.0 which is based on the receptor cavity method using "Eraser" algorithm (Venkatachalam *et al*., 2003). This study reveals the key residues in the target protein which are responsible for ligand binding, which are present in the active site.

Retrieval of Ligands -Zinc database

ZINC is a free public resource for ligand discovery. The database contains over twenty million commercially available molecules in biologically relevant representations that may be downloaded in popular ready-to-dock formats and subsets. The Web site also enables searches by structure, biological activity, physical property and name. Annotated compounds can be important controls for docking calculations and thus have an important role to play in ZINC (Li Q *et al*., 2010). 13 compounds from Zinc database was retrieved based on literature survey and submitted for docking.

Docking Methodology

In the current study Glide program was used for docking and (XP) mode was used for Docking calculations. The Ligand was prepared using Lig prep and Protein was prepared using Protein Preparation wizard.. Receptor Grid was generated for binding sites and it was calculated and stored. During the initial phase of docking calculation, the maximum poses generated from the variables were fixed to 5000 and the best variable which set the number of poses per ligand that enters the energy minimization was set to 1000. The dielectric constant of 4.0 and 1000 steps of conjugate gradient was applied in the energy minimization protocol. At the ending of each docking calculation, utmost 100 poses per ligand were generated. Using Glide scores (G-score) function, the best docked structure was chosen (Parasuraman *et al*., 2014)

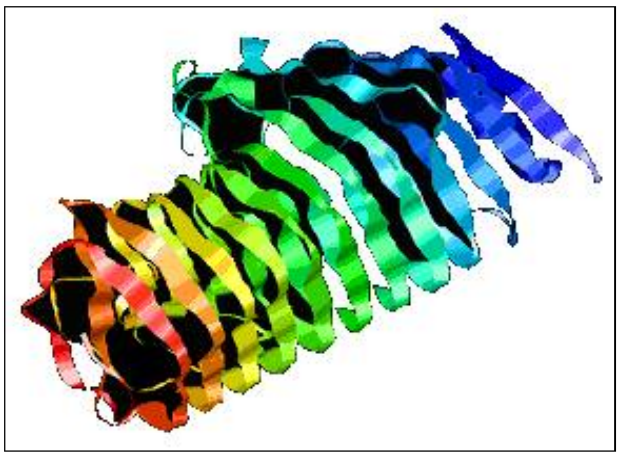

Fig. 1. Modelled protein of Endopolygalacturonase

RESULTS AND DISCUSSIONS

Homology modeling and validation

The amino acid sequence of our target protein was retrieved from NCBI and the physicochemical properties of the protein were studied. Multiple sequence alignment was carried out to identify the conserved regions of the target protein by aligning with the

template structure of 1IA5. The sequence identity and similarity of sequence is 63%. The structure is modeled and it is shown in Figure 1. Modelled protein is subjected for validation using SAVES server. The stereo chemical quality of the predicted model and accuracy of the model was evaluated after the refinement using Ramachandran Map calculations computed with the RAMPAGE server program represented in Table 1. The results of Ramachandran plot of the modelled protein is shown in (Figure 2). The percentage of residues in the most favorable regions of Ramachandran plot was 94.1% and of those lying in disallowed region was 0.3% that indicates good quality of Protein structure.

Docking studies

The structures of bioactive compounds were searched and their analogues show anti-fungal properties based on literature survey. The compounds are collected from Zinc

Table 1. Ramachandran plot calculation computed with the RAMPAGE- Server program

Server	Protein	Endopolygalacturonase
RAMPAGE	Residues in the most favoured regions	94.7 %
	Residues in additional allowed regions	5%
	Residues in outlier regions	0.3%

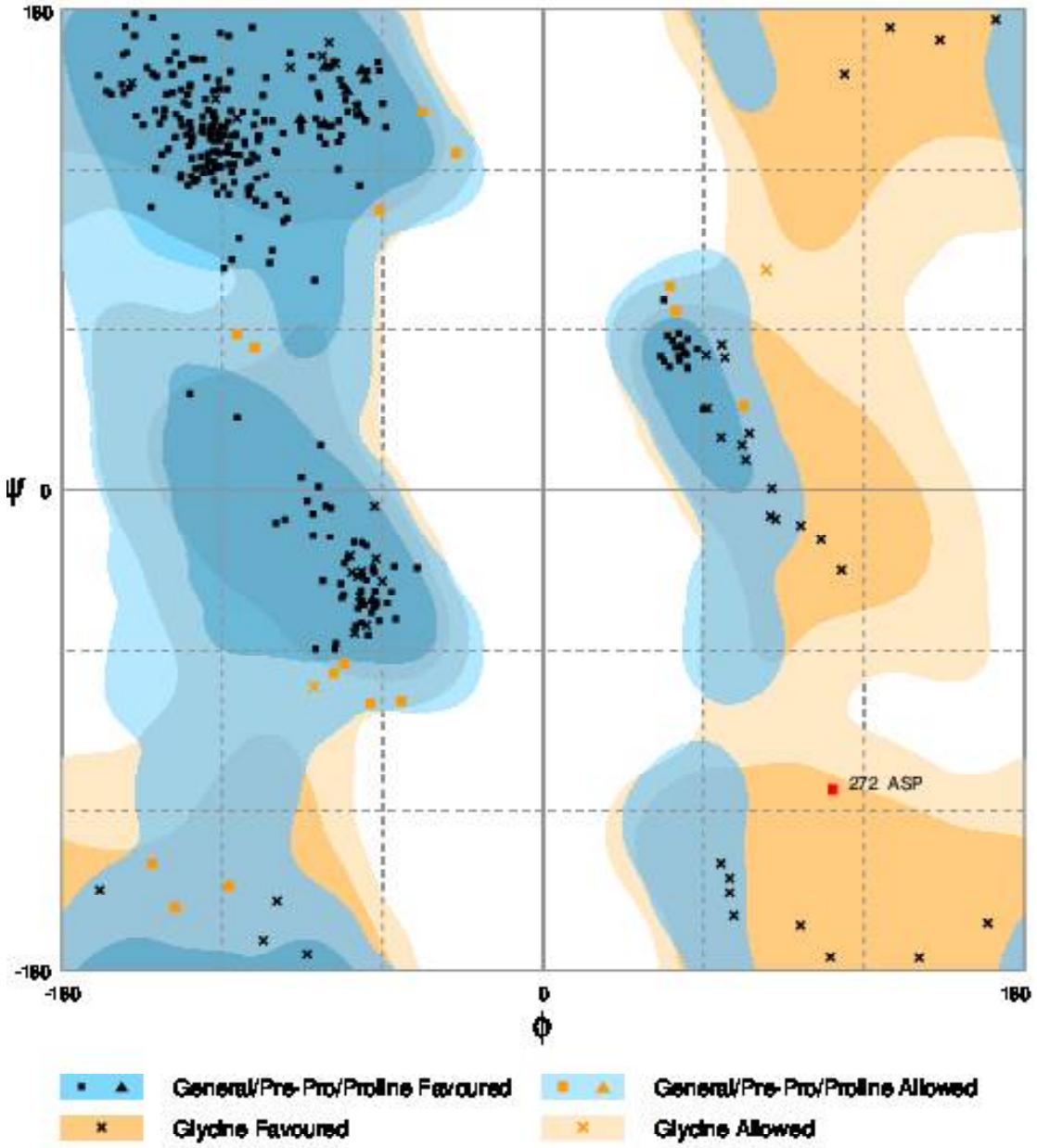

Fig. 2: Ramachandran plot of the modeled protein

Database. All the compounds has the structure.The mol and the SDL files are collected. The selected compounds were evaluated through molecular docking studies using Maestro, a GUI for Schrodinger (*in silico* analysis). Initially, the structures of these molecules were built by ligprep in all possible conformations to dock on the target Endopolygalacturonase . The size of the active site was determined by generating the Glide receptor grid. The orientations of the ligand in the binding sites are predicted. Docking was performed between the protein Endopolygalacturonase and the selected compounds. The scoring functions of the docked compounds are obtained in the form of G-Score. G-score indicates the binding ability of the ligand to the protein. The negative scoring indicates the better docking between ligands and protein. Table 2 illustrates the scoring functions of the docked compounds with the receptor in the form of G-score.

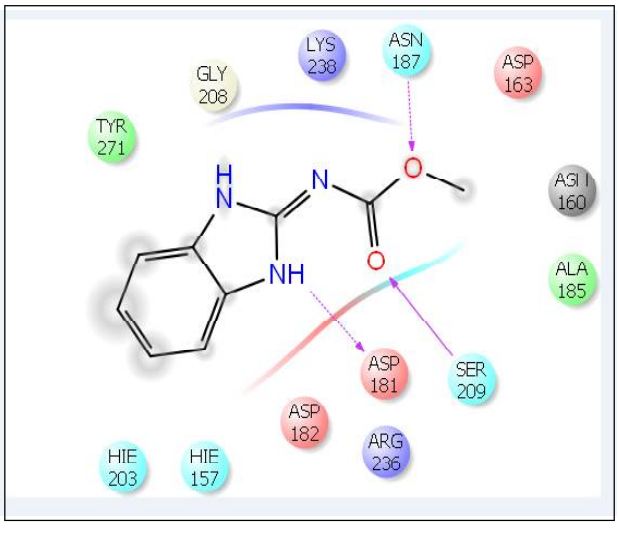

Fig. 3. Docked image of Carbendazim

Table 2. Glide scores of Docked compounds

S.no	Compound name	G- score
1.	[Disulfandiylbis(carbonothioylnitrilo)]tetramethan (Thiram)	-1.35
2.	2-(2,4-Dichlorophenyl)-1-(1H-1,2,4-triazol-1-yl)-2-hexanol (Hexaconazole)	-3.19
3.	methyl (E)-2-[2-[6-(2-cyanophenoxy)pyrimidin-4-]oxyphenyl]-3-methoxyprop-2-enoate (Azoxystrobin)	-2.81
4.	1-{[2-(2,4-Dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]methyl}-1H-1,2,4-triazole (Propiconazole)	-3.99
5.	(2-Chlorophenyl)(4-chlorophenyl)5-pyrimidinylmethanol (Fenarimol)	-2.32
6.	1,2-Ethanediyldicarbamodithioic acid diammoniate (Amobam)	-1.69
7.	1-({2-[2-Chloro-4-(4-chlorophenoxy)phenyl]-4-methyl-1,3-dioxolan-2-yl}methyl)-1H-1,2,4-triazole (Difenoconazole)	-3.94
8.	3-(3,5-Dichlorophenyl)-N-isopropyl-2,4-dioxo-1- imidazolidinecarboxamide (Iprodione)	-3.06
9.	2- [(Trichloromethyl)sulfanyl]-3a,4,7,7a-tetrahydro-1H-isoindole-1,3(2H)-dione (Captan)	-2.93
10.	2,4,5,6- Tetrachloroisophthalonitrile (Chlorothalonil)	-1.3
11.	Carbamic acid, N-1H-benzimidazol-2-yl-, methyl ester (Carbendazim)	-5.33
12.	Diethyl (1,2-phenylenedicarbamothioyl)biscarbamate (Thiophanate)	-3.97
13.	((1,2-Ethanediylbis(carbamodithioato))(2-)) manganese zinc salt (Mancozeb)	-1.72

Glide score for 13 ligands varies from the range between -1.3 to -5.33. The compound Carbendazim has the highest negative energy with docking score of -5.33 showing H-bond interactions with the binding site residues Asn 187, Ser 209 and Asp 181 respectively and it is shown in the Figure 3. This suggested that the compound have the highest binding ability upon docking against the structure of the protein. This docking studies reveals that the above compounds exhibited higher binding affinity with the active site residues of the target. It was also identified that there are good Intermolecular hydrogen bonding and interactions between the compounds and the receptor.

CONCLUSION

In the current study *Insilico* methods of modeling and Docking has been applied. 3D protein model determination of target protein can be used for designing of effective bio active compounds and their role in designing effective bio-fungicides. Hence Homology modeling has been done for prediction of Endopolygalacturonase structure and the model was validated. The validated protein was subjected to molecular docking studies using Glide. Glide score of a particular ligand describes its effectiveness and binding ability of the compounds with the target. A comparative study was

done for all the compounds and the compound Carbendazim have good docked pose by considering the G-score and Hydrogen bond interactions with the protein. This shows the importance of the compound as docking agent. From this study potential inhibitor for targeting Endopolygalacturonase has been identified as Carbendazim and hence it can be used as active compound in designing bio-fungicides and can be subjected to experimental procedures for validation.

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Major and Micronutrient Content in Soils of Grape Orchard as Influenced by Different Sources and Levels of Zinc and NPK

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ABSTRACT

A field experiment was conducted in three year old grape orchard *var*. Dilkush in order to know the nutrient status as influenced by different sources and levels of zinc along with recommended dose of NPK during 2015-16 and 2016-17, in Randomized Block Design with twenty treatments and three replications. Foliar spray was carried out at critical growth stages of the grape *viz*., vegetative stage, before flowering and after fruit set by using zinc metalosate, Zn-EDTA and zinc sulphate as zinc sources. Recommended dose of NPK and FYM were applied as per package of practice. Before experimentation soil samples were collected and analysed. The initial soils were slightly acidic, normal in EC, medium in organic carbon, available N, P_2O_5, K_2O and deficit in available zinc. Among different treatments significantly higher available nitrogen, phosphorus and potassium content were recorded in the treatment T_3(NPK+ FYM) and lowest was recorded in treatments T_{13} and T_{18} which consists of foliar application of zinc @ 0.150 per cent through zinc metalosate and Zn-EDTA along with recommended dose of NPK. Significantly higher available zinc was recorded in the treatments T_3, T_{19} and T_{20} compared to other treatments.

Key words *Grape, Foliar Spray, Zinc, Nutrient content, Harvest stage*

Fruit crop production is governed by several factors like climate, soil and irrigation status, varieties, pest and disease situation and nutritional status of soil as well as plant. Deficiency of various nutrients causes drastic reduction in growth, yield and quality of fruits. Among the nutrients, micronutrients though required in small quantities their importance in growth, yield and quality of fruit crops nutrition is quite essential (Raja, 2009). Zinc availability to the plant from soil is limited and it depends on factors like dynamic soil properties, organic matter, texture, cultivation, drought and microbial activity (Mengel and Kirkby, 2001). Hence, plant roots are unable to absorb these micronutrients adequately from the dry top soil therefore foliar application for better results deserves attention.

Grape (*Vitis vinifera* L.) is one of the important commercial fruit crop grown successfully in tropical and subtropical regions of the world. It is the third world's most widely cultivated fruit crop after citrus and banana and it contributes about 16 per cent towards the total fruit production. In world, it grown in an area of 7.50 lakh hectare with a production of 66 million tonnes (F.A.O, 2013). In India, it is cultivated in an area of 1.18 lakh hectares with an annual production of 25.85 lakh tonnes with productivity of 21.80 t ha^{-1} during 2013-14 (Horticultural statistics at glance, 2015). Its cultivation in India had greater significance due to its higher productivity as compared to other grape producing countries. Several research workers have reported the significant effect of foliar spray of zinc through different sources along with recommended dose of NPK on growth, yield and quality of grapes and other fruit crops but the information regarding available soil nutrient status after harvest of the crop is lacking. Hence, inorder to know the available soil nutrient content after harvest of the crop, the present research work was undertaken by using grape as test crop.

MATERIAL AND METHODS

The experimental work was undertaken in three year old grape *var*. Dilkush with twenty treatments and three replications in Randomized Block Design during 2015-16 and 2016-17. Before experimentation surface soil samples were collected and analysed for various parameters. Experimental soils were acidic (6.45), normal in EC (0.54 dS m^{-1}), medium in organic carbon (0.68%), available N (285.60 kg/ha), P_2O_5 (23.97 kg/ha), K_2O (175.20 kg/ha) and deficit in available zinc (0.55 mg /kg). Details of the treatments imposed include T_1: NPK, T_2: NPK+ Soil application of Zn as $ZnSO_4$, T_3: NPK + FYM, T_4 : NPK + Foliar spray of 0.01 % Zn as $ZnSO_4$, T_5: NPK + Foliar spray of 0.025 % Zn as $ZnSO_4$, T_6: NPK + Foliar spray of 0.050 % Zn as $ZnSO_4$, T_7: NPK + Foliar spray of 0.100 % Zn as $ZnSO_4$, T_8 : NPK + Foliar spray of 0.150 % Zn as $ZnSO_4$, T_9 : NPK + Foliar spray of 0.010% Zn as zinc metalosate, T_{10} : NPK + Foliar spray of 0.025 % Zn as zinc metalosate, T_{11}: NPK + Foliar spray of 0.050 % Zn as zinc metalosate, T_{12}: NPK + Foliar spray of 0.10 % Zn as zinc metalosate, T_{13} : NPK + Foliar spray of 0.150% Zn as zinc metalosate, T_{14}: NPK + Foliar spray of 0.010 % Zn as Zn-EDTA, T_{15}: NPK + Foliar spray of 0.025 % Zn as Zn-EDTA, T_{16}: NPK + Foliar spray of 0.050 % Zn as Zn-EDTA, T_{17} : NPK + Foliar spray of 0.10 % Zn t as Zn-EDTA, T_{18}: NPK + Foliar spray of 0.150 % Zn as Zn-EDTA, T_{19}: T_3+ Soil application of Zn as $ZnSO_4$ and T_{20} : T_3+ Foliar spray of 0.01 % (100 ppm) of Zn as $ZnSO_4$. Foliar spray was carried out at critical growth stages of grape viz., vegetative stage, before flowering and after fruit set by using zinc metalosate , Zn-EDTA and zinc sulphate

Table 1. Effect of foliar spray of different sources and levels of zinc on major nutrient content (kg ha^{-1}) of soil at harvest of grapes

Treatments	Nitrogen			Phosphorus			Potassium		
	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean
1	342.26	373.06	357.66	35.79	45.68	40.74	234.60	228.45	231.53
2	343.41	374.32	358.52	35.02	44.72	39.87	233.13	226.98	230.06
3	343.08	373.96	358.86	36.18	46.21	41.19	235.25	229.10	232.18
4	341.61	372.35	356.98	35.56	45.40	40.48	233.85	227.70	230.78
5	343.35	374.25	358.80	34.93	44.61	39.77	232.04	225.89	228.97
6	334.44	364.52	349.48	33.08	42.26	37.67	226.29	220.14	223.22
7	325.38	354.65	340.02	30.99	39.57	35.28	218.17	212.02	215.09
8	315.30	343.66	329.48	28.77	36.71	32.74	212.98	206.83	209.91
9	341.44	372.18	356.81	35.13	44.85	39.99	233.38	227.23	230.31
10	334.23	364.32	349.27	32.84	41.93	37.38	224.19	218.04	221.12
11	324.10	353.25	338.68	30.65	39.14	34.90	217.84	211.69	214.77
12	313.22	341.49	327.35	28.11	35.87	31.99	211.95	205.80	208.88
13	300.33	327.35	313.84	25.97	29.83	27.90	203.06	196.91	199.99
14	341.58	372.31	356.94	35.40	45.20	40.30	233.45	227.30	230.38
15	334.29	364.37	349.33	32.99	42.13	37.56	225.70	219.55	222.63
16	324.90	354.16	339.53	30.87	39.43	35.15	218.13	211.98	215.06
17	315.05	343.37	329.21	28.53	36.43	32.48	212.55	206.40	209.48
18	300.55	327.62	314.08	26.15	31.37	28.76	203.54	197.39	200.47
19	343.30	374.20	358.75	35.94	45.89	40.92	235.19	229.04	232.12
20	342.99	373.85	358.42	36.06	46.04	41.05	235.09	228.94	232.02
SEm ±	2.91	3.29	3.21	0.62	1.19	0.83	1.50	1.50	1.65
CD @ 5 %	8.32	9.42	9.20	1.78	3.39	2.37	4.29	4.29	4.72

sources of zinc. Recommended dose of NPK (500:125: 750 N, P_2O_5, K_2O) and FYM (20 kg plant^{-1}) were applied as per package of practice. After harvest of each crop soil samples were collected treatment wise and analysed for major and micronutrient content.

RESULTS AND DISCUSSION

Pooled data presented in the Table 1 indicating that significant increase in major nutrient content in soil at harvest of crop compared to initial values. Available nitrogen content varied from 313.84 to 358.86 kg ha^{-1} and recorded significantly higher in treatment T_3 (358.86 kg ha^{-1}) which received recommended dose of NPK along with farm yard manure. Lower available nitrogen content was recorded in treatment T_{13} (313.84 kg ha^{-1}) and T_{18} (314.08 kg ha^{-1}) which received zinc @ 0.150 per cent as zinc metalosate and Zn-EDTA along with recommended dose of NPK. Available phosphorus content varied from 27.90 to 41.19 kg ha^{-1} and recorded significantly higher content in treatments which received recommended dose of NPK along with farm yard manure (T_3: 41.19, T_{20}:41.05 and T_{19}: 40.92 kg ha^{-1}) and it recorded significantly lower content in treatments which received zinc @ 0.150 per cent as zinc metalosate and Zn-EDTA, respectively. About 199.99 to 232.18 kg ha^{-1} available potassium was recorded in soil at harvest and recorded more in treatment T_3, T_{19} and T_{20} which received recommended dose of NPK along with farm yard manure. Lower available potassium content was recorded in treatment which received 0.150 per cent zinc as zinc metalosate and Zn-EDTA, respectively *i.e* T_{13} (199.99 kg ha^{-1}) and T_{18} (200.47 kg ha^{-1}).

Higher available NPK content was recorded in treatments T_3 may be due to soil application of recommended dose of NPK and farm yard manure. Farm yard manure favoured mineralization of organic sources of nitrogen in the soil and also due to increased microbial activity which could have stimulated the nitrification process. Similarly increase in available phosphorus with FYM addition was due to release of more phosphorus from organic compounds, increase in microbial population as well as decomposition product of humic substances. Due to action of organic acids from organic matter complex available potassium was increased (Sharma, 2013). Similarly, Singh *et al*. (2012) noticed that soil application of inorganic fertilizers and organic manures, significantly increased the available

Table 2. Effect of foliar spray of different sources and levels of zinc on micronutrient content (mg kg^{-1}) of soil at harvest of grapes

Treat-ments	Zinc			Iron			Copper			Manganese			Boron		
	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean	Season I	Season II	Pooled mean
1	0.46	0.44	0.45	38.63	38.23	38.43	0.35	0.34	0.35	26.50	26.22	26.36	0.44	0.43	0.43
2	0.47	0.45	0.46	38.48	38.10	38.29	0.35	0.33	0.34	26.35	26.09	26.22	0.44	0.43	0.43
3	0.58	0.61	0.60	40.44	41.36	40.90	0.34	0.32	0.33	28.31	28.68	28.50	0.47	0.49	0.48
4	0.46	0.44	0.45	38.58	38.19	38.38	0.35	0.34	0.34	26.45	26.18	26.32	0.43	0.43	0.43
5	0.47	0.45	0.46	38.45	38.05	38.25	0.35	0.34	0.34	26.32	26.05	26.18	0.43	0.42	0.43
6	0.48	0.46	0.47	38.44	38.04	38.24	0.35	0.35	0.35	26.31	26.03	26.17	0.44	0.41	0.42
7	0.50	0.48	0.49	38.38	38.00	38.19	0.34	0.33	0.34	26.25	25.99	26.12	0.43	0.43	0.43
8	0.52	0.50	0.51	38.32	37.95	38.13	0.34	0.34	0.34	26.19	25.94	26.06	0.44	0.43	0.43
9	0.46	0.44	0.45	38.51	38.13	38.32	0.35	0.34	0.34	26.38	26.12	26.25	0.44	0.42	0.43
10	0.49	0.47	0.48	38.40	38.02	38.21	0.34	0.33	0.34	26.27	26.01	26.14	0.44	0.42	0.43
11	0.51	0.49	0.50	38.34	37.98	38.16	0.34	0.34	0.34	26.21	25.97	26.09	0.43	0.43	0.43
12	0.53	0.51	0.52	38.28	37.97	38.13	0.34	0.32	0.33	26.15	25.96	26.06	0.43	0.42	0.43
13	0.54	0.52	0.53	38.23	37.92	38.08	0.34	0.34	0.34	26.10	25.91	26.01	0.43	0.43	0.43
14	0.46	0.44	0.45	38.53	38.14	38.33	0.35	0.35	0.35	26.40	26.13	26.26	0.43	0.44	0.44
15	0.49	0.47	0.48	38.43	38.06	38.25	0.35	0.35	0.35	26.30	26.05	26.18	0.43	0.43	0.43
16	0.51	0.49	0.50	38.36	38.00	38.18	0.34	0.34	0.34	26.23	25.99	26.11	0.43	0.43	0.43
17	0.53	0.50	0.52	38.30	37.91	38.10	0.34	0.34	0.34	26.17	25.90	26.03	0.43	0.42	0.43
18	0.54	0.53	0.54	38.25	37.86	38.06	0.34	0.33	0.33	26.12	25.85	25.99	0.44	0.43	0.43
19	0.59	0.61	0.60	40.74	41.01	40.87	0.33	0.32	0.32	28.61	29.33	28.97	0.46	0.49	0.48
20	0.58	0.60	0.59	40.63	40.95	40.79	0.32	0.30	0.31	28.50	29.03	28.77	0.47	0.47	0.47
SEm ±	0.01	0.02	0.01	1.24	1.59	1.26	0.01	0.02	0.01	1.10	1.25	1.13	0.02	0.03	0.02
CD @ 5 %	0.03	0.06	0.03	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

N, P and K status in the soil. Addition of farmyard manure improved the physical properties of soil there by creating favourable conditions for microbial activity resulting in increase in the nutrient availability in the soil. The increase in soil available K content might be due to release of fixed K due to action of organic acids from decomposed organic manure. Similar observations were recorded in different fruit crops by Korwar *et al*. (2007), Selvamani *et al*. (2011), Mohanbai (2014), Mustafa *et al*.(2013), Thakur (2013) and Verma and Chauhan *et al.* (2014).

Significantly higher available zinc content in soil in treatment T_{19} (0.60 mg kg^{-1}) which received soil application of zinc sulphate along with farm yard manure and T_3 (0.60 mg kg^{-1}) which received farm yard manure followed by treatment T_{20} (0.59 mg kg^{-1}) which consists of farm yard manure. Among different sources and levels of zinc as zinc metalosate, Zn-EDTA and $ZnSO_4$, significantly higher zinc content in soil was recorded in treatment T_{18} (0.54 mg kg^{-1}) and T_{13} (0.53 mg kg^{-1}) which received 0.150 per cent zinc as Zn-EDTA and zinc metalosate, respectively. No significant difference was observed among the treatments with respect to DTPA extractable iron, copper, manganese and boron and which recorded in the range of 38.08 to 40.90, 0.31 to 0.35, 26.01 to 28.97 and 0.42 to 0.48 mg kg^{-1}, respectively (Table 2).

The increase in zinc content in the soil may be due to application of farm yard manure to soil. Farm yard manure is a good source of all nutrients, during decomposition it releases organic acids which reduces the fixation and conversion to unavailable form, which in turn contributed to increasing available zinc in soil. Similar findings were also made by Thakur (2013) who stated that application of 75% NPK + biofertilizers (60 g tree basin^{-1}) + green manure (Sunhemp @ 25 g seed/tree basin) + FYM (40 kg) + vermicompost (24 kg) resulted in available Zn of 2.10 mg kg^{-1} in soils of plum orchards.

CONCLUSION

Soil application of recommended dose of NPK along with FYM manure played significant role in improving available nutrient content in soil after harvest of grapes compared to other treatments. Lower available nutrients content in soil was recorded in treatments T_{13} and T_{18} due to enhanced uptake of these nutrients by the crop due to foliar application of higher levels of zinc *i.e.* 0.150 % zinc through zinc metalosate and Zn-EDTA.

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Biometric and Yield Response of Banana to Organic Fertilizer Produced by Rapid Decomposition of Solid Wastes

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ABSTRACT

A study was conducted to evaluate the suitability of an organic fertilizer produced by rapid chemical decomposition of degradable solid waste in terms of crop growth, development and productivity in banana.A field experiment on Banana (*Musa* spp. variety Nendran) was conducted from October 2014 to August 2015. The experiment was laid out in Randomised Block Design with 8 treatments and 3 replications. The treatments were selected to compare farm yard manure based conventional and soil test based fertilizer recommendations with those of the rapid organic fertilizer based. The rapid organic fertilizer based treatmentswere capable of imparting efficient pseudostem growth and development from the period of active growth upto harvest in banana, establishing its source to sink efficiency. The rapid organic fertilizer based treatment matched with the soil test based farm yard manure treatment in terms of crop productivity, thus proving to be an alternative to conventional farmyard manure.

Key words *Solid waste management, quick waste disposal, rapid organic fertilizer, pseudostem height, banana productivity*

Banana is a popular and commercially exploited fruit crop, cultivated and consumed widely all over the world.It is an important fruit crop of tropical and sub-tropical regions of the world. India is the largest producer of banana in the world contributing 17.3 percent to the global production (Kumar *et al.,* 2008). An annual crop of ten months duration, the growth and development of the crop is largely governed by several factors, the foremost among them being the nutritional requirements. The exuberance in uptake and accumulation of nutrients for the growth warrants application of large quantities of organic fertilizers in banana cultivation. Moreover application of organic fertilizers is a prerequisite towards restoration of soil health and maintenance of soil quality targeted at achieving sustenance in agriculture in the long run. There exists a scarcity of organic manures and fertilizers needed for large scale commercial applicationboth in organic farming as well as in farms adopting good agricultural practices. In India, the most commonly used organic manure is farm yard manure (Reddy *et al*., 2015). Availability of conventional organic manures like farmyard manure, poultry manure, bone meal etc. are limited and are comparatively costly. There is a wide gap between demand and availability. This is currently made up by application of composts. Organic fertilizers and compost produced from degradable solid waste form the secondary source of organic manure.The most attractive method for recycling organic wastes is composting as the waste materials are converted into environmentally benign products (Rivero *et al*., 2004). Composting technologies largely rely on microbial decomposition techniques which require prolonged periods for conversion. Although composting is a popular practice, scarcity of land and the long period required for process completion pose serious limitations for large scale practicing. Large scale dumping for long periods pave way to environmental and human health hazards. It is in this context that the organic fertilizer produced by rapid thermochemical processing as reported by Sudharmaidevi *et al.,* 2017 gains relevance. The method is scientific, efficient and capable of providing a quick and sustainable solution for hygienic waste disposal and production of organic fertilizer. Processing the waste at places of generation itself avoids transportation to centralized processing yards. Since the waste is processed on the day of generation itself, dumping is avoided, which prevents other environmental problems. The present landfill sites could be brought under plough contributing to enhanced food production. Availability of balanced organic fertilizer becomes possible, which will enhance crop yield, improve soil health and environmental quality. Hence this study was conducted to evaluate the suitability of the rapid organic fertilizer in terms of cropgrowth, development and productivity in banana.

MATERIALS AND METHODS

Experimental site

Field experiment on banana (*Musa* spp. variety Nendran) was conducted from October 2014 to August 2015 at the College of Agriculture, Trivandrum, Kerala, India.The experimental site belonged to agro ecological unit (AEU) 8. The chemical properties and fertility parameters of the site is given in Table1.

Experimental designand treatments

The experiment was laid out in Randomised Block Designwith8 treatments and 3replications (Table 2).Nendran variety ofbanana with 10 months duration was the crop tested. The plot size was36$m^2$with 9 plants in oneplot. Spacing between plants was 2 m x 2 m (2500 plants ha^{-1}). The treatments were selected to compare farmyard manure (FYM) based conventional and soil test based fertilizer recommendations with those of thenewly produced rapid organic fertilizer (ROF) based. Although the use of rapidorganic fertilizerwas found compatible with other organic or inorganic fertilizers, compatibility to bio fertilizerswas not tested. Therefore a treatment with Plant Growth Promoting Rhizobacteria(PGPR) was also included. There were treatments to compare conventional, rapid

Table 1. Soil fertility parameters of experimental site representative of AEU 8

Fertility parameters	Content	Status
pH	5.45 ± 0.05	Moderately acidic
OC %	1.69 ± 0.3	High
N (kg ha^{-1})	539 ± 13	Medium
P (kg ha^{-1})	180 ± 23	High
K (kg ha^{-1})	358 ± 26	High
Ca (mg kg^{-1})	448 ± 40.1	Sufficient
Mg (mg kg^{-1})	78.6 ± 4.4	Deficient
S (mg kg^{-1})	13.5 ± 5.4	Sufficient
Fe (mg kg^{-1})	193.9 ± 55.6	Sufficient
Mn (mg kg^{-1})	3.0 ± 1.1	Sufficient
Zn (mg kg^{-1})	12.60 ± 0.85	Sufficient
Cu (mg kg^{-1})	1.07 ± 0.21	Sufficient
B (mg kg^{-1})	0.08 ± 0.01	Deficient

organic fertilizer based and both combined. The farmyard manure was applied as basal. Inorganic fertilizers except P were applied in 6 equal top dressing applications at 1 month interval. P was applied in two split doses at one and two months after planting. In the plot where rapid organic fertilizer wastop dressed, 1 kg was applied in 6 splits fortified with the required quantity of fertilizers.

Observations on biometric and yield characters

The height of the pseudostem from the base at the soil level up to the axil of the youngest unopened leaf was measured and expressed in cm. Observations were recorded at bimonthly intervals of 2,4,6 and 8 months after planting.Weight of the bunch including the portion of the peduncle up to the first scar (exposed outside the plant) was recorded in kg.Crop productivity for total number of plants in 1 ha was calculated and expressed in kg ha^{-1}.

Statistical Analysis

The data on the field experiment were analysed statistically by applying the techniques of analysis of variance. The F values for treatments were compared with the table values. If the effects were significant, critical differences at the 5% significance level were calculated for effecting comparison among the means. Data analytical package Web Agri Stat Package (WASP) ver.2.0 was used for data analysis.

RESULTS AND DISCUSSION

Biometric characters

Observations on the mean pseudostem height of banana at 2, 4, 6 and 8 months after planting are furnished in Table 3. The ROF based treatments recorded the highest plant height at all stages. The OFSTSM treatment recorded the highest plant height of 333.83 cm at 8 M. The same treatment yielded highest plant height at 6 M also.Kulasekran (1985) opined that application of farmyard manure, neem and green manure, which are sources of nitrogen, increased the pseudostem height, girth and bunch weight in banana significantly. The plant height in various treatments at 8 M followed the order OFSTSM<FSTSMP< STSM(F)<ST<FSTSM<FSTSM(F)<STSM<CR while at 6M the order was OFSTSM<CR <FSTSM<STSM <ST) < FSTSM(F)<STSM(F)<FSTSMP. At 4 M, FFSTSMP scored the highest plant height of 211 cm. There was no significant difference among the various treatments in plant height at 2 months after planting. A clear supremacy of the rapid organic fertilizer based treatments over the farmyard manure based treatments was evident in imparting the plant growth

Table 2. Treatment combinations of field experiment

Treatment Code	Treatments
F	POP (FYM + NPK)
FST	Modified POP (FYM + STB NPK)
FSTSM	FYM + STB (NPK + Secondary + Micro)
FSTSM(F)	FYM + STB [NPK + Secondary + Micro (F)]
FFSTSM	FYM + COF (OF fortified with STB NPK + Secondary + Micro)
FSTSM(F)	FYM + COF [OF fortified with STB NPK + Secondary + Micro(F)]
FFSTSMP	FYM + COF (OF fortified with STB NPK + Secondary + Micro) + PGPR Mix I
OFSTSM	COF (basal) + COF (OF fortified with STB NPK + Secondary + Micro)

Table 3. Effect of rapid organic fertilizer and farmyard manure based treatments on pseudostem height of Nendran banana in AEU 8

Treatments	2 M	4 M	6 M	8 M
			cm	
CR	73.08	194.33 ^{abc}	237.67 ^{ab}	246.67 ^{d}
ST	80.10	171.33 ^{bcd}	226.00 ^{bc}	309.33 ^{b}
STSM	104.58	158.33 ^{cd}	230.00 ^{bc}	274.00 ^{c}
STSM(F)	99.83	199.67 ^{ab}	181.33 ^{c}	318.67 ^{ab}
FSTSM	84.75	149.33 ^{d}	234.33 ^{bc}	307.67 ^{b}
FSTSM(F)	91.57	149.67 ^{d}	203.33 ^{bc}	304.67 ^{b}
FSTSMP	98.80	211.00 ^{a}	197.00 ^{bc}	324.33 ^{ab}
OFSTSM	71.75	194.00 ^{abc}	289.67 ^{a}	333.83 ^{a}
SEm (±)	5.212	17.167	25.668	10.373
CD (0.05)	NS	36.824	55.058	22.25

characteristics in terms of plant height starting from the active growth stage which continued through bunch emergence stage till harvest of the banana crop. The early growth stage at 2M does not seem to be a characteristic stage for evaluating treatmental effects on plant height of the crop.Use of agricultural wastes either alone or in combination with N P K fertilizers is reported to enhance the growth and yield characters of maize (Agele*et al*., 2015). The enhanced pseudostem height might have resulted due to the effect of fortification that supply nutrients in readily available form for immediate crop utilization (Upadhyay, 1988).

Crop productivity

The yield in terms of crop productivity of banana with regard to the four farmyard manure based treatments and four rapid organic fertilizer based treatments have been outlined in Fig. 1. The highest productivity of26854.17kg ha^{-1}was recorded by STSM treatment which was on par with the 26666.67kg ha^{-1} in OFSTSM. The bunch productivity realised followed the order STSM > OFSTSM >ST >FSTSM >CR> FSTSMP > STSM (F) >FSTSM (F). The yield and crop productivity reflected the superiority of the FSTSM and OFSTSM treatments. The organic fertilizer application might have initially set right the internal nutritive base of the plant leading to accelerated growth and vigour associated with photosynthesis. The improved productivity may be ascribed to the biological efficiency imparted by the rapid organic fertilizer to banana crop (Natarajan, 2002). The organic sources of nutrients might have accelerated

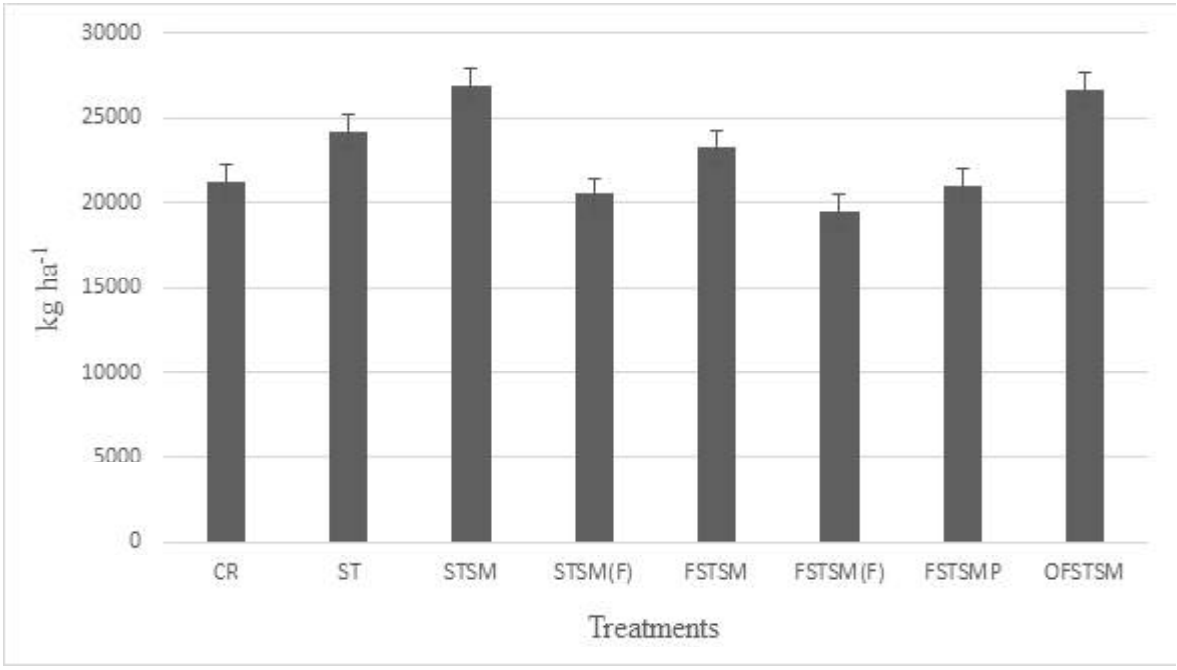

Fig. 1. Effect of rapid organic fertilizer and farmyard manure based treatments on crop productivity of banana in AEU 8

the source to sink photosynthatetransport mechanism, which is by and large influenced by growth hormones ultimately gets translocatedinto the fruits (Sharma *et al.,*2013). Moreover the rapid organic fertilizer might have catalysed the microbial population in the rhizosphere leading to betterment of uptake and utilisation of essential nutrients and improving the source to sink relationship and promoting movement of carbohydrates from leaves to fruits (Vanilarasu and Balakrishnamurthy, 2014). Soil test based nutrient supply from a combination of organic as well as an inorganic source proved to be ideal for prospective crop productivity in banana. El Monie*et al.,* (2008) obtained best results in Williams banana plants that received N via banana compost and mineral source at 50% each.

The rapidorganic fertilizer produced by chemical decomposition of degradable solid wasteswas capable of imparting efficient pseudostem growth and development from the period of active growth upto harvest in banana. The rapid organic fertilizer based treatment matched with the soil test based farmyard manure treatment in terms of crop productivity, thus proving to be an alternative to conventional farmyard manure. This clearly establishes the source to sink efficiency of the new rapid organic fertilizer.

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Effect of Establishment Methods and Nutrient Management Practices on Growth and Yield of Rice

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ABSTRACT

Field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru during the *Kharif* season of 2016 to study the effect of establishment methods and nutrient management practices on growth and yield of rice. The experiment was laid out in split plot design with three replications consisting of twenty treatment combinations. Four establishment methods of rice such as manual transplanted, mechanized transplanted, dibbling of seeds followed by SRI principles, and wet direct seeded rice by broadcasting were followed in main plots and five nutrient management practices such as 100 per cent RDF, 150 per cent RDF, 75 per cent inorganic + 25 per cent Organic, LCC based N application and UASB POP recommended dose of manure and fertilizers, in sub plot. Among the different establishment methods, Dibbling of seeds followed by SRI principles significantly influenced the growth, yield attributes and yield and was on par with mechanized transplanted. The plant height (93.27 cm), number of tillers/hill (25.17), leaf area/cm²/plant (1658.40), total dry matter (73.91 g), Root length (25 cm) at 90 DAS / T, Root weight (12.5 cm) at 90 DAS/T, Days to maturity (118), number of panicle/m² (451), length of panicle (20 cm), weight of 10 panicle (25.5 g), grain yield (5760 kg/ha) and straw yield (6178 kg/ha), were recorded under dibbling of seeds with SRI principles and lowest growth, yield attributes and yield were recorded under wet direct seeded rice by broad casting during *kharif* season.

Key words *Machine planting, rice establishment methods, nutrient management, LCC, SRI method*

RICE (*Oryza sativa*) is the staple food for more than half of the population of the world. The productivity and sustainability of rice-based systems are threatened by the inefficient use of inputs (fertilizer, water, and labour), increasing scarcity of resources, especially water and labour; climate variability, emerging energy crisis and rising fuel prices, rising cost of cultivation and emerging socio-economic changes such as urbanization, migration of labour, preference for non-agricultural work, and concerns about farm-related pollution. Method of establishment influences the performance of rice through its effect on growth and development. Although, transplanting has been reported to be the best establishment method, some alternatives like dry and wet direct seeding are being explored to reduce the cost of cultivation on account of high labour and water requirement. Integrated use of organic manures and chemical fertilizers has advantages over use of only organic manures or chemical fertilizers. Since sourcing of organic manure is difficult and the crop response to them during initial stages is not as spectacular, compared to the chemical fertilizers, an integrated approach of plant nutrition involving the judicious mix of organic, chemical and microbial sources could be helpful to sustain optimum yield and to restore the residual soil fertility.

MATERIAL AND METHODS

The investigation was carried out in the Zonal Agricultural Research Station, Vishveshwarya Canal Farm, Mandya, University of Agricultural Sciences, Bengaluru during the *Kharif* season of 2016. The experimental farm is located at an altitude of 704 m above mean sea level with the geographical location at 12º 34' North latitude and 76º 49' East longitudes comes under Southern dry zone of Karnataka (Zone-VI). The climate of the experimental field is classified as semi arid tropical with high humidity, moderate temperature and medium rainfall. The soil of the experimental plot was sandy loam in texture and well drained with acidic reaction (pH 5.1). Organic carbon content of the soil was found to be medium while available nitrogen was found to be low, phosphorous and potassium were found to be medium. The experiment was laid out in split plot design with three replications consisted of twenty treatment combinations. Four establishment methods of rice such as manual transplanted (M_1), mechanized transplanted (M_2), dibbling of seeds with SRI principles (M_3), and wet direct seeded rice by broadcasting (M_4) were grown in main plots and five nutrient management treatments of rice such as100 per cent RDF (F_1), 150 per cent RDF (F_2),75 per cent inorganic + 25 per cent Organic (F_3), LCC based N application (F_4) and UASB POP recommended dose of manure and fertilizers (F_5), in sub plot. Treatment F_5 UAS package of practices (10 t FYM/ha + 100: 50: 50: kg NPK / ha + 20 kg $ZnSo_4$). The variety IR-30864 was taken as test crop during *kharif*, in manual transplanted 18-20 days old seedlings are transplanted. With respect to mechanized transplanted, fourteen days old seedlings of mat nursery were transplanted with a spacing of 25 x 25 cm, dibbling of seeds with SRI principles, seeds were soaked in water for 24 hours and incubated in dark for 12 hours to induce sprouting which are placed 2-3 seeds per corners of square, marked ropes were used for square planting and for wet direct seeded rice by broadcasting, the seeds are broadcasted at 25 kg/ha seed rate to maintain optimum plant population. Intercultural operations such as gap filling, irrigation and plant protection were carried out as required. The crop was harvested at four different dates depending on the maturity of the varieties manually and grain yield was recorded at 16 per cent moisture level. Data was collected from five hills per plot and then averaged. Observations on growth and

Table 1. Growth of rice as influenced by establishment methods and nutrient management practices during *Kharif* 2016.

Treatments				
Establishment techniques (M)	**Plant height (cm) at harvest**	**Number of tillers (Hill^{-1}) at harvest**	**Leaf area (cm^2 plant^{-1}) at 90 DAS/T**	**Total dry matter (g/hill) at harvest**
M_1	88.70	19.68	1351.00	61.95
M_2	92.40	22.18	1504.50	66.52
M_3	93.27	25.17	1699.20	73.91
M_4	86.87	16.85	1237.60	53.75
S.Em±	0.63	0.51	20.99	1.68
C.D. at 5%	2.17	1.77	72.64	5.81
Nutrient management practices (S)				
F_1	88.08	19.08	1362.25	53.15
F_2	93.25	23.10	1564.88	73.66
F_3	88.96	20.08	1398.63	60.88
F_4	90.75	21.98	1483.13	69.50
F_5	90.50	20.60	1431.50	62.97
S.Em±	1.02	0.72	30.23	1.93
C.D. at 5%	2.94	2.08	87.08	5.57
Interactions				
S.Em±	2.04	1.44	60.46	3.87
C.D. at 5%	NS	NS	NS	NS

Methods of crop establishment (04)
M_1: Manual transplanted rice
M_2: Mechanized transplanted rice
M_3: Dibbling of seeds followed by SRI principles
M_4: Wet direct seeded rice by broad casting (DSR)

Subplot: Nutrient management practices (05)
F_1: 100 % RDF
F_2: 150 % RDF
F_3: 75 % inorganic + 25 % Organic (N equivalent basis)
F_4: LCC based N application
F_5: UASB package of practices (FYM 10 t/ha + 100: 50: 50: kg NPK/ha + 20 kg $ZnSo_4$)

DAS/T: Days after sowing/transplanting
NS: Non significant

yield were recorded during harvesting. Data recorded for different growth and yield parameters was compiled and tabulated in proper form for statistical analysis. Statistical analysis was performed following the method of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of establishment methods and nutrients on growth parameters of rice dibbling of seeds followed by SRI principles significantly influenced the plant height, number of tillers, leaf area and total dry matter production (Table I), root length, root weight and days to maturity (Table II). Dibbling of seeds followed by SRI principles recorded significantly higher growth characters. The maximum plant height (93.27 cm), number of tillers/hill (25.17), leaf area/cm^2/plant (1658.40), total dry matter (73.91 g), Root length (25 cm) at 90 DAS/T, Root weight (12.5 cm) at 90 DAS/T, Days to maturity (118) were recorded under dibbling of seeds followed by SRI principles which was on par with mechanized transplanted method on growth parameters like plant height (92.40 cm), number of tillers/ hill (22.18), leaf area (1504.50) total dry matter production (66.52 g), root length (24.2 cm), root weight (11.4 g) and days to maturity (120) in *kharif* season. There was a progressive increase in plant height, number of tillers, leaf area and TDMP under Dibbling of seeds followed by SRI principles system of planting when compared to manual transplanted, and mechanized transplanted methods. Wet direct seeded rice by broadcasting produced lesser plant height (86.87 cm), number of tillers/hill (16.85), leaf area (1237.60) and total dry matter production (53.75 g), root length (20.5 cm), root weight (9.7 g) and days to maturity (115). Dibbling of seeds followed by SRI principles which might have established quickly in the field due to wider spacing, less competition, without transplanting and started growing at a faster might be attributed to higher plant height. The number of tillers per plant was significantly higher in Dibbling of seeds followed by SRI principles. Dibbling of seeds in square method with wider spacing might have resulted in profused tillering under Dibbling of seeds followed by SRI principles, which might have facilitated plants for better utilization of the resources. This advantage of Dibbling of seeds followed by SRI principles in enhancing tiller numbers, leaf area and total dry matter production

Table 2. Growth of rice as influenced by establishment methods and nutrient management practices during *Kharif* 2016.

Treatments			
Establishment techniques (M)	**Root length (cm) at 90 DAS/T**	**Root weight (g) at 90 DAS/T**	**Days to maturity**
M_1	22.3	10.1	126
M_2	24.2	11.4	120
M_3	25.0	12.5	118
M_4	20.5	9.7	115
S.Em±	0.8	0.6	2
C.D. at 5%	2.6	2.0	6
Nutrient management practices (S)			
F_1	21.3	9.8	117
F_2	25.3	12.1	122
F_3	22.1	10.5	120
F_4	24.1	11.6	120
F_5	22.3	10.6	120
S.Em±	0.7	0.3	1
C.D. at 5%	2.1	0.8	NS
Interactions			
S.Em±	1.5	0.6	2
C.D. at 5%	NS	NS	NS

Methods of crop establishment (04)
M_1: Manual transplanted rice
M_2: Mechanized transplanted rice
M_3: Dibbling of seeds followed by SRI principles
M_4: Wet direct seeded rice by broad casting (DSR)
DAS/T: Days after sowing/transplanting

Subplot: Nutrient management practices (05)
F_1: 100 % RDF
F_2: 150 % RDF
F_3: 75 % inorganic + 25 % Organic (N equivalent basis)
F_4: LCC based N application
F_5: UASB package of practices (FYM 10 t/ha + 100: 50: 50: kg NPK/ha + 20 kg $ZnSo_4$)
NS: Non significant

root length, root weight may be attributed to young seedlings used for transplanting at shallow depth and wider spacing, which provided good aeration for better establishment of crop. Higher root dry weight and root length in dibbling of seeds followed by SRI principles also led to proliferation of root system by contributing to higher biomass.

Days to maturity was affected by crop establishment methods (Table II). The growth duration of manual transplanting was 8 days more than dibbling of seeds followed by SRI principles, whereas, it was 3 days more than wet direct seeded rice by broadcasting. Kumar *et al.* (2015) also reported that manual transplanting was 7 days more and matured later by 7 days compared to dibbling of seeds followed by SRI principles which were due to older seedlings and transplanting shock as reported earlier by Rakesh Choudary *et al*. (2016).

Among different nutrient management practices, significantly maximum plant height (93.25 cm), number of tillers/hill (23.10), leaf area/cm^2/plant (1564.88), total dry matter (73.66 g), Root length (25.3 cm) at 90 DAS/T, Root weight (12.1 cm) at 90 DAS/T and Days to maturity (122) were recorded with the application of 150 per cent RDF which was on par with LCC based N application [plant height (90.75 cm), number of tillers/hill (21.98), leaf area/ cm^2/plant (1483.13), total dry matter (69.50 g), Root length (24.1 cm) at 90 DAS/T, Root weight (11.6 cm) at 90 DAS/T and Days to maturity (120)] in *kharif* season. There was a progressive increase in plant height, number of tillers, leaf area and TDMP under 150 per cent RDF and LCC based N application system of planting when compared to UASB Package of practices, 100 per cent RDF and 75 per cent inorganic + 25 per cent Organic. 100 per cent RDF produced lesser plant height (88.08 cm), number of tillers/hill (19.08), leaf area/cm^2/plant (1362.25), total dry matter (53.15 g), Root length (21.3 cm) at 90 DAS/T, Root weight (9.8 cm) at 90 DAS/T and Days to maturity (117). Application of nutrients as per crop requirement at various growth stages eventually leads to better utilization of nitrogen for growth and development (Aabid *et al*., 2016). The number of tillers per plant was significantly higher in 150 per cent RDF could attribute to more assured nutrients supply to the plants at active tillering stage. Further, tiller number and leaf size are

Table 3. Yield attributes and yield of rice as influenced by establishment methods and nutrient management practices during *Kharif* 2016.

Treatments					
Establishment techniques (M)	**Number of panicles/m²**	**Panicle length (cm)**	**10 Panicle weight (g)**	**Grain yield (kg/ha)**	**Straw yield (kg/ha)**
M_1	421	18	22.1	4820	5427
M_2	440	20	24.7	5330	5990
M_3	458	20	25.5	5760	6178
M_4	337	17	20.9	4285	4888
S.Em±	7	0	0.7	148	101
C.D. at 5%	24	1	2.4	513	350
Nutrient management practices (S)					
F_1	395	18	21.6	4458	5069
F_2	436	20	25.4	5777	6090
F_3	406	18	22.6	4619	5354
F_4	422	19	24.3	5400	5904
F_5	410	18	22.7	4990	5688
S.Em±	8	0	0.8	142	161
C.D. at 5%	23	1	2.2	409	462
Interactions					
S.Em±	16	1	1.5	284	321
C.D. at 5%	NS	NS	NS	NS	NS

Methods of crop establishment (04)
M_1: Manual transplanted rice
M_2: Mechanized transplanted rice
M_3: Dibbling of seeds followed by SRI principles
M_4: Wet direct seeded rice by broad casting (DSR)

Subplot: Nutrient management practices (05)
F_1: 100 % RDF
F_2: 150 % RDF
F_3: 75 % inorganic + 25 % Organic (N equivalent basis)
F_4: LCC based N application
F_5: UASB package of practices (FYM 10 t/ha + 100: 50: 50: kg NPK/ha + 20 kg $ZnSo_4$)

DAS/T: Days after sowing/transplanting
NS: Non significant

the two important factors which influence leaf area and these, in turn, are greatly affected by soil nutrient availability. This advantage of application of 150 per cent RDF enhancing tiller numbers, leaf area and total dry matter production, root length, root weight and days to maturity may be attributed to better synchronization in supply and demand of nitrogen at all the critical growth stages. Besides, high leaf area coupled with high chlorophyll content at flowering has been reported to affect the amount of photosynthates available to the panicle (Avijit *et al*., 2011).

Effect of establishment methods and nutrients on yield attributes and yield of rice

Among the different establishment methods dibbling of seeds followed by SRI principles significantly influenced the yield attributes and yield like number of panicles/m², panicle length, Panicle weight, grain yield and straw yield and recorded significantly higher seed yield (5760 kg/ha) and straw yield (6178 kg/ha) (Table III) which was attributed to higher values of yield components *viz.,* number of panicles/m² (458), 10 panicle weight (25.5 g), panicle length (20 cm), which was on par with mechanized transplanted method [seed yield (5330 kg/ha) and straw yield (5990 kg/ha), number of panicles/m² (440), 10 panicle weight (24.7 g), panicle length (20 cm)]. Optimum plant population and geometry under SRI system of planting led to availability of more resources to the plants that resulted in increased plant height and more number of tillers. This advantage of SRI method in enhancing tiller numbers, leaf area and dry matter production has been reported earlier by Jayadeva and Prabhakar Setty (2011) and Senthil Kumar (2016). Wet direct seeded rice by broadcasting produced lesser seed yield (4285 kg/ha) and straw yield (4888 kg/ha), number of panicles/m² (337), 10 panicle weight (20.9 g), panicle length (17 cm), which was mainly due to closer spacing of rice seedlings in broadcasting has shown intra-plant competition for same resources resulted in poor growth and yield components.

Among different nutrient management practices, significantly higher seed yield (5777 kg/ha) and straw yield (6090 kg/ha) was recorded in 150 per cent RDF which was attributed to higher values of yield components *viz.,* number of panicles/m² (436), 10 panicle weight (25.4 g), panicle length

(20 cm), which was on par with LCC based N application on yield and yield attributes [seed yield (5400 kg/ha) and straw yield (5904 kg/ha), number of panicles/m^2 (422), 10 Panicle weight (24.3 g), Panicle length (19 cm)]. There was a progressive increase in yield and yield attributes under 150 per cent RDF and LCC based N application system of planting when compared to UASB Package of practices, 100 per cent RDF and 75 per cent inorganic + 25 per cent Organic. This shows that the supply of nutrients in 150 per cent RDF and LCC based N application matched more effectively with the crop nutrient demand. Improving the synchronization between crop nutrients demand and the available nutrients supply is an important key to improve NUE. Nitrogen losses from soil-plant system are large thereby leading to low fertilizer NUE when nutrients application is not synchronized with crop demand. The results confirm the findings of Gupta *et al*. (2011) and (Avijit *et al*., 2011) This amply clarifies that the existing recommendation approach of lower rate of nutrients applications at specified growth stages is not adequate to synchronize nutrient supply with actual crop nitrogen demand due to poor NUE and variations in crop N demand and also loss of N results in lower yield and yield attributes. Thus, the study revealed that after taking into account the overall results of all the observed parameters among different establishment methods of rice, Dibbling of seeds followed by SRI principles and mechanized transplanted are the best adjudged treatments and nutrient management treatments for rice do not match with the crop demand. Hence, 150 per cent RDF recorded significantly higher grain yield but remained on par with LCC based N application. Hence, 150 per cent RDF or LCC based N application is one of the best tool for nutrient management in order to increase grain yield and N-use efficiency of rice for the Southern dry zone of Karnataka.

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Impact of Some Heavy Metals and Pesticides on *In Vitro* Pollen Germination of *Solanum distichum* Schumach. & Thonn. (Solanaceae) Growing in Darjeeling Himalaya

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ABSTRACT

The effect of heavy metals and pesticides on *in vitro* pollen germination of *Solanum distichum* Schumach. & Thonn. of the family Solanaceae is inadequately known but it is crucial aspect in determining the crop yield . The present investigation was conducted to know the effect of various concentrations of heavy metals (Cd, Cu, Ni and Zn) and pesticides (Carbofuran and DDT) on *in vitro* pollen germination of selected taxon.Fresh sample of pollen grains were collected just after anthesis and pollen germination study was performed by hanging drop technique in 10% sucrose supplemented with 100 ppm boric acid solution individually (as control) or in combination with various concentrations of salts of heavy metals and pesticides. Addition of various concentrations (10 ppm, 20 ppm and 30 ppm) of different salts ($CdNO_3$; $CuSO_4$; $NiCl_2$ and $ZnSO_4$) of heavy metals to the basal medium i.e. control (10% sucrose supplemented with 100 ppm H_3BO_3 solution) inhibited germination percentage. Low pollen germination with inhibitory effects werealso observed in the pesticides of various concentrations (10, 20 and 25 ppm) supplemented with usual basal medium compared to the control.A linear correlation was noticed indicating a significant inhibitory impact of heavy metals and pesticides on pollen germination of this important vegetable as a result of which the yield potential of this valuable vegetable might be reduced.

Key words *pollen, in vitro germination, heavy metals, pesticides*

Solanum distichum Schumach. & Thonn. of the family Solanaceae is used as a vegetable in different parts of Asia and Africa and claimed in folk medicine also to guard against cardiovascular disorders. It is an unarmed shrub. The edible fruit is gathered from the wild for local consumption in Darjeeling market which is bitter tasting. It is widely used as green vegetable during the months of March to July by people of Darjeeling [27°133 N to 26°27 3 N latitude; 88°53 3 E to 87°593 E longitude; 3,149 square Km area; 6710 feet altitude; annual mean max. temperature 14.9° Celsius; annual mean min. temperature 8.9° Celsius and average annual rainfall 3092 mm] hill areas which are unique from environmental eco-perception. Local people used it to lower their blood pressure. It is cultivated throughout Darjeeling town. Usually two types of pesticide like Carbofuron and DDT are used as foliar spray (at the concentration of not more than 25 ppm as per recommended dose suggested by Agrochemical Industry) to protect the vegetable from attacking pests. At the same time the floral parts are exposed to the pesticides as results of which the male reproductive unit of this plant i.e. pollen grains are getting exposed to the pesticides. A good number of cultivated lands are situated behind the leather and handicrafts factory where from good quantity of effluents is drained off the field. Although the composition of effluents are yet to be studied but it is assumed that the effluents might contain various heavy metals like Ni, Cd, Zn and Cu which may show a great impact upon pollen germination of this species. The reproductive success rate and yield potential is dependent on viable pollen and loss of pollen viability in terms of low germinating ability of pollen is prerequisite for successful fruit set and crop yield (Shavanna and Johri, 1989).Considering this aspect, the studies on the impact of pesticides and heavy metals on pollen germination of this valuable crop species has been investigated as there are very little or scarce documentation in this frontier of research based on the selected crop species (Raskin *et al*., 1994; Sawidis and Reiss,1995; Pavlik and Jandurova, 2000; Tuna *et al*., 2002; Sawidis, 2008; Dutta Mudi and Mondal, 2015; 2016 and Ghanta and Mondal,2016).

MATERIALS AND METHODS

Fresh pollen grains from mature anthers of *Solanum distichum* Schumach. & Thonn. of the family Solanaceae were collected just after the pollen anthesis. For each culture the pollen was collected from the stamens of a single flower and the samples were mixed thoroughly. Pollen germination percentage was observed by hanging drop technique (Shivanna and Rangaswamy, 1992), using 10% sucrose supplemented with 100 ppm H_3BO_3 solution as basal medium (Brewbaker and Kwack, 1963) considered as controlled system. Effect of $CdNO_3$; $CuSO_4$; $NiCl_2$ and $ZnSO_4$ on germination percentage was studied by supplementing basal medium with 10, 20 and 30 ppm of these heavy metals. Effects of pesticides on germination percentage were studied by supplementing basal medium with 10, 20 and 25 ppm of Carbofuran and DDT solution. The cultures were stored at laboratory temperature (18-20$^{a\%}$C) in the PG Department of Botany of Darjeeling Government College. The pollen grains are considered as germinated when the length of the pollen tube becomes equal to the diameter of the pollen (Shivanna and Rangaswamy, 1992). All the cultures in grooved slides were run in duplicate and average results of ten microscope fields were scored at random and the data were analyzed for two-way analysis of variance (ANOVA, Model II) and test of significance ($P<0.05$) between each treatment. In order to determine the impact of heavy metals and pesticides on *in vitro* pollen

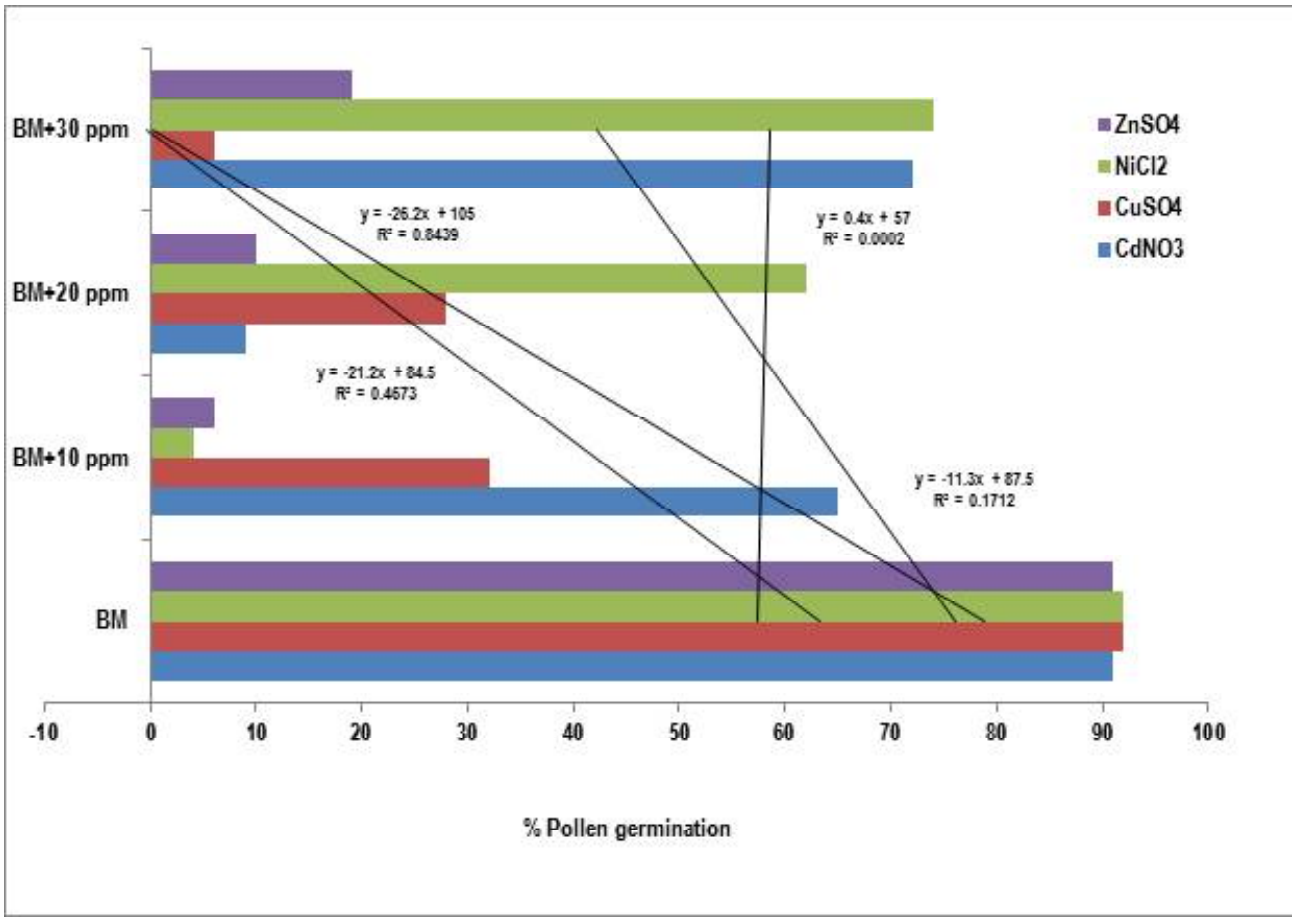

Fig. 1. Effects of heavy metals on *in vitro* pollen germination of *Solanum distichum* (BM=basal medium i.e. control)

germination of selected taxon, the independence of attributes in contingency table was tested using c^2statistics. Mean values from all replicates were pooled and standard error of these values was calculated and pair-wise comparisons of all combinations with student's t-tests was made using SPSS software (SPSS Inc., USA).

RESULTS AND DISCUSSION

Highest percentage of germinating pollens was recorded in basal medium i.e. controlled system (10% sucrose supplemented with 100 ppm H_3BO_3 solution. Addition of various concentrations (10 – 30 ppm) of different salts of heavy metalslike Cd, Cu, Ni and Znin combination with basal medium inhibited the rate of percent pollen germination showing significant reduction ($F= 6.158$, d.f. = 34, 69; $P<0.05$) of germinating ability and negetive correlation ($y = -26.2x + 105$, $R^2 = 0.843$; $y = 0.4x + 57$, $R^2 = 0.000$; $y = -21.2x + 84.5$, $R^2 = 0.467$; $y = -11.3x + 87.5$, $R^2 = 0.171$ for salts of Cd, Cu, Ni and Zn respectively) between the doses of heavy metal concentration (Fig. 1).Percentages of pollen germination were less in basal medium supplemented with 25 ppm solution of carbofuran and DDT. Highest percentages of germinating pollens were recorded in basal medium individually but significantly inhibitory effect($F= 4.954$, d.f. = 7, 17; $P<0.05$) of pesticides at various concentrations in combination with basal medium was also noticed showing negative correlation ($y = -25.4x + 126.5$, $R^2 = 0.919$; $y = -24.4x + 121.5$, $R^2 = 0.928$ for DDT and carbofuran respectively) between the doses of pesticide concentration (Fig. 2).

The family Solanaceae is one of the most important families of flowering plants from economical, floristic approach and, ethnobotanical point of view. In Angiosperms, the energy required for pollen germination is provided from the nutriment reserves. These reserved nutriments in pollens play a very important role in the regulation of sucrose concentration during pollen germination (Bhattacharya and Mandal, 2000). Pollen utilized sugar as an energy source for the synthesis of cell wall material like pectins, cellulose and callose, during pollen tube elongation (Derksen *et al*., 1995). It is also reported that, boron added to the medium improves pollen germination and growth in many taxa and boron is instantly involved in pectin synthesis and thus indirectly involved in the development of the pollen tube membrane (Bhattacharya and Mandal, 2004). By nature, style provided water, sugar, amino acids to nourish the growing pollen tube. It is also known that, boron is also provided by stigmas and styles and helps in sugar uptake and has a role in pectin production in the pollen tube (Taylor and Hepler, 1997). Boron deficiency can cause low pollen viability, poor pollen germination and decreased pollen tube growth (Nyomora and Brown, 1997). The farmers used to apply pesticides extensively on various crops; hence, there is an account of the biochemical changes and residual

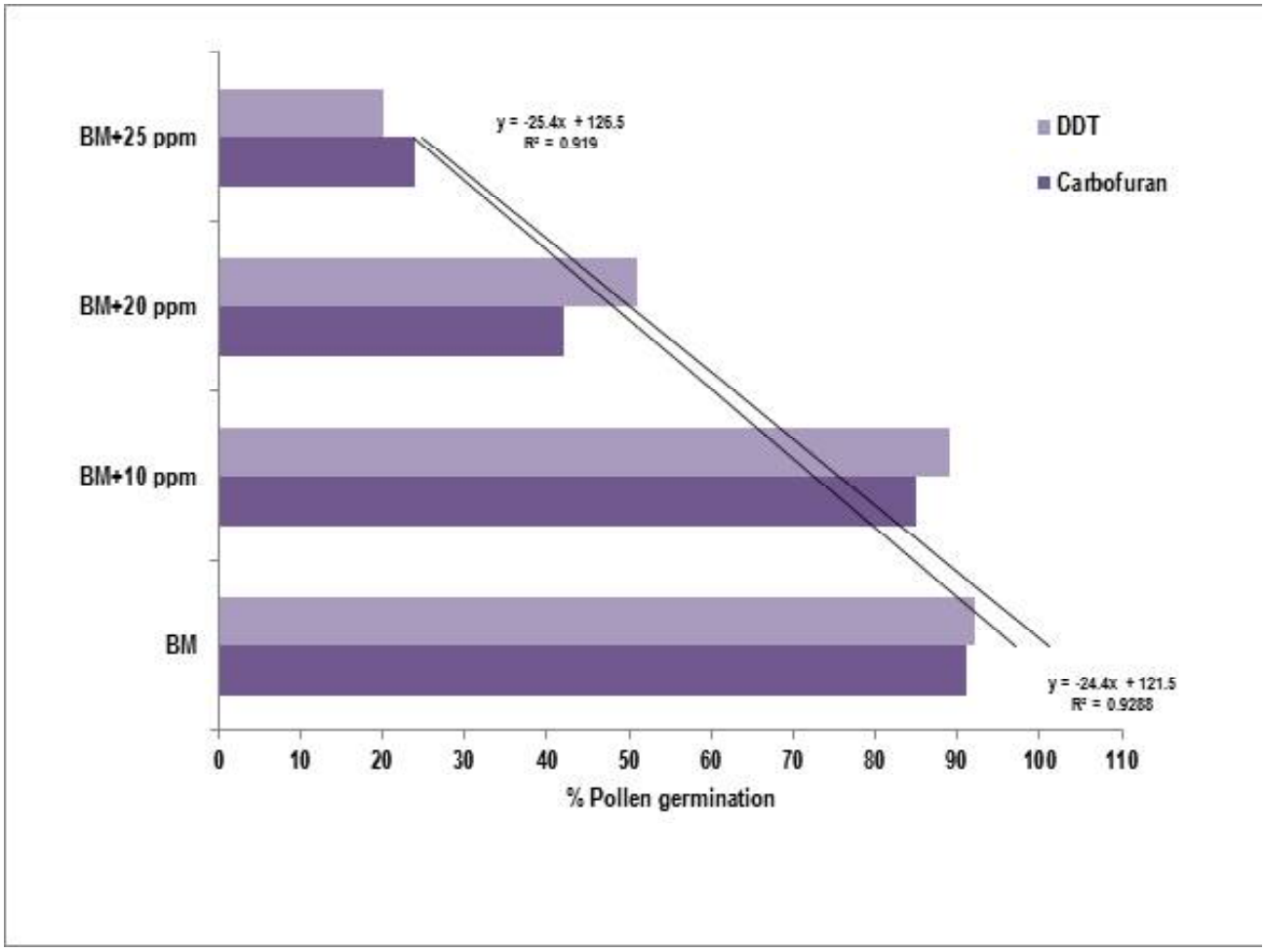

Fig. 2. Effects of pesticides on *in vitro* pollen germination of *Solanum distichum* (BM=basal medium i.e. control)

concentration induced in the plants (Pavlik and Jandurova, 2000). In spite of these, used concentrations are as per the recommendation given by the Agrochemical industry. But, it is noticed to decrease *in vitro* pollen germination. The decreased rate of germinating pollens following treatment with different salts of heavy metals and pesticides might be due to affected pollen grains along with pollen tube development. Affected pollen tubes showed different abnormalities like swelling of tube tip, thickened tube wall, uneven tube development, coiling and bulging of pollen tubes and finally bursting sometimes which may be due to changes involved in cytoskeleton and actin filaments, vesicular structure and cell wall organisation (Sawidis, 2008; Sawidis and Reiss,1995). The rate of pollen germination (%) was significantly found to be low following treatment with salts of heavy metals and pesticides. It is reported that Cd, Cu, Ni and Zn are toxic for plants (Raskin *et al*., 1994). Heavy metals affect the electron transportation during respiration and inhibit the plant growth indirectly by preventing enzyme activity (Larcher, 1995). The toxic effect of Cd, Cu, Ni and Zn on the germination, ultrastructure and pollen tube growth of *Lilium longiflorum* are reported by Sawidis and Reiss (1995). Compounds with Hg, Cd and Ni among heavy metals prevent DNA replication and protein synthesis, causing mitotic anomalies and that Cu has similar effects causing chromosomal aberration (De Flora *et al.,* 1994). The abnormalities of germination rate and pollen tube elongation might be due to the presence of cadmium toxicity which has a supposed role in reducing cell wall plasticity in growing pollen tubes. It is evident that cadmium acts primarily on cell wall development in germinating and growing pollen tubes where local wall thickenings or protuberances consisting of disordered micro fibrils were observed (Heumann, 1987). It is attributed that the interaction of metal ions with the anionic contents of secretory vesicles and the fact that pollen tube cell walls contain large quantities of pectins and callose but less cellulose (Sawidis and Reiss, 1995). This special feature of pollen tube cell walls may result in a reaction different from that of other plant cells that possess a normal cellulosic cell wall. Consequently, normal growth and germination rate are inhibited corroborating the views of Tuna *et al*., 2002; Dutta Mudi and Mondal, 2015; 2016 and Ghanta and Mondal,2016 who extensively studied the toxic effect of heavy metals like Ni, Fe, Pb, Co, Cd, Hg, Al, Zn and Cu showing pronounced effects on pollen germination and tube length of different plants having economic values where they haveproved the effect of heavy metals on pollen germination and pollen tube development, the important pre-requisite factor for successful fruit set and crop yield.The observation clearly suggest that the presence of air and water borne heavy metals which occur around our environment might inhibit pollen fertility and pollen germination of this important crop vegetable and ultimately reducing yield. It is attributed that the increased percentage of germinating pollens might be due to higher mobility of

storage sugar inside pollen grain for good enzymatic activity whereas, the enzymatic activities might be damaged due to the effect of pesticides as a result of which the germinating ability of pollens are reduced. There is a considerable impact of tested heavy metals and pesticides upon pollen germination as a result of which the yield potential of this important vegetable become less in Darjeeling district of West Bengal.

CONCLUSION

From the above discussion, it is concluded that as the dosage of heavy metals and pesticides increased, the pollen germination decreased than control. Further, a strong negative impact of heavy metals and pesticides tested on pollen growth and vigour in terms of germination and tube elongation is observed; although plants are adapted to tolerate the toxic effect imposed by heavy metals and pesticides; as such to be acclimatized more for sexual fitness and adaptive radiation, so that the exposed plants might be able to sustain in polluted environment.

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Feeding potential of *Chrysoperla zastrowi sillemi* (Neuroptera: Chrysopidae) on Cotton Aphid, *Aphis gossypii* Glover

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ABSTRACT

The feeding potential of *Chrysoperla zastrowi sillemi* (Esben-Peterson) larvae on cotton aphids were studied at Bio-control Laboratory, Department of Agricultural Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during September to October 2014. In no choice feeding against cotton aphids, the feeding potential of larvae of *C. zastrowi sillemi* was found more on nymphs (medium sized) than adults (freshly formed). The feeding potential was 264 to 350 (Av. 320.95 ± 17.86) nymphs of aphids with consumption rate of 26.40 to 37.00 (Av. 32.46 ±2.16) nymphs whereas it was 184 to 213 (Av. 198.15 ± 17.86) adults of aphids with consumption rate of 19.37 to 23.67 (Av. 21.67 ± 1.03) adults. The larvae developed little bit faster when fed exceptionally on younger adults (9.03 ± 0.11 days) than nymphs (9.50 + 0.31 days) of aphids. In free choice feeding, the feeding potential was 343 to 399 (376.10 ±11.13) aphids by giving preference to nymphs more as per the consumption proportion of 219 to 253 (241.15 ± 7.88) nymphs and 124 to 146 (134.10 ± 5.98) adults in mixed stages of aphids offered. The consumption rate was 34.30 to 42.22 (38.65 ± 2.16) aphids per day in its larval duration of 9 to 10 (9.75±0.44) days.

Key word *Aphis gossypii*, *Chrysoperla zastrowi sillemi,* feeding potential

Aphid, *Aphis gossypii* Glover is the most common and important sucking pest of cotton and many other crops causing significant yield reduction when high density infestation occurs. Due to growing environmental and economic concerns involved in the use of pesticides, there is need to develop alternative measures for the management of sucking pests. Pesticides lead to many serious problems like pollution, health hazards, biodiversity threat, pest resurgence, pest resistance and secondary pest out-breaks in ecosystem (Bellows, 2001). Biological control is an effective means of achieving insect control (Pedigo and Rice, 2000). In natural ecosystem, the common green lacewing, *Chrysoperla carnea* (Stephens) has been recorded as an effective predator of aphids, including *Aphis gossypii* Glover (Burke and Martin,1956; Yuksel and Gocmen, 1992; Balasubramani and Swamiappan, 1994; Zaki *et al.,* 1999) especially under pesticides free environment. The green lacewing, *Chrysoperla zastrowi sillemi* (Esben-Peterson) in the field preferred to oviposit on cotton followed by okra and laid eggs on stalks particularly on lower surface of leaves for oviposition followed by stem (Chakraborty *et al.*, 2011). The common green lacewing *Chrysoperla zastrowi sillemi* seems to be a good candidate in IPM programme, as it is a voracious feeder (Balasubramani and Swamiappan, 1994), display a relative broad range of acceptable preys (Hydron and Whitecomb, 1979), easy to mass produced (Morrison, 1985 and El-Arnaouty, 1991) and is tolerant to some groups of pesticides (Hassan *et al.,* 1989; Bigler and Waldburger, 1994 and Chen and Liu, 2002). The occurrence of *C. zastrowi sillemi* along with its prey insects in cotton ecosystem of south Gujarat necessities to evaluate the feeding potential of *C. zastrowi sillemi* larvae as biological control agents to different stages of aphid (nymph and adult) with no choice and free choice feeding under laboratory condition.

MATERIAL AND METHODS

The study of feeding potential of *C. zastrowi sillemi* on aphid and mealy bug was carried out in the Bio-control Laboratory, Department of Agricultural Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during September to October 2014 at average room temperature of 24.03 ± 1.75 °C and relative humidity of 73.08 ± 2.86 per cent.

Maintenance of Aphid and *Chrysoperla* culture:

The initial culture of aphid was collected from the cotton fields of Research farm, Main Cotton Research Station, Navsari Agricultural University, Surat during June to August 2014. For the purpose, aphid infested cotton twigs along with leaves preferably adults were plucked and collected in perforated plastic bags, separately. The initial culture, so obtained were released for establishment on 60 days old cotton plants raised in pots (45 cm height × 18.5 cm diameter) in the wire netting inventory of Bio-control Laboratory, Department of Agricultural Entomology, Navsari Agricultural University, Navsari. The culture so established within one and half month was utilized as prey hosts for studying feeding potential of *C. zastrowi sillemi.* The laboratory culture of *C. zastrowi sillemi* was obtained from *Chrysoperla* Rearing Unit, Bio-control Laboratory, Department of Agricultural Entomology, N.A.U., Navsari. The pupae of *C. zastrowi sillemi* were placed in glass vial separately for adult emergence. Freshly emerged adults were released in rectangular oviposition cage of size 50 × 30 × 17 cm (Length x Width x Height) covered with a black muslin cloth inside the lid of the cage to facilitate egg laying. Semi solid paste of artificial diet (composed of 4 g of each ingredients of honey, proteinex powder, glucose, fructose, yeast powder, milk powder in equal quantity of distilled water with dispersible vitamin E capsule along with castor pollens) were placed on cotton swab in small plastic container inside at the bottom of the oviposition cage as a adult artificial diet. Eggs laid by the female on the under surface of lid of the cage on black muslin cloth which were removed individually with the help of a soft sponge pad for

removing the stalk of eggs and kept individually with the help of fine camel hair brush and placed in separate plastic vials (5 x 2.5 cm) for further rearing and to avoid cannibalism. A special care was also taken to avoid mechanical injury to the eggs during detaching the eggs from the stalk. On hatching, the larval instar of *Chrysoperla* was reared on laboratory host (eggs of rice grain moth, *Corcyra cephalonica* (Stainton) till pupae formation and again the eggs were collected as per aforementioned techinique. Neonate larvae of *C. zastrowi sillemi* obtained through mass rearing as above were utilized for the present investiation.

Assessment of feeding potential, Consumption rate and developmental duration:

The predatory potential of the larval instars of *C. zastrowi sillemi* against nymphs and adult stage of aphid was studied as per no choice and free choice feeding trials separately under laboratory conditions. In both the trials, care was also taken to provide medium sized (second instar) nymphs and freshly formed adults of aphid for study purpose.

No choice feeding experiment: Twenty neonate larvae of *C. zastrowi sillemi* were kept individually in the plastic vial (5 × 2.5 cm). Two such sets of 20 larvae under plastic vials were prepared. One set was utilized for studying predatory potential against nymph of aphid as prey stage and in other set, adult aphids were provided as prey insect throughout the total larval development. While offering the adult aphids, utmost care was taken to remove matured aphids and provide only the second stage nymphs for release as food. In both the set, known number of prey stage was released as food and the record was maintained on rate of consumption daily. On next day, again counted number of prey stage was offered as food and the consumption of prey insect was calculated. Predatory insect were observed daily in the morning and evening for change of instar. Number of prey consumed by the predatory larvae in each instar was calculated for each individual and the total consumption during total larval stage was worked out. The total larval duration of *C. zastrowi sillemi* was also estimated for both the stages of aphid, separately and per day consumption of prey stages was also calculated.

Free choice feeding experiment: Twenty neonate larvae of *C. zastrowi sillemi* were kept individually in the plastic vial (5×2.5 cm). The set of 20 larvae under plastic vials were prepared. The set was utilized for studying predatory potential against mixed stages of aphid (both nymphs and adults) as prey provided throughout the total larval developmental period. In the set, known number of mixed stages (nymphs+adults) were released as food and the record was maintained separately for nymphs and adults consumed daily by the individual larvae. On next day, again counted number of nymphs and adults as mixed stages was offered as food and the consumption of prey insect (each of nymphs and adults) was calculated. Predatory larvae were observed daily in the morning and evening for change of instar. Number of mixed stages of prey consumed by the predatory larvae in each instar was calculated for each individual and the total prey consumption (both nymph and adults) during total larval stage was worked out. The total larval duration of *C. zastrowi sillemi* was also estimated and per day consumption of mixed stages with dominance of particular stage was also calculated.

RESULTS AND DISCUSSIOIN

No choice feeding :

Under no choice feeding experiment exclusively with nymphs of aphids as food source, the grubs of *C. zastrowi sillemi* consumed 54.55 ± 8.88, 109.85 ± 11.74 and 156.55 ± 13.67 nymphs of aphid in developmental durations of 2.90 ± 0.31, 3.10 ± 0.31 and 3.90 ± 0.31 days of first, second and third larval instars, respectively (Figure 1 and Table 1). The grub of *C. zastrowi sillemi* consumed 264 to 350 (Av. 320.95 ± 17.86) nymphs of aphids during developmental durations of 9 to 10 (Av. 9.90 ± 0.31) days. The prey consumption rate varied from 14.50 to 21.33 (Av. 18.71 ± 1.72), 32.00 to 40.67 (Av. 35.48 ± 2.50) and 27.25 to 53.00 (Av. 40.42 ± 5.03) nymphs

Table 1. Feeding potential of *C. zastrowi sillemi* on different stages of *A. gossypii* (No choice feeding)

Larval stages of *C. zastrowi sillemi*	No. of larvae exposed	No. of aphid consumed			Rate of consumption/day			Developmental duration in days		
		Min.	Max.	Av. ± S. D.	Min.	Max.	Av. ± S. D.	Min.	Max.	Av. ± S. D.
Nymphs of aphid as prey										
I instar	20	29	64	54.55 ±8.88	14.50	21.33	18.71 ±1.72	2.00	3.00	2.90 ±0.31
II instar	20	96	139	109.85 ±11.74	32.00	40.67	35.48 ±2.50	3.00	4.00	3.10 ±0.31
III instar	20	109	175	156.55 ±13.67	27.25	53.00	40.42 ±5.03	3.00	4.00	3.90 ±0.31
Total	**--**	**264**	**350**	**320.95 ±17.86**	**26.40**	**37.00**	**32.46 ±2.16**	**9.00**	**10.00**	**9.90 ±0.31**
Adults of aphid as prey										
I instar	20	12.00	34.00	25.00 ±6.20	6.00	11.33	8.79 ±1.25	2.00	3.00	2.80 ±0.41
II instar	20	45.00	91.00	67.95 ±14.99	21.67	27.33	24.29 ±1.69	2.00	4.00	2.80 ±0.62
III instar	20	82.00	131.00	105.20 ±14.88	27.33	35.33	31.03 ±2.13	3.00	4.00	3.40 ±0.50
Total	**--**	**184.00**	**213.00**	**198.15 ±8.16**	**61.33**	**71.00**	**66.05 ±2.72**	**9.00**	**9.50**	**9.03 ±0.11**

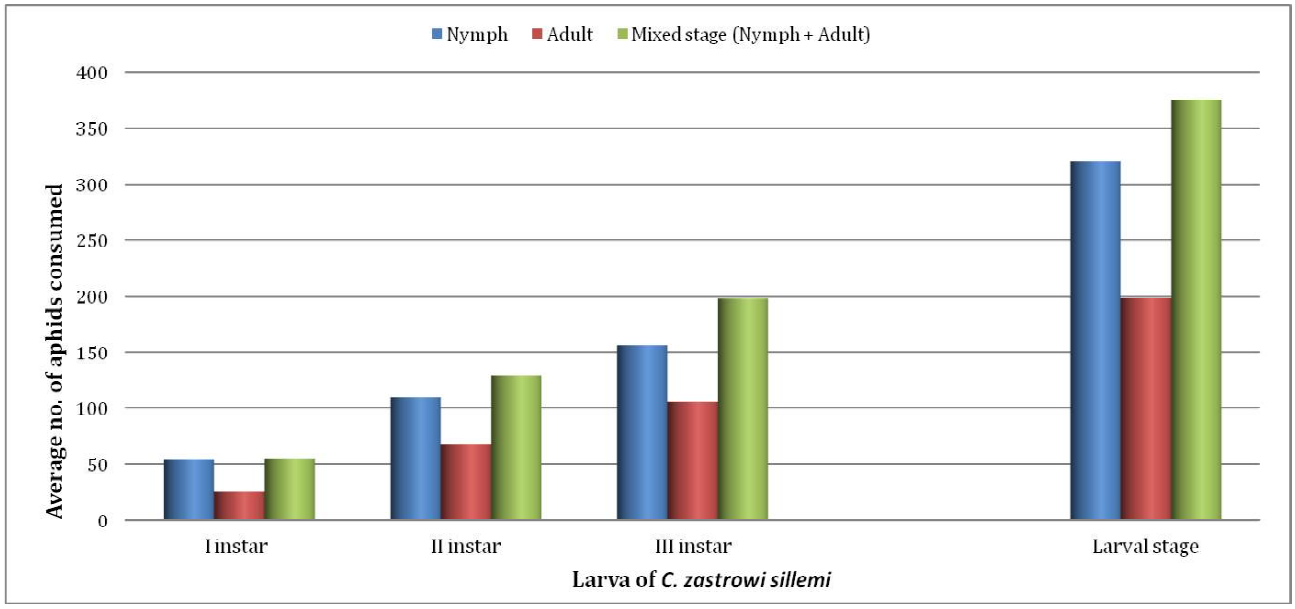

Fig. 1. Feeding potential of *C. zastrowi sillemi* on nymphs and adults (No choice feeding) and mixed stages (Free choice feeding) of aphids, *A. gossypii*

of aphid per day during first, second and third instars of *C. zastrowi sillemi*, respectively. During entire larval period prey consumption rate varied from 26.40 to 37.00 (Av. 32.46 ±2.16) nymphs.

Similarly, under no choice feeding exclusively by using younger adult aphids as food source, grubs of *C. zastrowi sillemi* consumed 25.00 ± 6.20, 67.95 ± 14.99 and 105.55 ± 14.88 adults of aphid in developmental durations of 2.80 ± 0.41, 2.85 ± 0.62 and 3.40 ± 0.50 days of first, second and third larval instars, respectively (Figure 1 and Table 1). The grub of *C. zastrowi sillemi* consumed 184 to 213 (Av. 198.15 ± 17.86) adults of aphids during developmental durations of 9 to 9.5 (Av. 9.03 ± 0.11) days. The prey consumption rate varied from 6.00 to 11.33 (Av. 8.87 ± 1.23), 15.33 to 27.33.67 (Av. 23.90 ± 2.62) and 27.33 to 35.33 (Av. 31.03 ± 2.13) adults of aphid per day during first, second and third instars of *C. zastrowi sillemi*, respectively. During entire larval period prey consumption rate per day varied from 19.37 to 23.67 (Av. 21.67 ± 1.03) adults.

Free choice feeding:

Under free choice feeding with mixed stages of nymphs and younger adults of aphids, the grubs of *C. zastrowi sillemi* consumed 55.20 ± 3.89, 129.20 ± 5.85 and 197.70 ± 8.25 mixed stages of aphid (nymphs and adult) in developmental durations of 2.9 ± 0.31, 3.1 ± 0.31 and 3.9 ± 0.31 days of first, second and third larval instars, respectively (Figure 1 and Table 2). The grub of *C. zastrowi sillemi* consumed 343 to 399 (Av. 376.10 ± 11.13) numbers of aphids (mixed stages) during developmental durations of 9 to 10 (Av. 9.75 ± 0.44) days. The grub of *C. zastrowi sillemi* preferred nymphs of aphid more compared to adult stage of aphid as indicated by proportion of 241.15 ± 7.88 nymphs and 134.10 ± 5.98 adults consumed out of 376.10 ± 11.13 number of aphids (mixed stages). The prey consumption rate varied from 16.67 to 21.67 (Av. 18.41 ± 1.29), 36.33 to 61.50 (Av. 43.11 ± 6.50) and 43.25 to 64.33 (Av. 51.03 ± 4.92) number of aphids (mixed stages) per day during first, second and third instars of *C. zastrowi sillemi*, respectively. During entire larval period prey consumption rate varied from 34.30 to 42.22 (Av. 38.65 ± 2.16) numbers of aphids (mixed stages).

Under no choice feeding, the second and third instar grubs of *C. zastrowi sillemi* fed more number of nymphs than first instar and were voracious feeder. Further, the third instar larva was very active and voracious feeder and observed to capture another nymph immediately after feeding on one nymph, might be due to more nutrition required for growth and development. The grub of *C. zastrowi sillemi* developed little bit faster when fed exclusively on adults of aphids than nymphs and consumed less number of adults than nymphs of aphids. This might be due to force feeding on nutritive diets in form of adults of aphids. Under free choice feeding, the grub was found to feed and capture more nymphs compared to younger adults as the soft body, small size and stationery feeding habit of nymphs provided easy arrest by the grub of *C. zastrowi sillemi*. Further, there was not much variation in development duration of larvae of *C. zastrowi sillemi* when fed on mixed stages (nymphs and adults) in no choice feeding then fed on nymphs of aphids in free choice feeding conditions. However, larvae of *C. zastrowi sillemi* developed little bit faster when fed exceptionally on adults of aphids in no choice feeding conditions.

The larvae of *C. zastrowi sillemi* preferred nymphs of aphid (younger) more as compared to adult under free choice feeding condition. Balasubramani and Swamiappan (1994) reported that the consumption of 419.8 aphids in 20.15 days. Liu and Chen (2001) found that the consumption of 292.4 aphids in 19.08 ± 0.4 days and Kale *et al.* (2014) reported that the consumption of 355.51 cotton aphids. In present study also, the larvae of *C. zastrowi sillemi* consumed 264 to 350 (320.95 ± 17.86) nymphs in 9 to 10 (9.90 ± 0.31) days in no choice feeding condition which was more or less in confirmation with above reports. The deviation in total larval developmental duration might be

Table 2. Feeding potential of *C. zastrowi sillemi* on *A. gossypii* (Free choice feeding)

Larval stages of *C. zastrowi sillemi*	Mathematical functions	No. of mixed stages of aphid consumed			Rate of consumption when mixed stages offered (No./day)			Duration in days
		Nymphs	Adults	Total	Nymphs	Adults	Total	
I instar	Min.	20	14	35	10.00	4.67	16.67	2
	Max.	44	21	65	14.67	7.00	21.67	3
	Av ± S. D.	36.7 ±5.16	17.65 ±2.08	55.2 ±3.89	12.40±1.25	5.88 ±0.69	18.41±1.29	2.9 ±0.31
II instar	Min.	66	43	109	22.00	14.33	36.33	3
	Max.	82	51	133	27.33	17.00	61.50	4
	Av ± S. D.	74.75 ±4.05	48.45 ±2.24	129.20 ±5.85	24.92 ±1.35	16.15 ±0.75	43.11 ±6.50	3.1 ±0.31
III instar	Min.	114	59	173	28.50	14.75	43.25	3
	Max.	138	74	211	34.50	18.50	64.33	4
	Av ± S. D.	129.70 ±5.14	68.00 ±4.74	197.70 ±8.25	32.43 ±1.29	17.00 ±1.18	51.03 ±4.92	3.9 ±0.31
Total Consumption	**Min.**	**219**	**124**	**343**	**73.00**	**41.33**	**34.30**	**9**
	Max.	**253**	**146**	**399**	**84.33**	**48.67**	**42.22**	**10**
	Av ± S. D.	**241.15±7.88**	**134.10 ±5.98**	**376.10±11.13**	**80.67 ±2.47**	**44.70 ±1.99**	**38.65 ±2.16**	**9.75 ±0.44**

due to prevailing environmental conditions and difference in rearing of prey host. The present findings on developmental duration of first, second and third instar of *C. zastrowi sillemi* was 2.90 ± 0.31, 3.10 ± 0.31 and 3.90 ± 0.31 days, respectively is in confirmation with the findings of Takalloozadeh (2015) who found that the developmental duration of 3.85 ± 0.17, 2.94 ± 0.91 and 3.13 ± 0.20 days in respective instars when reared on nymphs of *A. gossypii*.

The consumption rate of first, second and third instar grub of *C. zastrowi sillemi* was 14. 50 to 21.33 (18.71 ± 1.72), 32.0 to 40.67 (35.48 ± 2.50) and 27.25 to 53.00 (40.42 ± 5.03) nymphs, respectively which was in close proximity with the reports of Thite and Shivpuje (1999) who reported that the consumption rate was 32.40, 32.47 and 47.20 nymphs and Chakraborty and Korat (2010) as 22.47 ± 10.66, 25.13 ± 7.53 and 31.07 ± 8.63 nymphs in respective instars. Further, in present study, the first, second and third instar larvae of *C. zastrowi sillemi* consumed 29 to 64 (54.55 ± 8.88), 96 to 139 (109.85 ± 11.74) and 109 to 175 (156.55 ± 13.67) nymphs, respectively. Earlier, Kapadia and Puri (1992) found that the feeding potential of the first, second and third instar of *C. carnea* as 55.88 ± 19.59, 143.16 ± 30.73 and 566.47 ± 65.38 nymphs, respectively. Aravind *et al*. (2012) found that the feeding potential of 10.94, 37.07 and 213.71 aphids (*A. gossypii*) while Gosalwad *et al*. (2010) reported that 16.20, 47.0 and 215.70 aphids in respective instars. Solangi *et al.* (2013) reported that the feeding potential of 66.14 ± 2.18 nymphs of aphids in third instar larvae. The slight deviation in the present findings might be due to differences in nutrition and prevaling environmental conditions of rearing of prey insects and predator. The nutrition of the host plants on which aphids fed, might affect the quality of prey insect and indirectly the development and predation of *C. zastrowi sillemi*. Thus, the grub of *C. zastrowi sillemi* showed good potential against the nymphs of *A. gossypii* and can be taken advantage in integrated management of aphids infesting cotton.

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SHORT COMMUNICAITON

Study on Disease Symptoms and Character of Pathogen *Corynespora cassiicola* (berk. and curt.) wei. Caused by Target Leaf Spot of Soybean

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Soybean (*Glycine max.* L. Merril) belonging to family Leguminaceae is designated as miracle bean established its potential as an industrially vital and viable oilseed crop in many areas of India. Soybean plant is known to suffer from many diseases but target leaf spot caused by *C. cassiicola* is considered to be most important in India and also for the Chhattisgarh. The target leaf spot disease of soybean was first reported in 1945 (Olive *et al.,* 1945). Target leaf spot is considered potentially a serious disease, especially on late maturing cultivars. The yield losses to an extent of 18-32 percent have been recorded in susceptible soybean lines grown in Mississippi during years when rainfall was above normal in August and September

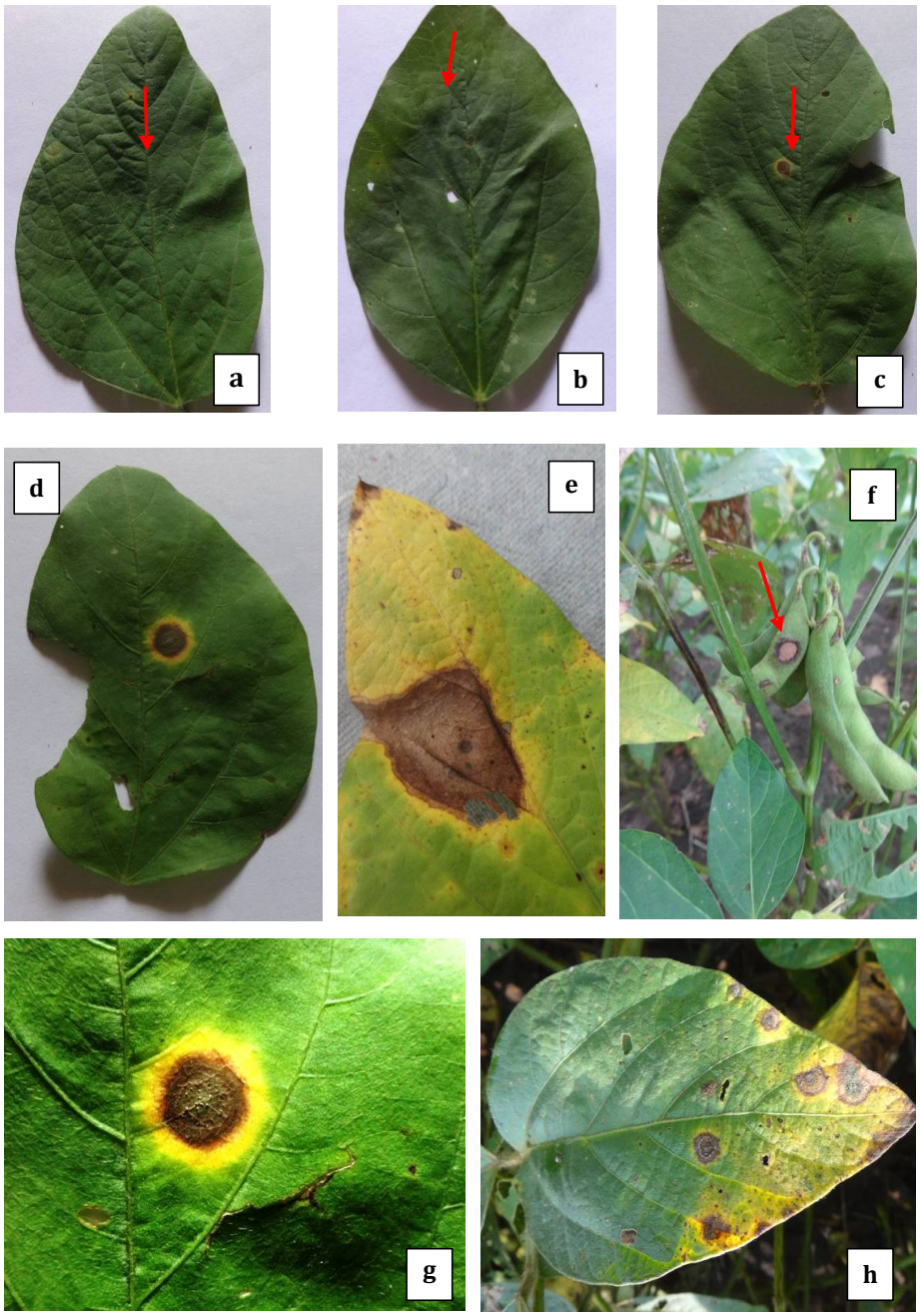

Plate 1. Exhibiting the symptoms of target leaf spot of soybean disease in different stage of development. Initial stage (a,b). Developed stage(c,d). Collapsed (e). Symptoms appeared on petiole and pod (f). Close up of d(g) . Later stage (h).

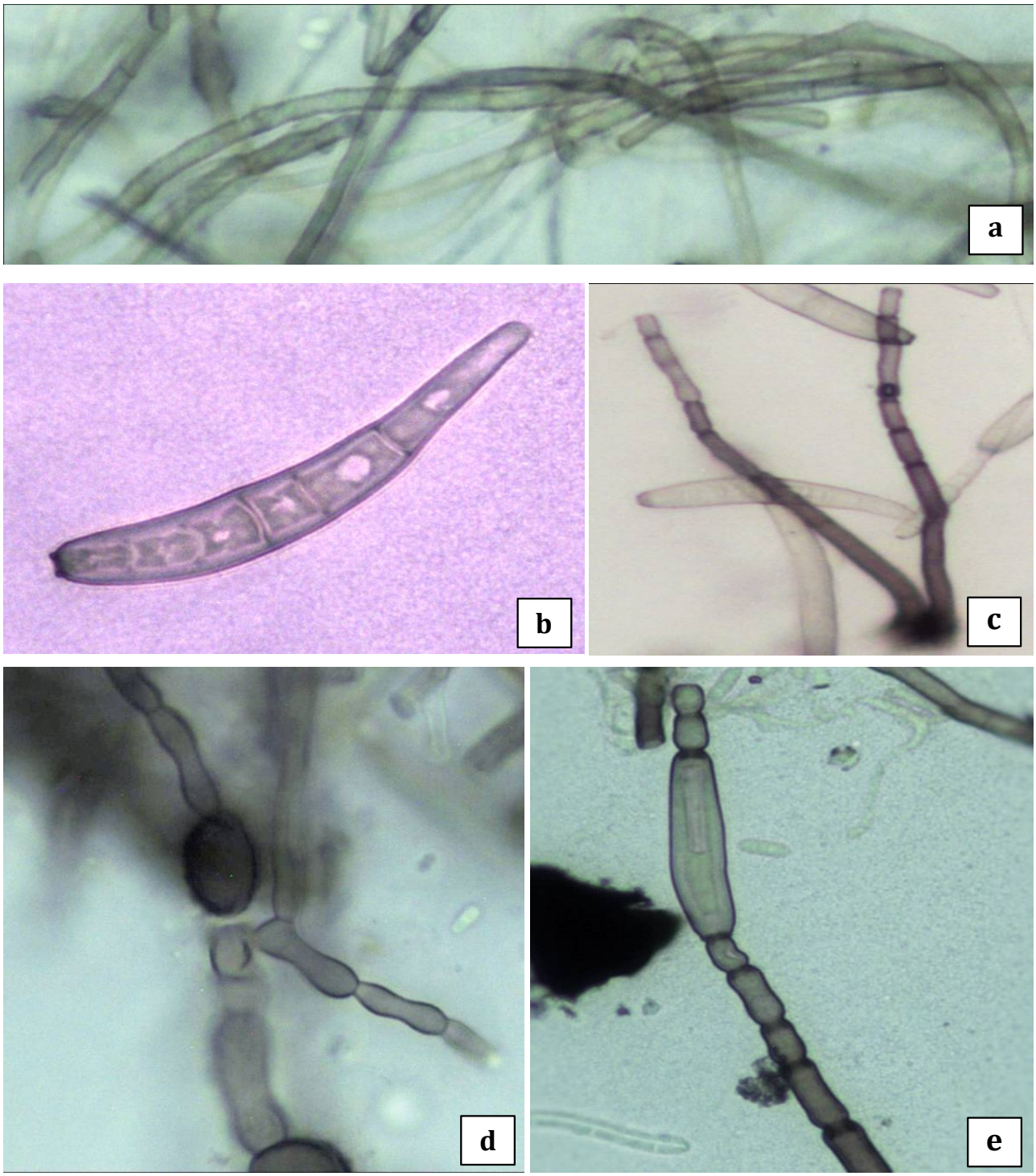

Plate 2. Characters of the fungus *Corynespora cassiicola*. a. mycelium. b. conidia. c. conidiophores. d. chlamydospores. e. conidia formed on conidiophores.

The present study was carried out Disease symptoms produce and characters of pathogen *Corynespora cassiicola*. The first study in disease symptoms after 60 days of sowing, disease appeared at lower leaves and affected the stems, petioles and pods of the soybean (Plate 1). The symptoms developed were as follows: 1. Leaves- The initial symptoms on leaves appeared as yellowish to brown dots on leaf surface, which later enlarged to become round to irregular and reddish brown in colour, the diameter of spots varied from 10 to 15 mm within 5-6 days under field condition. The initial lesion was surrounded by a dull or yellowish green halo. The number of such spot appeared on leaf lamina and collapsed to each other and formed a big spot. The leaves become yellow and drop prematurely. 2. Stems, petioles and pods- the infected areas on the stems and petioles were dark brown elongated and spindle shaped. The spots on pods were mostly circular with slightly depressed and dark brown in color. Sinclair (1982) also observed and reported similar symptoms on soybean plants. Target spot affected the leaves, stems, petioles and pods. Leaf lesions were rounded to irregular and reddish brown. Lesions were frequently surrounded by a dull green

or yellowish green halo. Large spots were often distinctly zonate. Severely infected leaves drop prematurely. Phipps *et al*. (2010) observed round to irregular, reddish-brown lesions surrounded by dull green or yellowish green halo. Larger spots may contain light and dark rings, hence the name, target spot.

The second study is character of pathogen mycelium septate, branched, slender, sub-hyaline to pale brown, hyphae mostly submerged in the sub stratum, Conidiophores arising singly from the mycelium, 3-7 septate, unbranched, erect, straight to slightly curved, pale-brown in colour. Conidia formed singly or in chains of 2 - 3 at the apex of the conidiophore, cylindrical to obclavate, straight to slightly curved, sub-hyaline to pale olivaceous brown, smooth walled, 0 - 16 pseudosepta, hilum at the base. The conidia formed on naturally infected leaves are somewhat bigger measuring 22.4 – 168.8 x 6.3 - 12.4 mu. Chlamydospores formed in older cultures, which were hyaline, terminal or intercalary and oval in shape (Plate 2). Similar type of results also obtained by Sinclair (1982), studied the microscopic symptoms and characterized the pathogen. Ellis and Holiday (1971) described colony morphology, conidiophores and conidia of *Corynespora cassiicola*. They described that the colony of pathogen was grey, black, dark brown and green in colour with concentric rings. Conidiophores were simple, erect, intermittently branching and septate. Enteroblastic conidiogenous cells produce subhyaline conidia singly or in chains. Conidia were variable in size and shape with 4-17 pseudosepta. The size of conidia range from 40-220 µm in length and to 8-22 µm in width, straight to curved with rounded apex and truncates base, conspicuous thickened hilum at the base.

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SHORT COMMUNICATION

Synthetic Milk : Imitation of Natural Milk

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ABSTRACT

Synthetic milk is not milk but an artificial imitation of natural milk with a high degree of adulteration to increase the volume of milk and thereby the profit. Main components of synthetic milk are urea, caustic soda, cheap cooking/ refined oil and common detergents. All of these components are very harmful to human health. This article put a glance about the synthetic milk, health hazards by synthetic milk and some suggestions for clear up this threat.

Key words *Synthetic milk, Natural milk, Human, Adulteration, Diseases*

Milk is a daily used edible household item. It is regarded as a complete food as it contains the high-quality carbohydrates, fats, proteins, minerals and vitamins in the right quantities [1]. It supplies nutrients in significant amount than any other single food. India is the world's largest producer of dairy products by volume, accounting for more than 13% of world's total milk production. Despite its huge production volume, the phenomenon of synthetic milk makes this achievement meaningless. Because India never the less faces the problem of population explosion which ensuing the adulteration of milk to overcome the gap between demand and supply.

The paradox here is the fact that India is also the first country where synthetic milk was produced. Synthetic milk is the most common form of adulteration and since milk is a major component of any dairy product, thus, its effects spread out. The synthetic milk technology was invented by milkmen of Kurukshetra (Haryana) about 15 years. The technology later spread to the other states like Rajasthan, Himachal Pradesh, Uttar Pradesh and the practice is feared to have been adopted in the deficit areas of Bihar, Madhya Pradesh, Karnataka and Orissa too. Has since then spread out to all over the country.[2]The following text is an attempt to have a look at that what is the synthetic milk as well as public health hazards by consumption of this synthetic milk and some suggestions of finding solutions to the menace.

How synthetic milk is produced

Synthetic milk is an excellent imitation of natural milk. As the name suggests, it is not milk but it is entirely a different component with a high degree of adulteration. It is the chemically produced milk that differs from the animal milk. It is manufactured by mixing the predefined and calculated amount of synthetic products urea, caustic soda, cheap cooking/ refined oil and common detergents. Milk fat is mimicked by refined oil; the nitrogen component & solid-not-fat(SNF)in milk is mimicked by urea and Caustic soda is added to neutralize acidity thereby preventing it from turning sour during transport. Detergent is used as an emulsifier and it helps in dissolving the oil in water to give it the frothy like look and white-cream colour of milk. [3, 4]. It is blended with some portions of natural milk so as to improve its taste. Thus, the product that we get is a properly thought out and carefully produced synthetic product, much like our soaps and shampoos. Hence it easily passes the tests carried out at the village level dairy co-operative society (fat and lactometer reading etc.) but from the health point of view of the consumers, it is highly dangerous. The taste is highly objectionable.

Comparison between natural and synthetic milk

Differentiating tests	Natural Milk	Synthetic Milk
Colour	White	White
Taste	No pronounced taste, but is slightly sweet to most persons (Palatable)	Bitter
Storage	On storage, it remains white	It turns pale yellow after some time
Texture	When rubbed on the palm, it doesn't form foam	When rubbed on the palm, foam formation noticed.
pH	6.6 to 6.8	10 – 11 (Highly alkaline)
Fat	4.5 – 5.0%	4.5 – 5.0%
Solids Not Fat	8 – 9%	8 – 9%
Heat	No change in colour on heating	It turns yellow on boiling
Urea test	Pale yellow colour develops	Dark yellow colour develops

Health hazard with synthetic milk

A recent Indian council of medical research (ICMR) report has suggested that such adulterated items have a cancerous effect on the human system and can lead to gradual impairment of the body.[5] Urea and caustic soda are very harmful to heart, liver and kidneys. Urea is an additional burden for kidneys as they have to do more work to remove urea from the body. [6, 7] Caustic soda which contains sodium acts as slow poison for those suffering from hypertension and heart ailments. Caustic soda also deprives the body from utilizing lysine, an essential amino acid in milk, which is required by growing babies. [8] Children are the biggest sufferers in this for their body's immune system get slowly degraded at an early

age. Also, the sodium being passed onto the body through this acts as a slow poison. The detergent in milk can cause food poisoning and other gastrointestinal complications. Because phosphates, the main cleaning ingredients in detergents and household cleaners. All these hazards make detergents toxic and the synthetic milk containing these detergents become unfit for consumption [9]. Apart from this, synthetic milk proves deadly for pregnant women, foetus and patients suffering from conditions of heart ailment and high blood pressure. It is extremely poisonous for small children. Continuous use of the synthetic milk turns the human body a farm house of diseases.

Solutions to the problems of synthetic milk

To safeguard from the ill effects of synthetic milk, the following noted suggestions must be taken into consideration:-

1) The entire population of the country should be made aware of the simple testing procedures of the synthetic milk through publicity and media including TV, Radio, print pamphlets, holding and the camps of consumer awareness program.
2) In cities and metros, only packaging milk should be encouraged and open selling milk should be completely banned by government notifications. Apart from this there should be a surprise checking by the officials of state food and civil supply department and the Dairy officials.
3) A committee under the presidency of local administrative official should be established at gram, tehsil and district levels to control the production of synthetic milk by keeping a strict vigil over the local government and private dairies local milk sellers and all the distributing terminals.
4) At the village level, Gram Panchayats/ Janpad panchayats/ Zilla panchayats (Jan- Bhagidari Samiti), a general awareness program should be frequently held which will deliberate upon complaints received against synthetic milk. Domestic women should be trained to test synthetic milk by government agencies or NGOS.

CONCLUSION

Synthetic milk is a sweet poison which though does not kill at once but it slowly makes the body a fertile ground for diseases. As a result of white revolution, new machinery with new techniques has been made available but also this machinery has been used to play with the lives of the humans in place of making its good uses. This happens because of the gap in demand and supply of milk. It is expected from the administration to have the production of synthetic milk checked under full control to avoid the loss of human life.

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AUTHOR INDEX

Instruction to the Authors

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