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Varate Giduga : A unique mango variety

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Short Communications

In this issue…

Every moment, there is an incremental addition to the knowledge base of any science. This issue of Journal of Horticultural Science hosts the reports on recent developments in different branches of Horticultural Science viz. crop production, crop improvement, crop protection and crop utilization.

A review on innovations in value chain management of tropical fruits by ***Oberoi and Dinesh*** *summarises the recent developments in the post-harvest processing of tropical fruits. It emphasizes the importance of Farmer Producer Organizations, Good Agricultural Practices, modified atmosphere packaging facilities, controlled atmosphere storage facilities and use of refrigerated containers during transport. Another review article is on importance of Zn in horticultural crops and status of Zn in soils of Karnataka, India written by* ***Ganeshamurthy et al.*** *Besides enumerating the factors affecting Zn availability, it describes how horticultural crops respond to Zn.*

There are seven Original Research Papers and Four Short Communications in this issue. ***Dinesh*** *et al. report a new mango variety with unique characters, "Varate Giduga" that has many characters contributing to deliciousness. Fruits have thick rough and the fruit can be cut into two halves and pulp can be scooped out easily.* ***Merin et al.*** *report on the best suitable timing for crossing in yard long bean.* ***Safeena et al.*** *have evaluated and identified the tuberose cultivars suitable for humid agro-climatic conditions.* ***Meena et al.*** *screened coriander varieties for their resistance to aphids and identified least susceptible varieties.* ***Mini Shankar et al****. identified the ferns species suitable for landscape purpose.*

With respect to production aspects, ***Linta Vincent et al.*** *identified the leaf parameters and their correlation to resistance to PRSV in wild relatives of papaya.* ***Satisha and Somkuwar*** *report the effect of leaf removal on composition of grape varieties grown in India.* ***Ganeshamurthy et al*** *report the Compositional Nutrient Diagnosis (CND) norms for potato that would help in hidden hunger of various nutrients and their management in potato.* ***Manisha and Priya Devi*** *report on the significant effect of calcium ions over potassium ions on papaya seed germination and seedling vigour when salts of these ions are used to prime papaya seeds. A short communication by* ***Chitra****, describes the superiority of use of tissue culture derived planting material of turmeric over the conventional rhizomes. Disease free planting material production can be facilitated by tissue culture in turmeric.*

The biotic stress management is ever demanding aspect. ***Jayanthi Mala et al.*** *report the management of Jamun seed borer (Anselmella kerrichi) using spinosad.* ***Amrutha and Reshmy*** *report on characterization of Rhizoctonia solani that causes fruit rot in strawbeery and its management using Trichoderma asperellum and Pseudomonas fluorescens.*

The new editorial team has tried to stand up to the expectations of the community of Horticultural Scientists and students. There is scope for improvement and the team will keep efforts to improve the standard of the Journal.

The Editorial Team gratefully acknowledges the reviewers who have contributed immensely for the better presentation of the journal.

Wishing you a very happy and scientifically productive new year 2020.

S. Sriram
Editor in Chief

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Review

Trends and Innovations in Value Chain Management of Tropical Fruits

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ABSTRACT

India produced about 97.35 million tons of fruits during 2017-18, of which less than 1% fruits were exported. In India, less than 5% of the total fruits produced are sold by the organized supply chain management and E-commerce companies and 3% of the total produce gets processed, indicating that more than 90% of fruits follow the traditional route of supply chain involving farmers, auctioneers, agents/intermediaries, wholesalers, sub-wholesalers, retailers, cart vendors before they reach the consumers. Post-Harvest (PH) losses occur at each stage of the supply chain and are compounded with each operation. A study on PH loss estimation has shown maximum loss of 15.88% in guava among fruits while other studies have reported much higher PH lossesin fruits. Value of tropical fruits, both in monetary terms and quality reduces during harvesting, handling, transportation from the farmer's field, packaging, storage, retail and even at the consumer's level. Important interventions that reduce the PH losses and improve the supply chain management are establishment of pre-cooling facilities and short term storage facilities through evaporative cooling/refrigeration mechanisms at the farm gate, primary processing and packaging provision at the farm gate or nearby collection centres, transportation of fruits in refrigerated/evaporative cooled vans with the use of alternate energy sources and provision for low temperature and high humidity storage at the retail centres. Establishment of a Postharvest management system for sorting, washing, partial drying, edible coating, if required and grading at the collection centres will help in reducing the PH losses in the supply chain and help farmers get a better value for their produce. Formation of farmer clusters or Farmers Producer Organizations (FPOs) provides farmers a better bargaining power because of higher volumes. Educating and bringing awareness among the farmers about the good agricultural practices (GAP), mechanization in field operations, availability of seeds for different seasons, eliminating the problem of seasonality are also important in production of quality output. Transportation of fruits, such as mango, banana and guava in vans/wagons operating through evaporative cooling/ cooling mechanism using phase change material will help in improving the shelf life of such fruits. An integrated radio frequency identification (RFID) system along with the sensors for ethylene, temperature and RH monitoring is likely to help in easy tracking and traceability of the fresh produce. Establishment of primary and secondary processing facility at the farmer cluster/ FPO levels will help in transforming the farmers to primary processors.

Keywords: Collection centres, Packaging, Post-Harvest management, Supply chain, Transportation and Value chain

INTRODUCTION

India is the second largest producer of fruits and vegetables in the world and even the largest producer for some of the tropical fruits, such as papaya, mango and banana. As per the report of National Horticulture Board (NHB), fruit and vegetable production during 2017-18 in India was 97.35 and 187 million tonnes, respectively. India exported about 0.69 million tons of processed fruits and vegetable products, earning a revenue of about Rs 5279 crores in 2018-19, while the export of about 3.80million tons of fresh fruits and vegetables during 2018-19 fetched a revenue of about

Rs 10,338 crores according to Agricultural and Processed Food Export Development Authority (APEDA). Export of fresh fruits from India during 2018-19 was less than 1% of the total quantityof the fruits produced in the country. As per Ministry of Food Processing Industries (MOFPI) data, only 2-2.2% fruits are processed in India. Organized supply chain management companiesin India like Reliance Fresh, Big Bazaar, Aditya Birla Retail Ltd or E-commerce companies like Big Basket or Grofers *etc*. account for procurement of less than 5% of the total fruits produced in the country. This data indicates that more than 90% of fresh fruits pass through the traditional supply chain involving farmers, auctioneers, agents/ intermediaries, wholesalers, sub-wholesalers, retailers, cart vendors and consumers as mentioned elsewhere in this paper. As the fresh perishable produce has to pass through several hands/ steps, Post-Harvest (PH) losses occur at each stage before the fruits actually reach the consumers. In addition to the measurable losses, a deterioration in quality (intangible loss) of the fruits takes place at each step, indicating that there are both quality and quantity losses in such a long supply chain having a direct impact on the value of the fresh produce. Losses even occur at the level of the consumers that cannot even be estimated.

Studies on PH losses in fruits and vegetables have reported maximum losses in guava at 15.88% among all the fruits (Jha *et al*., 2015). However, authors considered only eight fruits for PH loss estimation study *viz*., apple, banana, citrus, grapes, guava, mango, papaya andsapota. Salami *et al*. (2010) have reported losses in fruits and vegetables between harvest and final consumption at about 30-40%. Therefore,it becomes imperative to reduce the number of operations from farm-to-fork in order to retain the value of the fruits both from the quality and nutrition perspectives and minimize the PH losses.

Value chain model for horticultural crops

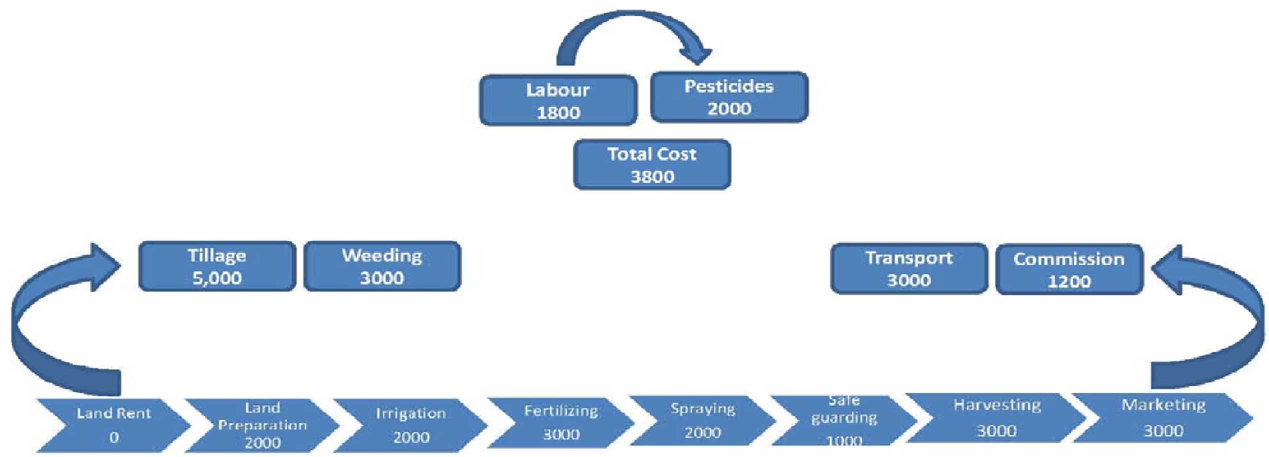
Value chains describe the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services) delivery to final disposal after use (Kaplinsky and Morris, 2000). Value chain integrates various factors together and provides communication of market information to all the players involved in the chain.

Supply chain activities consist of buying produce (purchasing), changing something about the produce to increase its value (processing e.g. packaging and/ or sorting) and transporting it to the location of demand (distribution). The demand chain consists of activities to stimulate demand for produce (marketing), facilitating transactions to enable people to buy the produce (sales) and providing any ‘after-sales’ service such as dealing with returns or unsold perishable goods (service).

Value chain encompasses different facets of supply and demand chain, starting from the land use planning, adoption of good agricultural practices (GAP), nutrient and agro-chemicals use management, precision farming for production of a good quality and uniform produce; supply chain management, discussed in detail elsewhere in this paper; market intelligence and demand forecasting/crop planning for fruits and vegetables and marketing of the fresh as well as processed fruits. Therefore, value chain for fruits is extremely important as it integrates different links together, starting from farmer/ FPO to consumer through different approaches. Value chain analysis of mango cultivation in one acre of land in Dharwad, Karnataka is presented in Fig.1. The input details and the price that the farmer gets in the market are obtained from the farmer who has mango plantations spread over 9 acres. Though the farmer is the primary producer of the crop, he gets least value for his produce, whereas the major share of value addition is distributed among the traders (intermediaries) and retailers. Despite the fact that the major stakeholder in this value chain is a farmer, he accounts for about 12%, whereas the retailers account for about 60% and the traders for about 30% in the value chain.

Smallholder (farmer’s) participation in the tropical fruits value chain is constrained by inadequate farm-level resources, farm-to-market logistical bottlenecks and transaction costs in matching and aggregating dispersed supplies to meet buyer and consumer demands (Chang *et al.*, 2014). These constraints are compounded by a new set of challenges associated with compliance with product and process standards enforced by the government agencies or supply chain management companies. Some of the major reasons for low-level participation of the smallholders/ farmersin the tropical fruit value chain in countries like Indiaare:

- Fragmented land holdings and low farm outputs which reduce the bargaining power of the individual farmers. It is therefore important to have the farmer co-operatives or FPOs who can have a better bargaining power *vis-à-vis* wholesalers or intermediaries.
- Lack of market intelligence, poor linkages to market and inadequate market information, distance from the farmer's fields to the retail markets and poor roads and transportation systems compound the problems for farmers.
- Lack of effective policies, including access to credit, on-farm infrastructure for storage, handling or primary processing of fruits, appropriate quality standards and compliance mechanism and lack of proper pre. and post. harvest technologies limit the involvement of the individual farmers in the value chain.



Benefit Cost Analysis /Acre	
Production Cost	: 32000
Total Yield	: 2000 kg
Selling price/kg	: 20.0
Total Revenue	: 40000
Profit/Acre	: 8000
Benefit Cost Ratio	: 1.25:1

Value addition of the Value Chain Actors			
Value Chain Actors	Average Price	Value Addition	Value Addition (%)
Inputs	16.0	-	-
Farmers	20.0	4.00	11.76
Traders	30.00	10.00	29.41
Retailers	50.00	20.00	58.81
Total	-	34.00	100

Fig. 1: Value chain analysis of Mango cv. Alphonso (1 acre) in Dharwad, Karnataka
(Input details for production of fruits and market price of the fruit are presented for illustration purpose and may vary from farm to farm, place to place and the method of cultivation)

Production and crop planning

Value chain begins with the farmer and the agricultural practices followed by the farmers in production of uniform and quality produce. Highest amount of waste in fruits and vegetables supply chain occurs at the farm gateitself. Even today, traditional cropping patterns are prevalent in most parts of India. For example, high density and ultra-high density plantations of tropical fruits, such as mango and guava increase the productivity as well as quality of the product, therebyhelping farmers to get better price for their produce. Problem of seasonality in fruits and vegetables could be handled largely using seeds available for different seasons.Application of GAP is widely recognized as the most important measure in assuring the safety of fresh produce, followed by the application of good hygienic practices (GHP) and the certification of food safety management systems (FSMS). Pre-harvest factors which have a profound influence on the pH quality attributes are the use of quality irrigation water (main source of contamination); maintenance or restoration of soil organic carbon, crop rotation, avoiding water and fertilizer run-off, water recycling, *etc.*, help in better quality output and minimizing the incidence of pathogen infestation, such as that of *Aspergillus* spp, largely responsible for production of aflatoxins. Mechanization in land preparation, planting, irrigation and pest and disease management are important components of GAP, which help in production of a good quality output.

In order to tackle the issues of perishability and seasonality of fruits and vegetables, it is important for the procurement agencies (both government agencies and supply chain management companies) to work closely with the farmers and help them in crop planning. Farmers should also be informed about the nutrient use management, use of biopesticides, micronutrient formulation, high density planting and irrigation techniques. Such crop planning and market intelligence techniques will help in adding value to the produce and getting a good remuneration for farmers for their produce.

Supply chain management of fruits in India

Recent advances in food markets around the world are driven by consumer demand and preferences, food safety concerns and the increased bargaining power of modern retail systems. Higher income and changing lifestyles have led to demand for more variety, better quality, year-round supply of fresh produce, "healthy" food and convenience. In addition, consumer's concerns for safe foodand also about the social and environmental conditions under which food is produced has led us to believe that technological interventions are needed to strengthen the supply chain as well as product development. It therefore becomes important to preserve the value of important perishable commodities at each stage in the supply chain as well as during processing.

Traditional model of supply of fruits and vegetables in India (Fig.2) from farmer to consumer involves a series of intermediaries. Loss in quantity because of physiological lossesand quality loss due to poor handling occurs at each stage. In certain parts of the country, banana combs are stacked over one another and transported in open trolleys and mini trucks to the auction sites/ wholesale markets. As the village roads and the approach roads to auction sites/ wholesale markets are undulating, broken and have many potholes, spoilage in fruits is intensified. Losses are accumulated at each stage of the supply chain (Fig.2) and a long supply chain like the one being used in the conventional system leads to significant PH as well as quality loss in fruits.

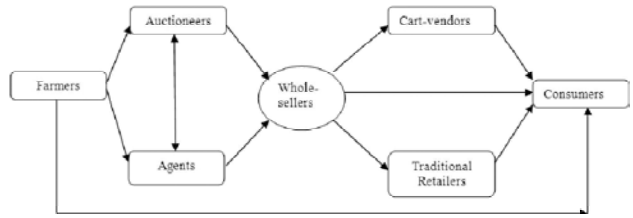


Fig. 2: Traditional supply chain system followed in India

Baskets made from bamboo with paddy straw as cushioning materials used as packaging for fruits like papaya and mangoes in various parts of the country (Fig. 3) result in very high spoilages during storage and transportation. All these losses reduce the value of the fruit in monetary terms for farmers, leading to distress sale. Traditional supply chain for fresh fruits in most cases does not fetch a good remuneration for the farmers.

Fig. 3: Packaging of mangoes in bamboo baskets with paddy straw as cushioning material

Supply chain being followed by the organized companies like Reliance Fresh and Aditya Birla Retail Ltd (More) in India isrelatively shorter than the traditional supply chain. Both these companies directly procure the produce from the farmers/ farmer producer organizations (FPOs)/ farmer co-operatives/ clusters. On most occasions, sorting of the fruits is done at the farm gate and the desired fruits are only procured by such companies for supply to their retail stores. Supply chain model involves transportation of fresh fruits and vegetables to their collection centres (CC)/buying centres, where the fruits and vegetables are weighed, sorted, if necessary and shifted to the distribution centres (DC), where primary processing operations, such as grading, packaging into small retail packs is done and subsequently, the material is shifted to the retail stores of the respective companies or consumers directly by the E-commerce companies (Fig.4). Facilities like graders, conveyors, washers and cold stores are available at DCs of these companies.

Reliance Fresh also deploys a fleet of refrigerated vehicles for transportation of the fruits to their retail stores. This kind of supply chain has helped in reducing the PH losses drastically. As per Sihariya *et al.* (2013) Reliance Fresh has successfully reduced the PH losses from the farmer's field to their retail stores from 25-30% to about 7-8% through pre-cooling of harvest, better post-harvest handling (less number of human touches/contacts), and special type of packages for highly perishable products. Reliance also uses coldchain for inter-state movement of fruits and vegetables and regularly conducts trainings for the staff in the supply chain, which contribute significantly to alleviation in the PH losses. Waycool Foods and Products Pvt Ltd, Chennai, India procures most fruits and vegetable directly from the farmers and FPOs located in and around Chennai and nearby districts of Tamil Nadu and transport the fresh horticultural produce to their collection centre which has facilities for sorting, grading, weighing, washing and temperature controlled compartments for storage of highly perishable materials. The company repacks the produce in bulk packages for supply to wholesalers and retails packages for supply to their franchisee retail outlets. The company also has developed transport vehicle based on phase change material (PCM) for transport of highly perishable produce from their collection centre to retail outlets or wholesale markets.Waycool has placed the ICAR-IIHR developed Arka High Humidity storage boxes in their franchisee retail outlets for storage of green leafy and other vegetables, thereby significantly reducing the PH losses at the retail level.

Big Basket, a large E-commerce company that supplies about 100,000 tons of fresh fruits and vegetables annually procures a substantial quantity of and vegetables (about 80%) directly from the farmers and FPOs and the remaining produce from other companies like Grofers, Waycool, etc. The company has its own CCs located near the production hubs, which have the basic facilities for weighing, sorting and grading. Fresh produce is directly transported from the CCs to DCs, where the fresh produce is graded, if required, repackaged in small packs, such as punnets for pomegranate, corrugated fibreboard (CFB) boxes for mangoes and papaya and transported directly to the consumer's doorstep. Some of the DCs of the company also have facilities for treatment and packaging of the selected fresh-cut fruits and vegetables. Highly perishable produce is transported either in refrigerated vans or in the containers with gel packs for small retail packs by the company.

Though the supply of fresh fruits and vegetables in an organized way by the above mentioned companies has brought down the PH losses significantly and have successfully added value to the fresh horticultural produce, these companies put together procure less than 5% of the total fruits produced in the country.

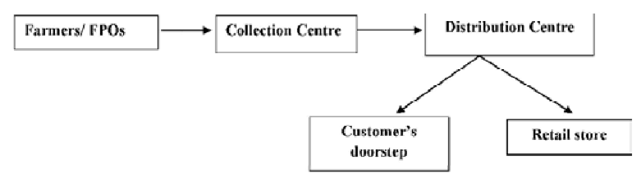


Fig. 4: Supply chain followed by the organized farm-to-fork companies for supply of fruits in India

Supply chain management practices followed in other countries

Supply of fruits and vegetables in most of the developed countries involves primary processing of fresh produce at the farm gate and supply of such produce to wholesalers/ agents, retailers and consumers directly (Fig.5). As per Jassi (2011), most of the produce after harvest is subjected to processing to increase the shelf life of the products and is then transported to wholesalers/ agents who deliver the product to the Hospitality industry and retail stores from where it reaches the consumer, which is considered as another good approach of saving the precious fruits and vegetables. In most developed countries, farmers supply fresh produce directly to the retail stores and at times to the consumer and the processing levels in such countries are substantially higher than that in India.

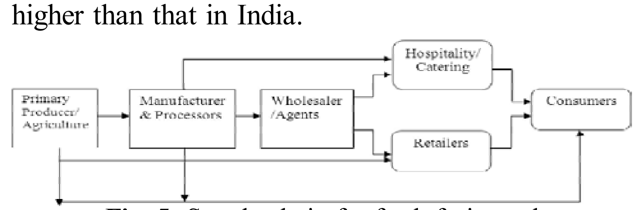
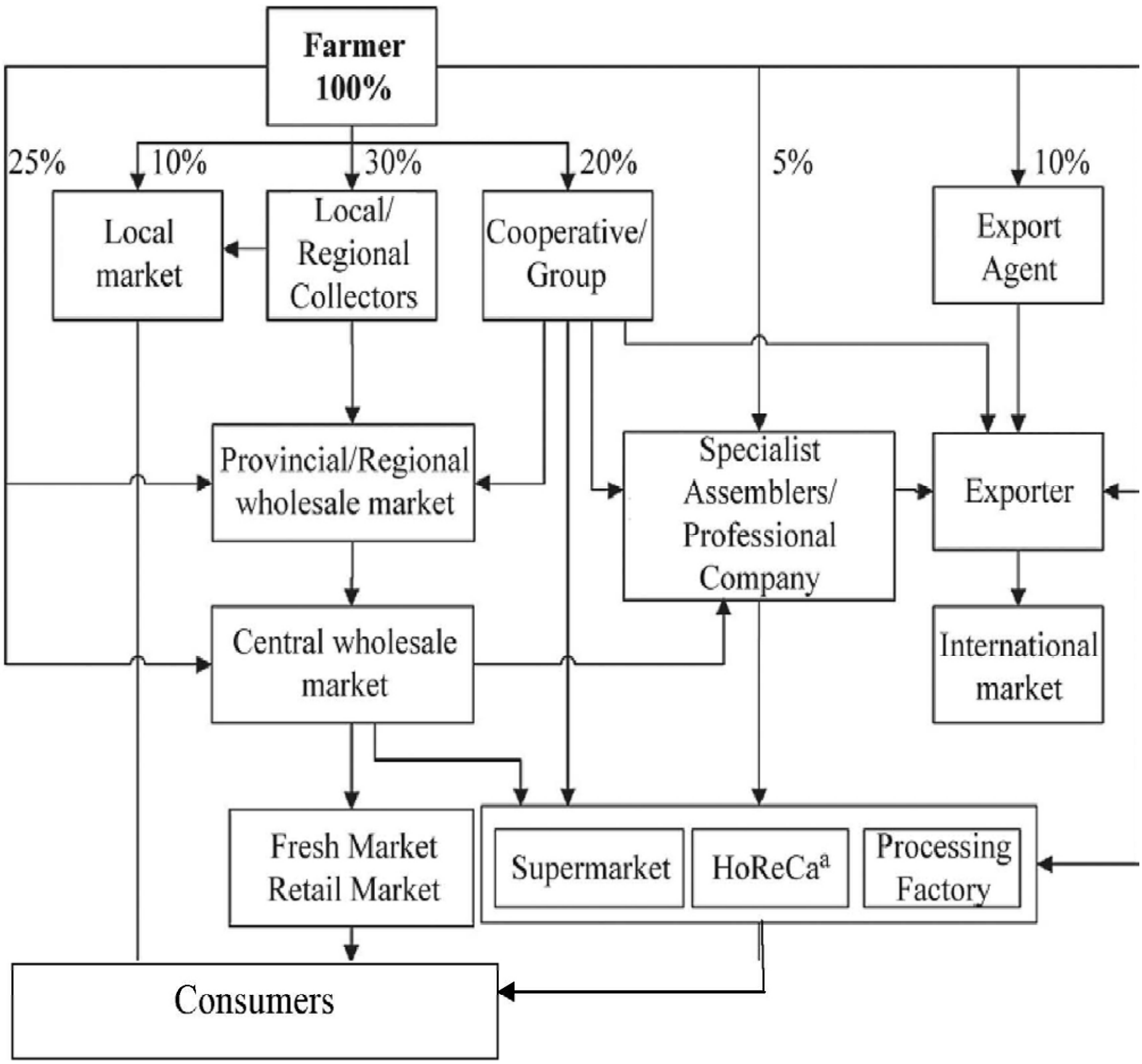


Fig. 5: Supply chain for fresh fruits and vegetables followed in developed countries

Thailand has similar climatic condition as India and so is the food consumption pattern. The supply chain in fruits and vegetables however is much better developed in Thailand as compared to India (Srimanee and Routray, 2012). Supermarkets in Thailand account for 40 % of fruit and 30 % of vegetables in urban areas, but a lower percentage in the context of the entire country (Fig. 6). Fresh fruits and vegetables have not only increased in percentage share of sales but also are very profitable relative to other products in the stores in Thailand. A consequence of the increasing importance of supermarkets for fruits and vegetables is that the procurement system has had an impact on small farmers, who are the major fruit producers in Thailand. The major channel from farmers to co-operative groups to supermarkets accounts for about 20% of supply of farmer's produce. There is no intermediaries between supermarkets and farmers' co-operative groups. This has reduced the incidence of multiple parties in the channel, thereby improving efficiency of the chain. Cooperatives and specialist assemblers are more beneficial to farmers, compared to other channels because of their openness and flexibility. Intermediaries of these channels are responsible for all the steps involved in grading, packaging and delivery, which are more efficient when carried out on a large scale.



Hotels, Restaurants and Catering

Fig. 6: Supply chain for fruits and vegetables followed in Thailand

Technological interventions for reducing Post-Harvest losses

Pre-cooling and storage structures

Harvesting methods and time of harvest play an important role in storage life of the fruit. Harvesting of fruits, such as mangoes at about 2 inches from their tip on the peduncle using mechanical harvesters (Fig.7) helps in improving the keeping quality of the mangoes. Harvesters for fruits, like citrus fruits, sapota, *etc*. help in reducing the damage/injury to such fruits, eventually leading to extended storage life for such fruits.

Fig. 7: Simple mango harvesters developed at ICAR-IIHR, Bengaluru

Pre-cooling of fruits reduces the field heat, thereby reducing the respiration rate and physiological activity in the fruits, thereby minimizing the spoilage. In addition, pre-cooling also helps in reducing the physiological loss in weight (PLW), thus helping in preservation of the value of the fruits. Pre-cooling also helps in delaying ripening and retarding senescence. Pre-cooling is extremely important for tropical fruits, as the temperatures during harvest are relatively high and therefore, the fruits need to be immediately pre-cooled for having an optimal shelf life. Different methods of pre-cooling include

- Hydro cooling which requires the use of cold water or cold water spray. Hydro cooling is generally achieved through flooding, immersion or spraying of cold water.
- Air-coolingwhich involves the use of refrigerated air as pre-cooling medium and this method is suitable for tropical fruits. Pre-cooling with air can be accomplished in a conventional cold storage room, a special pre-cooling, a funnel cooler, or a forced air cooler.
- Vacuum cooling that works on the principle of cooling by reducing atmospheric pressure in artificial hermetically sealed chambers. The major advantages of vacuum cooling are the speed and uniformity of cooling of the produce. Vacuum cooling is generally found to be useful and suitable for vegetables.

In order to save the fresh produce, it is suggested to have the pre-cooling facility at the farm gate or in the vicinity of the farmer's field. Pre-cooling at 10°C, packing in LDPE bags of 200-gaugethickness without vents followedby storage at 10°C resulted in optimum quality and minimal spoilage in guava (Dhara *et al*., 2017). Ravikumar *et al.* (2018) reported that banana cv. Grand Naine fruits pre-cooled with hydro cooling (spray at 13°C and stored in cold store at 13 °C) showed good shelf life. Kanade *et al.* (2017) reported that among all the treatments, pre-cooling at 12 °C followed by storage at 15 °C helped in extending the shelf life of fruits of mango cv. Alphonso to 28 days.

On- farm primary processing

Deterioration in fruits occurs largely due to factors, such as temperature, oxygen, light, moisture, and microbial growth. Deterioration process accelerates once these factors act together, resulting in fast spoilage of fruits. Tropical fruits like mango, guava and papaya generally come to harvest during hot and humid periods, such fruits being high in moisture with very less protection are vulnerable to deterioration because of physiological, biochemical and microbiological spoilage. Oxygen essentially provides conditions that enhance growth of aerobic microbes. Presence of oxygen enhances the growth of microorganisms, such as molds and yeasts, and contributes directly to deterioration in fats, vitamins, flavors, and colors within fruits through the action of enzymes.

Therefore, it is extremely important to have a disinfection facility at the farm level to have a good/ optimal shelf life for fresh fruits. Ozone is the strongest food grade antimicrobial agent. While destroying bacteria and viruses, the remaining ozone reverts to oxygen, for a pure, fresh taste without any chemical residue. Ozone is environmental friendly, quick, simple and effective against bacteria, pesticides, poisons and prolongs the storage life naturally. Ozone is reported to have 1.5 times the oxidizing potential of chlorine and 3,000 times the potential of hypochlorous acid (HOCl). Contact times for antimicrobial action with ozone are typically 4-5 times less than that of chlorine. Ozone rapidly attacks bacterial cell walls and is more effective against the thick-walled spores of plant pathogens and animal parasites than chlorine, at practical and safe concentrations (Suslow, 1998). Application of electrolyzed water has been primarily focused on fruits and vegetables; its potential for surface decontamination of food products still requires further study and optimization. Especially, application parameters, such as pH, oxidation reduction potential (ORP), temperature, treatment time, and active chlorine concentration, require optimization for washing fresh fruits to increase the microbiocidal effect of electrolyzed water washing as a promising alternative technique (Turantas *et al*., 2018). In some of the countries like USA, UK, washing and/or disinfection using electrolyzed water or ozone is done at the farmer's field. This helps in not only controlling the spoilage microorganisms as well as the food borne pathogens but also helps in reduced biochemical activity, resulting in a better storability of the produce.

Packaging and transportation

Cold storage of mango at 12-13°C is appropriate only for 2-3 weeks, beyond which the fruits tend to deteriorate rapidly. Cold storage limits the use of sea freight, which is usually more economical and eco-friendly than airfreight. Controlled atmosphere (CA) storage involves regulating the concentration of oxygen (O_2) and carbon dioxide (CO_2) using nitrogen, a right mix of storage temperature and relative humidity (RH) in the storage environment. Controlled atmosphere in combination with an optimum storage temperature prolongs the storage life and helps in maintaining the fruit quality including aroma volatiles in mango fruit depending upon the cultivar (Singh and Zaharah, 2015). Elhefny *et al*. (2012) reported that the optimal CA for long term storage of "Keitt" mango at 13°C with 3% O_2 + 6% CO_2+ 91% N_2 could extend the storage life up to 10 weeks. Shelf life of 3 months is ideal for export of mangoes through the sea route. Rao *et al*. (2018) have presented a consolidated information on different storage and packaging techniques to extend the shelf life of tropical fruits, which includes shrink wrapping, modified atmosphere packaging (MAP) and controlled atmosphere (CA) storage.

Transportation of tropical fruits from the farmer's field to the retail stores or CC of the supply chain companies is one of the major operations having a direct impact on the PH losses and shelf life of the produce. Generally, the tropical fruits require a temperature ranging from 12-15 °C and RH ranging from 85-95% for optimal storage. If the similar conditions could be provided during transportation, the PH losses in such fruits can be brought down significantly. Studies conducted by ICAR-IIHR, Bengaluru on solar operated evaporatively cooled vans for retail sale of fruits and vegetables have shown an extended shelf life of fruits by 36-48 hours depending on the ambient conditions (Fig 8a). Evaporative cooling through misting helped in increasing the RH to the tune of 80-85%, which subsequently helped in reducing the physiological loss in weight (PLW) and retained freshness in fruits and vegetables. Incorporation of phase change material (PCM) [Fig. 8b], such as gel packs also help in reducing the temperature, therebyhelping in extending the storability of tropical fruits. Integrating the incorporation of PCM along with the misting system and running this system through solar power is the need of an hour. Such kind of storage vans which do not use the fuel of the vehicle for evaporative cooling/cooling mechanism are suitable for short distance transportation as well and will help in reducing the carbon footprint. Integrating the use of solar power and PCM not only will reduce the environmental pollution but also help in saving energy.

Fig. 8: a. Fruit and vegetable vending van using the solar power and evaporative cooling mechanism through misting for maintaining high RH inside the structure

Fig. 8: b. Vending van using the Phase Change Material (PCM) for maintaining low temperature during transportation

Establishment of on-farm storage structures based on evaporative cooling/ refrigeration and hybrid systems help in improving the shelf life of the fresh horticultural produce. Increase in humidity to about 90% with a decrease in temperature by 10-12 °C, compared to ambient temperatures help in improving the shelf life of the tropical fruits. On-farm establishment of evaporative cooled (EC) storage structures help in reducing the PH losses in fruits and vegetables (Chopra *et al*., 2004). On-farm storage structures like the ICAR-CIPHET designed evaporatively cooled structure (Fig. 9a) or the refrigerated structures (Fig. 9b)can serve as ideal structures for pre-cooling as well as storage to improve the shelf life of fruits as well as avoid distress sale of the fresh fruits.

(a)

(b)

Fig. 9: (a) Evaporatively cooled structures and (b) Solar power refrigerated structure for on-farm pre-cooling and storage of fruits and vegetables

In addition to on-farm storage and/or pre-cooling, on-farm primary and secondary processing of fruits will help in adding significant value to the fruits and improve their shelf life. Primary and secondary processing facility for sorting, washing, grading, waxing (wherever required) and packaging at the farm gate will improve the marketability of the fruits, in addition to improving their shelf life. Creation of secondary processing activities at the farm gate level, for fruits such as mango, guava, papaya pulp processing facility with the product having a shelf life of six months or more will help the farmer/FPO to add value to the fruit and enable them to sell the product at the appropriate time, whenever demand of such products is on the rise.

Tracking and traceability of the produce

Tracking of the fresh fruits through the supply chain helps in monitoring the movement of the produce throughout the chain. Traceability of the produce gives details about the farmer who produced the fruits, planting date, spray schedule, quality of water used for irrigation, test reports and harvesting date, so that the information could be put to use for improving the cultivation practices at the time of recall. With the traceability system in place, one can identify the root cause for the pathogen infestation or epidemic outbreak so that appropriate preventive action could be taken to ensure that such epidemics do not recur. Information about traceability can be incorporated in the farm of bar codes and readable radio frequency identification (RFID) tags and can be made available to a person sitting at a distant place through a mobile app. During the supply chain, installation of the RFID tags on the crates and integrating them with the sensors for temperature, RH, weight, ethylene production and biosensors in the transport vehicles will help in reducing the wastages in the supply chain (Oberoi, 2008). Such information once made available to the farmer/ producer on a mobile or any other device will help him in deciding if the produce needs to be diverted to a processing unit during transportation to the destination because of the deterioration in the quality of the produce or could be taken to the destination (Fig. 10). This is an important innovation, which will help in significantly reducing the transit losses in perishable commodities.

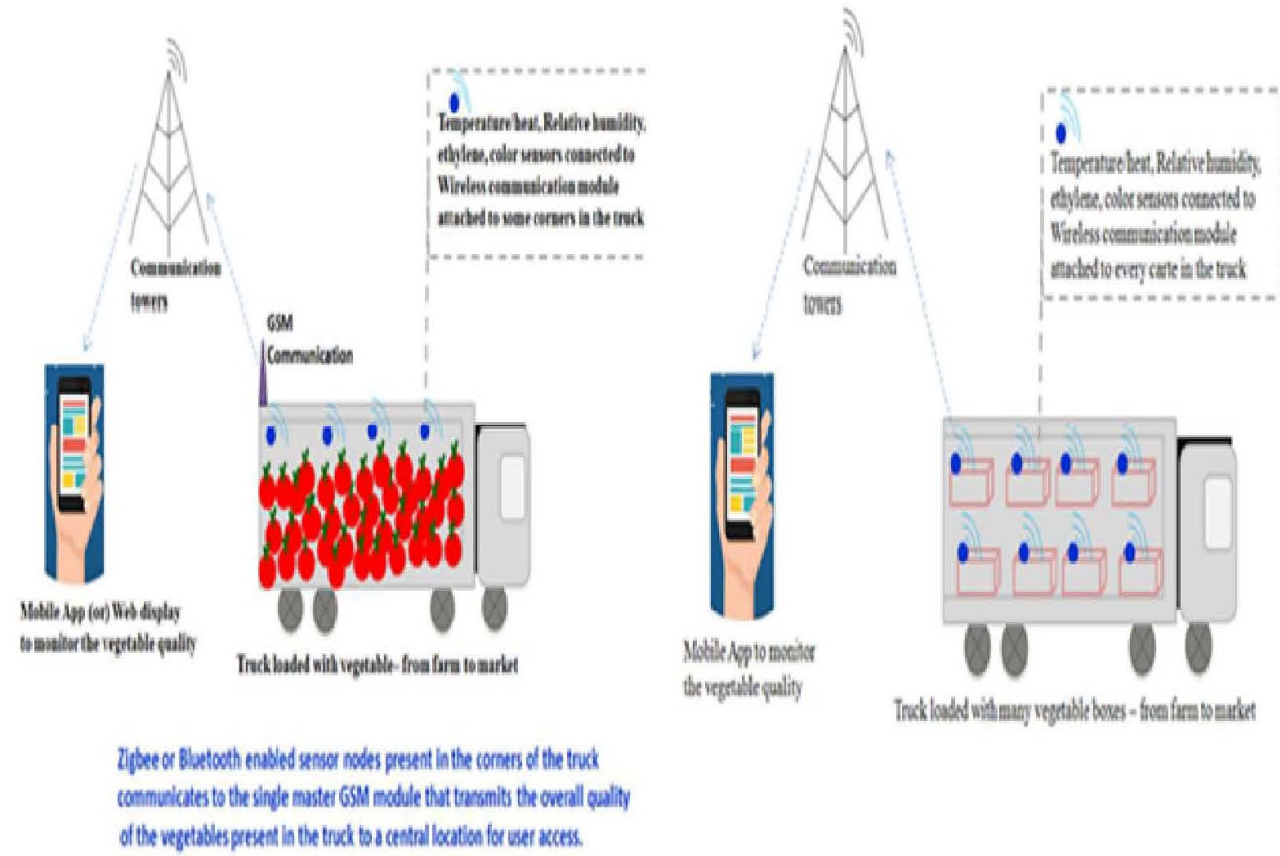


Fig. 10: Traceability studies integrating the RFID tags with different sensors for the produce transported directly or in crates in the trucks

Conclusion

Value chain integrates different actors in the chain of operations right from the farmers to consumers, involving technological innovations so that the value addition takes place at each stage. In case of fruits, value chain deals with value addition in monetary terms at each stage of the value chain and quality maintenance throughout the value chain. It is extremely important to have a shorter supply chain to ensure the delivery of quality output to the consumer. Farmers/ FPOs need to be educated about suitable varieties, GAP, use of micronutrients and biopesticides, nutrient use management, mechanization in field operations and better irrigation techniques, thus helping in production of quality and uniform output. Efficient crop planning and use of market intelligence and integrating them with GAP will help in adding value to the farm produce. Establishment of on-farm primary processing and storage facility including the facility for pre-cooling and cold storage is extremely important to preserve the quality and nutritional value of the fruits. Appropriate packaging, such as packaging of fruits in punnets using laser micro-perforated films or other appropriate films creating MAP and CA storage are important techniques for value addition to the tropical fruits, such as mango and banana. Transportation of tropical fruits using refrigerated containers or wherever possible, evaporatively cooled containersusing renewable sources of energy, such as solar energy will help in extending the shelf life of fruits.Tracking and traceability of the fresh produce using the RFID tag, sensors, bar codes help in effective monitoring of the produce through the supply chain. Formation of more and more farmer producing organizations (FPOs) will help in improving the bargaining power of the farmers and in creation of on-farm storage and processing facilities. Creating on-farm processing will help in improving the shelf life of tropical fruits and add value to them through processing facilities.

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Review

Zinc Status in the Soils of Karnataka and Response of Horticultural Crops to Zinc Application : A Meta-analysis

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ABSTRACT

Zinc is considered as the fourth important yield limiting nutrient in India, after N, P, and K. From the regular soil analysis data, Indian soils (50%) are found to be deficient in Zn and the zinc deficiency is likely to increase in future. Areas with low soil available Zn are often regions with widespread zinc deficiency in humans. Zinc malnutrition and deficiency in human is alarming and is gaining attention in recent years. Application of zinc to soil and crops is one of the simple and easiest ways to mitigate or alleviate Zn deficiency in human. Moreover Zn uptake, its translocation and yield response of various crops to applied Zn are need to be focused for finding sustainable solutions to the problem of zinc deficiency in crops and humans. In this manuscript, importance of Zn to plants and human, Zn malnutrition problems in India and global level, soil Zn status of Karnataka, various factors that responsible for Zn deficiency in the soils of Karnataka and the response of various horticultural crops to Zn application in the region is discussed. Soil maps are believed to be an important tool to delineate and manage nutrient deficient areas. It also elaborates the effective Zn management strategies to improve crop productivity and farm income.

Keywords: Crop production, Crop quality, Karnataka, Horticultural crops, Zinc deficiency, Zn management

INTRODUCTION

Zinc is one of the essential nutrients for plant growth and development. Though it is required in small quantity, it is crucial for plant development. In plants, Zn is a key constituent of many enzymes and proteins and plays a major role in wide range of processes such as growth hormone production and internode elongation. Zinc is absorbed by the plant through roots mostly in divalent ionic form (Zn^{2+}) from the soil solution. The primary source of Zn in soil is chemical and physical weathering of parent rocks and minerals. Mean soil Zn concentrations ($[Zn]_{soil}$) varied from 50 and 66 µg of total Zn g^{-1} soil are typical for mineral and organic soils, respectively, with most agricultural soils containing 10 to 300 µg Zn g^{-1}(Alloway, 1995). Secondary inputs of Zn to soils arise because of atmospheric (e.g. volcanoes, forest fires, and surface dusts) and biotic (e.g. decomposition, leaching/wash-off from leaf surfaces) processes (Friedland, 1990). Further anthropogenic emission of Zn inputs to soil has increased due to industrial revolutions and resulted in buildup of Zn in soil particularly as a result of mining and smelting activities (Nriagu, 1996). The ratio of Zn emissions arising from anthropogenic and natural inputs is estimated to be >20:1 (Friedland, 1990). However this is much localized and area specific accumulation that leads to Zn contamination in soil and crop Zn toxicity. But in general Zn deficiency is widely realized across the globe,resulting in substantial losses in crop yields and human nutritional health problems. Nearly25% of the world's population is at risk due to Zn deficiency. Zinc deficiency affects about 2.2 billion people world-wide (Prasad, 2012). Many agricultural countries around the world are affected by zinc deficiency (Tuerk and Fazel, 2009). Further it is reported that areas with zinc deficient soils are often regions with widespread zinc deficiency in humans. A basic knowledge of the dynamics of zinc in soils, understanding of the uptake and transport of zinc in crops and characterizing the response of crops to zinc deficiency are essential steps in achieving sustainable solutions to the problem of zinc deficiency in crops and humans (Alloway, 2008). Increasing the amount of zinc in the soil and thus in crops and animals/humans is considered as an effective preventative measure. This paper is mainly discusssoil Zn status of Karnataka and the responses of various horticultural crops to Zn application for effective management and utilization of Zn in crop production as well as to mitigate the Zn deficiency or malnutrition in human/animals.

Physiographic Landforms and Land Use Pattern of Karnataka

Physiographically, Karnataka is part of well defined regions of India such as the Deccan Plateau, the Western Ghats, and the Coastal Plains. It is located approximately between 11.5-18.5°N latitude and 74-78.5°E longitude. The state can be divided into 1. Coastal zone, 2.Malnad area (Central plateau), 3. Northern maidan 4.Northern dry maidan and 5. Southern Karnataka Plateau. It is land of rivers, waterfalls, plains, hills, peaks and plateau. The main rivers are Cauvery, Hemavati, Tungabhadra, Godavari, Krishna, Palar, North and South Pennar, etc. It has a dynamic weather due to land's altitude, topography and the distance from sea. The climate of Karnataka ranges from arid to semi-arid to humid tropical. South West and North East monsoon bring rainfall to Karnataka and mean annual rainfall is around 1355 mm. It experiences four seasons in a year: Summer (March-May); Monsoon (June-September); Post-monsoon (October-December); and Winter (January-February). The land use pattern of Karnataka is described in Table 1 and about 55% of total geographical area is put under cultivation. Mostly rainfed farming is followed in Karnataka and the area-sown more than once in a year is very low (only 8% of cultivated area).

Table 1: The land use pattern of Karnataka

Land use pattern	Area (in m ha)
Total geographic area	19.17
Reporting area for land utilization statistics	19.05
Forest	3.03
Not available for cultivation	1.92
Other uncultivated land excluding fallow land	2.13
Fallow land	1.56
Net area sown	10.40
Area sown more than once	0.84
Total cropped area	11.24

Source: Directorate of Economics and Statistics (2015)

Soils of Karnataka

Soils of Karnataka are grouped into different major soil orders *viz*., Alfisols, Aridisols, Entisols, Histosols, Inceptisols, Ultisols and Vertisols (Fig. 1). According to Soil Survey Data, the soils of Karnataka can be divided under nine groups. They are red sandy soils, red loamy soils, shallow black soils, medium black soils, deep black soils, mixed black and red soils, laterite soils, laterite gravelly soils and coastal alluvium. Most of the soils has acidic to neutral to slightly alkaline pH, low-medium organic carbon, medium to high available N and K, low in available P, deficient in Zn and sufficient in other micronutrients.

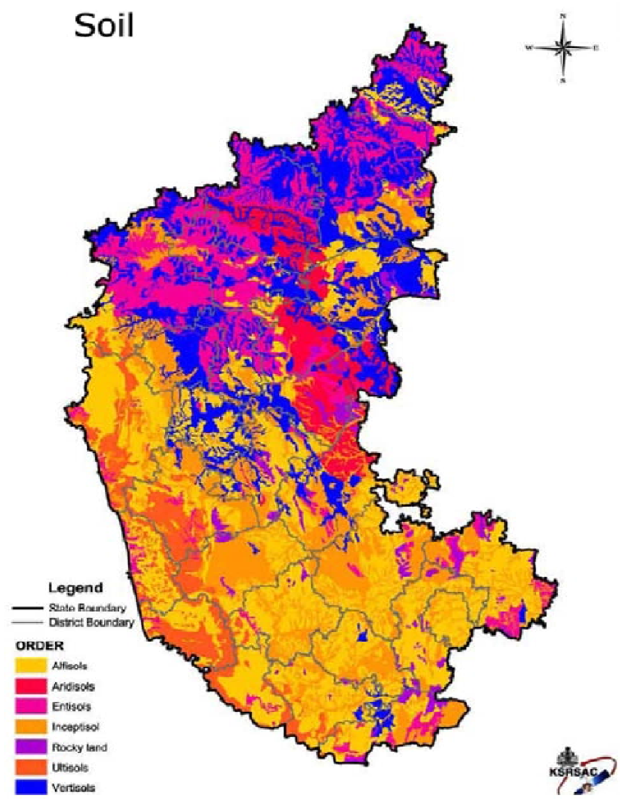

Fig. 1: Major soil orders of Karnataka

Soil Zn status of Karnataka

In India, Zn is now considered as fourth most important yield limiting nutrient after N, P and K, respectively. Analysis of 256000 soils and 25000 plant samples from all over the India showed that 49% of the soils and 44% of the plant samples were potentially Zn deficient and that this was the most common micronutrient problem affecting crop yields in India (Arunachalam et al. 2013). Deficiency of Zn has increased in Southern states because of intensive cropping and extensive use of NPK fertilizers without micronutrients. Further it has been reported from periodic assessment of soils that, by the year 2025, Zn deficient soils in India is likely to increase from 49 to 63% as most of the marginal soils brought under cultivation are showing Zn deficiency (Singh, 2006). Families consuming the farm produce from Zn deficient soil leads to low Zn in their blood plasma compared to those who were fed on produce from regular Zn supplied soils. Therefore application of Zn is essential to maintain soil, seeds/crops and blood plasma of humans and animals (Singh, 2009). In view of the emerging Zn deficiencies in Southern States and micronutrient malnutrition problems in rural population, it is inevitable to study soil Zn status as well as its response in various horticultural crops.

More than 75% of the soil samples in Karnataka are found to be deficient in Zn (Fig.2). This might be due to high soil pH, poor organic matter content, excessive removal by crop intensification and faulty management practices like imbalance fertilizer

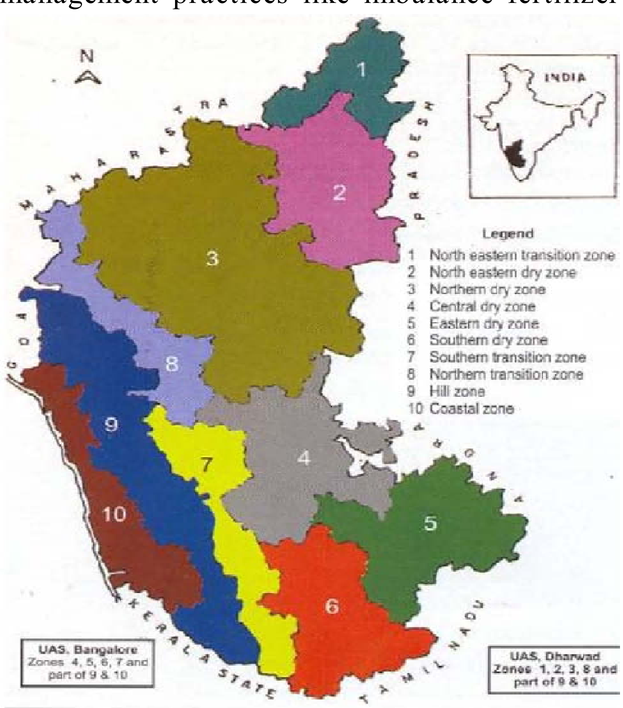

Fig. 2: Agro-ecological zones of Karnataka state

management. In traditional areca nut growing soils of Karnataka, the available zinc content of soils ranged from 2.9 to 8.2 mg/kg with a mean value of 4.17 mg/kg. Similarly Thirthahalli area had 4.7 mg Zn kg^{-1} soil; Sagar area had 3.7mg Zn kg^{-1} soil and Sringeri area had 4.7 mg kg^{-1} soil whereas, zinc status in soils under mulberry (Mysore, Tumkur, Bangalore, Kolar) ranged from 0.40 to 0.69 mg/kg. More than 95% of the samples analyzed were found to be deficient in zinc and the remaining samples recorded just sufficient zinc status in Malaprabha right bank command area (Ravikumar *et al.*, 2007). Agro-ecological regions of Karnataka and their Zn status is depicted in Fig. 2 & 3 (Table 2).

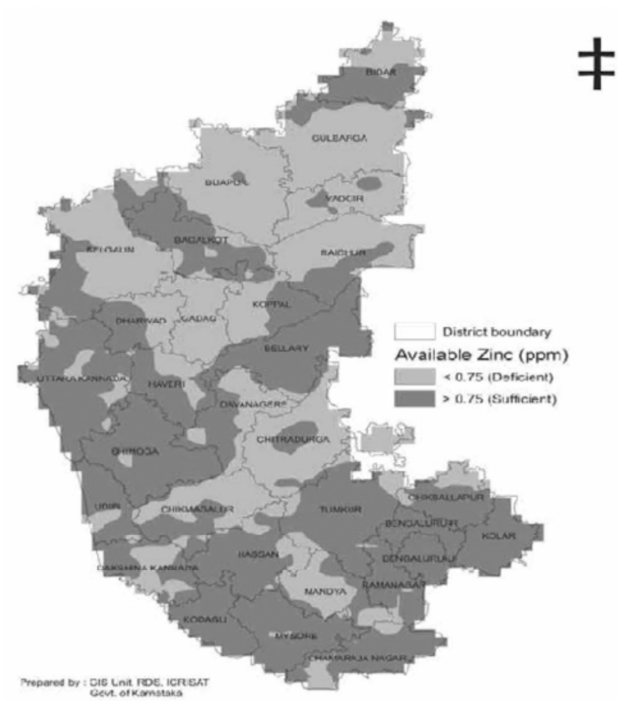

Fig. 3: Soil Zn status of Karnataka

Factors Affecting Zinc Availability in Soils

The total zinc content of the soils is of little importance in predicting the zinc supplying capacity of a soil. The solubility of zinc in soil is controlled by the matrix of iron, aluminium, manganese and other elemental oxides, carbonates, silicates and organic compounds. Soil reaction, organic matter, type and extent of clay, calcium carbonate, iron and aluminium oxides, and soil phosphorus affect the zinc availability to plants. Let us see some of the major soil factors that affect the Zn availability in this region.

Table 2: Response of banana to Zn an on farm study, Doddaballapur, Karnataka

Name of the Farm	Yield (t/ha)		Leaf Zn (mg/kg)		Leaf P (%)	
	No Zn	Zn @0.25%	No Zn	Zn @0.25%	No Zn	Zn @0.25%
CG Farm	65.4	74.5	14.2	24	1.16	0.84
KA Farm	55.6	58.4	15.0	26	0.96	0.64
PS Farm	49.4	60.4	9.0	28	0.91	0.72
MG Farm	64.4	74.4	18.0	32	0.48	0.74

Soil reaction

The pH of Karnataka soils are mostly in neutral to slightly alkaline range particularly in Northern, Central and Southern plateau region. Coastal as well as Western Ghats region and its surrounding areas have acidic pH range (Fig. 4). Availability of zinc decreases with the increase in soil pH. The solubility of zinc is highly dependent on pH and decreases by 100 folds for each unit increase in soil pH. The solubility of zinc is maximum in the pH range of 5 to 7 in the mineral soils and 4.5 to 6.0 in the organic soils. Zinc deficiencies occur usually in soils of pH 6.0 or more. So expected zinc deficiency is mainly in Northern, Central and Southern plateau region. Soil pH may influence the transport of adsorbed zinc to plant tops.Stability of soluble and insoluble organic complex of zinc depends on soil pH. The reduced availability of zinc with increase in soil pH was attributed to the formation of zinc hydroxides.

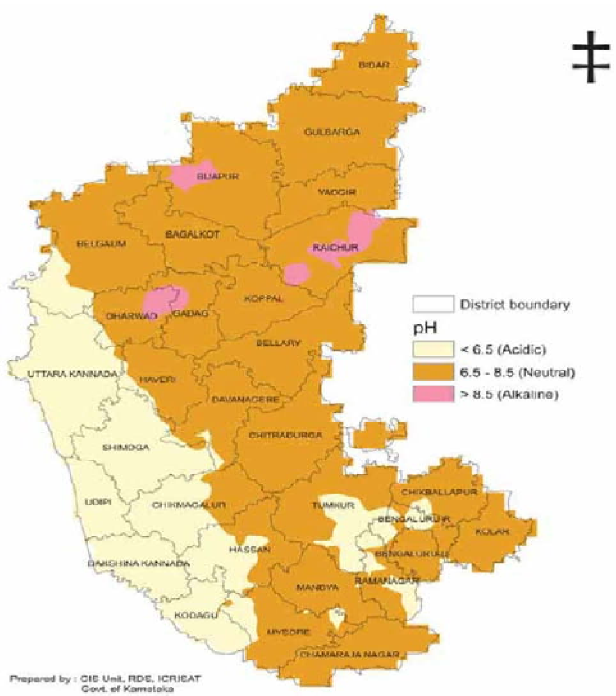

Fig. 4: Soil pH status of Karnataka state

Soil organic matter

Organic matter status of soils of Karnataka is depicted in Fig. 5. Organic matter can have negative influence on available zinc in organic matter rich acid soils of coastal Karnataka.The zinc availability increases with increased content of organic matter. Organic matter plays an important role on the availability of zinc through the formation of soluble organo-metal complexes and stable metalo-organic complexes. Metal complex with fulvic acid fraction of organic matter is highly water soluble. Natural complexing agents present in the organic materials effectively enhance concentration of soluble zinc complexes in soil solution through dissolution of sparingly soluble zinc compound and chelation of zinc ions so liberated.

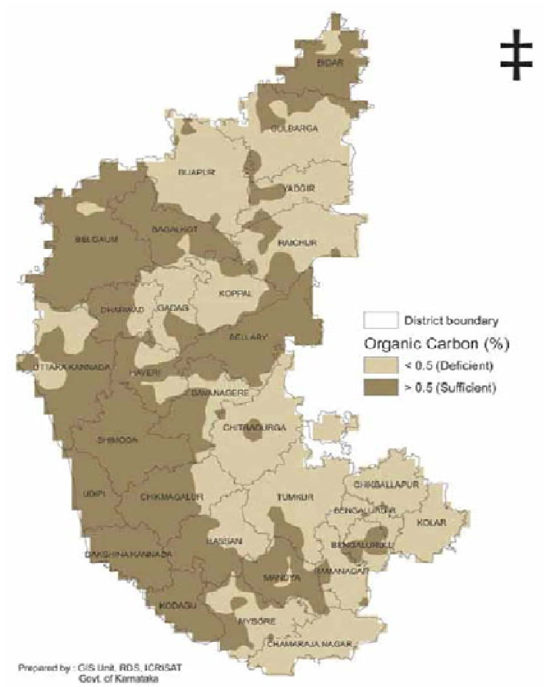

Fig. 5: Spatial distribution of organic carbon in soils of Karnataka

Soil phosphorus

The soil P status of Karnataka is depicted in Fig. 6. A large area is having either sufficient available P in

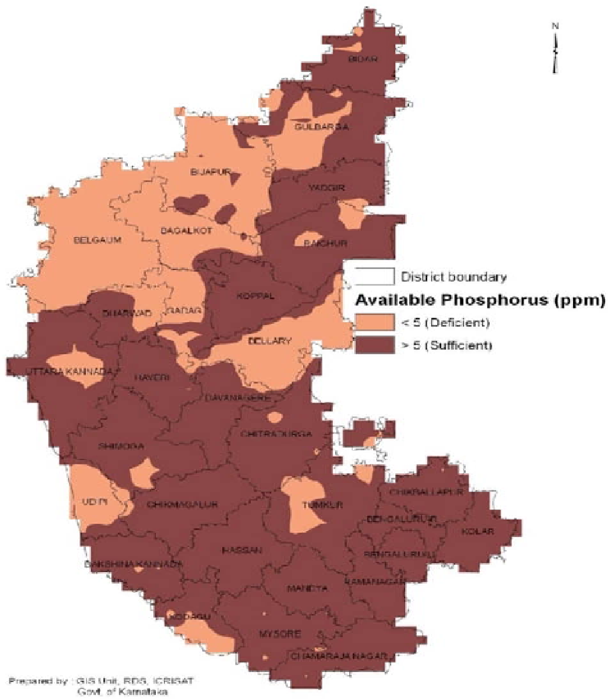

Fig. 6: Soil Phosphorus status of Karnataka

soil or in excess due to accumulations following continuous application of phosphatic fertilizers. Phosphorus induced Zn disorder in plant is commonly associated with high levels of available P or with the application of P to the soil.

Four possible causes of P induced Zn deficiency

(a) slower rate of translocation of Zn from roots to top

(b) Accentuating Zn deficiency in plants in presence of high available P

(c) Simple dilution effect on Zn concentration in the top owing to growth response of P. Excess P interferes with metabolic functions of Zn within the plant cells. When there is slight or more of yield to P application, Zn concentration at the top of the plant and uptake of Zn reduces

(d) Metabolic disorder with plant cells related to an imbalance between P & Zn. Green house experiments have shown that the concentration and uptake of Zn increased in the roots and decreased in the leaves, nodes and internodes of vegetables due to the increased levels of P application. Zn availability in acid soils of Karnataka with high available phosphorus P (30.8 kg P_2O_5 ha^{-1}) was non-significantly correlated with available Zn.

Considering the above four factors, Karnataka soils having high P status in major area shows P induced Zn deficiency in many crops either in the form of visible symptoms or hidden hunger of varying degree.

Soil Maps as Tools to Delineate and Manage Deficient Regions

Soil testing can be used to diagnose and manage nutrient problems in the farmers' fields. Typical results from ICRISAT on soil Zn status for two districts in Karnataka are included here as an example (Fig.7). A large contiguous tract of land deficient in Zn was identified across Bagepalli and Gudibanda blocks in

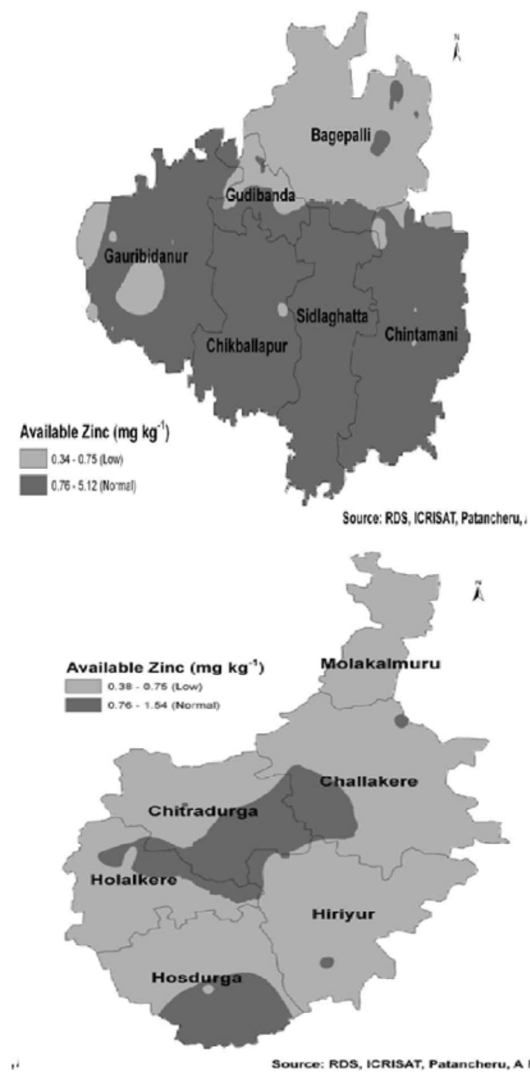

Fig. 7: Block level soil Zn status of Chikballapur and Chitradurga district.

Table 2 : Status of Zn in agro-ecological regions of Karnataka

Agro-ecological region	Districts name (Number of Taluks)	Taluks name	Zn status	Reference
Southern transition zone of Karnataka	Hassan (4), Chickmagalur (1), Shimoga (3), Mysore (3), Davanagere (2).	H.D.Kote, Hunsur, Periyapatna, H.N.Pura, Alur, Arkalgud, Belur, Tarikere, Bhadravathi, Shimoga, Honnali, Shikaripura, Channagiri.	Above critical levels*	Ramana et al. (2000)
Coastal agri-eco zone of Karnataka	Udupi (3), D. Kannada (5), U. Kannada (5)	Karwar, Kumta, Honnavar, Bhatkal, Ankola, Bantwal, Udupi, Belthangadi, Karkala, Kundapura, Mangalore, Puttur, Sulya.	Much higher than the critical levels	Gowda et al. (2001a)
Northern dry and northern transition zones of Karnataka	Koppal (4), Gadag (5), Belgaum (9), Bijapur (5), Bagalkot (6), Bellary (7), Davangere (1), Raichur (2), Dharwad (4), Haveri (6),	Gangavathi, Koppal, Kushtagi, Lingasugur, Sindhanur, Yelburga, Badami, Bagalkote, Bagewadi, Bilgi, Bijapur, Hungund, Indi, Jamkhandi, Mudhol, Muddebihal, Sindhagi, Bellary, Hagaribommanahalli, Harapanahalli, Hadagali, Hospet, Kudligi, Sandur, Siruguppa, Ron, Navalgund, Naragund, Gadag, Mundargi, Ramdurga, Gokak, Raibag, Soundatti, Athani, Hukkeri, Chikodi, Bailhongal, Belgaum, Haveri, Shiggaon, Shirahatti, Kundagol, Savanur, Hubli, Dharwad, Byadgi, Hirekerur, Raneebennur.	Well above the critical levels	Ramana et al. (2000)
Eastern and southern dry zones of Karnataka	Bangalore Rural (4), Ramanagar (4) Bangalore Urban (3), Kolar (5), Chikkaballpur (6) Tumkur (2). Mysore (4), Chamarajnagar(4), Mandya (7), Tumkur (2), Hassan (2).	Gubbi, Tumkur, Anekal, Bangalore South, Bangalore North, Channapatna, Devanahalli, Doddabalapur, Hosakote, Kankapura, Magadi, Nelmangala, Ramanagar, Bagepalli, Bangarpet, Chikkabalapur, Chintamani, Gudibanda, Gowribidanur, Kolar, Malur, Mulbagal, Sidalaghatta, Srinivasapura, K.R.Nagar, T.Narasipur, Mysore, Kollegal, Nanjangud, Turuvekere, Kunigal, Nagamangala, Srirangapatna, Malavalli, Maddur, Mandya, Pandavapura, K.R.Pet, Channarayapatna, Hassan, Chamarajanagar, Yelandur, Gundlupet.	Above the critical level	Gowda et al. (2001b)
North east transition and dry zones of Karnataka	Bidar (5), Gulbarga (2), Gulbarga (5), Yadgir (3) &Raichur (3)	Aland, Bhalki, Basvakalyan, Bidar, Chincholi, Humnabad, Aurad, Afzalpur, Chitapur, Gulbarga, Jewargi, Sedum, Shahapur, Yadgir, Shorapur, Raichur, Deodurga, Manvi.	Below the critical levels	Ramana et al. (2001b)
Hilly and central dry zones of Karnataka	U.Kannada (6), Belgaum (1), Dharwad (1), Haveri (1), Shimoga (4), Chickmangalur (6), Kodagu (3), Hassan (2), Chitradurga (6), Davangere (3), Tumkur (6)	Sirsi, Siddapura, Yellapura, Supa, Haliyal, Mundgod, Khanapur, Soraba, Hosanagar, Sagar, Thirthahalli, Koppa, Sringeri, Mudigere, Narasimharajapur, Chickmagalur, Kalaghatagi, Hangal, Sakleshpur, Virajpet, Somwarpet, Madikere, Challakere, Chitradurga, Davanagere, Harihara, Hiriyur, Hosadurga, Holalkere, Jagalur, Molkalmuru, Arasikere, Kadur, Madhugiri, Pavagada, Koratagere, C.N.Halli, Sira, Tiptur.	Below the critical range	Gowda et al. (2002)

*Critical level of zinc in soil 0.75 mg kg^{-1}

Chikballapur district. Other blocks *viz.* Gauribidanur and Chintamani in Chikballapur district also had pockets potentially deficient in Zn. The results also showed that almost all blocks in Chitradurga district were critically deficient in Zn (Fig.7)

Response of Horticultural Crops to Applied Zn

Zinc is applied to crop by soil application, foliar spray, coating/soaking of seeds or seedling in Zn solution or slurry. Among these methods, soil and foliar application is generally practiced (Ganeshamurthy et al., 2015). The optimum micronutrient content of plant tissues of various horticultural crops is depicted (Raghupathi *et al.* 2014). In case of Zn, optimum range in most of the fruit crops is 20-50 ppm. Further, the response of crops to Zn application is reported by many workers across the country. In the following paragraphs, the response of Zn along with other micronutrient in many horticultural crops studied in the region is briefly elaborated.

Zinc and Boron deficiency are the most important micronutrient disorders in horticultural crops. Foliar spray of 0.15% zinc corrects the deficiency (Ganeshamurthy *et al.*, 2013). Studies in sweet orange have indicated that soil application of zinc sulphate at 1 kg/plant once in every 4 years is the most effective method for controlling Zn deficiency in neutral and alkaline soils. Foliar spray with zinc sulphate (0.3%) along with humectant ($CaCl_2$ at 2%) once in a year during the active flush period is equally effective.

Effect of Zn application in vegetable crops

Zinc fertilizer application can increase yield from 15 to 25% in French bean, capsicum, chili, onion, tomato and cabbage. Screening of a number of tomato varieties for their tolerance to low zinc in the soil indicated that varieties with semi-determinate growth habits like ‘Arka Saurabh’, ‘Arka Vikas’ and some F_1 hybrids are least tolerant, whereas those with determinate growth like ‘Sioux’ and ‘Pusa Ruby’ are more tolerant and IIHR selection 1098 was the most tolerant. Tolerant varieties obtained adequate zinc from the soil with the help of more fibrous roots and lowering the pH of the rhizosphere. Combined application of B, Zn,Cu, Fe, Mn @ 100 ppm and Mo @ 50ppm produced the highest tomato fruit yield of 26.7 t ha^{-1}compared to the yield of 24.0 tobtained with Zn and 20.0 t ha^{-1} in control (Bhatt *et al.*, 2004). In cabbage, activity of enzyme carbonic anhydrase was found to be a good index of metabolically active zinc. Foliar application of 0.5% $ZnSO_4$ recorded minimum mean weight loss (20.16%) of cabbage heads (Sarma et al., 2005). Application of 20 kg $ZnSO_4$ ha^{-1} to cauliflower cultivar Snowball-16 produced the highest marketable curd yield. Performance of the applied Znwas distinctly superior when applied in conjunction of 22 kg Pha^{-1}. Application of 8 kg Zn ha^{-1} gave16% higher yield of potato than control and 4.5% higher than foliar sprays @ 1kg ha^{-1} (Raghav and Singh, 2004). Foliar spray of1% $ZnSO_4$ to onion produced highest seed yield per plant andunit area with high germination percentage (Khalate *et al.*, 2002), indicating the usefulness of the Zn in improving the seed health. Foliar sprayof $ZnSO_4$@0.75% to ‘Pudukottailocal’cucumber produced maximumfruit set, number of fruit/vine,fruit weight and yield (Madhu sudhan and Shakila, 2003). In okra, combined spray of Zn and Mo (20 ppm each) gave highestpod yield of 6.9 t ha^{-1} compared to2.8 t in control (Srihari et al., 1987).Significantly higher okra yield of 5.5 t ha^{-1} was obtained when 40 kg $ZnSO_4$ $ha^{-1}$was applied as basal soil applicationas compared to 4.1 t ha^{-1} obtained with 2.5 kg $ZnSO_4$ ha^{-1} dose appliedto foliage twice and control (Raghavand Sharma, 2003).

Effect of Zn application in Mango

From the results of two years data on application of Zn to Dashehari mango, it is observed that Zn application had increased the mango yield and other quality parameters such as TSS, ascorbic acid and sugar: acid ratio (Singh *et al.*, 2003). Application of Zn increased the mango yield by 21% and fruit quality also enhanced. These parameters are further improved when Zn was applied with other micronutrients (B and Cu).

Influence of Zn on Banana Yield, Leaf Zn and P

On farm studies conducted in four different farms of Doddaballapur, Karnataka revealed that foliar spray of Zn at 0.25% at regular interval had tremendously increased the banana yield (at the scale of 5.01-22.26%) and leaf Zn content and reduced the leaf P content in the most cases when compared to the control treatment (where no Zn is applied). It showed that application of Zn is very useful to the crop growth and development and to attain higher yield.

Response of mandarin orange to Zn application

The effect of Zn and other micronutrients on yield and quality of mandarin orange has been reported by Saraswathy *et al.* (1998) and Dineshbabu and Yadav (2005).Application of Zn along with urea and other micronutrients boosted the number of fruits per tree, fruit weight and yield. In addition, it enhanced fruit juice content, TSS, titratable acidity, total sugars and ascorbic acid content of mandarin orange.

Zinc application on growth and yield of papaya

Papaya showed clear-cut response to Zn and other micronutrients (Fe and B) application (Pant and Lavania, 1998). Application of $ZnSO_4$ (0.15%) through foliar spray improved the number of fruits per plant and fruit yield. Moreover, application of Zn along with other micronutrients further enhanced the plant growth and yield of papaya.

Effect of application of Zn and B on Sapota

Soil application of $ZnSO_4$ (50 g/tree) has increased fruit weight and number of fruits per tree and yield of sapota. Increasing the amount of $ZnSO_4$from 50-100 mg did not show any significant improvement in these parameters. Application of $ZnSO_4$(50 g) along with 25 g borax per tree had further improved fruit weight and number of fruits per tree and yield of sapota and which are at par with that of $ZnSO_4$ (100 g) + borax (50 g) per tree (Saraswathy *et al.* 2004). Moreover, the highest yield and fruit weight and numbers has been observed in plants that received $ZnSO_4$(50 g) + borax (25 g) per tree + 0.5% $ZnSO_4$ spray. From the study, it was clear that the combined practices of both soil and foliar application of Zn is more beneficial to plant than any single practices.

Effect of Zn and B on Pineapple

Application of $ZnSO_4$ alone and in combination with borax influenced fruit weight and quality parameters of in 'Giant Kew' pineapple. When compared among different levels of $ZnSO_4$ application (0.2, 0.4 and 0.6% foliar spray), though 0.6% $ZnSO_4$ spray was found to be superior, application of 0.4% $ZnSO_4$ spray is effective and economical (Kar *et al.* 2012). Further combined application of borax (0.05%) along with $ZnSO_4$ did not show any significant change in these parameters.

Influence of Foliar Spray of $ZnSO_4$ on Grapes

Under field trials, foliar application of $ZnSO_4$ @ 0.4% in 5-year old 'Perlette' grape vines was the most effective in increasing yield, bunch weight and berry weight and quality parameters (Dhillon and Bindra, 1995).

Effect of Zn Application in Guava

In 7-year old 'Allahabad Safeda' guava, application of foliar spray of 0.6% $ZnSO_4$ produced significantly higher yield and quality of fruits. Application of zinc caused 72% fruit set against 64% in control, 166g fruit weight against 143g in control, 499 fruits/tree against 426 in control, 82 kg fruit yield against 60 kg/tree in control, 11.3% TSS against 9.6% in control, 0.36% acidity against 0.43 in control, and 127 mg ascorbic acid against 103 mg in control. Bronzing', a common disorder in guava occurring on the red soils of poor fertility in Karnataka was found to be caused due to combined deficiencies of phosphorus, potassium and zinc. Severe cases of disorder result in trunk splitting. Foliar spray with DAP (0.5%), potassium sulphate (0.5%) andzinc sulphate (0.3%) controls the disorder. Zinc deficiency alone can be effectively controlled by soil application of zinc sulphate @ 800 g/plant once in 4 years in guava.

CONCLUSIONS

Wide spread Zn deficiency is a reality in soils of Karnataka and is equally distributed in all the agro-climatic regions of the state. District level deficiency maps helps to a great extent in management of Zn deficiency in soils and crops. Horticultural crops respond very significantly to Zn application. Further, the response and amount of Zn required by individual crops vary and it is influenced by climate and soil factors. Many site-specific nutrient management studies need to be done for effective management of Zn. From the available data, it is obvious that application of Zn to horticultural crops enhances the Zn content of the produce. This helps in enhancing the availability of Zn in the food.

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Original Research Paper

Evaluation of Different Cultivars of Tuberose (*Polianthes tuberosa* L.) under Humid agro Climatic conditions of Goa

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ABSTRACT

Tuberose (*Polianthes tuberosa* L.) is one of the most important tropical bulbous-ornamental cultivated for production of long-lasting flowers spikes. Adaptation and acclimatization of different cultivars under humid agro-climatic conditions of Goa are to be confirmed for their better performance. The present investigation was conducted to evaluate the performance of tuberose cultivars under agro-climatic conditions of Goa during 2014-2017. Five single and six double cultivars of tuberose were evaluated during the study period. All the cultivars differed in their growth and flowering behaviour. Among the single cultivars, evaluated, maximum number of florets per spike (47.00) was observed in Pune local whereas spike-length (75.59 cm) was maximum in Mexican Single. Among the double cultivars, evaluated, maximum plant height (52.21 cm) and maximum number of leaves per plant (59.63) were recorded with cultivar Arka Suvasini. Leaf length was significantly higher (52.93 cm) in Pearl double whereas leaf width (2.04 cm) was maximum in Calcutta Double. Days to appearance of flower spike were earlier in Arka Suvasini. Minimum days taken for opening of basal floret (84.88 days) were recorded with cultivar Arka Suvasini. Spike girth (0.68 cm), Spike fresh-weight (69.06 cm), floret stalk-length (3.6 cm), floret diameter (5.24 cm), weight of individual floret (3.49 g) and vase life (7.93 days) was significantly maximum in Cv. Arka Suvasini followed by Pearl Double. Based on the performance evaluation cv. Mexican Single among single types and cv. Arka Suvasini and Pearl Double among double types could be recommended for commercial cultivation under agro climatic conditions of Goa.

Key words: Cultivars, double, Evaluation, Single and Tuberose

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.), popularly known as Rajanigandha or Nishigandha is one of the most important tropical ornamental bulbous flowering plants cultivated for production of its long-lasting flower spikes. It is a native of Mexico and belongs to the familyAsparagaceae. Flowers of the Single type (single row of perianth) are commonly used for extraction of essential oil, loose flowers, making garland etc., while that of Double varieties (more than two rows of perianth) are used as cut flowers and for garden display. Flowers of the 'Single' cultivars are more fragrant than 'Double' type and contain 0.08 to 0.14 percent concrete, which is used in high-grade perfumes (Singh and Uma, 1995). In India, tuberose is cultivated commercially in Bagnan, Kolaghat, Midnapur, Panskura, Ranaghat, Krishnanagar of West Bengal; Coimbatore, Dindigul, Kadalur, Krishnagiri, Dharmpurui, Sathyamangalam, Theni and Madurai districts of Tamil Nadu; Pune, Nashik, Ahmednagar, Thane, Sangli of Maharashtra; East Godavari, Guntur, Chittoor, Krishna District of Andhra Pradesh ; Mysore, Tumkur, Kolar, Belgaum and Devanhalli taluk in Karnataka ; Guwahati and Jorhat in Assam ; Udaipur, Ajmer and Jaipur in Rajasthan; Navsari and Valsad of Gujarat and parts of Uttar Pradesh and Punjab. Some of the tuberose cultivars have beenintroduced, while some are evolved in India. The information available on recommendations of the suitabletuberose cultivars for growth, floral and economicparameters under coastal humid agro climatic conditions of Goa is scanty. Adaptation and acclimatization of different tuberose cultivars under humid agro climatic conditions of Goa are to be confirmed for their better performance. This will enable the farmers to grow released and new introduced and improved cultivars of tuberose and helps in making them understand their superiority over local cultivars. Keeping these facts in view, the present study was conducted to evaluate the performance of different tuberose cultivars under coastal humid climatic conditions of Goa and to find out the suitable tuberose cultivar under agroclimatic conditions of Goa.

MATERIALS AND METHODS

The present experiment was conducted at Floriculture Research Farm, Horticulture Science Section, ICAR-Central Coastal Agricultural Research Institute, Ela, Old Goa, Goa, India during 2014-2017. The state of Goa is located between 140 16" North latitude and 730 75" East longitude with the states of Maharashtra on the North and Karnataka on the East and South and Arabian Sea on the West. The five single type cultivars, viz., Mexican Single, Calcutta Single, Hyderabad Single, Pune Local Single and Phule Rajni,and six double type cultivars (Pearl Double, Arka Suvasini, Bidhan Rajani, Calcutta Double, Hyderabad double and Pune local double) were used for the present study. The uniform sized bulbs of size(2 cm diameter) were planted with the spacing of 45 x 30 cm in a plot size of 1.50 m x 1.0 m. Uniform cultural practices were adopted for all the cultivars. The experiment was laid out in randomized block design (RBD) with five replications. Ten plants from each plot were randomly selected for recording various observations. The observations were recorded for two consecutive years on vegetative growth, floral and bulb parameters. The observations, viz., plant height at shoot emergence (cm), number of leaves per plant, leaf length (cm), leaf width (cm), days to appearance of flower spike, number of florets per spike, length of spike (cm), diameter of spike (cm), fresh weight of the spike (g), stalk length of the floret (cm), diameter of the floret (cm), fresh weight of the individual floret (g), vase life of the spikes (days), weight of the bulbs, average number of bulbs per clump and bulblets per clump were recorded. The data recorded on various parameters were compiled and analysed statistically as per the methods described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Significant differences were observed for various morphological characters and floral quality traits among different single cultivars of tuberose evaluated (Table 1 and 2) under coastal humid agro climatic conditions of Goa.Tallest plant (49.18 cm), and more number of leaves per plant (82.66) were obtained in cv. Mexican Single in single flower types (Table 1). The highly significant variation in plant height and number of leaves per plant among various tuberose cultivars may be attributable to the hereditary traits, which is further altered by prevailing environmental conditions. The results of the present study are in conformity with the findings of Bhaskar and Reddy

Table 1: Plant growth and floral characteristics in single-type tuberose cultivars under humid agro-climatic conditions of Goa

Treatments	Plant height at shoot emergence (cm)	No. of leaves	Days to appearance of initial spike	No. of spikes/ clump	No. of florets/ spike	Length of spike (cm)	Diameter of spike (cm)
Mexican Single	49.186	82.660	112.003	3.67	37.083	75.590	0.532
Calcutta Single	46.643	64.047	114.177	3.17	35.223	68.177	0.810
Hyderabad Single	42.640	60.940	136.273	3.50	45.057	61.023	0.905
Pune Local Single	38.030	63.167	123.41	2.83	37.167	62.093	0.915
Phule Rajni	40.387	68.170	131.073	3.13	38.050	58.113	0.540
S.Em+	0.115	0.858	0.564	0.093	0.704	0.294	0.005
CD (0.05)	0.346	2.575	1.693	0.289	2.113	0.882	0.014

(2006), Bhaskar*et al*. (2006) and Mahawer *et al*. (2008) in tuberose.

In case of single flower type cultivars earliest flowering was recorded in cv. Mexican Single (112 days) whereas it was very late in Hyderabad single (136.273days) (Table 1) (Fig. 1).The variation in days to appearance of flower spike was chiefly due to the different genetic make-up of the cultivars evaluated under the present study and prevailing environmental conditions.Mexican single recorded significantly maximum spike length (75.59 cm) (Table 1). This variation in spike length among various tuberose cultivars evaluated in the present study may be due to different genetic make-up of the cultivars and prevailing environmental conditions.

Fig. 1: Tuberose crop in flowering stage under humid agro-climatic conditions of Goa

Significant variation was noticed with respect to number of florets per spike in single types (Table 1). The variation in number of florets per spike may be due to genetic variability among the different cultivars of tuberose and prevailing environmental condition during field trial.Further, in single flower type tuberose cultivars, higher trends for floret stalk length (1.84 cm), diameter of floret (4.085 cm) and weight of individual floret (2.123g) was recorded in cv. Mexican single (Table 2). The variations observed in various floral

Table 2: Floral and Bulb characteristics in single-type tuberose cultivars under humid agro-climatic conditions of Goa

Treatments	Floret stalk length (cm)	Diameter of floret (cm)	Weight of individual floret (g)	Vase life (days)	Weight of bulb (g)	No. of bulbs/ clump	No. of bulblets/ clump
Mexican Single	1.840	4.085	2.123	6.702	31.953	7.467	26.000
Calcutta Single	1.721	3.820	1.543	6.730	22.087	6.123	23.667
Hyderabad Single	1.372	4.047	1.717	6.920	19.700	5.680	22.633
Pune Local Single	1.821	3.803	1.023	5.917	21.517	6.133	20.300
Phule Rajni	1.741	3.123	1.440	5.400	19.003	5.000	20.367
S.Em +	0.007	0.053	0.029	0.019	0.407	0.104	0.525
CD (0.05)	0.020	0.160	0.087	0.059	1.221	0.313	1.575

characters might be due to the presence of sufficient genetic variability as reported earlier by Bichoo *et al.* (2003) in gladiolus.

Among the single flowered types, Mexican single, Calcutta Single and Hyderabad Single had better vase life of 6.70 days, 6.73 days and 6.92 days respectively (Table 2). Sateesha *et al*. (2011) reported good vase-life in tuberose cultivars, Vaibhav and Prajwal. The highly significant variation for the vase-life of cut spike among tuberose cultivars may be due to its different genetic make-up with prevailing environmental conditions, which ultimately affects various physiological processes like turgidity of the cell, water uptake through xylem tissue, water loss through transpiration, respiration and breakdown of their served food, which influences vase-life under laboratory conditions.

In case of single flower type cultivar, highest bulb weight per clump was recorded in cultivar Mexican Single (31.953 g), while, lowest (19.003 g) in Phule Rajni (Table 2). These differences might be due to the genetic characters of the different tuberose varieties taken up for the present study.The variation in weight of bulbs per plant among different tuberose cultivars at bulb harvesting stage can be attributed to the distinguished varietal genetic make-up of the cultivar.

Significant differences were observed for various morphological characters and floral quality traits among different doublecultivars of tuberose evaluated (Table 3 - Table 4) under coastal humid agro climatic conditions of Goa.It is evident from the data in Table 3 that out of the different double type tuberose cultivars evaluated for their vegetative characteristics,

Table 3: Plant growth and floral characteristics in double-type tuberose cultivars under humid agro-climatic conditions of Goa

Treatments	Plant height at shoot emergence (cm)	No.of leaves per plant	Leaf length (cm)	Leaf width (cm)	Days to appearance of flower spike	No. of spikes/ clump	No. of florets/ spike	Length of spike
Pearl Double	42.171	44.633	52.930	1.664	164.417	3.36	43.253	71.018
Arka Suvasini	52.211	59.630	41.449	1.148	105.767	3.97	42.247	70.463
Bidhan Rajani	39.554	48.300	34.767	1.643	172.33	2.28	30.083	57.483
Calcutta Double	37.300	47.500	37.257	2.040	111.433	2.39	33.233	57.507
Pune local	37.377	38.127	37.635	1.456	114.603	2.40	47.033	65.733
Hyderabad double	41.030	49.927	38.307	1.138	138.06	3.17	35.540	69.063
S. Em+	0.214	0.148	0.132	0.086	1.896	0.028	0.292	0.240
CD (0.05)	0.643	0.444	0.392	0.258	5.689	0.088	0.875	0.720

the maximum plant height and number of leaves per plant were recorded in cv. Arka Suvasini (52.21 cm and 59.63 no's). Panse (1957) reported that the variation in plant height and number of leaves per plant among the cultivars might be due to the genetic constitution of the germplasm, which has close bearing in response to selection.

Out of the six tuberose cultivars evaluated for their floral parameters (Table 3) among the double flower types, days to appearance of flower spike were earlier in Arka Suvasini (105 days) while it was late in Bidhan Rajani(172 days).Similar results with respect to variation in days to first flowering among different cultivars were reported earlier by Bhaskar *et al.* (2006) and Mahawer *et al.* (2008). Among the double flowered types, length of the spike (71 cm) was maximum in Pearl Double as recorded in Table 3. Being genetically controlled factor, significant variation occurred in length of the spike due to the hereditary traits of different cultivars under prevailing

Table 4: Floral and bulb characteristics in double-type tuberose cultivars under humid agro-climatic conditions of Goa

Treatments	Diameter of spike (cm)	Fresh weight of spike (g)	Floret stalk length (cm)	Diameter of floret (cm)	Weight of indi. floret (g)	Vase life (days)	Weight of bulb (g)	No. of bulbs/ clump	No. of bulblets/ clump
Pearl Double	0.645	62.504	3.523	5.186	3.383	7.600	56.067	12.733	30.167
Arka Suvasini	0.680	69.060	3.600	5.240	3.490	7.930	52.133	11.500	29.600
Bidhan Rajani	0.617	25.897	1.814	4.397	1.580	5.350	34.567	9.400	26.300
Calcutta Double	0.547	25.217	2.007	5.000	1.750	7.023	33.467	9.733	28.167
Pune local	0.563	25.548	3.349	4.726	1.698	5.725	36.267	8.200	19.733
Hyderabad Double	0.542	45.311	3.021	4.068	1.481	6.030	32.800	9.167	17.800
S. Em+	0.017	0.180	0.042	0.032	0.013	0.056	0.236	0.034	0.087
CD (0.05)	0.051	0.540	0.125	0.095	0.038	0.167	0.709	0.103	0.261

environment. Present results are in accordance with the findings of Patil *et al.* (2009) and Mahawer *et al.* (2008) who obtained significant variation among the tuberose cultivars for length of the spike.

The two-year pooled data revealed that maximum trend for number of florets per spike (47) was observed in Pune local while minimum trend was recorded in Bidhan Rajani (30) among the double flowered types (Table 3). These results are in accordance with the findings of Patil *et al.* (2009) and Mahawer *et al.* (2008) who noted significant variation in number of florets per spike in different cultivars of tuberose.The cultivar Arka Suvasini performed better in different floral qualitative traits like spike girth (0.68 cm), stalk length of the floret (3.6 cm), diameter of the floret (5.24 cm) and weight of individual floret (3.49g) which was followed by Pearl Double (Table 4).

Further, the highest fresh weight of the spike was recorded in cultivar Arka Suvasini (69.06 g), followed by the cultivar Pearl Double (62.50 g) among double flower type tuberose cultivars (Table 4). Variation in fresh weight of the spike might be due to different genetic make-up of the different cultivars and prevailing environment conditions. Present findings are in accordance with the findings of Kumar and Yadav (2005) in gladiolus.The vase life was found to be significantly maximum (7.93 days) in cv. Arka Suvasini followed by Pearl Double (7.60 days) among the double flowered tuberose types (Table 4).

The maximum bulb weight per plant were recorded in cultivar Pearl Double (56.06 g), whereas, minimum (32.80 g) in Hyderabad Double in double flower type of tuberoses evaluated under the present study (Table 4).The cultivars with more number of leaves have higher photosynthetic activity, source sink relationship, thereby accumulating more amount of carbohydrates and improved bulb weight per plant under prevailing environmental conditions. The significant variation in bulb weight of different tuberose cultivars were also recorded earlier by Mahawer *et al.* 2008.

Based on results obtained, it may be concluded that cv. Mexican Single among single types and cv. Arka Suvasini and Pearl Double among double types could be recommended for commercial cultivation under coastal humid agro climatic conditions of Goa since they were found to be promising in respect of plant growth, floral and bulb characteristics.

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Original Research Paper

Effect of Leaf Removal on Composition of Wine Grape Varieties Grown in Semiarid Tropical Climate of India

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ABSTRACT

Removing leaves from cluster zone is one of the management practices followed to improve fruit composition in temperate wine grape growing countries. However, knowledge on canopy management practices to improve fruit and juice composition for quality wine making is still lacking in semiarid tropical regions of India. Due to ample sunlight availability during fruit growth in semiarid tropics, it is unclear whether the leaves have to be removed from cluster zone. In case the leaves have to be removed, the direction from which it has to be done is also important. Hence, this study was conducted to see the effect of leaf removal from two sides of canopy on fruit composition in two wine grape varieties. In Cabernet Sauvignon vines leaf removal from both east and west side of the canopyimproved fruit quality in terms of reduced pH, potassium, malic acid and increased phenolics. Nevertheless, removing leaves from eastern side was found to be better than western side, because clusters are exposed toexcess sunlight. However, in Sauvignon Blanc, leaf removal from east side improved most of the desirable fruit composition parameters, while leaf removal from west side reduced the fruit quality in terms of sugars, acids, pH, total phenols etc.

Key words: Cabernet sauvignon, Sauvignon blanc, Fruit composition, Leaf removal, Organic acids, Phenolic compounds

INTRODUCTION

Though practice of wine grape cultivation is increasing in many of the tropical countries of the world, its commercial cultivation is gaining impetus only from past 50 years as compared to traditional temperate wine producing countries. Among tropical countries, Brazil, India, Venezuela etc. are playing a lead role in production of wine grapes. In last two decades, there was a substantial increase in area of grape cultivation in tropical countries. The increase was most rapid in Asian countries like India, Thailand, Myanmar and Vietnam, where new vineyards for table grape and wine production are established every year. As there is no dearth of sunlight in these areas during the annual vine growth cycle, there is a need to study the impact of sunlight exposure to clusters and high temperature on berry composition and thereby wine quality. Most of the work on canopy management practices in wine grapes is reported from UAS (Main and Morris, 2004; Bergqvist *et al.,* 2001), New Zealand (Kemp *et al.,* 2011), Australia (Ristic *et al.,* 2013), European countries (Targaduila *et al.,* 2008) etc. Important canopy management practices which are being practices in most of the wine grape growing countries are shoot thinning, shoot positioning, cluster thinning and leaf removal in cluster zone etc. either alone or in combinations. These management practices help in optimizing sunlight interception, photosynthetic capacity of leaves and fruit microclimate to improve fruit composition and wine quality. Leaf removal at fruit zone in many of the cultivars showed improved fruit composition in terms of soluble solids, juice pH, phenolic compounds, anthocyanins and aroma (Kemp *et al.,* 2011). However, in some varieties there was no significant influence in quality of grapes or wines from leaf removal treatment (Reynolds *et al.,* 1986). Leaf removal at veraison stage is known to improve the fruit composition by reducing juice pH due to reduced potassium and malic acid concentration (Lang and Thorpe, 1989). The senescing leaves before falling from vines re-translocate photosynthates into permanent vine parts. During that period, developing clusters are strong sink and hence more potassium diverts towards clusters from older leaves (Kodur, 2011). Hence, removing leaves at veraison is found to be beneficial in reducing potassium accumulation and it improves cluster exposure to sunlight improving accumulation of several beneficial secondary metabolites. Since leaf removal is one of the important management practices in improving the wine grape quality in warmer regions, it is always a question in which side of the canopy; leaves should be removed or retained to optimize cluster exposure to sunlight to harness the advantages. Hence, this study was undertaken to study the influence of leaf removal from two sides of canopy at cluster zone to know its effect on fruit composition of both red and wine grape cultivars.

MATERIALS AND METHODS

Location and plant material

This experiment was conducted at the experimental vineyard of ICAR-National Research Centre for Grapes, Pune that is located in Midwest of Maharashtra state (India) at an altitude of 559 m above the mean sea level. It lies in 18.32° N latitude and 73.51° E longitude. Five-year-old Cabernet Sauvignon and Sauvignon Blanc grapes grafted on to 110R rootstock were selected for this study. The vines were planted at a spacing of 2.5 m between rows and 1.2 m between vines within a row. The row orientation was in the direction of North - South. The vines were trained to double cordon small T system. The pruning biomass of the vines was in the range of 1.0-1.25 kg. Approximately 32 to 36 shoots were retained per vine by thinning out excess shoots.

Imposition of leaf removal treatments

Leaf removal treatments were imposed during veraison stage of berry development. On all fruit bearing shoots, leaves at cluster zone (basal five leaves and 2-3 leaves above clusters) were removed. Four different sets of variations were created on about 40 vines (10 vines per replication) as follows:

Treatment 1: Leaf removal on East side of the canopy (East LR)

Treatment 2: No leaf removal on East side of the canopy (East Control)

Treatment 3: Leaf removal on West side of the canopy (West LR)

Treatment 4: No leaf removal on West side of the canopy (West Control)

Harvesting and recording fruit composition parameters

Harvesting was done at about 110 days after pruning in Sauvignon Blanc and about 140 days in Cabernet Sauvignon varieties. After harvesting, about 250 berry samples were collected from each treatment replication wise. Half of the samples were utilized immediately for analysis of basic fruit composition parameters such as total soluble solids (TSS), titratable acidity, juice pH and Potassium content. Before analyzing these parameters, weight of 100 berries and weight of 50 seeds was recorded using electronic balance. The remaining half of the berry samples was stored in -20°C for analysis of organic acids and phenolic compounds using High Performance Liquid Chromatography (HPLC).

The fresh fruits were macerated in cheesecloth and were centrifuged and the supernatant was analysed for TSS (hand held refractometer with temperature compensated to 20°C); acidity (titration of juice against 0.1N NaOH using phenolphthalein as indicator); pH (pH meter, Model 420, Thermo Orion,) and potassium (Flame photometer, Model, PFP 7, Jenway Ltd, UK).

HPLC analysis of organic acids and phenolic compounds

The fruit samples stored in -20°C freezer were used for HPLC analysis. After removing samples from freezer, they were thawed overnight under refrigerated conditions. Later the fruits were macerated in cheesecloth; the resultant must was centrifuged and the supernatant was used for HPLC analysis.

Phenolic compounds

Chromatographic analysis of phenolic compounds was performed using the 1260 series Agilent Technologies HPLC, equipped with an inbuilt 4 channel-degassing unit, standard auto-sampler, 1260 infinity quaternary pump, Agilent 1260 infinity Diode array detector and an injector. The system was interfaced with a personal computer utilizing the Agilent EZ chrome elite software for control, data acquisition and further analysis. A Zorbax Eclipse plus C18 column (4.6 mm x 100 mm 1.8 µm particle size.) was used. The analytical column was preceded by a C18 guard column to prevent any non-soluble residues from samples from contaminating the column. The injection volume maintained was 10µl with a flow rate of 0.80 mL/minute. The mobile phase consisted of A (0.2% acetic acid in 10% acetonitrile) - 95% and B (0.2% acetic acid in acetonitrile) - 5%. Prior to use, the solvent was filtered through vacuum filter and then sonicated for 5-10 minutes in an ultrasonic bath to remove air bubbles. The column temperature was maintained at 30°C. Peaks were determined at 280 nm for all the phenolic compounds.

Organic acids

The analysis of organic acids (Tartaric acid and malic acid) was done with Agilent technologies 1260 series HPLC system with Diode array detector (DAD) at wavelength of 214 nm and bandwidth of 4.0. The column used was Agilent Zorbax eclipse plus C 18 (4.6 ×100 mm 5um). The separation was done with mobile phase of A - 95% Acidified water with orthophosphoric acid (pH 2.0) and B - 5% absolute methanol with flow rate of 0.8ml/min. Column temperature was 25^{o} C. The injection volume was 10µl and total run time was 7 minutes.

Statistical analysis

The experiment was conducted in randomized block design with four replications and the data was analysed using SAS Version 9.3. Tukey's test was used for comparing treatment means.

RESULTS AND DISCUSSION

Leaf removal and its influence on fruit composition

The influence of leaf removal from two different sides of canopy on basic fruit composition parameters in Cabernet Sauvignon is given in Table 1. Leaf removal from both east and west side of the canopy has reduced the berry weight compared to their control counterparts. The maximum 100-berry weight of 100.60 g was recorded in west control vines followed by east control vines. Leaf removal from east side of the canopy has recorded minimum berry weight of 95.2 g. There was no significant difference among the treatments for seed weight. The maximum total soluble solids (TSS) of 22.43°B and lowest acidity (0.53%) were recorded in vines with east leaf removal treatment, while west control recorded the least TSS on vines. Significant difference was recorded for potassium content with highest in east control vines (1748 ppm) and lowest in west leaf removal (1570 ppm) vines. Similarly highest juice pH was recorded with east control vines (3.58) and least with west leaf removal vines (3.43). There were no significant differences among treatments for anthocyanin and malic acid content.

The fruit composition parameters of Sauvignon Blanc grape in relation to leaf removal treatments from different canopy sides are presented in Table 2. The highest berry weight was recorded in vines which received east leaf removal treatment (104.40 g) followed by those on west leaf removal vines (101.60 g). Significant differences were recorded for TSS, acidity, pH, potassium, tartaric and malic acid content. Highest TSS (22.62 °B) and lowest acidity (0.50%) were recorded on vines with east leaf removal vines. Both east and west control vines recorded higher values for potassium (1782 and 1658 ppm) than leaf removal treatments. The lowest juice pH was recorded with east leaf removal treatment (3.46), while it was highest in east control vines (3.62). Highest malic acid was recorded in east control (3.87 g/L) followed by west control (3.78 g/L) vines, while it was lowest in east leaf removal vines (2.89 g/L). Sunlight intensity received at different zones in the vine canopy is known to strongly influence fruit composition such as sugars, acids, and other secondary metabolites involved in wine aroma including phenolics (Downey *et al.,* 2006).

Accordingly, many viticultural treatments associated with canopy management are intended to manipulate photosynthetic photon flux (PPF) of the fruiting zone or the distribution of photon flux across the total leaf area of the canopy to achieve metabolic effects. In grapevines, depending on cultivars and canopy management practices, leaves and bunches can develop in zones varying from heavily shaded to fully exposed clusters. Generally, the berries that develop in open canopies have high sugar concentrations, improved acid metabolism and increased concentrations of berry phenolics including anthocyanins (Gladstone, 1992).

The sunlight exposure to clusters through these canopy management practices to obtain good quality fruits varies with variety to variety. In the present study, leaf removal on both the sides of the canopy in Cabernet Sauvignon vines resulted in reduced berry weight and increased TSS compared to control vines. However, in Sauvignon Blanc, there was increase in berry weight on leaf-removed vines compared to control vines. This variation in berry weight among different varieties is in agreement to the previous findings of reduced berry weight in clusters developed in shaded part of canopy compared to that of exposed clusters. The reduced berry weight in Cabernet Sauvignon might be due to elevated berry temperature through more exposure of clusters in leaf-removed vines resulting in reduced berry cell division and elongation coupled with increased berry transpiration and consequent berry dehydration (Bergqvist *et al.,* 2001).

Many investigators found that sunlight exposed fruits are generally rich in total soluble solids and reduced titratable acidity compared to non-exposed or shaded canopy (Ferree *et al.,* 2004; Main and Morris, 2004). But, in contrast some workers found that defoliation had no effect on soluble solids and titratable acidity (Vasconcelos and Castagnoli, 2000; Poni *et al.,* 2006).The decline in titratable acidity with increased exposure to sunlight may be attributed to increased malic acid degradation due to the higher temperatures of exposed fruit (Lakso and Kliewer, 1978). Though acidity was highest on grapes harvested from control vines, the juice pH was also highest on those vines, while it was least on leaf-removed vines. The pH of grape juice or wine usually results from the balance between anionic forms of organic acids (mainly malic acid and tartaric acid) and the major cations such as potassium (Boulton, 1980).It is very well established concept that juice pH in grapes is determined by concentration of juice potassium and malic acid (Kodur *et al.,* 2010; Kodur, 2011). In this study, leaf removal treatments in both the varieties recorded least juice pH and lower concentrations of malic acid and potassium content compared to control vines.

Leaf removal at veraison stage affects synthesis of primary and secondary metabolites and this effect is directly related to leaf layer number, photosynthetic rate and canopy surface area. Several experiments have shown increased sugars, flavor, flavonoids and decreased acidity when leaf removal was done at veraison stage (Poni *et al.,* 2006). In contrast, leaf removal at veraison on plants with low canopy density does not affect grape sugar, acidity, or color (Reynolds *et al.,* 1986). In this study, the leaves were removed from cluster zone at the time of veraison in both the varieties. It is observed that at the time of veraison, most of the potassium accumulated in leaves get diverted towards developing berries leading to increased potassium content in berries (Lang and Thorpe, 1989). Similarly, clusters developed in shaded portion of the canopy are known to accumulate more malic acid than open canopies. The increase concentration of malic acid in control berries may be due to reduced metabolic rate of malate degradation, which was otherwise used as respiratory substrate in post veraison berries (Morrison and Noble, 1990). Thus, leaf removal at cluster zone during veraison had dual advantages of reducing the potassium translocation from older leaves into clusters and reduced malic accumulation. Kliewer and Smart (1989), also recorded more potassium, malic acid in shaded berries than fully exposed berries.

Leaf removal and its influence on phenolic profile

The influence of leaf removal on phenolic profile of Cabernet Sauvignon grapes is presented in Table 3. Among flavan - 3- ols, there was increase in catechin and epicatechin content in vines, which received leaf removal treatment on both the sides, compared to their control counterparts. Highest catechin content was recorded in east leaf removal vines followed by west leaf removal vines. There was significant increase in quercetin content from control vines to leaf removed vines. Vines with west leaf removal treatment recorded maximum quercetin content (13.12 mg/L) while, it was minimum in east control (6.61 mg/L). Most of the non-flavonoid phenolic compounds such as gallic acid, vanillic acid, coumaric acid and chlorogenic acids were increased with leaf removal treatment compared to control treatments. The concentration of these phenols was in the order of gallic acid > coumaric acid > chlorogenic acid > cafateric acid > vanillic acid. Most of these compounds were highest in East leaf removal treated vines than in west leaf removal treated vines except coumaric acid, which was highest in west leaf removal treated vines (3.80 mg/L). Piceatanol, a stilbene was highest in west leaf removal treated vines (39.41 mg/

L) followed by west control vines (30.97 mg/L). The resveratrol was detected in very trace amounts and was highest in east control vines (0.056 mg/L). The total phenolic compound was significantly highest in west leaf removal vines (94.01 mg/L) compared to east leaf removal vines (72.09 mg/L).

The influence of leaf removal from different sides of canopy on phenolic profile of Sauvignon Blanc grapes is given in the Table 4. Among flavan – 3 - ols, catechin and epicatechin accounted for maximum concentration followed by quercetin and myrecetin (both flavonols). Highest catechin content was recorded in East leaf removal (16.77 mg/L) followed by west control (14.86) vines. Most of the non-flavonoid contents were increased in east leaf removal vines as compared to east control vines, while it was decreased in west leaf removal treated vines compared to west control vines. The concentrations of non-flavonoid phenolic compounds in east leaf removal treated vines were on par with west control vines, while it was minimum in west leaf removal vines. The total phenolic content was highest in east leaf removal vines (43.11 mg/L) followed by west control vines (37.37 mg/L), while minimum total phenolic compound was recorded in west leaf removal vines (30.39 mg/L).

Though there was no significant difference among treatments in anthocyanin concentration in Cabernet Sauvignon grapes, there was slight reduction in its accumulation in control vines. In control vines, it is likely that light is a limiting factor for anthocyanin accumulation. Many authors have confirmed that shading reduces anthocyanins accumulation (Dokoozlian and Kliewer, 1996; Jeong *et al*., 2004). Similarly, it was opined that anthocyanin synthesis is directly regulated by both the light exposure and the temperature conditions to which a grape bunch is subjected (Smart *et al*., 1988). Management practices that create a canopy architecture where bunches receive sufficient light for anthocyanin synthesis, but berries are protected from excessive berry heating, would seem appropriate for the production of fruit with optimal levels of anthocyanins for vines grown in hot climates. Based on the previously established scientific reports, Haselgrove *et al.* (2000) suggested that a desirable canopy forvines grown in hot climatic conditions is one where bunches are moderately exposed. Cluster shading resulted in a substantial reduction in accumulation of flavonols and skin proanthocyanidins and minimal differences in anthocyanins in 'Pinot Noir' grapes (Cortell and Kennedy, 2006). The fruit composition with respect to juice pH, potassium and malic acid in Cabernet Sauvignon grapes with east leaf removal and west control vines are quite comparable. Hence, one should take decision whether to remove leaves from west side of the canopy as it may expose clusters to direct afternoon sunlight as it is undesirable to expose clusters to excess sunlight in hot climate as suggested by Haselgrove *et al.* (2000).

Leaf removal on different sides of canopy showed different pattern of phenolic profiles in two of the varieties studied. In Cabernet Sauvignon, leaf exposure on both east and west side of the canopy recorded increased phenolic content though percent increase was more (123%) when leaves were removed from west side compared to control vines. In variety Sauvignon Blanc, there was about 129% increase in total phenolic compounds when leaves were removed in east side of the canopy compared to control, but when leaves were removed from west side of the canopy there was about 81% reduction in total phenolic compounds compared to control vines (Figure 1). Most of the different classes of phenolic compounds increased in response to leaf removal treatment on both east and west side of the canopy in Cabernet Sauvignon variety, while in Sauvignon Blanc, increased concentration of different phenolic compounds was observed only when leaves were removed from east side of the canopy. There was reduction in all the phenolic compounds when leaves were removed from west side of the canopy compared to control vines. The increased concentration of phenolic compounds in Cabernet Sauvignon vines in response to leaf removal is in accordance to the findings of Ristic *et al.* (2007), wherein shaded clusters of Shiraz could accumulate only traces of quercetin compared to those in exposed clusters. This clearly suggests the role of leaf removal to expose clusters to sunlight for accumulation of quercetin is a light dependent process in colored varieties. However, when clusters were exposed on west side of the canopy in Sauvignon Blanc, there was reduction in Quercetin content. Among stilbenes, content maximum concentration of piceatannol was recorded in both the varieties compared to resveratrol. Leaf removal from both sides of canopy in Cabernet sauvignon increased piceatannol content, but it was reduced in Sauvignon Blanc. The increased concentration of piceatannol compared to resveratrol might be because it is glucosylated resveratrol metabolite as opined by Waterhouse and Lamuela-Raventos (1994). Though it is said that colored grapes have high concentration of stilbene, some studies could not establish as they could determine higher concentration of stilbene (trans resveratrol, piceid etc.) in some white grape cultivars compared to those in red grape cultivars (Mikes *et al.,* 2008).

CONCLUSIONS

Practice of removing leaves from different sides of vine canopy may not be uniform for all grape varieties grown in a given soil and climatic conditions. In this preliminary study, significant variation in fruit composition parameters was observed due to leaf removal from different sides of vine canopy in both the varieties. Cabernet Sauvignon being red variety could produce fruits with lower pH, high TSS; lower potassium and malic acid content and higher concentration of anthocyanin, when leaves were removed from east side of the canopy.However, better fruit quality with respect to juice pH, potassium and malic content were comparable between east leaf removal and west control vines.

In Sauvignon Blanc, leaf removal on west side of the canopy resulted in drastic reduction of phenolic compounds compared to leaf removal from east side of the canopy. In this particular variety, leaf removal from east side of the canopy was found to be better. Hence, leaf removal should be carried out selectively in different sides of the canopy depending on the vigor of the variety. In both the varieties, leaf removal on east side of the canopy could produce quality grapes measured in terms of lower juice pH coupled with reduced potassium and malic acid. A high degree of leaf removal to expose bunches in west side of the canopy under tropical climatic conditions may not be desirable for obtaining good quality wine grapes. Further studies on degree of variation in light intensity and berry temperature under the influence of leaf removal will help in better understanding of fruit chemistry on leaf-removed vines.

Fig. 1: Effect of leaf removal on percent change in phenolic contents in comparison to control vines

Table 1: Effect of leaf removal on fruit composition of Cabernet Sauvignon grapes

Treatment	Berry wt (g)	Seed wt (g)	TSS (°B)	Acidity (%)	Juice pH	Potassium (ppm)	Antho cyanin (g/mg)	Tartaric acid (g/L)	Malic acid (g/L)
East Control	100.00	1.43	21.37	0.59	3.58	1748	0.83	6.50	3.84
East LR	95.20	1.45	22.43	0.53	3.43	1648	1.00	5.04	3.51
West Control	100.60	1.47	21.31	0.61	3.52	1636	0.80	6.52	3.92
West LR	95.60	1.46	21.86	0.56	3.56	1570	0.84	6.26	3.62
SEM ±	1.59	0.015	0.32	0.01	0.041	33.06	0.12	0.225	0.22
CD@ 5%	3.39	0.032	0.69	0.03	0.087	70.46	0.26	0.479	0.47
Pd"0.05	0.049*	NS	NS	0.004	0.044	0.012	NS	0.023	NS

*: Values below 0.05 are statistically significant at Pd"0.05; NS: Non significant

Table 2: Effect of leaf removal on fruit composition of Sauvignon Blanc grapes

Treatment	Berry wt (g)	Seed wt (g)	TSS (°B)	Acidity (%)	Juice pH	Potassium (ppm)	Tartaric (g/L)	Malic (g/L)
East Control	96.39	1.43	21.26	0.606	3.62	1782	7.40	3.87
East LR	104.40	1.46	22.62	0.500	3.46	1588	6.14	2.89
West Control	98.60	1.46	21.88	0.622	3.61	1658	7.15	3.78
West LR	101.60	1.46	21.62	0.582	3.52	1650	6.66	3.21
SEM ±	1.953	0.017	0.268	0.016	0.039	29.46	0.239	0.208
CD@ 5%	4.161	0.036	0.571	0.034	0.083	62.77	0.509	0.443
Pd"0.05	0.049	NS	0.016	0.0003	0.030	0.002	0.002	0.001

*: Values below 0.05 are statistically significant at P=0.05; NS: Non significant

Table 3: Effect of leaf removal on phenolic profile (mg/L) of Cabernet Sauvignon grapes

Rootstocks	Flavonoid phenolic compounds						Non flavonoid phenolic compounds							Total
	Flavan -3-ols		Flavonols and Flavonol aglycons				Hydroxy benzoic acids		Hydroxy cinnamates			Stilbene		
	Catechin	epicatechin	Quercetin	Rutine hydrate	Kaempferol	Myrecetin	Gallic acid	Vanillic acid	Cafteric acid	Coumaric acid	Chlorogenic	Resveratrol	Piceatannol	
East Control	20.78	7.11	6.61	0.027	0.23	0.000	3.48	0.21	2.07	1.39	2.05	0.056	17.26	62.65
East LR	24.89	6.80	10.56	0.030	0.37	0.015	3.92	0.57	2.20	2.16	2.87	0.026	17.34	72.09
West Control	20.98	5.62	7.78	0.041	0.13	0.001	3.20	0.11	0.97	2.29	1.77	0.033	30.97	76.01
West LR	22.30	5.87	13.12	0.036	0.11	0.000	3.89	0.40	0.80	3.80	1.68	0.025	39.41	94.01
SEM±	2.39	1.07	0.803	0.006	0.033	0.003	0.30	0.12	0.48	0.396	0.290	0.023	1.432	5.034
CD@ 5%	5.09	2.28	1.711	0.012	0.070	0.006	0.64	0.26	1.03	0.843	0.617	0.049	3.051	10.424
Pd”0.05	NS	NS	0.0001	NS	0.0002	0.010	NS	NS	NS	0.004	0.04	NS	0.001	0.0036

*: Values below 0.05 are statistically significant at Pd”0.05; NS: Non significant

Table 4: Effect of leaf removal on phenolic profile (mg/L) of Sauvignon Blanc grapes

Rootstocks	Flavonoid phenolic compounds						Non flavonoid phenolic compounds							Total
	Flavan -3-ols		Flavonols and Flavonol aglycons				Hydroxy benzoic acids		Hydroxy cinnamates			Stilbene		
	Catechin	epicatechin	Quercetin	Rutine hydrate	Kaempferol	Myrecetin	Gallic acid	Vanillic acid	Cafteric acid	Coumaric acid	Chlorogenic	Resveratrol	Piceatannol	
East Control	13.95	8.30	4.06	0.50	0.36	1.51	0.77	0.13	0.82	0.05	1.26	0.39	1.27	33.38
East LR	16.77	8.65	5.91	1.23	0.80	2.51	0.84	0.14	0.62	0.26	1.53	0.27	0.89	43.11
West Control	14.86	8.99	5.33	0.35	0.18	2.04	0.80	0.16	0.63	0.15	1.59	0.16	1.50	37.37
West LR	11.71	6.63	4.60	0.89	0.15	1.33	0.79	0.11	0.87	0.05	1.34	0.20	1.34	30.39
SEM±	1.021	0.502	0.470	0.25	0.175	0.248	0.066	0.034	0.240	0.018	0.138	0.117	0.244	1.648
CD@ 5%	2.175	1.069	1.001	0.532	0.372	0.528	0.140	0.072	0.511	0.038	0.294	0.249	0.477	3.511
Pd”0.05	0.022	0.024	0.063	0.001	0.063	0.016	0.710	0.024	0.835	0.001	0.332	0.548	0.375	0.0003

*: Values below 0.05 are statistically significant at Pd”0.05; NS: Non significant

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Original Research Paper

Screening of Coriander Genotypes for their Relative Susceptibility against Aphids under Field Conditions

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ABSTRACT

The field experiments were conducted during Rabi 2013-14 and 2014-15 to screen out twelve varieties/entries of coriander (*Coriandrum sativum* L.) for their relative susceptibility against aphids. None of the varieties/entries escaped the infestation of aphids. The build-up of aphid infestation started from second half of December and reached to its maximum in the first to third week of February in both years and then gradually declined. On the basis of grade index of mean aphid population, coriander varieties RCr-684 (25.45 aphids/plant), RCr-446 (26.45 aphids/plant), ACr-1 (26.60 aphids/plant), RCr-436 (41.75 aphids/plant), Gujarat Coriander-2 (42.45 aphids/plant), Pant Haritma (43.50 aphids/plant) and Gujarat Coriander-1 (43.70 aphids/plant) were categorized as least susceptible, Rajendra Swati and RCr-41 were moderately susceptible, whereas, Swati (CS-6), Sadhna (CS-4) and Sindhu (CS-2), 73.88, 70.60 and 69.50 aphids/plant, respectively were categorized as highly susceptible varieties of coriander against aphids under field conditions. Coriander variety RCr-684 received maximum yield (16.82 and 16.63 q/ha) for both the years followed by ACr-1 and RCr-446.

Key words: Aphids, Coriander Genotypes, Semi-arid region and Susceptibility.

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an important major seed spice crop, grown for leaves as well as seed purpose.It belongs to the family Apiaceae, is a native of southern Europe and northern Africa to southwestern Asia. The coriander plants are annual herb, stems erect, branched or bushy, diploid, chromosome number 2n=22. Coriander seeds and leaves contain essential oils, which account for aromatic character of the plant (Sankaracharya and Sankaranarayana, 1989). The seeds have a lemony citrus flavour when crushed, due to the linalool, terpenes, pinene, and limonene, among others (Zheljazkov *et al*., 2014). Coriander seeds are considered as carminative, diuretic, stomachic, antibilious, refrigerant and aphrodisiac (Butani, 1984).The fresh leaves are an ingredient in many South Asian foods (such as rasams, chutneys, and salads); in Chinese and Thai dishes; in Mexican cooking, particularly in salsa and guacamole and as a garnish; and in salads in Russia and other CIS countries (Moulin, 2002). It is mainly grown in Rajasthan, Madhya Pradesh, Andhra Pradesh, Gujarat and Assam in a large area as major*Rabi* season crop and cultivated in many more states in large to small areas. Coriander is most susceptible crop to aphids in semi-arid region, if plant protection measures not applied on time; it causes nearly 40-50% yield losses. In present situation of agriculture, farmers are using a number of pesticides for aphid control resulting development of pest resistance to various commonly used insecticides, pest resurgence, and outbreaks as well as severe mortality of natural enemies and pollinators particularly honeybees, hence the identification of resistance source against aphids is the main factor to manage the pest.

Keeping these in view, field experiment were conducted at research farm, ICAR-National Research Centre on Seed Spices, Ajmer to evaluate twelve varieties/entries of coriander *viz*., Gujarat Coriander-1, Gujarat Coriander-2, Sadhna (CS-4), ACr-1, Swati (CS-6), RCr-41, RCr-436, RCr-684, Hisar Sugandh, Pant Haritma, Sindhu (CS-2) and Rajendra Swati for their resistance/susceptibility against aphids during *Rabi* 2013-14 and 2014-15 to find out the resistance sources as breeding material against aphids.

MATERIALS AND METHODS

The field experiments on screening of different varieties/entries of coriander for their relative susceptibility against aphids were conducted at ICAR-National Research Centre on Seed Spices, Ajmer for two consecutive years 2013-14 and 2014-15. The study location is lying between 74^0 35' 39" to 74^0 36' 01" E longitude and 26^0 22' 12" to 26^0 22' 31" N latitude at an altitude of 486 m above mean see level. The region fall under III agro-climatic zone of Rajasthan is considered under semi-arid region. Soil fertility status of institute's experimental field is sandy loam, poor fertility and water holding capacity, having pH 8-8.3, EC 0.07-0.12 and organic carbon 0.15-0.23 percent along with available N 178.5 kg/ha (low), P_2O_5 12kg/ha (Medium), K_2O kg/ha (low). The area receives annual rainfall 250-350 mm and temperature range 22-36 ^{0}C (maximum) and 5-20 ^{0}C (minimum) with 64-80% relative humidity during cropping Rabi season.

Twelve varieties/entries *i.e.* Rajendra Swati, ACr-1, Gujarat Coriander-1, RCr-41, Pant Haritma, RCr-684, Sadhna (CS-4), Swati (CS-6), RCr-446, Sindhu (CS-2), Gujarat Coriander-2 and RCr-436 were sown in well prepared and statistically laid out fields in Randomized Block Design concept with 03 replications. The seeds of above varieties/entries were sown in the plot sized of 3x3 meter, under specified geometry adopted in pop of the institute. Seeds were treated with *Trichoderma viride* @ 6g/kg of seed to avoid the seed borne diseases. Plant protection measures were not applied during standing crop to allow the aphid incidence on the crops. The observations on aphid population were recorded at weekly intervals from five randomly selected and tagged plants/plot. Initially, whole plants were taken in to study and later on it was sifted to 10 cm twig when crop was in full grown and umbels during flowering and finally it was considered as aphid population per plant. The relative susceptibility was determined on the basis of grade index worked out on peak infestation by using formulae $\bar{X} \pm \sigma$ ($\bar{X}$: mean of peak aphid population; σ: standard deviation for insect population) as given below, wherein, the incidence was measured on the basis of mean aphid population per plant.

Grade	Mean aphid population/plant
Least susceptible	<48.36
Moderately susceptible	48.36-66.13
Highly susceptible	>66.13

The data were obtained and transformed in sqrt. X + 0.5 values and subjected to analysis of variance to find out the critical difference (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION

Twelve varieties/entries of coriander were screened out for their relative susceptibility to aphids (*Hyadaphis coriandri* Das and *Myzus persicae* Sulzer) and the data on mean aphid's mixed population per plant were taken for two consecutive years and presented in Table 1 and 2, revealed that, none of the varieties/entries was free from aphid infestation. Initially, the aphid infestation started in second half of December (35 DAS) with very less in populations in both the years. In 2013-14, the aphid infestation started on second half of December with few aphids per plant on some coriander varieties, whereas RCr-684, RCr-446 and ACr-1 were remained free from the aphid infestation at this stage. Then after, pest infestation increased gradually and reached to its maximum during February month with three peaks depending upon the varieties/entries (Table 1). The coriander variety RCr-684 received lowest aphid infestation (23.70 aphids/plant) followed by RCr-446 and ACr-1 with 24.10 and 24.20 aphids/plant, respectively. The maximum aphid infestation was observed on variety Swati (CS-6) 71.10 aphids/plant followed by Sadhna (CS-4) Sindhu (CS-2) and RCr-41 having aphids population of 66.40, 65.00 and 64.20 aphids/plant, respectively. The remaining varieties/entries were received the aphid infestation with ranged from 41.70 to 52.30 aphids/plant. Over the season, the lowest mean aphid infestation (9.21 aphids/plant) was recorded on variety RCr-684 followed by ACr-1 and RCr-446, whereas, maximum on Swati (CS-6) and Sadhna (CS-4) and Sindhu (CS-2). The highest yield of coriander seed was also recorded from the variety RCr-684 (16.82 q/ha) followed by ACr-1 (15.74q/ha) and RCr-446 (12.89 q/ha), while minimum yield 4.14 q/ha was obtained

Table 1: Screening of popular coriander varieties for their relative susceptibility against aphids during 2013-14

Varieties	Average population of aphids per plant												Mean	Yield (q/ha)
	23rd Dec	31st Dec	7th Jan	14th Jan	21st Jan	28th Jan	04th Feb	11th* Feb	18th* Feb	25th* Feb	04th Mar	11th Mar		
Rajendra Swati	0.33#	0.40	1.40	4.60	15.00	21.30	42.20	52.30	31.70	32.00	18.40	9.20	19.07	10.55
	(4.55)	(4.78)	(7.00)	(11.40)	(19.80)	(23.40)	(32.60)	(36.60)	(28.00)	(28.10)	(21.30)	(15.40)	(19.41)	
ACr-1	0.00	0.20	1.00	3.10	9.60	14.00	18.20	24.20	15.00	16.20	10.80	5.20	9.79	15.74
	(3.54)	(4.12)	(6.10)	(9.70)	(16.10)	(19.10)	(21.80)	(24.60)	(19.80)	(20.20)	(16.70)	(12.00)	(14.48)	
Gujarat	0.40	0.60	3.10	4.60	13.70	19.00	36.00	35.80	43.20	30.30	18.20	5.60	17.54	11.15
Coriander-1	(4.83)	(5.23)	(9.40)	(11.20)	(19.00)	(22.20)	(30.40)	(30.40)	(32.90)	(27.90)	(21.80)	(12.50)	(18.98)	
RCr-41	0.66	1.60	1.90	5.20	16.30	20.00	34.20	35.00	41.30	64.20	20.10	11.10	20.97	4.14
	(5.32)	(7.36)	(7.60)	(12.10)	(20.70)	(22.60)	(25.80)	(29.80)	(29.20)	(40.50)	(22.90)	(17.20)	(20.10)	
Pant Haritma	0.60	2.00	2.00	7.10	10.00	16.40	30.10	43.00	21.80	22.00	17.20	10.10	15.19	10.66
	(5.23)	(7.86)	(8.00)	(13.80)	(16.30)	(20.60)	(27.80)	(29.60)	(23.80)	(23.20)	(20.80)	(16.40)	(17.78)	
RCr-684	0.00	0.00	1.20	1.20	8.30	12.40	14.20	18.60	23.70	17.70	10.20	3.10	9.21	16.82
	(3.54)	(3.54)	(6.50)	(6.50)	(14.90)	(17.80)	(19.10)	(21.70)	(24.70)	(21.70)	(16.50)	(9.20)	(13.81)	
Sadhna (CS-4)	0.60	2.00	1.80	6.00	19.80	25.10	35.00	35.40	66.40	55.20	23.00	10.20	23.38	5.55
	(5.14)	(8.02)	(7.80)	(13.10)	(22.50)	(25.30)	(30.00)	(30.00)	(41.00)	(37.00)	(24.50)	(16.60)	(21.74)	
Swati (CS-6)	1.00	2.33	2.10	6.60	23.00	24.10	39.20	40.00	42.10	71.10	36.20	13.10	25.07	8.48
	(6.12)	(8.32)	(8.10)	(13.20)	(24.70)	(24.80)	(31.60)	(31.60)	(32.60)	(38.00)	(30.40)	(18.10)	(22.29)	
RCr-446	0.00	0.00	1.20	1.00	10.20	11.00	12.30	21.20	24.10	18.20	14.70	6.20	10.01	12.89
	(3.54)	(3.54)	(6.50)	(6.30)	(16.40)	(17.10)	(17.70)	(23.40)	(24.70)	(22.00)	(19.30)	(13.00)	(14.45)	
Sindhu (CS-2)	0.20	1.60	2.00	4.90	18.20	22.70	34.50	41.30	65.00	54.10	20.30	10.00	22.90	7.65
	(4.12)	(7.25)	(8.00)	(11.70)	(21.60)	(24.10)	(29.70)	(32.30)	(40.70)	(37.10)	(23.00)	(16.50)	(21.34)	
Gujarat	0.40	0.80	1.60	5.70	20.10	20.00	22.10	29.60	41.80	27.20	11.60	6.70	15.63	7.23
Coriander-2	(4.72)	(5.78)	(7.20)	(12.80)	(22.70)	(22.60)	(23.80)	(27.60)	(32.30)	(26.20)	(17.20)	(13.30)	(18.01)	
RCr-436	0.00	2.40	1.80	5.60	14.10	18.30	20.40	28.60	41.00	41.70	12.00	5.40	15.94	10.54
	(3.54)	(8.57)	(7.70)	(12.20)	(19.00)	(21.60)	(22.90)	(26.90)	(31.90)	(32.50)	(17.50)	(11.40)	(17.98)	
SEm±	0.04	0.05	0.11	0.12	0.11	0.09	0.39	0.41	0.56	0.74	0.21	0.17		0.69
CD (p=0.05)	0.10	0.15	0.33	0.34	0.33	0.28	1.15	1.20	1.65	2.18	0.63	0.51		2.06

Mean of three replications.
* Peak population of aphids
Figure in parenthesis are sqrt. X + 0.5 transformed values

Table 2: Screening of popular coriander varieties for their relative susceptibility against aphids during 2014-15

Varieties	Average population of aphids per plant												Mean	Yield (q/ha)
	20th Dec	27th Dec	03rd Jan	10th Jan	17th Jan	24th Jan	31st Jan	07th* Feb	14th* Feb	21st* Feb	28th Feb	07th Mar		
Rajendra Swati	0.20# (4.17)	0.00 (3.54)	3.56 (10.20)	13.80 (19.13)	20.22 (22.98)	23.60 (24.77)	40.36 (31.69)	51.53 (36.29)	47.66 (34.65)	44.20 (33.73)	25.00 (25.11)	13.60 (19.17)	23.64 (22.12)	10.92
ACr-1	0.00 (3.54)	0.00 (3.54)	0.10 (3.80)	2.33 (8.48)	6.18 (12.87)	14.40 (19.40)	23.20 (24.22)	29.00 (27.09)	25.22 (25.52)	20.44 (22.63)	17.33 (20.80)	8.00 (14.17)	12.18 (15.50)	14.75
Gujarat Coriander-1	0.00 (3.54)	1.10 (6.36)	2.56 (8.60)	14.20 (19.42)	18.66 (21.72)	20.60 (23.18)	38.20 (31.39)	41.60 (32.56)	44.20 (33.34)	32.66 (28.83)	21.00 (23.30)	12.20 (17.79)	20.58 (20.84)	10.80
RCr-41	1.20 (6.59)	1.20 (6.48)	2.40 (8.32)	14.26 (18.97)	24.97 (25.49)	24.00 (25.01)	36.20 (30.47)	40.33 (32.25)	56.38 (38.52)	65.10 (40.79)	25.33 (25.76)	14.33 (19.58)	25.48 (23.19)	6.65
Pant Haritma	1.00 (6.26)	0.80 (5.69)	2.40 (8.66)	12.40 (17.70)	16.22 (19.93)	21.00 (23.67)	36.80 (30.98)	44.00 (31.13)	40.12 (31.78)	27.20 (26.38)	17.30 (20.87)	10.20 (16.51)	19.12 (19.96)	10.62
RCr-684	0.00 (3.54)	0.00 (3.54)	0.20 (4.17)	3.66 (10.10)	5.00 (11.48)	13.20 (18.53)	21.45 (23.43)	22.00 (23.70)	27.20 (26.66)	19.20 (22.68)	13.00 (18.67)	5.33 (12.02)	10.85 (14.88)	16.63
Sadhna (CS-4)	0.60 (5.14)	2.00 (8.02)	3.20 (9.55)	8.60 (14.98)	25.22 (25.57)	28.10 (26.97)	36.40 (30.70)	53.20 (37.03)	74.80 (43.85)	65.00 (40.76)	34.10 (29.69)	12.00 (18.15)	28.60 (24.20)	6.00
Swati (CS-6)	1.33 (6.47)	2.00 (7.68)	2.20 (8.15)	6.66 (13.25)	26.10 (25.98)	27.00 (26.88)	38.60 (31.31)	53.00 (36.60)	53.10 (36.89)	76.66 (39.37)	50.20 (36.13)	13.30 (18.23)	29.18 (23.91)	8.72
RCr-446	0.00 (3.54)	1.02 (6.16)	0.60 (5.33)	1.33 (7.01)	7.56 (13.69)	15.33 (20.06)	16.00 (20.37)	24.53 (25.31)	28.80 (27.22)	19.20 (22.69)	16.10 (20.25)	7.00 (13.86)	11.46 (15.46)	14.89
Sindhu (CS-2)	1.20 (6.48)	2.10 (8.07)	3.60 (10.26)	10.00 (16.50)	18.20 (21.64)	31.77 (28.69)	35.92 (30.40)	60.10 (39.38)	74.00 (43.70)	50.00 (35.50)	23.20 (24.75)	10.00 (16.47)	26.67 (23.49)	7.82
Gujarat Coriander-2	1.10 (6.48)	1.40 (6.86)	1.40 (6.73)	7.60 (13.94)	16.00 (19.76)	16.66 (20.06)	35.60 (29.99)	35.00 (30.17)	36.20 (29.37)	43.10 (32.79)	15.80 (20.51)	11.20 (17.37)	18.42 (19.50)	6.95
RCr-436	0.00 (3.54)	1.00 (6.03)	2.00 (8.06)	8.04 (14.22)	15.60 (20.11)	16.00 (19.85)	36.10 (30.22)	40.00 (32.21)	41.80 (32.25)	21.66 (23.89)	14.20 (18.98)	9.80 (15.35)	17.18 (18.73)	11.24
SEm±	0.06	0.06	0.09	0.20	0.17	0.37	0.47	0.56	0.59	0.79	0.32	0.27		0.75
CD (p=0.05)	0.19	0.19	0.27	0.59	0.50	1.10	1.37	1.64	1.75	2.34	0.93	0.79		1.68

\# Mean of three replications.
* Peak population of aphids
Figure in parenthesis are sqrt. X + 0.5 transformed values

from the variety RCr-41, which was highly susceptible to aphid.

Similarly, in 2014-15 the aphid infestation started in third week of December with few aphids per plant on some coriander varieties, whereas RCr-684, RCr-446 and ACr-1 were remained free from the aphid infestation at this stage. Then after pest infestation increased gradually and reached to its maximum during the month of February with three peaks *i.e.* 7th February (on varieties Rajendra Swati, and Pant Haritma), 14th February (on varieties Gujarat Coriander-1, RCr-684, Sadhna (CS-4), RCr-446, Sindhu (CS-2) and RCr-436) and 21stFebruary (RCr-41, Swati (CS-6) and Gujarat Coriander-2) depending upon the varieties/entries (Table 2). The coriander variety RCr-684 received lowest aphid infestation (27.20 aphids/plant) followed by RCr-446 and ACr-1 with 28.80 and 29.00 aphids/plant, respectively. Meena*et al.* (2002b) also reported that coriander varieties RCr-446 and RCr-436 were found least susceptible against aphids are in accordance the present finding. These three varieties were found statistically at par for aphid infestation. The maximum aphid infestation was observed on variety Swati (CS-6) 76.66 aphids/plant followed by Sadhna (CS-4) Sindhu (CS-2) and RCr-41 having aphids population of 74.80, 74.00 and 65.10 aphids/plant, respectively. The remaining varieties/entries were received the aphid infestation with ranged from 41.80 to 51.33 aphids/plant. The highest yield of coriander seed was recorded from the variety RCr-684 (16.63 q/ha) followed by RCr-446 (14.89 q/ha) and ACr-1 (14.75q/ha), while minimum yield 6.00 q/ha was obtained from the variety Sadhna (CS-4) and RCr-41 (6.65q/ha), which were highly susceptible to aphid. Based on two year results, it was evident from the study that the coriander varieties i.e. RCr-684 (25.45 aphids/plant), RCr-446 (26.45 aphids/plant), ACr-1 (26.60 aphids/plant), RCr-436 (41.75 aphids/plant), Gujarat Coriander-2 (42.45 aphids/plant), Pant Haritma (43.50 aphids/plant) and Gujarat Coriander-1 (43.70 aphids/plant) are moderately susceptible, whereas, Swati (CS-6), Sadhna (CS-4) and Sindhu (CS-2) with aphid population 73.88, 70.60 and 69.50 aphids/plant, respectively were categorized as highly susceptible varieties of coriander against aphids under field conditions.

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Original Research Paper

Correlation of Leaf Parameters with Incidence of *Papaya Ring Spot Virus* in Cultivated Papaya and its Wild Relatives

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ABSRACT

Papaya ring spot virus (PRSV) disease has been the major impediment in papaya cultivation. The disease is transmitted through three aphid vectors and field tolerance towards this disease varies among *Carica papaya* cultivars as well as within the *Vasconcellea* genus. Leaf morphological traits are known to have influence on the probing preferences of aphids. Hence, this study was conducted to know whether the leaf parameters could contribute to the incidence of PRSV possibly by influencing the probing or feeding behaviour of aphid vectors. Leaf parameters *viz*., leaf thickness, leaf epicuticular wax content, presence and type of trichomes, trichome density were correlated with disease incidence at field conditions. The result revealed that leaf thickness along with epicuticular wax content had significant negative correlation with disease incidence. Similarly, trichome density had negative impact on disease incidence at 99.92% significance level. High epicuticular wax content and high trichome density in *V. cauliflora* and *V. cundinamarcensis* were found to be negatively associated with low to very low infection indicating that these parameters may have limited the vector transmission significantly.

Keywords: Epicuticular wax content, Papaya, Trichome density and *Vasconcellea.*

INTRODUCTION

Papaya is ranked as the third most traded tropical fruit (excluding bananas). The area and production of papaya is on the increase in recent years due to its wide ecological adaptability, easiness in cultivation, high palatability, early fruiting, year round bearing, higher productivity and economic returns. Papaya is a nutrition basket filled with vitamins (2020 IU of vitamin A, 40 mg of vitamin B_1 and46 mg ofvitamin C per 100g of fruit), minerals, carbohydrates, proteins, iron, calcium and phosphorous (Dinesh, 2010). However, the production of papaya is hampered by a serious outbreak of viral disease caused by Papaya ring spot virus (PRSV-P). This virus affects production and productivity by decreasing photosynthetic capacity of plant, and subsequently leading to stunted growth, deformed and inedible fruitsand early mortality. PRSV is transmitted by several species of aphids in a non-persistent manner. Generally, aphids do not colonize papaya and transmission of PRSV is through transient aphid vectors.*Aphis gossypii* is the predominant vector followed by *A. craccivora* and *Myzus persicae*. Recent study suggested that *M. persicae* is more efficient than the other two species with 52.5 % transmission after the first inoculation access period (IAP) (Kalleswaraswamy and Krishnakumar, 2008).

Field tolerance towards PRSV varies between the *Carica papaya* varieties as well as the *Vasconcellea* species. *Vasconcellea* species *viz*., *V. cundinamarcensis*,*V. candicans*, *V. stipulata*, *V. cauliflora* and*V. quercifolia* are reported to be resistant to PRSV. Even though the genetic variability within the *Carica* genus for PRSV resistance is very low, a few varieties have shown tolerance to PRSV. This might be due to the non-preference of aphids to these varieties or species in addition to the innate resistance mechanism in *Vasconcellea* genepool. Morphological traits such as higher density of simple and glandular trichomes, epicuticular waxes and leaf thickness are reported to hinder the aphid attack in plants (Bin, 1979; Guerrieri and Digilo, 2008;

Wojcicka, 2015). A preliminary study was carried out to explore the possibility of aphid tolerance in papaya varieties as well as *Vasconcellea* species.

MATERIALS AND METHODS

Plant material

The experiment was carried outat ICAR- Indian Institute of Horticultural Research, Bengaluru during the period of June 2016 to August 2017 under open field conditions consecutively in two different locations during *kharif* and *rabi* seasons.The experiment plot surrounded by papaya crop with already established with PRSV incidence was selected. Six cultivars of *Carica papaya* namely Arka Surya, Arka Prabhath, Red Lady, Pusa Dwarf, Pusa Nanha and CO8, two intergeneric hybrids of Arka Surya and *V. cauliflora* (IGHI and IGHII) and four wild relatives *V. cauliflora*, *V. goudotiana*, *V. cundinamarcensis* and *V. parviflora* were used in this study. Twenty plants of each accession in three replicates were maintained as per the randomized block design.

Observations

Characters such as leaf thickness, leaf pubescence, epicuticular wax content and trichome density were recorded after three months of transplanting in the field, since symptoms appeared in susceptible genotypes after three months of transplanting. Leaf thickness was measured using Digital Vernier Caliper (Mitutoyo, Digimatic Caliper). Presence of leaf pubescence was visually recorded while the type of the pubescence was observed under stereo-microscope (Leica M205A) and Scanning Electron Microscope (Hitachi, TM3030 plus, Tabletop microscope). Epicuticular wax content was estimated as described by Ebercon *et al.* (1977). Trichome density was calculated as number of trichomes per centimetre area. These observations were correlated with per cent infection (PI) and per cent disease index (PDI). PDI was calculated after first symptom development in field condition at fortnightly intervals and calculated as per the formula.

$$PDI = \frac{\in n}{5N} x\ 100$$

Where, n = individual ratings, N= total number of leaves/ plant; 5= maximum rating

The individual ratings (n) were given using the scale adopted by Dhanam (2006) and ranged from 0 to 5 (0 = no disease symptoms; 1 = slight mosaic on leaves; 2 = mosaic patches and/or necrotic spots on leaves; 3 = leaves near apical meristem deformed slightly, yellow, and reduced in size; 4 = apical meristem with mosaic and deformation; 5 = extensive mosaic and serious deformation of leaves, or plant dead).

RESULTS AND DISCUSSION

Leaf thicknessat three months of transplanting ranged from 0.22 mm to 0.40 mm. The thickest leaf was observed in Pusa Nanha (0.40 mm) which was on par with *V. cundinamarcensis* (0.38 mm) and *V. cauliflora* (0.37 mm), followed by *V. parviflora* (0.35 mm). Among the accessions, thinnest leaves were noticed in TNAU papaya CO8, Arka Parbhath and IGH2 (0.22 mm) which was on par with IGH1 and Arka Surya (0.23 mm).

The accessions such as Arka Surya, Arka Prabhath, Red Lady, Pusa Dwarf, Pusa Nanha, TNAU Papaya CO8, IGH1, IGH2 and *V. goudotiana* lack leaf pubescence on both dorsal and ventral surfaces (Fig.1). However, the wild species viz., *V. cauliflora*, *V. cundinamarcensis* and *V. goudotiana* had leaf pubescence with higher trichome density on ventral surface than dorsal surface. Trichome density was highest in *V. cundinamarcensis* (192.75/cm^2) followed by *V. cauliflora* (25.25/cm^2) and *V. goudotiana* (14.88/cm^2).

The type of trichome on the leaves were also observed under scanning electron microscope. *V. cundinamarcensis* consisted of single celled non-glandular trichomes, whereas *V. cauliflora* and *V. goudotiana* comprised of multicellular glandular trichomes (Fig.2). Trichomes were present as extension of veins in *V. cauliflora* and *V. goudotiana*, while these were distributed throughout the leaf surface in *V. cundinamarcensis*.

Studies suggested that trichome density has more impact on entry of aphids rather than the type of trichomes, as higher trichome density blocked aphids (Musetti and Neal, 1997). It is the first feature affecting the selection behaviour of an aphid. Most of the resistant varieties or wild relatives are characterized by presence of trichomes (Bin, 1979). However, the glandular trichomes might have produced toxic exudates or acyl sugars that repel aphids (Goffreda *et al.*, 1989).

Table.1. Leaf thickness, leaf epicuticular wax content, trichome density, PRSV percentage infection, disease intensity score and PDI at field condition

Accessions	Leaf thickness (mm)	Leaf epicuticular wax content (μg/cm²)	Trichome density (number/cm²)	Per cent infection (%)	Disease intensity score	Per cent Disease index (%)
Arka Surya	0.23[de]	95.00[ef]	Nil	100.00[a] (89.71)	4/5	65.71[a] (54.16)
Arka Prabhath	0.22[e]	109.38[de]	Nil	100.00[a] (89.71)	4/5	61.25[b] (51.51)
Red Lady	0.27[cd]	143.75[c]	Nil	100.00[a] (89.71)	4/5	51.04[c] (45.60)
Pusa Dwarf	0.29[c]	134.38[c]	Nil	100.00[a] (89.71)	4/5	62.50[ab] (52.25)
Pusa Nanha	0.40[a]	114.38[d]	Nil	25.33[e] (29.77)	1	1.56[f] (9.34)
TNAU Papaya CO 8	0.22[e]	96.25[ef]	Nil	100.00[a] (89.71)	3/4	35.64[d] (36.65)
IGH1	0.23[de]	94.38[f]	Nil	81.33[d] (64.66)	3/4	21.46[e] (27.59)
IGH2	0.22[e]	106.25[def]	Nil	86.67[c] (68.60)	3/4	25.24[e] (28.24)
V. goudotiana	0.26[cde]	114.38[d]	Nil	87.66[b] (70.35)	4	25.00[e] (29.97)
V. cauliflora	0.37[ab]	200.00[a]	25.25[b]	0.00[f] (0.286)	0	0.00[g] (0.286)
V. cundinamarcensis	0.38[ab]	170.00[b]	192.75[a]	0.00[f] (0.286)	0	0.00[g] (0.286)
V. parviflora	0.35[b]	105.00[def]	14.88[b]	23.62[e] (29.32)	1	2.46[f] (9.02)
Mean	0.29	123.59	77.63	67.05 (59.32)		29.32 (28.74)
CV (%)	9.96	3.32	3.17	1.61		5.02
SE(d)	0.012	3.353	1.231	0.78		1.18
Tukey HSD at 1%	0.045	14.667	4.26	1.73		1.91

Values inparentheses are arc sine transformed values

A correlation was drawn between the leaf parameters and disease scoring (Table.2). Epicuticular wax content in leaves was negatively and significantly correlated with percentage of infection. Epicuticular waxes are complex mixture of long chain aliphatic and cyclic components such as fatty acids, hydrocarbons, alcohols, aldehydes, ketones, esters, terpenoids, sterols, flavanoids and phenolic substances. Higher epicuticular wax content might be a reason for reduction in aphid landing or movement, which in turn could have contributed, to inhibition of the sap transmission of PRSV. Similar negative effects of leaf epicuticular waxes were reported on neonate larval movement of *Spodoptera frugiperda* on *Zea mays* (Ostrand et al., 2008), resistance in cabbage to aphids *Bravicoryne brassicae*, sorghum to green bug (*Schizaphis graminum*) and winter wheat to English grain aphid (*Sitobion avenae*) (Shepherd *et al.*, 1999). The presence of thick wax content might have affected the probing and feeding by aphids, thereby rejecting the particular variety or species.

Leaf thickness was negatively correlated with PDI and infection percentage. Leaf thickness was positively contributed by the epicuticular wax content, which indirectly influences the disease tolerance or resistance. Thick cell wall has been attributed to resist the feeding activity of aphids (Guerrieri and Digilo, 2008).

The association analysis reveals that there is a significant negative correlation between trichome density and infection percentage. Surface resistance is the first barrier against aphid attack (Wang *et al.*, 2004). Either or both of epicuticular wax content or presence of trichomes is known to hinder the aphid movement and stylet insertion (Bin, 1979).

Table.2. Correlation between disease incidence and leaf parameters

	Epicuticular Wax Content	Leaf Thickness	Trichome Density	Per centage Disease Index	Per centage Infection
Epicuticular Wax Content	**1.00**	0.62*0.031	0.76*0.004	-0.360.247	-0.61*0.033
Leaf Thickness		**1.00**	0.390.201	-0.71*0.009	-0.90*<.0001
Trichome Density			**1.00**	-0.390.201	-0.53*0.076
Percentage Disease Index				**1.00**	0.87*0.000
Percentage Infection					**1.00**

First value represents 'r' value and second value represents p value. *<0.05 p value shows significant correlation.

Higher field tolerance to PRSV was observed in 'Pusa Nanha', which had thicker leaves. The PRSV incidence was significantly low in both *V. cauliflora* and *V. cundinamarcensis, which* registered thicker leaves, higher epicuticular wax content and denser trichomes. The preliminary study broadly indicates that leaf thickness, presence of trichomes in higher density and epicuticular wax content in papaya is likely to play a definitive role towards reduction in PRSV incidence probably by restricting the aphid vector incidence.

Higher leaf thickness, epicuticular wax content and trichome density in papaya is found to have negative impact on the incidence of Papaya ring spot virus in papaya and these factors may have a role to play in restricting the virus transmission by aphid vector. Future research needs to be focussed on the biochemical constituents of glandular trichomes and its effect on aphids.

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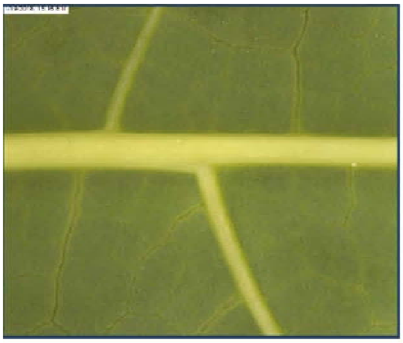


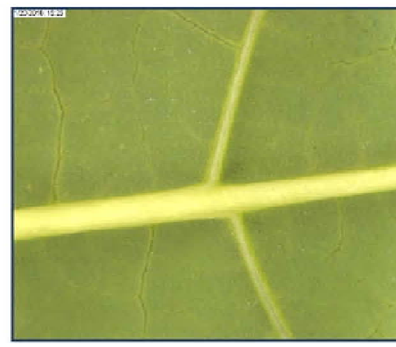
Arka Surya

Arka Prabhath

Red Lady

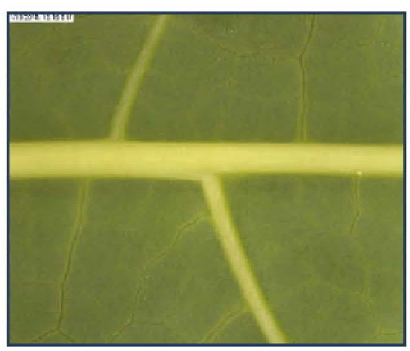
Pusa Dwarf

Pusa Nanha



CO8

IGH1

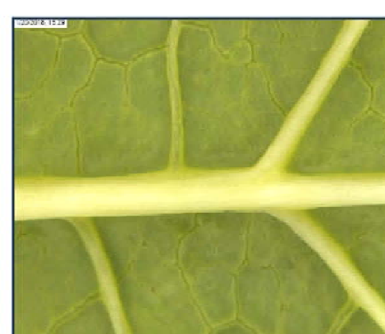


IGH2

V.goudotiana

V.cauliflora

V.cundinamarcensis



V.parviflora

Fig. 1: Stereo microscope view of leaf ventral surface pubescence

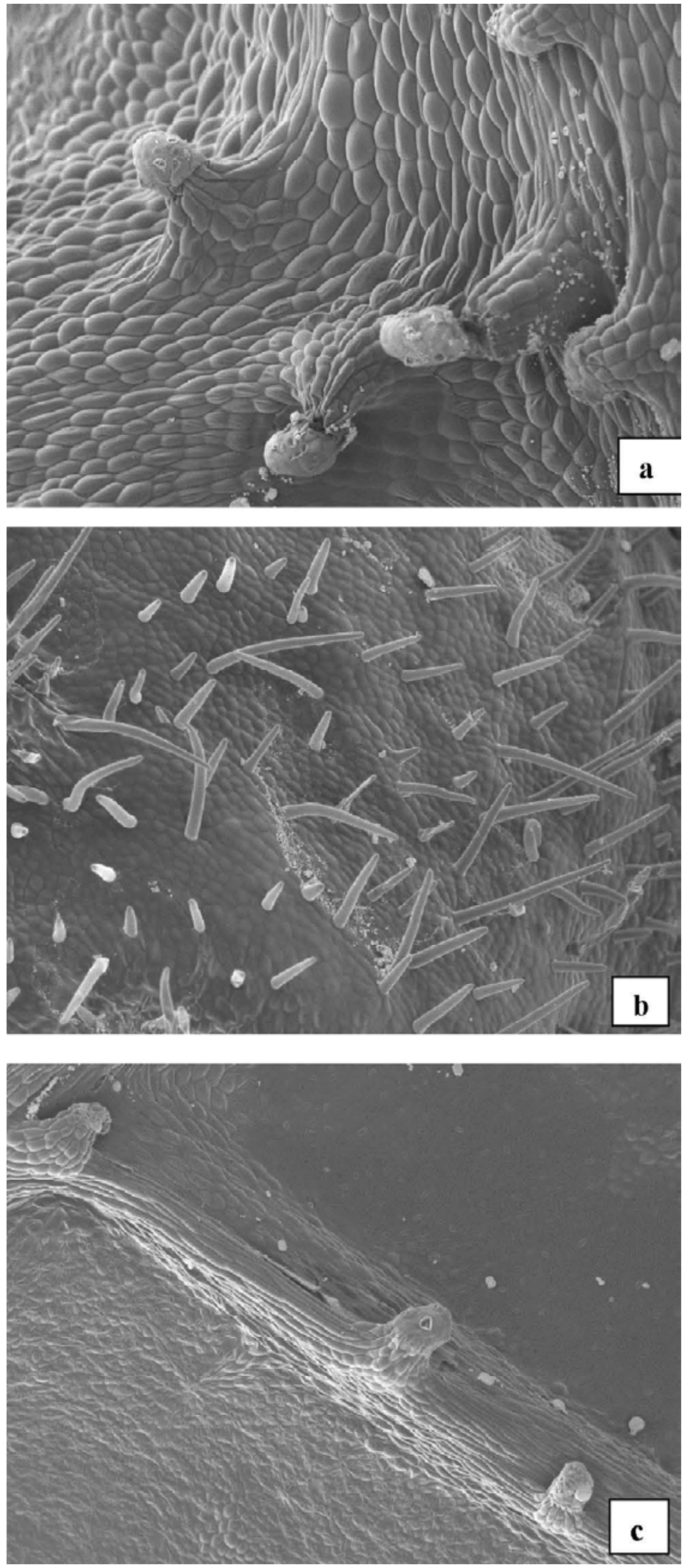


Fig. 2: Scanning electron microscope view of leaf ventral surface pubescence at 500µm
a) *V. cauliflora* (b) *V. cundinamarcensis* (c) *V. goudotiana*

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Original Research Paper

Performance Evaluation of Ferns for Cut Green and Landscape Purpose

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ABSTRACT

Ferns can be used as ground covers, specimen plants and for group, background and border planting in landscape. They can also be used as fillers in bouquets and flower arrangements. Hence, the objective of the study was to evaluate the performance of different fern species and to identify the suitable species for commercial cultivation. Eleven species of ferns belonging to different genera *viz., Adiantum tenerum, Asplenium nidus, Asplenium longissimum, Asplenium scolopendrium, Diaplazium acrostichoides*, *Nephrolepis biserrata* 'furcans', *Nephrolepis exaltata* 'chidisii', *Nephrolepis exaltata, Bostoniensis compacta*, *Nephrolepis cordifolia, Nephrolepis biserrata miniata* and *Pteris ensiformis* were evaluated for growth pattern and suitability for landscape and commercial uses. Vegetative characters like eplant height and spread were highest in *Asplenium nidus* and a maximum number of leaves were observed in *Adiantum tenerum*. Based on growth pattern they were classified under tall, medium and dwarf groups *Asplenium nidus* and *Nephrolepis biserrata miniata* were grouped under the tall category. The species which come under medium category are *Asplenium longissimum, Diaplazium acrostichoides*, *Nephrolepis biserrata* 'Furcans', *Nephrolepis exaltata* 'Chidisii', *Nephrolepis exaltata, Bostoniensis compacta*, *Nephrolepis cordifolia, Pteris ensiformis* and *Asplenium scolopendrium* where as *Adiantum tenerum* comes under dwarf category. All species evaluated were found to be suitable for pot plants. *Nephrolepis biserrata miniata, Nephrolepis biserrata* furcans, *Nephrolepis cordifolia, Asplenium nidus* and *Diaplazium acrostichoides* can be recommended as houseplants. *Nephrolepis biserrata-Miniata, Nephrolepis biserrata* furcans and *Nephrolepis cordifolia* can be used as border plants in landscapes. *Nephrolepis exaltata, Bostoniensis compacta*, *Asplenium longissimum and Pteris ensiformis* were observed to be attractive in hanging baskets. *Nephrolepis biserrata-Miniata, Nephrolepis exaltata* chidisii, *Nephrolepis exaltata, Bostoniensis compacta* and *Diaplazium acrostichoides* are suitable for bouquets and flower arrangements.

Keywords: Cut green, Evaluation, Ferns and Landscape

INTRODUCTION

Ferns are heterogeneous group of vascular plants widely distributed in humid and shady habitats. They are tropical flowerless plants and most of the species are low growing and herbaceous in nature. Ferns are excellent materials, which can provide greenery in a landscape. They are adapted to shady areas and they can be used to enhance the indoor environmental conditions. The great diversity of the ferns make them exceptional landscape materials and the characteristic features of foliage make them excellent fillers in flower arrangements, bouquets *etc.* large number of fern species having great ornamental value are seen widely grown in Kerala especially in western ghat regions. There is a tremendous potential for exploring the commercial and landscape value of these ferns. Due to the varied forms, shape and long post harvest life of their fronds, they are highly recommended as filler materials in bouquets and flower arrangements. There are numerous species of ferns grown in Kerala, the landscape and commercial value of those are yet to be exploited. There is a need to collect and evaluate those potential groups to introduce new species to the floriculture industry in Kerala. Hence, the study was aimed to collect the ferns available in humid forest regions of Kerala and evaluate the performance of different fern species and to identify the suitable species for commercial cultivation.

MATERIALS AND METHODS

The study was carried out in the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara. Eleven species of ferns from the existing germplasm collection *viz*; *Adiantum tenerum, Asplenium nidus, Asplenium longissimum, Asplenium scolopendrium, Diaplazium acrostichoides*, *Nephrolepis biserrata* 'Furcans', *Nephrolepis exaltata* 'Chidisii', *Nephrolepis exaltata Bostoniensis compacta*, *Nephrolepis cordifolia, Nephrolepis biserrata-Miniata* and *Pteris ensiformis* were selected for evaluation. The experiment was laid out in CRD with three replications. Standard cultural practices were followed throughout the study period. The observations on following quantitative parameters *viz*., plant height, plant spread, number of leaves per plant, longevity of leaf on plant, leaf production interval and vase life were recorded. The qualitative traits such as texture of frond, shape of frond, nature of margin, nature of tip, presence of marking/pigments, colour of frond, branching habit and reaction to peat and diseases were also recorded.

RESULTS AND DISCUSSION

Quantitative characters

Morphological characters of different species of ferns are given in the Table 1. Among vegetative characters, plant height is an important parameter and based on the plant height categorization of plants can be done for various landscape uses. Plant height was maximum in species *Asplenium nidus* (113.00 cm) and minimum plant height was observed in *Adiantum tenerum* (12.33 cm).The species *Asplenium nidus* was also superior regarding plant spread (144.00 cm NS and 159.00 cm in EW). Number of leaves per plant were recorded the highest in *Adiantum tenerum* (159.70). Since foliage is the attractive part of ferns, longevity of leaf on a plant is very important and in the present study the maximum value for this parameter was observed in *Asplenium nidus* (292.30) followed by *Nephrolepis biserrata miniata* (209.30). Similar findings were also reported by Oloyede, (2012).

Leaf production interval

Post harvest longevity of fronds decides the commercial value of ferns since they are mainly used as cut foliage and filler materials. Vase life was maximum in *Asplenium longissimum* and *Asplenium nidus* (10 days) and minimum vase life was observed in *Diaplazium acrostichoides* (table 1).

Qualitative characters

Among the qualitative characters, leaf texture was smooth in all the species except *Diaplazium acrostichoides* in which the texture was rough compared to other species. The shape of frond ranges from reniform to lanceolate. The colour of the fronds ranges from light green to dark green and all species evaluated were resistant to pests and diseases except *Diaplazium acrostichoides, which* was susceptible to leaf spot disease. Variation in quantitative and qualitative characters of ferns may be due to the peculiar genetic makeup of each genotype as reported by Safeena (2013) and Vasco *et al.* (2013).

Based on the performance, suitable species for various landscape uses were identified. All species evaluated were found to be suitable for pot plants. *Nephrolepis biserrata miniata, Nephrolepis biserrata* furcans, *Nephrolepis cordifolia, Asplenium nidus* and *Diaplazium acrostichoides* can be recommended as indoor plants. This is in accordance with the findings of Lerner, (2001) who reported the suitability of the ferns as indoor plants. *Nephrolepis biserrata-Miniata, Nephrolepis biserrata* furcans and *Nephrolepis cordifolia* can be used as border plants in landscapes. *Adiantum tenerum* is a very low growing fern with soft textured attractive leaves and this can be recommended ground covers in shady areas. Bharathi *et al*., (2013) had also reported ferns as excellent as ground cover in shady areas. *Nephrolepis exaltata Bostoniensis compacta*, *Asplenium longissimum* and *Pteris ensiformis* were observed to be attractive in hanging baskets. *Nephrolepis biserrata-Miniata, Nephrolepis exaltata* chidisii, *Nephrolepis exaltata Bostoniensis compacta*, *Nephrolepis cordifolia* and *Diaplazium acrostichoides* are suitable as cut foliage can be used for bouquets and flower arrangements. The popularity of ferns as cut foliage had also been reported by Stamps and Conover, (1986) and Safeena, (2013).

Hence, it can be concluded that, all ferns evaluated were suitable for landscape and pot plant purpose, Nephrolepis *biserrata miniata, Nephrolepis biserrata* furcans, *Nephrolepis cordifolia, Asplenium nidus* and *Diaplazium acrostichoides* can be recommended as indoor plants. *Nephrolepis biserrata-Miniata, Nephrolepis biserrata* furcans and *Nephrolepis cordifolia* can be used as border plants in landscapes. *Adiantum tenerum* is a very low growing fern with soft textured attractive leaves and this can be recommended ground covers in shady areas. *Nephrolepis exaltata Bostoniensis compacta*, *Asplenium longissimum* and *Pteris ensiformis* were observed to be attractive in hanging baskets. *Nephrolepis biserrata-Miniata, Nephrolepis exaltata* chidisii, *Nephrolepis exaltata Bostoniensis compacta*, *Nephrolepis cordifolia* and *Diaplazium acrostichoides* are suitable as cut foliage.

Table 1: Evaluation of different species of ferns for vegetative characters

Species/Varieties	Plant height (cm)	Plant spread NS (cm)	Plant spread EW (cm)	No. of leaves per plant	Longevity Longevity plant	Leaf production interval	Vase life (days)
Aspleniumlongissimum	33.75	44.67	46.00	37.30	152.00	22.00	10.00
*Nephrolepisexaltata*childsii	37.25	45.00	46.00	29.70	181.00	12.00	7.30
Nephrolepisexaltata	40.42	53.33	49.80	26.30	124.30	15.30	6.70
Pterisensiformis	57.25	65.00	72.80	63.80	94.30	11.70	4.70
Diplaziumacrostichoides	49.83	62.67	61.20	14.50	91.30	19.70	3.30
Nephrolepiscordifolia	48.83	57.92	54.30	91.80	181.00	14.00	9.30
Nephrolepisbiserrataminata	77.67	82.00	85.70	31.00	209.30	10.70	7.30
Adiantumtenerum	12.33	21.33	21.50	157.00	178.30	12.30	7.00
Aspleniumscolopendrium	69.67	78.17	77.70	24.30	85.70	24.30	5.70
Aspleniumnidus	113.00	144.00	159.70	21.30	292.30	155.70	10.00
Nephrolepisbiserrata var. *furcans*	27.83	40.08	41.20	34.50	149.00	17.70	6.70
Range	12.33-113.00	40.88-144.00	21.50-159.70				
CD (0.05)	15.23	14.29	17.90	13.60	15.60	6.90	

Table 2: Evaluation of different species of fern for qualitative characters

Species/ Varieties	Texture of frond	Shape of frond	Nature of margin	Nature of tip	Presence of marking/ pigments	Colour of frond	Reaction to pests and diseases
Aspleniumlongissimum	Smooth	Oblong	Undulate	Emargi nated	Absent	Dark green	Resistant
Nephrolepisexaltata- childsii	Smooth	Ovate	Pinnatisect	Acute	Absent	Medium green	Resistant
Nephrolepisexaltata	Smooth	Lanceolate	Undulate	Acute	Absent	Light green	Resistant
Pterisensiformis	Smooth	linear	Entire	Acute	Absent	Dark green with white markings	Resistant
Diplaziumacrostic-hoides	Rough	Lanceolate	Pinnatifide	Acute	Absent	Dark green	Susceptible to leaf spot and leaf blight
Nephrolepiscordifolia	Smooth	Reniform	Entire	Round	Absent	Dark green	Nil
Nephrolepisbiserrata minath	Smooth	Lanceolate	Entire	Acute	Absent	Dark green	Resistant
Adiantumtenerum	Smooth	Oblong	Entire	Obtuse	Absent	Light green	Resistant
Aspleniumscolopend-rium	Smooth	Triangular	Pinnatisect	Acute	Absent	Dark green	Highly susceptible to leaf spot
Aspleniumnidus	Smooth	Oblanceo late	Entire	Obtuse	Absent	Medium green	Resistant
Nephrolepisbiserrata-furcans	Smooth	Oblong	Dentate	Lobed	Absent	Light green	Moderately susceptible to leaf spot diseases

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Original Research Paper

Compositional Nutrient Diagnosis (CND) Norms and Indices for Potato (*Solanum tuberosum* L.)

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ABSTRACT

A survey was conducted in potato fields for collection of leaf samples to establish nutrient concentration yield data bank. The data bank was used for developing multivariate compositional nutrient diagnosis (CND) norms for assessing the nutritional status of selected centres of potato growing fields. The mean N, P and K concentrations were 2.09, 0.25 and 4.16 %, respectively. The mean Ca (1.11%) concentration was twice higher compared to Mg (0.63 %) concentration. The mean values of Zn, Cu, Fe, Mn and B were 43.69, 31.24, 986.71, 192.76 and 59.98 ppm, respectively. The CND norms for V_N, V_P and V_K were 3.04, 0.94 and 3.73, respectively. The norm for Ca (V_{Ca}=2.45) and Mg (V_{Mg}=1.78) were much narrower compared to the absolute nutrient concentration. The norm for V_{Zn}, V_{Cu}, V_{Fe}, V_{Mn} and V_B were -3.24, -3.60, -0.23, -1.98 and -2.89respectively. The multivariate CND norms developed for ten nutrients proved to be an important tool for diagnosis of nutrient imbalance in potato. The nutrient indices developed indicated that Zn was the most common yield-limiting nutrient. The CND norms and the indices developed can be used for identifying the hidden hunger of various nutrients in potato for evolving nutrient management strategies.

Keywords: CND norms, Nutrients and Potato

INTRODUCTION

Potato (*Solanum tuberosum L.*) is the world's fourth most important food crop after wheat, rice and maize because of its great yield potential and high nutritive value. It constitutes nearly half of the world's annual output of all root and tuber crops, with an annual world production of about 388 m t (FAO, 2019). India produces 48.23m t of potatoes from an area of 2.15 m ha (Anon., 2017) with a productivityof 2.24 t ha^{-1}. Potatois a crop of temperate climates. Optimum soil temperature for normal tuber growth is 15 to 18°C.Potato requires a well-drained, well-aerated, porous soil with pH of 5.0 to 6.0. As well as providing starch, an essential component of the diet, potatoes are rich in vitamin C, minerals, high in potassium and an excellent source of fibre.

The potato crop requires substantial amounts of nutrient sources for maximum yield and quality. Fertilizer management could be guided in part by plant analysis. Reliable nutrient norms for obtaining adequate nutrient balance with minimum application of fertilizers are required (Parent *et al.*, 1994). Nutrient status in plants is currently diagnosed using nutrient concentration or dual ratios in selected tissues (Walworth and Sumner, 1987). Elemental concentrations vary vastly with time and the critical level of one element can shift widely if another element can substitute or interfere with the uptake of the first element planttissues possess a multivariate character with respect to elemental composition that could be interpreted for diagnostic purposes. Mineral composition of plant tissues, expressed as concentrations or relative (ratio) values forms the basic numerical information for diagnosing nutrient status in plants (Parent and Dafir, 1992).

Several approaches are adopted for identification of nutrient imbalances, a one being the compositional nutrient diagnosis (CND). It provides a correction factor for any nutrient, given all the nutrients under analysis (i.e. multinutrient ratios). In addition, CND generates new variables and it is amendable to multivariate analysis of tissue compositional data (Parent and Dafir, 1992). It recognizes that, given a change in certain nutrient proportions in the foliage, other proportions must be altered since plant composition is constrained to 100 per cent the dry matter content. Thus, nutrient diagnosis is generally conducted at a particular growth stage for which norms were derived (Parent *et al*., 1994).

The CND norms are multivariate norms that give due weightage to all the elements, including unmeasured factors and therefore, have higher diagnostic sensitivity (Anjaneyulu *et al*., 2008).

The present investigation was carried out with the main objective to develop multivariate diagnostic norms for potato leaves collected from different centres of All India Coordinated Research Project (AICRP) on potato using CND to improve diagnostic precision and to understand interaction among different nutrients governing yield and quality of the potato crop.

MATERIALS AND METHODS

The leaf samples of potato were collected from different centres of AICRP on potato under Indian Council of Agricultural Research (ICAR) *viz*., Sardar Krishinagar (Gujarat), Bidhan Chandra Krishi Vishwavidyalaya (West Bengal), Indira Gandhi Agricultural University, Raipur (Chhattisgarh), G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), Assam Agricultural University, Jorhat (Assam), Rajendra Agricultural University (Bihar) and ChaudharyCharan Singh Haryana Agricultural University, Hisar (Haryana) to establish nutrient concentration versus yield data bank for developing diagnostic norms. A total of 78 leaf samples were collected by selecting the 3rd to 6th leaf from growing tip were collected just before bloom stage, which provides the index leaf in potato. About 25 to 30 samples were collected from each plot from different centres of AICRP on potato. The leaf samples were decontaminated by washing in a sequentially with tap water, 0.2 per cent detergent solution, 0.1 N HCl and finally with double distilled water. Leaf samples were dried at 65 to 70^{0}C for 48 h. The samples were then powdered in a cyclotec mill and analysed for different nutrients by digesting 1g tissue in diacid mixture (9:4 ratio of nitric acid and perchloric acid) using standard analytical methods (Jackson, 1973). The samples were analysed for major (N, P and K), secondary (Ca, Mg and S) and micronutrients (Zn, Cu, Fe, Mn and B) by standard method (Piper, 1966; Jackson, 1973 and Jones and Case, 1990). Thus, nutrient concentration vs yield data bank (based on standard procedure, below 30 t ha^{-1} and above 30 t ha^{-1} are considered as low yield and high yield) was established for developing nutrient diagnostic norms.

The CND norms (mean and standard deviation (SD) of the analysed leaf samples) were developed by adopting the procedure outlined by Parent and Dafir (1992). This was accomplished by following the steps proposed by Khiari *et al.* (2001) as follows.

Ist step: To convert all the plant nutrient concentrations to percentage (%).

IInd step: Sum all the plant nutrient concentration i.e.

Total = $\sum$ (N+P+K+Ca+Mg+Zn+Cu+Fe+Mn+B)

IIIrd step: Calculate residue (R_d)

R_d = 100-$\sum$ (N+P+K+Ca+Mg+Zn+Cu+Fe+Mn+B)

Where,

Rd = it is the filling value between 100 and the sum of the nutrient proportions.

IVth step: Calculate Geometric mean (G)

G= $(N*P*K*Ca*Mg*Zn*Cu*Fe*Mn*B)^{1/n}$

Where,

n = no. of nutrient elements taken for calculation.

Vth step: row centred log ratios of the nutrient proportions (V_x) were calculated using the equation.

V_N = ln (N/G), V_P = ln (P/G), V_K = ln (K/G), V_{Ca} = ln (Ca/G), V_{Mg} = ln (Mg/G), V_{Zn} = ln (Zn/G), V_{Cu} = ln (Cu/G), V_{Fe}= ln (Fe/G), V_{Mn} = ln (Mn/G) and V_B = ln (B/G)

VIth step: CND norms are computed using means and SD corresponding to the row centred log ratios V_X of the nutrients for high yielding populations.

$V*_N$, $V*_P$, $V*_K$, ...$V*_B$i.e mean = average (V_{X1}+ V_{X2}+ V_{X3}+ ....+V_{Xn})

Where,

V_x = average of no. of row centred log ratios of all the nutrients proportions.

$SD*_N$, $SD*_P$, $SD*_K$, ...$SD*_B$i.e SD = stdev (V_{X1}+ V_{X2}+ V_{X3}+ ....+V_{Xn})

Where,

V_x = SD of no. of row centred log ratios of all the nutrients proportions.

VII[th] step: the standardized variables $(V_N - V^*_N)/SD^*_N$ to $(V_B - V^*_B) / SD^*_B$ are CND nutrient indices for low yielding population.

$I_N = (V_N - V^*_N) / SD^*_N$, $I_P = (V_P - V^*_P)/ SD^*_P$, ... $I_B = (V_B - V^*_B)/ SD^*_B$.

Independent values for V_N to $V_B$were introduced in the equation for diagnostic purpose. Once CND norms and indices have been developed, an independent database can validate them. The validations of CND norms and indices have been reported by Parent and Dafir (1992), Parent *et al.* (1994) and Khiari *et al.* (2001).

RESULTS AND DISCUSSION

Nutrient concentration range

The mean concentrations of N, P, K, Ca, Mg, Zn, Cu, Fe, Mn and B in leaf of potato are presented in Table 1. The mean N concentration was 2.09 % and ranged from 0.40 to 3.68 %. Maximum yield in potato was reported when N concentration in leaf ranged from 1.19 to 1.30 % (Vijaykumar, 2010). The mean P concentration was 0.25 % and varied from 0.42 to 0.46 %. The K concentration varied widely from 1.80 to 7.95 % with a mean of 4.16 %. The increased content of primary nutrients (N, P and K) might be attributed to the better crop growth because of increased availability of nutrients due to application of fertilizers. Besides, application of nutrients in proper balance generally results in better utilization of added nutrients (Vijaykumar, 2010).

Similarly, Ca concentration showed a wide variation ranging from 0.60 to 1.57 %. The mean Ca (1.11 %) was twice higher to Mg (0.63 %), which was comparable to the values reported by Anjaneyulu *et al,* (2008) in guava and Anjaneyulu and Raghupathi (2010) in papaya. The mean leaf concentration of Zn, Cu, Fe, Mn and B were 43.69, 31.24, 986.71, 192.76 and 59.28 ppm, respectively. The optimum range varied from 10.60-104.98, 20.08-76.40, 205.53-5721.60, 4.85-448.00 and 20.86-104.99 ppm for Zn, Cu, Fe, Mn and B respectively (Jones, 1991 and Tisdale *et al.,* 1997). This was attributed to increased availability of these nutrients due to the supply of these nutrients through micronutrient fertilizers (Vijaykumar, 2010). Gopalakrishnan (2007) reported that the micronutrients for early flower set and helps in production of growth hormones for their good growth and development for the crops.

Compositional Nutrient Diagnosis (CND) norms

The CND norms for N (V_N), P (V_P) and K (V_K) for leaf of potato were 3.04, 0.94 and 3.73 respectively (**Table 2**). The norms derived indicated higher requirement of K compared to N that might be due to continuous flowering in potato. Similarly, high CND norm for K was reported in banana (Raghupathi*et al.,* 2002) indicating higher K requirement. The norm for Ca (V_{ca}= 2.45) was higher compared to that of Mg (V_{Mg}= 1.78) norm. The higher norm value noticed for Ca was mainly due to the presence of high free calcium carbonate in soils, which might have overwhelming influence on calcium uptake. This finding corroborates with the results observed by Anjaneyulu and Raghupathi (2010). Among the micronutrients, Fe requirement was much higher compared to Mn, Zn. Cu and B with a norm value of V_{Fe} = – 0.23. CND norms are multivariate norms with due weightage to all the other elements, including the unmeasured factor. Sum of the tissue components is 100 % and therefore the sum of row centred log ratios (including filling value) is zero. CND norm values developed were difficult to comprehend compared to nutrient concentrations, expressed as per cent or ppm (Anjaneyulu *et al.,* 2008). Therefore, the CND norms are having higher diagnostic precision (Parent and Dafir, 1992) compared to the bivariate diagnosis and recommendation integrated system (Walworth and Sumner, 1987).

Compositional Nutrient diagnosis (CND) indices

Independent values were introduced from low yielding potato crops for the purpose of diagnosis of a nutrient that limits the yield. The CND indices identified Zn, Ca and K as the most common yield limiting nutrients (Table 3). Among the 44 selected low yielding potato fields, both Zn and K were common yield limiting nutrients. Similarly, the results are in conformity with the findings of Anjaneyulu (2007) in which Zn and K were identified as common yield limiting nutrients in papaya diagnosis and recommendation integrated system (DRIS) technique. Boron and Manganese were also found to be low in some potato fields as reflected through indices (Anjaneyulu and Raghupathi, 2010). However, no single nutrient was found solely responsible for low yield (Anjaneyulu *et al.,* 2008). The concentration of N when below the critical level manifested visual symptoms of nutritional imbalance, which exhibited negative indices. Thus, the yield limiting nutrients were differing from field to field though some of the nutrients were more prominent. The order in which nutrients were limiting the yield indicated that most often more than one nutrient was limiting the yield. Among different nutrient elements, B showed a significant positive relationship (Table 4) with both Ca and Mg, whereas K whose requirement is very high for crops like potato showed negative relationship with B.

Multivariate technique (compositional nutrient diagnosis) was proved to be an important tool for interpretation of complex interaction pattern among nutrients concentration in rapidly growing potato plants. The norms derived indicated higher requirement of K compared to N. Among different nutrients, the CND indices identified Zn, Ca and K as the most common yield limiting nutrients in potato.

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Table 1: Mean and range of nutrients concentration for Potato (High yielding Potato)

Nutrient	Unit	Mean	Minimum	Maximum
N	%	2.09	0.40	3.68
P	%	0.25	0.42	0.46
K	%	4.16	1.80	7.95
Ca	%	1.11	0.60	1.57
Mg	%	0.63	0.12	1.01
Zn	ppm	43.69	10.60	104.98
Cu	ppm	31.24	20.08	76.40
Fe	ppm	986.71	205.53	5721.60
Mn	ppm	192.76	4.85	448.00
B	ppm	59.98	20.86	104.99

Table 2: Compositional nutrient diagnosis (CND) norms for Potato

CND variate	CND norms	SD
V_N	3.04	0.43
V_P	0.94	0.36
V_K	3.73	0.37
V_{Ca}	2.45	0.36
V_{Mg}	1.78	0.63
V_{Zn}	-3.24	0.52
V_{Cu}	-3.60	0.55
V_{Fe}	-0.23	0.63
V_{Mn}	-1.98	0.92
V_B	-2.89	0.69
V_R	6.89	0.24

Table 3: CND indices for selected low yielding fields of potato

N	P	K	Ca	Mg	Zn	Cu	Fe	Mn	B	R
2.01	2.75	0.86	0.41	0.31	-1.41	-0.93	-0.71	-0.22	-0.90	0.16
2.20	2.71	0.66	-0.31	0.19	-1.06	-1.01	-0.68	-0.14	-0.74	0.27
2.09	2.64	0.88	0.08	0.06	-1.12	-1.05	-0.81	-0.23	-0.52	0.21
2.16	2.67	0.92	0.05	0.16	-1.24	-0.99	-0.71	-0.33	-0.60	0.34
2.17	2.64	1.09	0.31	0.23	-1.01	-0.90	-1.23	-0.29	-0.70	0.27
1.72	0.52	0.77	-0.47	-0.16	-0.58	-0.37	0.39	-0.14	-0.79	-0.45
1.79	0.67	0.69	-0.06	-0.17	-0.70	-0.49	0.33	0.01	-1.02	-0.65
1.88	0.67	1.31	-0.12	-0.10	-0.67	-0.61	0.23	-0.23	-0.97	-0.44
1.96	0.73	0.48	-0.15	-0.18	-0.96	-0.43	0.51	-0.24	-0.69	-0.68
1.71	0.95	-0.16	-0.58	-0.31	-0.57	-0.58	0.58	0.13	-0.70	-0.73
-0.15	0.40	-0.09	-0.16	0.55	-0.65	0.67	1.36	-0.64	-0.90	-0.60
0.25	-0.10	0.19	0.15	0.67	-1.00	0.44	-0.03	-0.26	-0.11	-0.24
0.55	0.19	-0.27	0.33	0.39	-0.72	0.80	-0.09	-0.09	-0.71	-0.23
0.33	0.48	0.65	0.06	0.76	-0.76	0.81	-0.30	-0.54	-0.60	-0.86
0.62	0.54	0.80	0.05	0.77	-0.81	0.63	-0.32	-1.09	0.05	-0.61
2.02	1.43	-0.04	0.04	0.70	-1.46	-0.41	-1.38	-0.27	0.41	0.23
1.54	2.11	-0.34	-0.09	0.55	-1.48	-0.38	-1.46	-0.28	0.79	-0.11
1.98	0.34	0.11	0.01	0.83	-1.57	-0.26	-1.67	-0.26	1.05	0.58
1.30	1.59	0.02	-0.10	0.86	-1.37	-0.36	-1.47	-0.57	1.04	0.67
2.30	1.34	-0.13	1.07	1.35	-1.18	-0.66	-1.78	-1.66	1.41	2.09
-2.25	1.88	-2.85	-0.23	-0.39	-0.01	0.92	0.74	0.56	0.28	-1.08
-0.73	2.18	-3.10	-0.60	-0.65	-0.24	0.71	0.65	0.70	-0.01	-1.52
0.06	3.22	-0.78	0.71	0.46	-1.40	-0.23	0.24	-0.24	-0.74	0.05
-0.80	2.25	-0.48	0.36	0.24	-1.16	0.02	0.22	0.10	-0.30	-0.72
-0.80	2.30	0.34	0.45	0.32	-0.63	1.33	-1.52	-0.58	0.17	0.25
1.90	3.67	1.02	-0.72	0.17	-1.08	-0.70	-0.74	-0.26	-1.04	0.14
2.12	3.68	0.74	-0.09	0.22	-1.15	-0.61	-0.89	-0.42	-1.07	-0.13
2.06	2.47	1.87	-0.12	0.23	-1.25	-0.89	-0.88	-0.37	-0.79	-0.18
2.13	2.71	1.24	-0.42	0.13	-1.13	-0.47	-0.77	-0.32	-0.95	0.14
2.17	2.71	0.65	-0.20	0.21	-1.25	-0.67	-0.68	-0.26	-0.76	-0.05
1.74	1.04	0.08	-0.30	-0.31	-0.61	-0.41	0.47	-0.02	-0.85	-0.48
2.04	0.83	0.13	-0.54	-0.40	-0.53	-0.41	0.50	0.05	-0.92	-0.48
1.63	0.10	0.25	-0.30	-0.35	-0.47	-0.34	0.56	0.09	-0.73	-0.29
-0.96	-0.11	-1.02	-0.44	0.07	0.19	-0.18	1.60	-0.07	0.01	-1.09
-1.24	0.02	-1.05	-0.36	0.06	0.30	-0.03	1.48	-0.09	0.02	-1.15
-0.54	0.32	-2.00	-0.65	0.01	0.67	-0.44	1.53	0.04	-0.03	-1.28
-0.52	0.17	-1.32	-0.86	-0.13	0.40	0.19	1.42	-0.05	-0.17	-1.44
-0.61	0.12	-1.33	-0.20	-0.04	0.48	-0.54	1.55	0.01	-0.18	-1.26
0.44	0.05	-3.16	-0.43	0.36	-0.56	0.70	0.53	0.04	0.64	-0.87
0.81	-0.17	-0.63	-0.69	0.21	-1.08	0.63	0.35	0.29	-0.30	-1.25
1.19	-0.15	-1.10	-0.22	0.50	-0.86	0.63	0.60	0.17	-1.02	-0.77
1.54	-0.40	-1.19	0.09	0.36	-0.99	0.16	0.65	0.05	-0.51	-0.48
1.64	0.94	-2.05	-0.24	0.41	-0.97	0.39	0.70	-0.04	-0.80	-0.41
0.89	0.52	1.93	0.27	1.26	-1.73	-0.59	-1.42	-0.52	0.62	0.68

R = Residue

Table 4: Correlation coefficient among the indices for the low yielding population

-	N	P	K	Ca	Mg	Zn	Cu	Fe	Mn	B	R
N	1										
P	0.132	1									
K	0.711	0.077	1								
Ca	-0.119	0.022	0.035	1							
Mg	0.09	-0.11	0.231	0.639	1						
Zn	-0.52	-0.357	-0.444	-0.384	-0.625	1					
Cu	-0.853	-0.415	-0.538	0.091	0.072	0.54	1				
Fe	-0.417	-0.361	-0.355	-0.387	-0.623	0.699	0.307	1			
Mn	-0.306	0.083	-0.481	-0.545	-0.802	0.42	0.077	0.514	1		
B	-0.193	-0.185	-0.397	0.367	0.569	-0.245	0.233	-0.525	-0.328	1	
R	0.498	0.241	0.363	0.542	0.667	-0.649	-0.438	-0.782	-0.687	0.44	1

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Original Research Paper

Effect of Calcium Nitrate and Potassium Nitrate Priming on Seed Germination and Seedling Vigour of Papaya (*Carica papaya* L.)

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ABSTRACT

The effect of seed priming with calcium nitrate $Ca(NO_3)_2$ and potassium nitrate (KNO_3) on germination and seedling vigour were studied in papaya varieties. Open pollinated local (gauty) papaya seeds were soaked in $Ca(NO_3)_2$and KNO_3 solutions (10000 ppm, 15000 ppm and 20000 ppm) up to 24 hours and germination percentage and seedling characteristics were recorded. The least number of days taken for seed germination (4.33 days), the highest germination percentage (82.56 %), the highest shoot length (14.31 cm) the highest fresh biomass (1.36 g) and dry biomass (0.174 g) were recorded in 10000 ppm $Ca(NO_3)_2$treatment. Further, seeds of papaya varieties *viz*., Arka Surya, Arka Prabhat and Madhu bindhu were treated with 5000 ppm, 10000 ppm and 15000 ppm $Ca(NO_3)_2$ and observed that Arka Prabhat seeds treated with 10000 ppm $Ca(NO_3)_2$had taken the least number of days for germination (4.75 days) and also the highest shoot length (25.2 cm). The results of the experiment proved the significant effect of calcium ions over potassium ions on papaya seed germination and seedling vigour.

Keywords: Calcium nitrate, Papaya, Potassium nitrate, Seed germination and Seedling vigour.

INTRODUCTION

Papaya is one of the important tropical fruit crops cultivated in India. It is a highly nutritious with high amount of vitamin A (258 µg), vitamin C (60.90 mg) and folic acid (37 µg). It also contain dietary fibers (1.7 g), calcium (20 mg), iron (0.25 mg), magnesium (21 mg), phosphorus (10 mg), potassium (182 mg), protein (0.47g) and fat (0.26 g) (USDA, 2019). Papaya is mostly consumed as a fresh fruit and raw fruits are used as vegetable. Processed products like tutty fruity, jam and squash are prepared from papaya. Papain (vegetable pepsin) is a digestive enzyme extracted from mature unripe papaya, which is widely used in meat and leather industry as a tenderizing agent. The medicinal properties of papaya plant are also well exploited by pharmaceutical and cosmetic industries. Total area under papaya cultivation in India is 0.146 million hectare with a production of 6.096 million tonnes and productivity of 41.8 tonnes per hectare (Indiastat, 2019).

Commercially, papaya plant is propagated by seeds sown in protrays, poly bags or raised beds in nursery. The seedlings are transplanted to the main field after 45 days maturity in the nursery. Earliness in seed germination and seedling growth at the nursery stage are the indicators of the vigour of the plant. Poor germination percentage, low seedling vigour and diseases like damping off and viral diseases are major problems faced by papaya growers in nursery stage. Stored papaya seeds germinate faster than the fresh seeds, but long storage period causes asynchronous and slow germination with low germination percentage (Andred *et al.*, 2008). Seed germination is affected by internal factors like seed maturity, age of seeds, moisture condition of the seeds (Ellis *et al.,* 1991), nutritional and health status of the mother plant and inhibitors present in the sarcotesta and seed coat (Reyes *et al.*, 1980 and Chow and Lin, 1991). The external factors like storage conditions and duration of storage, pH and nutritional conditions of the growing media and biotic and abiotic stress factors also influence papaya seed germination. Heat shock induced stimulation of germination in pre-dried and re-imbibed papaya seed were reported by Webster *et al.,* (2016) They also reported the effect of exogenous application of gibberellic acid ($GA_3 \geq 250$ µM) to replace the heat shock stimulation. Seed treatments with chemicals or growth hormones are usually practiced in papaya for early and uniform seed germination and better seedling growth. Pre-sowing treatment of papaya seeds in 2.0-3.0 mM GA_3 solution improves germination in papaya (Pandit *et al.,* 2001). According to Marcos Filho (2015) osmopriming with chemical agents such as polyethylene glycol (PEG), calcium nitrate, and potassium nitrate activate germination of seeds by forming a water potential equilibrium between seeds and the solution by osmosis. External nitrogenous compounds can substitute costly plant growth substances, which are difficult to dissolve. Calcium nitrate and potassium nitrate are cheap and familiar chemicals with strong dissolving capacity. These cations can imbibe water fast and change the water potential of the seeds. Calcium nitrate pretreatment removed dormancy and enhanced germination in Brachiaria seeds (Silva *et al.,* 2017). The priming of tomato seeds with $CaCl_2$ and KNO_3 solution was efficient to improve the seedling growth under salinity conditions (Ebrahimi *et al.,* 2014). Batista *et al.* (2015) reported that the priming with KNO_3 and Ca $(NO_3)_2$ resulted in greater growth of pepper (*C. frutescens*) seedlings.The effectiveness of seed treatments varies with varieties in papaya (Rodriguez *et al.,* 2019). Therefore, this experiment was constituted to study the effects of calcium and potassium ions on seed germination and seedling vigour of different papaya varieties.

MATERIALS AND METHODS

Effect of $Ca(NO_3)_2$ and KNO_3 on seed germination and plant biomass of local papaya var. Gauty

In Goa and adjoining areas, an open pollinated tall papaya variety (Gauty) is commonly grown in the back yards. The tree will bear profusely with small round fruits with sweet yellow flesh. This local variety shows comparatively good field tolerance to Papaya Ring Spot Virus (PRSV) and other viral diseases. For this experiment, seeds were collected from the well-ripened fruits and washed thoroughly in tap water to remove the sarcotesta (mucilaginous coat surrounding the seed). The seeds were shade dried and stored in butter paper covers under room temperature. The seeds were treated with three different concentrations (10000 ppm, 15000 ppm and 20000 ppm) of *Calcium Nitrate* ($Ca(NO_3)_2$) and *Potassium Nitrate* (KNO_3). The treatment solutions were prepared on the same day of treatment application using distilled water. Fifty seeds were counted and soaked in the treatment solution for 24 hours. The next day the solutions were drained and the seeds were sown in the black polythene nursery bags (20 cm x 10 cm) with drainage holes. The experimental design was completely randomized design with three replications.

Observations on days taken for germination, germination percentage, shoot length, root length, fresh weight of leaves, dry weight of leaves; leaf area, fresh biomass and dry biomass were recorded on 15 days after germination. Chlorophyll was extracted using 80 % acetone and chlorophyll a, chlorophyll b, total chlorophyll and chlorophyll a/b ratio were estimated using spectrophotometer as per the method suggested by Arnon (1949). Specific leaf weight and specific leaf area were calculated by the standard formula given below.

Specific leaf Area (SLA) =
Leaf area/ Leaf dry weight

Specific Leaf Weight (SLW) =
Leaf dry weight/ Leaf area

Effect of $Ca(NO_3)_2$ on seed germination and seedling characteristics of important commercial varieties

In this experiment, three varieties of papaya *viz.*, Arka Surya, Arka Prabhat and Madhu bindu seeds were treated with three different concentrations of calcium nitrate (5000 ppm, 10000 ppm and 15000 ppm). Experimental design was factorial completely randomized design (FCRD) with three replications. All other experimental procedures and observations were same as that of previous experiment. The data of both the experiments were analyzed in ANOVA at 0.05 probabilities using the statistical software WASP 2.0 of ICAR-CCARI, Goa.

RESULTS AND DISCUSSION

Effect of $Ca(NO_3)_2$and KNO_3 on seed germination and plant biomass of local papaya var. Gauty

The effect of $Ca(NO_3)_2$and KNO_3 at different levels (10000 ppm, 15000 ppm and 20000 ppm) to the seeds of local (Gauty) papaya showed that, there is a significant influence of seed treatment on papaya seed germination. The least number of days taken for germination (4.33 days)) and the highest germination percentage (82.56 %), shoot length (14.31 cm), fresh biomass (1.36 g) and dry biomass (0.174 g) were recorded in 10000 ppm $Ca(NO_3)_2$treatment. Number of leaves, fresh weight and dry weight of the leaves and leaf area showed non- significant difference between the treatments (Table 1). Effect of calcium ions on papaya seed germination was studied earlier by Bautista-Calles *et al.* (2008) and reported that**,** seeds treated for 4 days in 10^{-5} M calcium chloride solution increased seed germination up to 262 % and seedlings generated from treated seeds accumulated more biomass than the control seedlings. According to Salles *et al.* (2019), calcium nitrate enhanced the germination of eggplants in adverse environmental conditions.

Chlorophyll is the pigment molecule responsible for the light absorption and photosynthesis. The concentration of chlorophyll content in the leaves is an indication of the photosynthetic capacity and the productivity of the plant. Total chlorophyll content of the leaves, chlorophyll a, chlorophyll b and the chlorophyll a/ b ratio had no significant difference among the treatments (Fig. 1). Specific leaf area and specific leaf weight are parameters, which indirectly show the efficiency of photosynthesis. The partitioning of dry matter to leaf area is an important determinant of plant growth rate during early phases of development

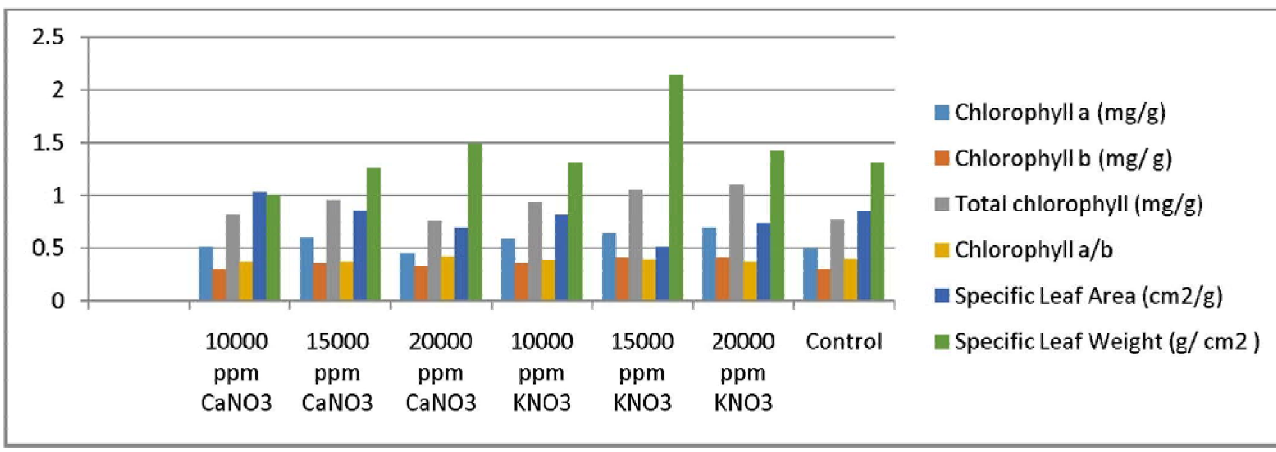

Fig. 1: Effect of calcium nitrate and potassium nitrate on physiological parameters of local (gauty) papaya variety

Table 1: Effect of calcium and potassium nitrate on germination and seedling vigour of local (gauty) papaya variety

Treatments	Days taken for germination	Germi-nation %	Number of leaves	Shoot length (cm)	Fresh leaf weight (mg)	Dry leaf weight (mg)	Leaf area (cm^2)	Fresh biomass (g)	Dry biomass (g)
10000 ppm $Ca(NO_3)_2$	4.33^{a}	87.80^{a}	4.93	14.31^{a}	109.41	14.00	14.00	1.36^{a}	0.17^{a}
15000 pm $Ca(NO_3)_2$	6.00^{ab}	57.27^{ab}	4.92	11.67^{b}	136.31	16.33	12.93	0.88^{b}	0.12^{b}
20000 ppm $Ca(NO_3)_2$	7.00^{abc}	66.03^{b}	3.87	12.11^{abc}	89.10	14.66	10.31	0.77^{bc}	0.09^{c}
10000 ppm KNO_3	8.00^{bc}	43.59^{b}	4.33	10.92^{abc}	98.33	14.67	11.25	0.67^{c}	0.05^{c}
15000 ppm KNO_3	7.67^{c}	48.72^{b}	4.23	9.31^{bc}	90.00	19.67	10.54	0.53^{b}	0.09^{c}
20000 ppm KNO_3	7.33^{d}	48.72^{b}	4.22	13.26^{ab}	101.83	17.00	12.27	1.01^{c}	0.12^{b}
Control	8.33^{e}	43.59^{b}	4.13	10.42^{bc}	90.46	13.33	10.42	0.42^{c}	0.04^{c}
CD (0.05)	0.76	27.42	NS	3.08	NS	NS	NS	0.41	0.05

(Potter and Jones, 1977; Nelson, 1988).Specific leaf weight (leaf weight/leaf area) has been positively correlated with photosynthesis per unit of leaf area for genotypes of many species (Nelson, 1988). However, in this experiment, the results showed that, the seed treatments have no significant role in the photosynthetic efficiency of the plants.

Effect of $Ca(NO_3)_2$ on seed germination and seedling characteristics of important commercial varieties

Three varieties of papaya (Arka Surya, Arka Prabhat and Madhu bindhu) were treated with $CaNO_3$ at different levels (5000 ppm, 10000 ppm and 15000 ppm) along with control. Among the three varieties, Arka Prabhat treated with 10000 ppm $Ca(NO_3)_2$ recorded the lowest number of days taken for germination (4.75 days) and the highest shoot length (25.2 cm). Fresh weight of the leaves, dry weight of the leaves, leaf area and specific leaf weight were also estimated (Table 2). The experiment proved the significant effect of calcium ions in the papaya seed germination at low concentration.

The interaction effect of the three varieties with the three different concentration of calcium nitrate treatment showed that, Arka Prabhat treated with 5000 ppm and 10000 ppm calcium Nitrate had taken the least number of days for germination. The highest germination percentage was recorded in Arka Prabhat treated with 5000 ppm calcium nitrate (87.85%). Shoot length, fresh weight of the leaves, dry weight of the leaves, leaf area and specific leaf weight was

Table 2: Effect of $Ca(NO_3)_2$ on seed germination and seedling vigour of papaya varieties

Treatments	Days taken for germination	Germination %	Number of leaves	Shoot length (cm)	Fresh biomass (g)	Dry biomass (g)	Leaf area (mm^2)	Specific leaf area (mm^2/g)
V1 (Arka Surya)	5.50	70.40	6.50	20.49	0.37	0.18	3388.13	1949.16
V2 (Arka Prabhat)	4.75	70.40	5.90	20.95	0.51	0.30	4682.75	1668.22
V3(Madhu bindhu)	6.50	78.99	6.25	18.63	0.47	0.26	3936.00	1504.51
CD (0.05)	0.62	12.40	0.82	2.77	0.10	0.04	902.20	421.61
C1 (5000 ppm $Ca(NO_3)_2$)	5.33	85.77	6.67	21.75	0.44	0.24	4188.50	1933.09
C2 (10000 ppm $Ca(NO_3)_2$)	5.50	72.92	6.33	22.37	0.42	0.22	3871.33	1783.47
C3 (20000 ppm $Ca(NO_3)_2$)	5.50	71.88	6.33	21.12	0.53	0.26	4415.50	1718.51
C4(Control)	6.00	62.50	5.50	14.85	0.42	0.27	3533.83	1394.12
CD (0.05)	0.72	14.31	0.95	3.20	0.12	0.05	1041.77	486.84
V1 C1	4.50	84.73	7.00	20.90	0.30	0.12	3110.00	2574.64
V1C2	5.50	68.75	6.00	20.95	0.43	0.21	4159.00	2031.32
V1C3	6.00	65.63	6.50	24.20	0.48	0.23	4042.00	1756.80
V1C4	6 .00	62.50	6.50	15.90	0.27	0.15	2241.50	1433.90
V2C1	5.00	87.85	6.50	24.95	0.50	0.29	5760.50	1981.77
V2C2	4.50	65.63	6.00	25.20	0.43	0.21	4140.00	1960.28
V2C3	4.50	65.63	6.00	20.45	0.63	0.30	4892.00	1738.45
V2C4	5.00	62.50	5.00	13.20	0.48	0.40	3938.50	992.36
V3C1	6.50	84.73	6.50	19.40	0.51	0.30	3695.00	1242.87
V3C2	6.50	84.38	7.00	20.95	0.40	0.25	3315.00	1358.81
V3C3	6.00	84.38	6.50	18.70	0.49	0.25	4312.50	1660.28
V3C4	7.00	62.50	5.00	15.45	0.49	0.25	4421.50	1756.09
CD (0.05)	1.24	24.79	1.64	5.539	0.21	0.09	1804.39	843.22

higher in Arka Prabhat variety treated with 10000 ppm calcium nitrate. Gouveia *et al.* (2017) reported that the priming of corn seeds with calcium nitrate and phenylalanine promoted greater germination rate of low vigour seeds.The priming of cucumber seeds with potassium nitrate showed little effect in improving the germination and growth rate of seedlings under salt stress conditions (Oliveira and Steiner, 2017). Reis *et al.* (2012) also reported that KNO_3 priming resulted in higher germination rate and lower mean germination time in eggplant cv. Embu. From the results, it is very clear that the seed priming with calcium nitrate at low concentration can hasten and improve the germination of papaya, but there is no significant effect in the further growth.

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Short Communication

Characterization of *Rhizoctonia solani* causing Fruit rot of Strawberry (*Fragaria* x *ananassa* Duch.) in Wayanad and *in vitro* Evaluation of Fungicides, Organic preparations and Bioagents for its Management

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ABSTRACT

Strawberry, one of the most delicate, sweet and refreshing temperate fruit has grabbed the minds of several farmers and consumers all over the world. Several fungal diseases affect it. As part of the study, surveys were carried out in major strawberry growing parts of Kerala *viz*., Wayanad, Idukki, Malappuram and Thrissur. However, rotten fruits with dark and hard encrustations were collected only from Wayanad district during 2015-16. Pathogen was isolated by following the standard protocol and Koch's postulates were proved. Upon culturing, the fungal isolate produced white mycelia turning brown on maturation with rapid growth. The hyphae were branched at right angles and did not produce spores. The pathogen was identified as *Rhizoctonia solani* based on cultural and morphological characters. *In vitro* evaluation was carried out with 9 fungicides and carbendazim 12% + mancozeb 63%, cymoxanil 8% + mancozeb 64%, propineb and Bordeaux mixture at all concentrations showed cent per cent inhibition. Copper hydroxide and difenoconazole inhibited the pathogen from 54.44 to 75 per cent and 58.88 to 70.55 per cent at 0.1, 0.15 and 0.2 and 0.05, 0.1 and 0.15, respectively. Copper oxychloride recorded less than 45 per cent inhibition, whereas carbendazim and potassium phosphonate were found to be least effective. Comparing the efficacy of organic preparations against *Rhizoctonia,* calphomil recorded highest inhibition of 55.33 to 63.88 per cent at different concentrations. Panchagavya and baking powder + vegetable oil mixture could inhibit the mycelial growth only by 23.33 to 25.50 per cent and 22.22 to 26 per cent, respectively. Whereas, neem oil was found to be least effective. Biocontrol agents were evaluated against the pathogen and *Trichoderma asperellum* could restrict growth of the pathogen by 66.67 per cent and *Pseudomonas fluorescens* by 33.33 per cent.

Keywords: Bioagents, Fungicides, Bioagents, *Rhizoctonia solani* and Strawberry

Strawberry (*Fragaria* x *ananassa* Duch.), a delicious fruit, is a hybrid species of *Fragaria* which is cultivated all over the world and is valued for its flavour, aroma and colour. Strawberry is an excellent table fruit and has a great demand in processing industry such as preserves, juices, jam and ice cream. United States is the largest producer of strawberry followed by China and Spain. Panchgami-Mahabaleshwar in Maharashtra accounts for 85 per cent of India's production. Kerala has become an important producer of strawberry as it is being cultivated in high range areas likeMunnar, Vattavada and Kanthalloor of Idukki district and several other places in Wayanad. But, the crop is seriously inflicted by several diseases caused by *Colletotrichum* spp., *Pestalotia* sp., *Gnomonia comari*, *Botrytis cinerea*, *Rhizoctonia solani*, *Alternaria alternata, Rhizopus nigricans* and *Mucor* spp. among which, *R. solani* causing hard rot causes significant yield losses. Dodge and Stevens (1924) first reported rotting of strawberry fruits in Florida incited by *R. solani* that lead to half the loss of total plants. Sharma and Bhardwaj (2001), De Los Santos *et al.* (2003) and Timudo-Torrevilla *et al*. (2005) has also investigated on strawberry fruit rot caused by *R. solani*. As the crop shares a major part of the fruit industry, there is an emerging trend for the cultivation and processing of the fruits. Thus the present investigation was taken up to study the loss caused by the disease in specific locations of Kerala, symptomatology and characterization of the associated pathogen, managementof the pathogen usingf ungicides, organic preparations and selected biocontrol agents *in vitro*.

Intensive surveys were conducted in different strawberry growing tracts of Kerala *viz.,* Wayanad, Malappuram, Idukki and Thrissur during December-January, March-April and July-August.During the surveyin Ambalavayal, Wayanad during December-January, rotten fruits showing similar symptoms were collected and percent incidencewas recorded (Wheeler, 1969).The pathogen was isolated from infected fruits as per the standard protocol on potato dextrose agar. The cultures thus obtained were maintained at 4°C for further studies. Pathogenicity tests were carried out by placing mycelial bits on fruits wounded with sterile needle and observed for development of symptoms. Symptoms observed during the survey were recorded and the symptoms shown during the artificial inoculation of pathogen for pathogenicity tests were noted down and compared.

Cultural and morphological characters *viz*., colony colour, pigmentations, colour of hyphae, branching pattern, presence of septation on hyphae or conidia were studied. The isolate were identified up to genus level and sent to National Centre for Fungal Taxonomy (NCFT), New Delhi for further confirmation.

Nine fungicides (Table 1) and four organic preparations (neem oil, panchagavya, Calphomil and baking powder + vegetable oil mixture) each at three different concentrations (recommended, lower and higher) were evaluated *in vitro* against *R. solani* by poison food technique (Zentmeyer, 1955). Media without the fungicide or organic formulation served as control. The plates were then incubated at room temperature (26-±1°C). Organic formulations were disinfected under UV light for one hour before mixing with PDA medium to avoid contamination. Tween 20a non-ionic surfactant, @ 0.2 per cent, was added to the mixture of PDA and neem oil to ensure perfect mixing of neem oil with the medium (Neves *et al*., 2001). Then required quantity of each formulation was mixed with the medium and plated. Observations were taken daily noting the growth rate of fungal pathogen until the cultures on control plates attained full growth. The per cent inhibition of mycelial growth in each treatment was recorded (Vincent, 1947).Efficacy of reference cultures of fungal and bacterial biocontrol agents from Kerala Agricultural University (KAU) *viz*., *Trichoderma asperellum* and *Pseudomonas fluorescens* were tested against fungal pathogen of strawberry following dual culture technique (Dennis and Webstar, 1971).

During the survey, rotten fruits with disease were collected during December-January from Ambalavayal, Wayanad. During pathogenicity testing symptoms developed as brownish sunken lesions two days after inoculation, which later turned water, soaked spreading to an area of 4cm^2. Under field conditions, rotten fruits collected from open fields of Ambalavayal were black and hard encrustations were formed on either side of the fruits, which ultimately led to fruit rot that was reported,by Dodge and Stevens (1924) and De Los Santos *et al.* (2003).

Mycelia of pathogen in culture appeared white,later turning light brown producing long thread like hyphae showing fast abundant growth, which attained 90mm within three days in Petri plate. Margin of colony was circular, smooth and hyphae were hyaline gradually turning brown and branching at 90° below the septa with distinct constrictions. Sporulation was absent and the hyphal length ranged from 121.23 to 150.98 μm with new hyphae arising at right angles (Fig. 1). Based on these cultural and morphological characteristics, the isolate was identified as *Rhizoctonia* spp. and for further confirmation, upto the species level, the isolate was send to NCFT, New Delhi where the cultures were identified as *Rhizoctonia solani* and thereafter maintained in the repository with ID. No. 8232.16. These observations were similar with that of Sneh *et al*. (1991), Nechet and Halfeld-Vieira (2007) and Lal and Kandhari (2009) in various crops like pigeon pea and rice.

In vitro screening of fungicides against *R. solani* revealed that carbendazim 12% + mancozeb 63%, cymoxanil 8% + mancozeb 64%, propineb 70WP and Bordeaux mixture at all concentrations were 100 per cent effective (Fig. 2). According to Srinivas *et al.* (2013) and Raj *et al.* (2016), carbendazim 12% + mancozeb 63%showed cent per cent and propineb 96.27 per cent efficacy against *R. solani* of rice and chilli. However, copper hydroxide and difenoconazole

Table 1: *In vitro* evaluation of fungicides against *Rhizoctonia solani*

Fungicide	Conc (%)	Per cent Inhibition *Rhizoctonia solani*
Carbendazim 12% + Mancozeb 63%	0.15	100(10)[a]
	0.2	100(10)[a]
	0.25	100(10)[a]
Cymoxanil 8% + Mancozeb 64%	0.15	100(10)[a]
	0.2	100(10)[a]
	0.25	100(10)[a]
Copper hydroxide 77WP	0.1	54.4(7.45)[f]
	0.15	70.87(8.38)c
	0.2	75(8.7)b
Copper oxychloride 50WP	0.2	38.88(6.29)[i]
	0.25	41.66(6.51)[h]
	0.3	43.55(6.67)[g]
Propineb 70WP	0.25	100(10)[a]
	0.3	100(10)[a]
	0.35	100(10)[a]
Carbendazim 50WP	0.05	0(.7)
	0.1	0(.7)
	0.15	0(.7)
Difenconazole 25EC	0.05	58.55(7.69)[e]
	0.1	67.31(8.19)[d]
	0.15	70.44(8.4)[c]
Potassium phosphonate	0.25	0(.7)[j]
	0.3	0(.7)[j]
	0.35	0(.7)[j]
Bordeaux Mixture	0.5	100(10)[a]
	1	100(10)[a]
	1.5	100(10)[a]
CD (0.05)		0.031

*Mean of the three replications
In each column figure followed by same letter do not differ significantly according to DMRT.
"x+0.5 transformed values are given in parantheses

inhibited the pathogen from 50 to 70 per cent (Table 1). Apart from other fungicides, copper oxychloride recorded less than 45 per cent in inhibiting pathogen. Conversely, Srinivas *et al*. (2013) and Raj *et al*. (2016) recorded 70 to 100 per cent inhibition of *R.solani* of rice and chilli with copper oxychloride. Carbendazim and potassium phosphonate were found to be the least per cent effective. Nevertheless, Seema *et al*. (2010) pointed out higher efficacy of Carbendazim in inhibiting *R. solani* of tobacco.

Among all the organic preparations tested against *R. solani*,calphomil recorded the highest inhibition of 55.33 to 63.88 per cent at different concentrations

(Fig.2) while neem oil was found the least effective. However, panchagavya and baking powder + vegetable oil mixture could restrict the mycelial growth upto 26 per cent (Table 2). Several workers pointed out the antifungal activity of panchagavya against *R. solani* (Dogra, 2006; Ashlesha and Paul, 2014 and Jandaik and Sharma, 2016) in capsicum. Observations on the *in vitro* evaluation of *R. solani* with *Trichoderma asperellum* tested 66.67 per cent inhibition and *Pseudomonas fluorescens* exhibited only 33.33 per cent control (Fig. 2). In congruence with above findings, Amin and Razdan (2010), Seema and Devaki (2012) and Srinivas *et al*. (2013) noticed upto 63.52 and 71.4 per cent control over *R. solani*with *Trichoderma viride* infecting tomato, tobacco and rice.However, Mezeal (2014) noted a higher inhibition of 81.30 per cent with *P. fluorescens*against *R. solani* from tomato whereas, Tapwal *et al*. (2015) reported an inhibition of only 1.45 per cent and 5.10 per cent with *T. viride* and *T. harzianum* when tested against *R. solani*.

Table 2: *In vitro* evaluation of organic preparations against *R.solani*

Sl. No.	Formulation	Conc (%)	Per cent inhibition
1.	Calphomil	0.2	55.33(7.47)[c]
		0.25	58.33(7.67)[b]
		0.3	63.88(8.01)[a]
2.	Neem oil	0.15	0
		0.2	0
		0.25	0
3.	Panchagavya	2.0	23.33(4.88)[g]
		3.0	25.38(5.02)[f]
		4.0	25.50(5.11)[e]
4.	Baking powder + Vegetable oil	0.2	22.22(4.76)[h]
		0.25	23.40(4.8)[g]
		0.3	26.0(5.16)[d]
CD(0.05)			0.019

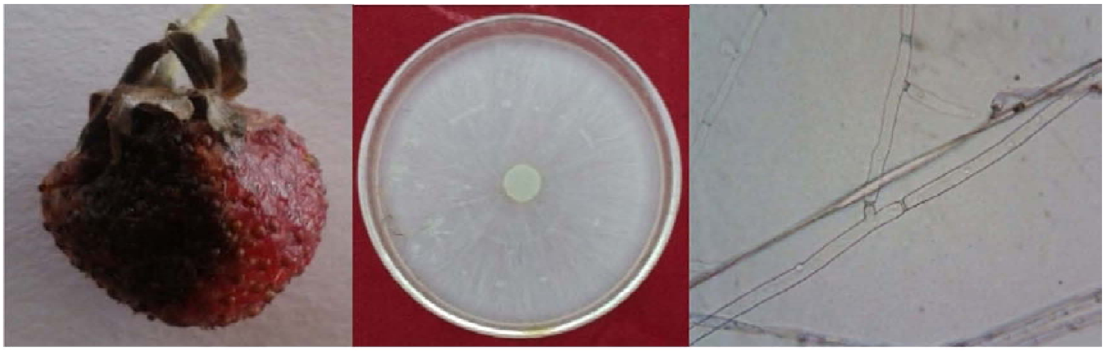
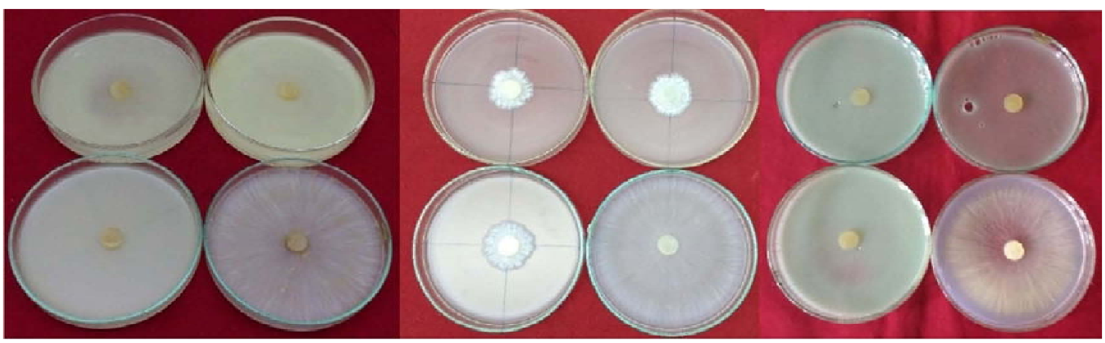


Fig. 1: (a) Rhizocotonia solani infected straw berry fruit, (b) R. solani on PDA, (c) Hyphae of R. solani with right angle branching.



a) Cymoxanil 8%+ Mancozeb 64% b) Difenoconazole 25EC c) Carbendazim 12%+ Mancozeb 63%

d) Copper oxychloride 50WP e) Calphomil f) Neem oil

g) *Trichoderma asperellum* h) *Pseudomonas fluorescens*

Fig. 2: *In vitro* evaluation of fungicides and organic formulations against *Rhizoctonia solani*

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Short Communication

Varate Giduga (Acc. No. 21067; IC No. 418238) : A unique mango (*Mangifera indica* L.) variety

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Varate Giduga is one of the unique variety from Sirsi region of Karnataka. The tree is Semi-circular shaped with dense foliage, leaves about 25cm long; dark green in colour with wavy margin. It is a very consistent and heavy producer. The fruit of this tree matures by mid-April and fruit has a distinctive yellow skin color on fruit exposed to the sun. The fruit shape is round, fruit weight ranged from 350-400 g, fruit length was 9.8 cm, fruit diameter was 9.2 cm, fruit thickness was 8.0cm and bisexual flowers were 16.53%. Biochemical constituents such as the total phenols (317.50 mg/100 g), flavonoids (5.79 mg/100g), carotenoids (1.46 mg/100 g) and acidity (0.19%) were recorded which suggests that these characters are unique as compared to other varieties. The fruit skin is rough and glossy in appearance and the fruit has little or no fiber. It is very delicious in taste with high pulp percentage (74.0%) and high TSS (23.4º B). The flesh color is orange. The fruits have deep orange firm pulp and very sweet with pleasant flavor. Besides,several other traits have drawn special attention to this mango variety as it has large sized fruits (Fig-1), late variety with very good taste, fruit can be cut into two halves by retaining the stone in one half, regular bearer and fruit fly resistant genotype because of its thick peel and high phenolic content in pulp (317.50 mg/100 g).

Fig. 1: Fruits and cut fruits of Varate Giduga genotype.

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Short Communication

Comparative studies on growth and Yield of Conventional and Tissue culture plants of Turmeric (*Curcuma longa*) var. CO2

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ABSTRACT

Turmeric (*Curcuma longa* L.) is an ancient spice, native of India and South East Asia used from antiquity as spice and a dye. It is commonly propagated through rhizomes. The availability of disease free quality planting material is scarce during the cropping season (June – September). An experiment was conducted to study the performance of *in vitro* derived turmeric plants with conventional rhizome under field condition. The results indicated that the tissue culture plants showed better performance over the conventional rhizome planting. Tissue culture plants grew vigorously and taller than conventional type. The highest yield potential was observed in tissue cultureplants (40.83 tons/ha) as compared to the conventional rhizome planting (30.14 tons/ha). The rhizome rot incidence was lower (3.87%) in tissue culture plants than rhizome-derived plants (25.58%). However, the agronomic traits observed during the present study in tissue culture plants are stable and rhizome harvested from tissue culture plants can be used as disease free planting materials for further planting.

Keywords: Conventional propagation, Rhizome yield, Tissue culture plants and Turmeric.

Turmeric (*Curcuma longa* L.) is the third important spice crop, grown in tropical part of India. It is mainly used as condiment, dye and in drug and cosmetic industries. In India, it is grown in an area of 1,94,000 ha with a production of 9,90,000 tons. In the state of Tamil Nadu it is grown in an area of 35,700 ha with production of 1,90,000 tons and productivity of 5.3 tons of dried rhizome/ha. Turmeric is propagated through rhizomes and large quantity of rhizome is required as planting material for the commercial cultivation. Planting material requirement is about 2.5 t/ha and total requirement of the country is about 2 lakh tonnes per year. Storage loss of rhizomes due to rhizome rot disease is severe which causes tissue senescence and degeneration. Propagation of turmeric through seed is not economical because of poor flowering and seed set (Balachandran *et al*., 1990).

Curcumin, a major constituent of rhizome has been widely used in various medicinal purpose, which increased the demand of the rhizomes (Chattopadhyay *et al*., 2004). The conventional methods of propagation are incapable to produce large quantities of quality planting material, which necessitates the new method. Tissue culture is used to multiply large quantities of pest and disease free planting material and performance evaluation of tissue-cultured plants is necessary to determine the potential benefits. Main purpose of this study was to assess the field performance of the *in vitro* derived plantlets and its effect on morphology and development of turmeric plants.

The present study was carried out at HC & RI, Coimbatore, Tamil Nadu, India. *In vitro* plants were obtained by following the procedure described in the previous protocol (Babu *et al*., 2007). In this study, bud sprouts were used as explant and inoculated on to half strength MS media supplemented with 3 mg l^{-1}BA and1 mg l^{-1} NAA. Contamination free one-week-old cultures were transferred into multiplication medium (MS medium containing 5 mgl^{-1} BA and 1.0 mgl^{-1} NAA). Sub-culturing was done using 7- 8 weeks old culture for further multiplication. Well root *in vitro* plantlets were transferred to polythene bags containing garden soil, sand and farmyard manure in equal proportions and kept in shade net for hardening and establishment. The rhizome was obtained from true-to-type plants maintained in shade house for conventional rhizome planting. Plants were planted during 2016-17, using a completely randomized block design with equal number of replication. Plants were spaced at 0.45 x 0.25 m with the plot size of the experiment was 3 x 5 m. A fertilizer dose of 25:60:106 NPK Kg ha^{-1} was uniformly applied to all the plots. Data were collected on the important morphological characters such as plant height, number of tillers per plant, number of leaves, length and width of leaves, number of finger per plant, average finger diameter, total weight of rhizome per plant, weight of mother rhizome and number days for maturation of the plant. Each of the morphological characters except rhizome morphology was scored and recorded every two months interval, until the time of harvest. Statistical analysis was conducted for each experiment and pooled analysis over the experiments was conducted using a randomized complete block design method. Significance was determined at the 0.05 probability level. All statistical analyses were performed with SPSS 16.0 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) was used to compare means.

Phenotypic variant or off type plants are commonly observed in *in vitro* raised population of *C. longa* var. CO 2. Variants were observed in micropropagated plants in all the three different replicated sites exhibiting the changes in leaf morphology and colour. The χ^2 test for independence indicated that phenotypic variation and propagation methods were independent criteria. (χ^2 = 3.70, p = 0.32) (*i.e.*, the ratio of true-to-type to off type plants remained the same for both methods of propagation). The micropropagated plant showed two times higher variation frequency than rhizome-derived plants (Table 1). Similar result was observed in banana (Smith and Drew, 1990; Smith, 1988; Dirk *et al.,* 1996). Among the variation observed in both the populations (*in vitro* and conventional plant), tillers of approximately 3.7% of *in vitro* raised plants and approximately 1.8% of conventional rhizome plants had leaves with one half of the lamina green and the other half albino and variegation on the edge of lamina (Table 1). Neeta et al. (2002) also documented similar results in turmeric var. 'Elite'. However, conclude that results of phenotypic variation rate were not always

Table 1: Growth and yield of tissue culture and conventional grown plants of turmericvar.CO_2

Characters	Conventional rhizome derived plants	Tissue culture plants	Difference
Off type (%)	1.8^z	3.7^z	1.9**
Plant height (cm)	$65.61 \pm .19^a$	$76.88 \pm .27^b$	11.27*
Number of leaves per plant	$10.93 \pm .10^c$	$13.13 \pm .12^d$	2.20*
Leaf length (cm)	$39.38 \pm .18^e$	$43.05 \pm .21^e$	3.67**
Leaf breadth (cm)	$12.69 \pm .14^f$	$14.01 \pm .25^f$	1.32**
Number. of tillers per plant	$2.73 \pm .17^g$	$4.60 \pm .15^g$	1.87**
Weight of mother rhizome (g)	$105.83 \pm .27^h$	$136.62 \pm .22^i$	30.79*
Weight of primary rhizome (g)	$148.30 \pm .30^j$	$164.58 \pm .58^k$	16.28*
Weight of secondary rhizome (g)	$72.43 \pm .35^l$	$85.58 \pm .27^m$	13.15*
Fresh rhizome yield/plot (15 m^2) (kg)	$45.62 \pm .15^n$	$61.25 \pm .10^o$	15.63*
Estimated fresh rhizome yield/ha (t)	30.14	40.83	10.69**
Maturity (days)	276**	255**	-21.00**
Rhizome rot incidence (%)	$25.58 \pm .25^n$	$3.87 \pm .40^n$	-21.71**

Value are means ± SE, n=108.*Significant at *p* d" 0.05; **non-significant; ***maturity date, when 95% of leaves become yellowish. Means followed by same letters are not significantly different at *p* = 0.05.

consistent over trial, which however, may be greatly influenced by environmental factor.

True-to-type plants were included in the analysis of variance of the horticultural performance of conventional propagated vs. micropropagated plants of turmeric var. CO 2.Growth and yield parameters were recorded on tissue culture and rhizome derived plants, which showed significant differences in all charactersexcept number of tillers, leaf length and breadth (Table 1). *In vitro* turmeric was significantly taller than the conventional type, throughout the vegetative growth cycle. Plant height is a measure of plant vigour, indicating that *in vitro* plants established more quickly and grows vigorously than conventional plants (Dirk *et al*., 1996; Sheela *et al*., 2001). The tissue culture plants showed vigorous and fast increase in the length of shoots as well as new shoot emerged out from the base after one week. Development was more advanced (76.88±.27 cm) than that reached by conventional plant (65.61±.19 cm) of the same age after 6 months. Similar result was documented by Beruto *et al*. (1996) in *Ranunculus asiaticus* and Singh *et al*. (2013) in turmeric.

Fast growing *in vitro* plants produced new leaves at a faster rate, resulting in larger leaf area during vegetative growth than that of conventional type. *In vitro* raised plant gaveapproximately 2.20 more number of leaves and produced higher number of leaves (13.13±.12) as compared to plants from conventional rhizome (10.93±.10) throughout the growing period (Table 1). This is in agreement with the finding of Neeta *et al*. (2001), Israeli *et al*. (1988) and Hwang *et al*. (1984), noted that micro-propagated plant retained more healthy leaves than conventional plant due to fast rate of leaf emission. The tissue culture plant showed appreciable vegetative growth, produced longer shoots and more number of leaves, after 6 months of propagation in both the propagation type. Presumably, the increase in vegetative growth has contributed to the increase in shoot yield and number of leaves of tissue culture plants of turmeric. The comparison of *in vitro* plants showed no significant variation for number of tiller and leaves width.

Tissue culture plants recorded significantly higher weight of finger rhizome (164.58±.58 g) than that of conventional plant (148.30±.30 g) (Table 1). An increased of weight of finger rhizome (16.28 g) may be attributed to genetic uniformity of the plant, due to selection of superior types of micropropagated plants (Dikash *et al*., 2012). Increased in the weight of finger rhizome ultimately increase in the yield of turmeric plant. This is in support with the finding of Neeta *et al.* (2001). Considering the weight of mother and fingers rhizome produced per plant, tissue culture plants, gave significantly better rhizome yield per plant than conventional rhizome. This is consistent with the fact that tissue culture plant has more potential in growth, yield and rhizome production than conventional type (Neeta *et al*., 2002; Dirk *et al*., 1996; Sheela *et al*., 2001; Beruto *et al*., 1996).

The mean rhizome yield plot^{-1} of *in vitro* raised plants was observed more (61.25±.10 kg) than the conventional rhizome yield (45.62±.15 kg). During the present investigation, there was no significant difference in the time taken for maturation for harvest between tissue culture and conventional plant. The enhanced growth rate exhibited by *in vitro* plants did not delay the plant maturation; however, it has shown less variability in the time taken for rhizome maturation under the same treatment. They were able to complete maturation in three weeks earlier as compared to plants from conventional rhizome. Among the yield attributes, the number of tillers and the total weight of rhizome plant^{-1} had the greatest correlations with the yield. Estimated fresh rhizome yield plant^{-1} was highest in tissue culture plants (40.83 t ha^{-1}) than rhizome derived plants (30.14 t ha^{-1}). Singh *et al.* (2013) also observed same trend in turmeric var. Lakadong. The tissue culture plant had the lowest rhizome rot incidence (3.87±.40%) when compared to conventional plant (25.58±.25%). Babu *et al.* (1997) reported that micro propagation technique could be used for production of disease-free planting material of elite plants. Apart from the production of pathogen free planting material, *in vitro* propagation of turmeric can also used for the conservation and exchange of germplasm (Cheethaparambil *et al*., 2014).

It should be concluded that the present investigation could be beneficial as the tissue culture plants showed suitable agronomic performance than conventional plants and resulted in the increased fingers weight and subsequently marketable rhizome yields. Field evaluation of tissue culture and conventional plants revealed that *in vitro* plants were superior in performance over conventional plant exhibiting vigorous vegetative growth, disease free, increased and uniformity of rhizome production.

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Short Communication

Management of Eulophid Seed Borer, *Anselmella kerrichi* (Narayanan *et al.*) (Hymenoptera : Chalcidoidea : Eulophidae) on Jamun

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ABSTRACT

A field experiment was conducted at ICAR-Indian Institute of Horticultural Research, Bengaluru during 2019 to evaluate certain insecticides and botanicals against jamun seed borer, *Anselmella keriichi* (Naryanan*et al.*). The results revealed that the seed borer infestation was significantly low in λ-cyhalothrin (4.20%) and cypermethrin (5.77%) treatments followed by spinosad (6.36%), deltamethrin (6.40%) and imidacloprid (6.71%) (*F*=7.9; df=11; *P*<0.0001). Among the organic insecticides *viz.*, spinosad @ 0.2 mL/L showed significant reduction in jamun seed borer infestation.

Keywords: *Syziumcumini,* Chemical insecticides, Botanical insecticides, Hymenoptera and Insect pest

Fruits of Jamun, *Syzium cumini* L. (Family Myrtaceae; commonly known as jambul, black plum, Indian blackberry, jambulan, java plum *etc.*) are known for their economic importance with several medicinal properties (Warrier *et al.*, 1996). Jamun is attacked by number of insect pests and recently a eulophid seed borer, *Anselmella kerrichi* (Narayanan *et al.*,) (Hymenoptera: Chalcidoidea: Eulophidae) causing huge economic losses in jamun cultivation have been reported (Kamala Jayanthi *et al.*, 2019; Anjana *et al.*, 2019). The adult female wasp lays eggs inside the tender fruits. After completing the life cycle inside the Jamun seeds, fully-grown adults emerge out making a circular hole, in turn causing both quantitative and qualitative losses. The infested fruits bore black, pinprick size oviposition punctures along with circular exit holes on the rind. Heavy infestation of jamun fruits by *A. kerrichi* rendering the fruits unmarketable was observed (Fig.1).

The present study was conducted during March-April 2019 at an experimental block of ICAR-Indian Institute of Horticultural Research, Bengaluru, India located at 13°58' N Latitude and 78° E Longitude at an elevation of 890 m above mean sea level. A total of 12 treatments (as listed in Table 1) were evaluated against jamun seed borer. Each treatment involved three consecutive sprays with 15 days interval and each treatment replicated thrice in three different sets. A total of 1200 fruits were harvested for each treatment. Each set containing 1200 fruits per treatment in which randomly 400 fruits per replication were observed. Keeping the fact in view that jamun fruits are consumed fresh for its high medicinal value, all the experimental sprays were restricted to early stages of fruiting (during G3 to G4 stages; Kamala Jayanthi *et al.*, 2019) to avoid pesticide residue issues. The observations were recorded on total number of fruits and number of fruits infested with jamun seed borer. Data were subjected to ANOVA (using *F* test as criteria at *P*=0.05 level). Net benefit per acre for each treatment was derived by subtracting the total cost of plant protection from total income. Cost: Benefit ratio of each treatment was derived by subtracting the income of the control treatment from the net income of each sprayed treatment and the products were divided by total cost of plant protection for each treatment (Shabozoi *et al.*, 2011).

The results pertaining to the efficacy of various treatments in the management of jamun seed borer were given in Table 1. The mean per cent fruit infestation by *A. kerrichi* varied significantly from 4.20-19.45 among the treatments (*F*=7.9; df=11; *P*<0.0001). After administering all the three experimental sprays the per cent fruit infestation by *A.kerrichi* was significantly lower in treatments viz., λ-cyhalothrin, cypermethrin, spinosad, deltamethrin and imidacloprid with a fruit infestation of 4.20, 5.77, 6.36, 6.40 and 6.71% respectively compared to the control. However, all above treatments were found on par with each other with respect to seed borer infestation. The treatments viz., abamectin, pongamia soap, neem soap, neem oil did not reduce the seed borer infestation compared to the control (Table 1).

Relative economic performance of the treatments was compared with the control using the cost:benefit (C:B) ratio. The synthetic pyrethroid viz., λ-cyhalothrin (1:9.67), gave the highest C:B ratio followed by spinosad (1:8.57), cypermethrin (1:8.48), and deltamethrin (1:8.23). The present study revealed that spinosad and other synthetic pyrethroids could be recommended for the management of jamun seed borer at the early stage of fruiting. Anjana *et al.*, (2109) studied the possibility of using color sticky traps as a strategy for management of *A. kerrichi* in jamun. Their results showed that females were attracted to blue sticky trap whereas, male wasps attracted to yellow sticky trap. Considering the need for eco-friendly pest management modules for jamun, integrated management strategies involving colour traps and need based spray interventions have to be standardized to minimize the economic losses caused by jamun seed borer *A. kerrichi.*

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Fig. 1: a. Pricks on immature Jamun fruits, b. adult Jamun seed borer, c & d. galleries

Table 1: Efficacy of different insecticides against jamun seed borer, *A.kerrichi* (Narayanan *et al.*)

	Treatment	Fruit infestation (%)				C: B Ratio
		Set I	Set II	Set III	Overall Mean	
T1	Cypermethrin (1.0 mL/L)	4.83 (12.70)	8.12 (16.55)	4.38 (12.07)	5.77 (13.77)	1:8.48
T2	Deltamethrin (1.0 mL/L)	5.00 (12.92)	7.57 (15.97)	6.62 (14.91)	6.40 (14.60)	1:8.23
T3	Spinosad (0.2 mL/L)	3.57 (10.89)	4.35 (12.04)	11.14 (19.50)	6.36 (14.15)	1:8.57
T4	Quinalphos (2.5 mL/L)	10.00 (18.43)	17.87 (25.01)	13.64 (21.67)	13.84 (21.70)	1:2.14
T5	Chlorantraniliprole (0.3 mL/L)	13.46 (21.52)	10.56 (18.96)	1.74 (7.59)	8.59 (16.02)	1:6.53
T6	λ- cyhalothrin (1.0 mL/L)	5.00 (12.92)	4.32 (11.99)	3.27 (10.42)	4.20 (11.78)	1:9.67
T7	Imidacloprid (0.5 mL/L)	6.67 (14.96)	7.33 (15.71)	6.14 (14.34)	6.71 (15.01)	1:7.57
T8	Abamectin (0.5 mL/L)	24.00 (29.33)	18.13 (25.20)	15.20 (22.95)	19.11 (25.83)	1:1.14
T9	Pongamia soap (10 g/L)	12.08 (20.34)	12.63 (20.82)	16.43 (23.91)	13.71 (21.69)	1:2.15
T10	Neem soap (10 g/L)	24.17 (29.45)	19.57 (26.25)	14.61 (22.47)	19.45 (26.06)	1:1.57
T11	Neem oil (10 mL/L)	13.33 (21.42)	19.40 (26.14)	22.22 (28.13)	18.32 (25.53)	1:0.84
T12	Control	13.68 (21.71)	17.39 (24.65)	20.00 (26.57)	17.03 (24.31)	-
CD @0.05%					5.80	

*Figures in the parenthesis are arcsine transformed values

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Short Communication

Pod set and Pollen Viability Studies in Yard Long Bean (*Vigna unguiculata* sub sp. s*esquipedalis*)

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ABSTRACT

A study was conducted in a yard long bean *(Vigna unguiculata* sup/ssp. s*esquipedalis)* hybrid VS 50 (Kakkamoola Local) x VS 26 (Vellayani Jyothika) to assess the percentage fruit set at two time intervals and to identify the best time interval for pollination in yard long bean hybrids. Hand pollination was done using VS 50 as female parent and VS 26 as male parent for seven consecutive days at two time intervals, 6.30 – 7.30 am and 7.30 – 8.30 am. Higher percentage of fruit set (36.8 %) was observed between 6:30 – 7:30 a.m. as compared to the time interval 7:30 – 8:30 am. (23.8%). Pollen viability was determined for the parents VS 50 (Kakkamoola Local) and VS 26 (Vellayani Jyothika) at 6.30, 7.30 and 8.30 am. Highest pollen viability for both the parents VS 50 and VS 26 was observed during 7.30 am. The present study shows that the best time interval for crossing in yard long bean is 6.30- 7.30 a.m.

Keywords: Hybridization, Pod set, Pollen viability and *Vigna unguiculata* sub sp. s*esquipedalis*

INTRODUCTION

Vigna unguiculata sub sp. *sesquipedalis* (L.) Verdcourt commonly known as yard long bean or pole type vegetable cowpea is a commercially used leguminous plant with very long pods and climbing growth habit, widely grown in China, South and South East Asia. It belongs to the family Fabaceae and is one of the most popular and remunerative vegetable crop traditionally grown in Kerala, cultivated mainly for crisp and tender pods that are consumed both fresh and cooked. It is a rich and inexpensive source of vegetable protein and its cultivation enriches soil fertility by fixing atmospheric nitrogen. It has become an essential component of sustainable agriculture in marginal lands of the tropics because of its quick growth habit.

Productivity of the crop is limited by a complexity of biotic (pest and diseases) and abiotic (rainfall, temperature, relative humidity and light intensity) factors. Some attempts have been made to study the genetic and environment variability for various productive traits, inheritance of these traits and correlation between yield and its components. So far no public sector hybrids of yard long bean are available for cultivation in Kerala, which makes farmers to depend on private sector hybrids by paying exorbitant prices. So there is an urgent need to improve the crop for better yield and quality through heterosis breeding. Cultivar improvement in self-pollinated species is done by hybridization. Because of poor crossing success and less number of seeds per pod, heterosis is difficult. Pod yield and yield attributes in vegetable cowpea are complex traits governed by polygenic inheritance, affected by environment. Both genotype and environment affect the crossing success in self-pollinated species such as vegetable cowpea.

Cowpea is highly self – pollinated, the result of a cleistogamous flower structure and Simultaneous pollen shed and stigma receptivity (Ehlers and Hall, 1997), although some crossing may occur due to insects. Self-pollinated nature is due to hermaphrodite sex form, homogamy and dehiscence of anther much earlier than anthesis. Stamens and pistil in opened flower remain enveloped together inside the tube like structure of joined petals called as Keel, leading to cleistogamous nature. Flowers open only once between 7.00 and 9.00 a.m. On cloudy days the flowers may open even in the afternoon. Anther dehiscence is influenced by environmental factors such as clear sky, presence of moonlight, warm temperature etc. and it may vary from 10.00 pm. at night to 1.00 am. Stigma become receptive and pollen become fertile on the day of anthesis. Several hybridization procedures have been developed (Rachie *et al.* 1975; Blackhurst and Miller 1980). High hybrid pod set is observed when emasculation is done before anthesis which is followed by pollination on the day of anthesis in morning hours. Rachie *et al.* (1975) reported that some cowpea genotypes are superior pollen donors as compared to others which are seed parents. Time and efforts in crossing play an important role in expressing efficient parental donors for crossing.

The cross VS 50 x VS 26, identified as a superior hybrid for yield and quality, was used for the present study. The aim of the study was to observe the percentage fruit set at two time intervals in the yard long bean hybrid VS 50 x VS 26 and the influence of pollen viability of the parents at different times on fruit set, in order to identify the best time interval for pollination in yard long bean hybrids. Resmi and Gopalakrishnan (2004) reported problems such as delayed and erratic flowering and low pod set in yard long bean.

The study was conducted at the Department of Olericulture, College of Agriculture, Vellayani during February to March 2017. Lakshmi (2016) conducted a diallel analysis to study the heterosis and combining ability of yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) and to develop superior hybrids with high yield and quality. Based on the mean performance, specific combining ability and standard heterosis, the hybrid VS 50 x VS 26 (Kakkamoola Local x Vellayani Jyothika) was observed to be one of the most promising for yield and quality characters. With this background, the cross VS 50 x VS 26 (Kakkamoola Local x Vellayani Jyothika) was selected for the study. The source and characters of the parents VS 50 and VS 26 are given in Table 1.

Hand pollination was done using VS 50 as female parent and VS 26 as male parent for seven consequetive days at two time intervals, 6.30 – 7.30 a.m. and 7.30 – 8.30 a.m. Ige *et al.* (2011) studied the floral biology and pollination ecology of three varieties of cowpea (*Vigna unguiculata* L. Walp.) and observed that flower opening is initiated between 6.00 to 6.30 am and closes between 11.30 to 12.00 pm. in all the varieties and that when the weather is hot and dry the flowers close earlier.

Pollen viability was determined for the parents VS 50 (Kakkamoola Local) and VS 26 (Vellayani Jyothika) at 6.30, 7.30 and 8.30 am. Flower bud due to open the next day, was selected in the female parent (VS 50). Emasculation was done in the afternoon hours by removing the keel petal. Cowpea flowers drop off easily as they are highly sensitive. Hence butter paper bag was used to cover the bud and to prevent drying out of emasculated bud. Pollen was collected next day morning from a freshly opened flower. The standards and wings from the intended male parent (VS 26) was removed and by slight depression of the keel, the stigma covered with the pollen grains protrudes out which itself can be used as brush for pollination. It was brushed on the stigmatic surface of the emasculated flower. The crossed flowers were covered and labeled**.**

Pollen viability was determined by acetocarmine staining method. Anthers were collected from a minimum of 3 mature flowers per plant at 6.30 am. One drop of 1 % acetocarmine was placed on a slide glass. Pollen grains were mounted slightly in a drop of acetocarmine: glycine (1:1). The slides were left for 30 minutes for proper staining. A cover slip was placed gently over the slide and examined under a microscope. Pollen viability was studied by counting the number of stained pollen grains and unstained, aborted pollen grains. An average of 100 pollen were counted in different microscopic fields. The above procedure was repeated at 7.30 and 8.30 am. for both the parents.

Table 1: Source and characters of parents used for the study

Parent	Name of Accession	Source	Character
VS 50	Kakkamoola Local	Kakkamoola, Thiruvananthapuram, Kerala	High yield, long pods
VS 26	Vellayani Jyothika	College of Agriculture, Vellayani, Kerala	High yield, long pods

The number of pods that set on hand pollination was counted and recorded. Percentage of pod set was calculated using total number of crosses done. Pollen viability was calculated as follows:

Pollen viability % =

$$\frac{\text{Number of well filled and stained pollen grains}}{\text{Total number of pollen grains counted}} \times 100$$

The data on percentage of pod set in the cross VS 50 x VS 26 is presented in Table 2. Higher percentage of fruit set (36.8 %) was observed in the cross VS 50 x VS 26 between 6:30 – 7:30 am. as compared to the time interval 7:30 – 8:30 am. (23.8%). According to Ehlers and Hall (1997), pollinations performed after 10 am. are less successful than pollinations performed between 7- 10 am. Rachie *et al.* (1975) reported an average success of 10-20 % in cowpea pollination.

Table 2: Percentage of pod set in the cross VS 50 x VS 26

Days	Time interval			
	6: 30 – 7:30 a.m.		7:30 – 8:30 a.m.	
	No. of crosses	Pod set	No. of crosses	Pod set
1	5	2	7	1
2	5	1	4	2
3	8	3	7	1
4	5	2	8	2
5	5	2	7	2
6	6	3	5	1
7	4	1	4	1
Total	**38**	**14**	**42**	**10**
Pod set (%)	**36.8**		**23.8**	

Pollen viability of the parents VS 50 and VS 26, determined at 6.30, 7.30 and 8.30 a.m. is given in Table 3. Highest pollen viability for both the parents VS 50 and VS 26 was observed during 7.30 a.m. Warrag and Hall (1983) and Faisal *et al.* (1992) attributed low pod set in cowpea to low pollen viability and anther dehiscence. Animasaun (2014) reported that fruit set in plants is determined to a greater extent by the amount of viable pollen in a flower. The present study showed that the best time interval for crossing in yard long bean is 6.30- 7.30 a.m.

Table 3: Percentage of Pollen viability

Time	Pollen viability (%)	
	VS 50	VS 26
6.30 a.m.	86.50	90.90
7.30 a.m.	89.50	93.00
8.30 a.m.	88.50	88.50

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Hybrids from IIHR (2019)

High yielding muskmelon variety : Arka Siri

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Garden Rose Variety : Arka Sinchana

Varieties from IIHR (2019)

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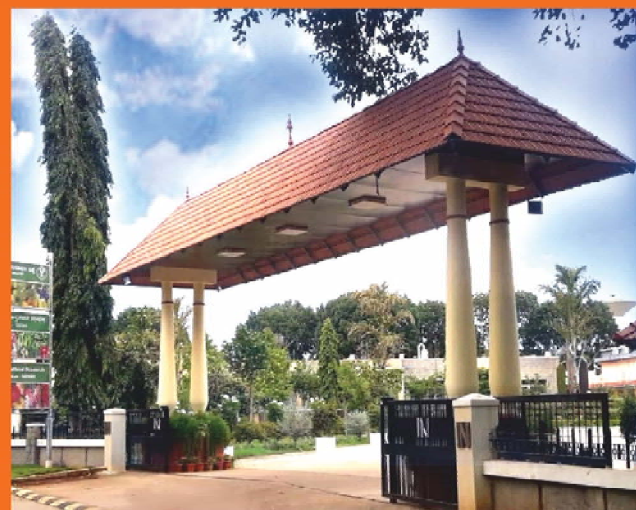
राष्ट्रीय बागवानी बोर्ड
NATIONAL
HORICULTURE BOARD

Karnataka State Horticulture Department

KSDA

ICAR-Indian Institute of Horticultural Research

- ICAR-IIHR, Bengaluru was established in 1967.
- Presently working on 54 horticultural crops (13 fruits, 26 vegetables, 10 flowers and 5 medicinal crops)
- Released 289 varieties viz., 34 in fruits, 131 in vegetables, 111 in flowers and 13 in medicinal crops
- 145 technologies of crop production and protection have been released.
- 80 technologies have been commercialised to 400 clients with 800 licences
- More than 300 students have completed post graduation studies
- Institute is contributing more than Rs.13,000 crores annually to the horticulture sector in the country



About National Horticulture Fair 2020

The ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru is organizing National Horticulture Fair-2020 during 5-8 February in collaboration with Society for Promotion of Horticulture, Bengaluru; Department of Horticulture, Government of Karnataka, National Horticulture Board, Gurugram & Karnataka State Department of Argiculture.

Programme Aims at

Knowledge sharing on innovations in horticulture through showcasing of technologies and demonstrations.

Scientists - Farmers - Stakeholders discussions on emerging challenges in Horticulture for effective dissemination of horticultural technologies.

Providing common platform to the service providers in the area of horticulture viz., ICAR institutes, SAUs, Developmental Departments, Private industries, Financial institutions, NGOs, FPOs and market functionaries, etc., for interaction with the farming communities.

STATEMENT OF OWNERSHIP AND OTHER PARTICULARS ABOUT

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I, Dr. S. Sriram, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Sd/-

December 31, 2019

(S. Sriram)
Editor-in-Chief

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Journal of Horticultural Sciences, an international journal, is the official publication of **Society for Promotion of Horticulture (SPH).** It covers basic and applied aspect of original research on all branches of horticulture and other cognate disciplines, which promotes horticulture in its broadest sense. Its goals are to apprise horticultural scientists and others interested in horticulture of scientific and industrial developments and extension findings. The area of research include evaluation of germplasm, breeding, agronomic practices, physiology, biochemistry, biotechnology, soils and plant nutrition, plant protection, weed control, pesticide residue, post harvest technology, economics, extension, farm machinery and mechanization, etc. which facilitate in the growth and expansion of horticulture. The journal is published twice a year, in June and December.

The *Journal of Horticultural Sciences* (JHS) publishes critical reviews, research papers and short communications. Three copies of the manuscript and an electronic form (CD, MS Word) should be submitted to the Chief Editor, JHS, SPH, Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore-560 089. The manuscript should preferably pertain to the research work carried out during the last five years. Author(s) must certify that the manuscript (s) has/have not been sent elsewhere for publication. All the authors have to become the members of SPH when a paper is accepted for publication. All papers will be refereed. Short communications on significant research findings, new record / technology are welcome. Besides invited review papers, scientists with vast experience on a particular field of research can also submit review papers which will be refereed. Decision of the Chief Editor / Editorial board is final. Authors are permitted to photocopy their article for non-commercial and scientific purpose. No reprints shall be provided *gratis*.Acceptance of manuscript for publication in JHS shall automatically mean transfer of copyright to the SPH. The chief editor/ Editorial board assumes no responsibility for the statements, opinion or facts expressed in the journal, which rests entirely with the author(s) thereof. Mention of a pesticide or a commercial or proprietary product does not constitute an endorsement or recommendation for the use.

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Panse, V. G. and Sukhatme, P. V. 1978. Statistical methods for Agricultural workers. ICAR, New Delhi, p 108.

Srinivas, K. 1987. Response of watermelon (*Citrullus lanatus* Thunb. Musf) to drip and furrow irrigation under different nitrogen and plant population levels. Ph.D thesis, UAS, Bangalore

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