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EVALUATION OF DIFFERENT ELITE GUAVA (*PSIDIUM GUAJAVA*) VARIETIES FOR NORTH WESTERN PLAIN ZONE OF U.P.

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ABSTRACT

The present study was conducted during 2019-20 and 2020-21 at Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Modipuram, Meerut. The experiment was laid out in Randomized Block Design (RBD) on a 6-year-old guava orchard and the number of treatments was 4, each replicated 3 times. Each treatment consisted of one plant. A total 12 plants were selected for study spaced at a distance of 3×3 m. The obtained results showed that the number of flowers per plant, stem girth, number of fruits per plant, fruit weight, fruit length and fruit width were found significant. On the other side, number of primary branches and plant height were found to be non-significant. The results of present study indicate that on the basis of their vegetative behaviour, Dhawal appeared to be superior variety in terms of tree morphology and other as moderate. Further, it can be concluded that variety Shweta had more productivity and the fruits of Dhawal and Shweta were having more marketable fruit traits.

Keywords: Quality, attributes guava, fruit quality and yield.

INTRODUCTION

Guava, sometimes known as the “apple of tropics,” is a popular tropical and subtropical fruit tree of Indian subcontinent native to tropical America, extending from Mexico to Peru having chromosome number $2n = 22$. The Portuguese are believed to have introduced it to India in the 17th century (6). However, it has become so popular in India that it appears to be a native fruit. It belongs to family myrtaceae and is regarded as one of the most attractive, nutritionally rich and remunerative fruit crops. About 150 species belong to the genus *Psidium*, the most frequently cultivated of which is *Psidium guajava* (2,5). The fruit is a berry and has a

fleshy pericarp with numerous tiny, firm, yellowish-cream seeds. The skin is often dark green when it is immature, turning yellowish-green, pale yellow, or yellow with a crimson blush on the shoulder when it is ripe, depending on the variety. Also, the pulp of ripe guava fruit is often white, pink, or salmon-red in colour based on varieties. It is soft and delicious. Guava fruits are consumed fresh and used for processing as well. In terms of productivity, hardiness and adaptability it outperforms most other fruit trees. Besides its great nutritional content, it bears heavy crop each year and provides good economic returns with relatively little investment. Guava is the most important protective fruit

in India due to its high vitamin C content (299 mg/100g) among table fruits, even higher than oranges. Since a very long time, guava has been used as both a food crop and a medicinal plant. Fresh guava fruit is high in vitamins and minerals and low in calories. The National Nutrient Database of the United States Department of Agriculture (USDA) estimates that 100 g of guava fruit contain 14.32 g of carbohydrates, 5.4 g of fibre, 2.55 g of protein, 8.92 mg of sugars, 228.1 mg of vitamin C, 0.110 mg of vitamin B6, 18 mg of calcium, 0.26 mg of iron, 22 mg of magnesium, 40 mg of phosphorus, 417 mg of potassium, 2 mg of sodium and 0.23 mg of zinc. Furthermore, pectin is abundant in it. Fruit has an average pectin level of 0.5-1.8%. Guava's peel, flesh, and core each contain 1.68%, 0.60%, and 0.51% pectin, respectively (8). Guava is a popular fruit because of its excellent taste, great nutritional content and affordable cost. Guava cultivars, on the other hand, exhibit more variation in tree size, bearing habit, production, as well as fruit size, shape, quality and ripening season.

MATERIALS AND METHODS

The investigation entitled "Evaluation of different elite Guava (*Psidium guajava*) varieties for North Western Plain Zone of Uttar Pradesh" was conducted at Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Modipuram, Meerut, Uttar Pradesh during the year 2019-20 and 2020-21. The experimental field is situated at 29°04' North latitude, 77°42' East longitude, at a height of 237.75 metres above mean sea level. The experimental material consisted of 12 guava trees and all of them were subjected to uniform cultural practices avoiding pruning during the course of experimentation. The experiment was performed on a 6-year-old guava orchard spaced at 3 m × 3 m laid out in a

Randomized Block Design (RBD) and required parameters were recorded. The number of treatments were 4, each replicated 3 times. The cultivars were considered as a factor and each plant under study as a replication. Three cultivars of guava were studied namely Lalit (collected from CISH, Lucknow), Shweta (collected from CISH, Lucknow), Dhawal (collected from CISH, Lucknow) and Red Fleshed (collected from GBPUA&T, Pantnagar).

RESULTS AND DISCUSSION

The 9 more important quantitative characters were measured in plant samples are summarized in table no. 2. Among the 4 cultivars studied, earliest flowering occurred in cv. Redfleshed (30 April) while the cv. Dhawal flowered last (5 May) in the year 2019-20 (table no. 1). In the year 2020-21, the earliest flowering was again recorded in cv. Redfleshed (28 March) followed by cv. Shweta (1 April) and cv. Dhawal (1 April) but last observed in cv. Lalit (5 April). The data further revealed that the maximum number of flowers per plant was borne in cv. Dhawal with an average of 648 flowers followed by Shweta (460), Redfleshed (364) and Lalit (348) in 2019-20. In 2020-21, maximum number of flowers per plant was observed in Dhawal (721), Lalit (720), Shweta (717) and Redfleshed (544). The data was found to be significant. (3) reported that the flowering date and period are subject to change, based on the cultivar's ability as well as ecological and cultural factors. Among the four cultivars studied, earliest full bloom was recorded in cv. Redfleshed (10 May) and last was observed in cv. Shweta (20 May) in the year 2019-20 (Table no. 1). In the year 2020-21, the same pattern of full bloom was observed with the highest in cv. Redfleshed (8 April) and last in the cv. Shweta (12 April) along with cv. Dhawal (12 April).

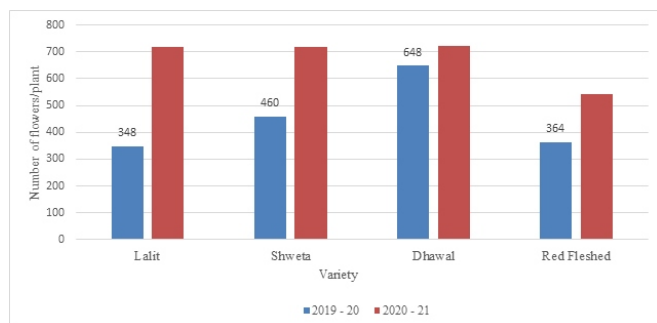


Figure 1: Number of fruit / plants

Number of primary branches per plant was found to be non-significant. However, the number of primary branches per plant were almost the same in the year 2019-20 with the highest in cv. Redfleshed (5), whereas the cv. Dhawal (6) and cv. Redfleshed (6) showed the highest number of primary branches in 2020-21.



Figure 2: Number of Primary branches /plants

Canopy spread was also found to be non-significant in both the years i.e., 2019-20 and 2020-21. In the year 2019-20, cv. Lalit (6.52 m) showed the maximum area under its canopy followed by cv. Redfleshed (6.22), Dhawal (5.57 m) and Shweta (5.56 m). However, the cv. Dhawal (7.53 m) showed the maximum canopy spread followed by cv. Shweta (6.80 m), Lalit (6.52 m) and Redfleshed (6.22 m) in the year 2020-21.

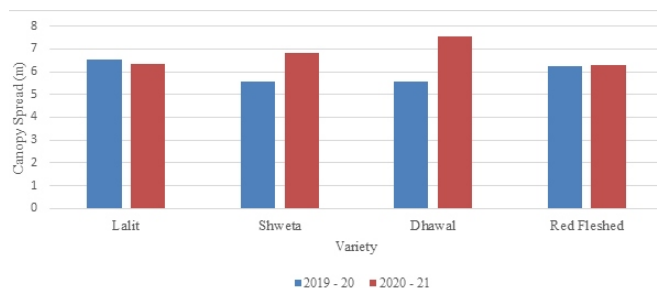


Figure 3: Variety wise canopy spread

Stem girth was found to be significantly maximum in cv. Lalit (35.67 cm) among all the four cultivars in the year 2019-20. This was followed by cv. Dhawal (28.67 cm), Redfleshed (26.67 cm) and Shweta (25.67 cm). In the year 2020-21, similar pattern was observed with the cv. Lalit (46.67 cm) having the maximum stem girth followed by cv. Dhawal (28.67 cm), Redfleshed (28 cm) and Shweta (27 cm).

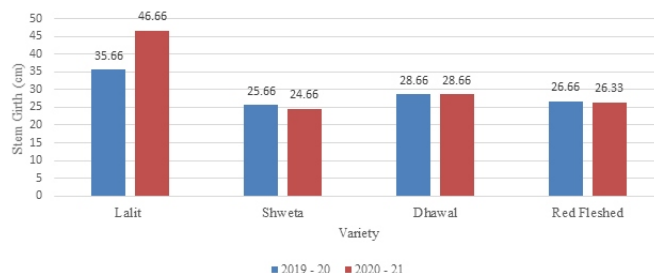


Figure 4: Variety wise stem girth (cm)

Cultivar Lalit (2.95 m) showed the highest plant height in the year 2019-20, while the shortest plant height was reported in cv. Redfleshed (2.31 m) in the same year.

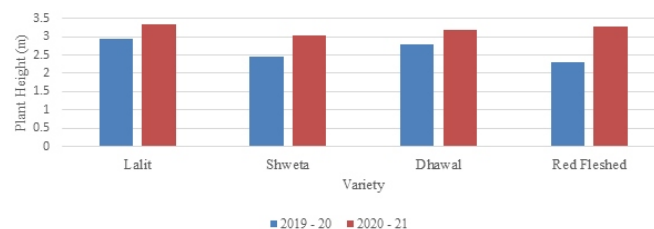


Figure 5: Variety wise plant height

Cultivar Dhawal and cv. Shweta reported a plant height of 2.8 m and 2.45 m respectively in the year 2019-20. In the year 2020-21, Lalit (3.33 m) again showed the maximum plant height followed by cv. Redfleshed (3.27 m), Dhawal (3.20 m) and Shweta (3.04 m). The data was found to be significant.

The maximum number of fruits per plant in the year 2019-20 was produced by cv. Dhawal (281) and was followed by cv. Shweta (265), Lalit (250) and Redfleshed (211). Cultivar Shweta produced maximum number of fruits per plant in the year 2020-21 i.e. 575 and was followed by Dhawal (492), Redfleshed (421) and Lalit (300). The obtained data was found to be significant.

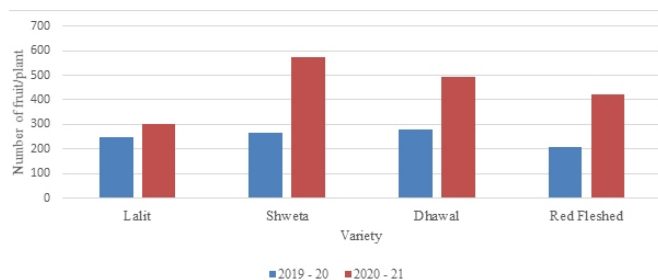


Figure 6: Number of fruit / plant

Fruit size is a key criterion for selecting superior genotypes in breeding programmes (11). The length of the fruit was found to be longest in cv. Redfleshed (50.76 mm) in the year 2019-20. In the same year, the other three cultivars, namely, Shweta, Lalit and Dhawal showed 50.74 mm, 47.91 mm and 47.79 mm fruit length, respectively. In the year 2020-21, the cv. Shweta (53.20 mm) reported the longest fruit length followed by cv. Redfleshed (52.51 mm), Dhawal (49.40 mm) and Lalit (47.28 mm). The data was found to be significant.



Figure 7: Variety wise fruit length

Fruit size in width was found to be highest in cv. Dhawal (54.76 mm) in the year 2019-20 and was further followed by cv. Redfleshed (51.30 mm), Lalit (39.96 mm) and Shweta (32.46 mm). In the year 2020-21, the cv. Dhawal (57.51 mm) again produced fruits with highest width and was followed by cv. Redfleshed (51.97 mm), Shweta (42.15 mm) and Lalit (39.22 mm). The obtained data in

this experiment was found to be significant.

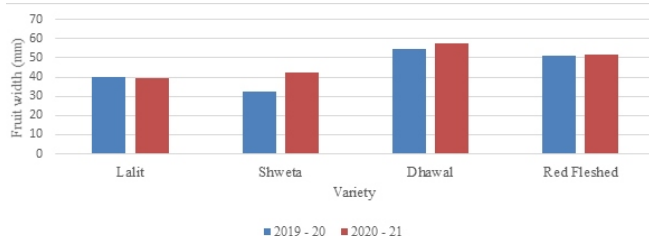


Figure 8: Variety wise Fruit width

(4) reported that fruit size and weight may be influenced by genetic variables relating to their phylogenetic behaviour. Fruit weight per fruits revealed that in the year 2019-20, cv. Dhawal (123.33 g) produced the heaviest fruit. This was further followed by Shweta (105 g), Lalit (100 g) and Redfleshed (96.67 g) in the same year. In the year 2020-21, cv. Dhawal (127.67 g) again produced the heaviest fruit among the four cultivated cultivars followed by Lalit (124.33 g), Shweta (111 g) and Redfleshed (100 g). The data was found to be significant.

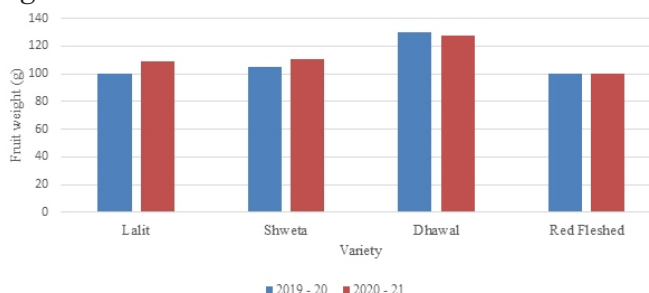


Figure 9: Variety wise fruit Weight

(10) outlined that the genetic, environmental and cultural behaviours, all interact to determine fruit weight. Producing larger fruits could be due to a genotype's innate ability to efficiently use resources to reach a specific fruit size.

Table no. 1: Date of first flowering and full blossom in the year 2019-20 and 2020-21

S. No.	Cultivars	Date to first flowering						Date to full bloom					
		R1		R2		R3		R1		R2		R3	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
1.	Lalit	2 May	5 Apr	2 May	5 Apr	2 May	3 Apr	16 May	24 Apr	15 May	18 Apr	15 May	16 Apr
2.	Dhawal	3 May	2 Apr	3 May	4 Apr	5 May	1 Apr	16 May	12 Apr	18 May	16 Apr	15 May	15 Apr
3.	Shweta	1 May	1 Apr	1 May	2 Apr	1 May	5 Apr	20 May	12 Apr	18 May	13 Apr	11 May	13 Apr
4.	Red Fleshed	30 Apr	30 Mar	30 Apr	28 Mar	30 Apr	1 Apr	10 May	8 Apr	10 May	10 Apr	11 May	14 Apr

Table no. 2: Mean values of different traits of four guava varieties in the year 2019-20 and 2020-21

S. No.	Character	Lalit		Shweta		Dhawal		Red Fleshed		CD		CV	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
1.	No. of flowers per plant	348	720	460	717	648	721	364	544	110.89	126.06	12.20	9.34
2.	Number of primary branches	4	4	4	4	4	6	5	6	N.S.	N.S.	21.12	39.21
3.	Canopy spread (m)	6.52	6.77	5.56	6.80	5.57	7.53	6.22	6.30	N.S.	N.S.	25.67	11.71
4.	Stem girth (cm)	35.67	46.67	25.67	27.00	28.67	28.67	26.67	28.00	6.82	8.16	11.71	12.54
5.	Number of fruits/plants	250	300	265	575	281	492	211	421	33.54	165.65	6.67	18.55
6.	Plant height (m)	2.95	3.33	2.45	3.04	2.8	3.20	2.31	3.27	N.S.	N.S.	22.99	15.99
7.	Fruit weight (g)	100	124.33	105	111	123.33	127.67	96.67	100	18.84	19.76	8.87	8.54
8.	Fruit length (mm)	47.91	47.28	50.74	53.20	47.79	49.40	50.76	52.51	2.46	3.44	2.50	3.40

CONCLUSION

All the four varieties tested in the experiment were found to be promising for cultivation under North-Western Plain Zone of Uttar Pradesh and can further be recommended for research trials, mass multiplication programmes and ultimately adoption by the farmers and orchardists. On the basis of vegetative behaviour, Dhawal appeared to be a more promising and superior variety in terms of tree morphology and others were found to moderate. Further, it can be concluded that the fruits of Dhawal and Shweta had more marketable fruit traits. The present study also confirms that there is much diversity in guava cultivars studied in this experiment, and hence, it becomes necessary to preserve and conserve these unique genetic resources for future breeding programmes for the development of innovative, market-driven cultivars for future.

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USE OF NANOTECHNOLOGY IN HORTICULTURE

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ABSTRACT

Horticulture could benefit from using nanotechnology, which has the potential to disrupt and alter a number of industries. Crop production, plant breeding, pest control, and post-harvest technologies are just a few of the many activities that fall under the umbrella of horticulture, the science and art of nurturing plants. Exciting potential exist to address significant issues facing the horticulture sector, such as increasing crop output, promoting plant nutrient uptake, controlling diseases, and reducing environmental consequences. Nanotechnology-based methods have been investigated in the field of crop production to optimize nutrient delivery systems, enhance seed germination, and enhance plant development in general. A controlled release and targeted distribution of fertilizers, insecticides, and growth regulators are made possible by nanoparticles and nano coatings, which maximizes their effectiveness and reduces wastage. Furthermore, real-time monitoring of soil conditions, water availability, and plant health using nano sensors and nano biosensors has proven invaluable in enabling accurate and effective crop management techniques. Nanotechnology has potential for managing diseases and protecting plants. Nanoparticles have antibacterial qualities, making them an environmentally acceptable alternative to conventional pesticides made of chemicals. They can efficiently battle plant illnesses while reducing negative effects on the environment thanks to their capacity to limit pathogen growth, improve plant defense mechanisms, and provide particular bioactive substances. Early pathogen identification is made possible by nanotechnology-driven biosensors, allowing for prompt intervention and a reduction in crop losses. There are still difficulties despite the enormous promise of nanotechnology in gardening. Thorough study and risk evaluation are required due to the safety implications of nanoparticles on human health and the environment. For the successful integration of nanotechnology into horticulture practices, scalability, cost-effectiveness, and regulatory frameworks are also crucial factors.

Keywords – Horticulture, fertilizers, insecticides, plant growth regulators, nano sensors,

INTRODUCTION

Nano, which means dwarf in Greek, is the root of the phrase “nanotechnology.” There is plenty of room at the bottom, as Nobel Prize

laureate Richard Phillips Feynman famously said, and this quote has a significant bearing on the development of nanotechnology (9). Nanotechnology is the science, engineering, and technology applied at the nanoscale

(about 1 to 100 nanometers). (7,4,30,28,33) Since nanoparticles have a high surface to volume ratio compared to bulk materials, they actually exhibit fascinatingly unique characteristics (28,33,34,16) Additionally, the catalytic activity of any molecule, element, or material is noticeably increased by the quantum processes that take place at the nanoscale (28,34,24,14,12). Nanoparticles are therefore extensively employed in telecommunications, electronics, textiles, the automobile sector, biomedical equipment, environmental technology, biotechnology, and alternative energy. The use of novel high-efficiency agrochemicals for the nutrition and protection of agricultural plants as well as the generation of new crop types through genetic engineering have all been demonstrated to be very promising applications for novel nanomaterials in agriculture (13,11). Additionally, the use of nanoparticles enhances the production of nutraceuticals as well as food processing, packaging, food safety, and plant nutrition. It also increases pesticide and fertilizer effectiveness and reduces environmental pollution. Nanotechnology has potential for genetic engineering and plant breeding in addition to these immediate uses. The production of genetically modified crops with better features, such as resistance to pests, diseases, and environmental challenges, can be aided by nanoscale delivery methods, which can make it easier to transport genetic information into plant cells.

Although nanotechnology has a lot of potential, its long-term effects on the environment and public health need to be carefully considered and regulated. The ethical and responsible development of nanotechnology in horticulture must be guided by ethical and safety concerns.

Nanomaterials on Growth and Development of Horticultural Crops

The macromolecular components that make up nanoparticles are solid colloidal particles. The nanoparticles are capable of encasing, dissolving, encapsulating, or absorbing active elements like bioactive substances or therapeutic molecules. Inputs that are environmentally benign and cost-effective, nano fertilizers provide highly effective plant nutrition and ultimately boost crop plant output. There are three methods that nanofertilizers offer nutrients to crop plants: (i) the nutrient can be covered by nanoparticles in the form of nano porous materials or nanotubes; (ii) wrapped in a thin protective coating of polymer; and (iii) provided as an emulsion or particles of nanoscale dimensions. Plants get the discharge of nanofertilizers in a controlled, effective manner. The production of peanuts (*Arachis hypogea*), for instance, is increased by ZnO nanoparticles (23). Similar to this, applying SiO₂ nanoparticles improves plant biomass as well as the levels of biomolecules in the grains of maize, including proteins, phenols, and chlorophyll (36). Hexaploid wheat's roots grow faster when carbon nanotubes are present in low concentrations. Similarly, mustard (*Brassica juncea*), black gramme (*Phaseolus mungo*), rice (*Oryza sativa*), and tobacco (*Nicotiana tabacum*) all have improved seed germination and seedling growth when carbon nanotubes are present in low concentrations. Nanomaterials made of TiO₂ and SiO₂ appear to speed the growth of soybean seedlings and increase nitrate reductase activity (39). Similar to how nanomaterials are used to benefit field crops, horticulture crops are also encouraged to thrive and develop.

In horticulture, nanofertilizers are used to boost flower fertility, pollination, and vegetative development, which increases fruit tree productivity and improves product quality (39,40). Under salt stress circumstances, exogenous nano-Ca supplementation on blueberries results in higher vegetative development and increased chlorophyll content in the leaf (27). Similar to this, spraying nano-boron on mango tree leaves increases overall yield and improves the chemical characteristics of the fruits, which is probably related to the increased content of chlorophyll and important nutrient elements like nitrogen (N), phosphorus (P), potassium (K), manganese (Mn), magnesium (Mg), boron (B), zinc (Zn), and iron (Fe) in the leaves (1). When mango trees are sprayed with nano-zinc, other benefits include a rise in fruit weight, fruit yield, leaf chlorophyll and carotene content, and concentrations of numerous nutrients like N, P, K, and Zn (39). Similar to this, adding fertilizers containing nano-boron and nano-zinc enhances fruit quality, boosts fruit yield, and increases the amount of total soluble sugars (TSS), total sugars, and total phenols in pomegranates (8).

1. Nanofertilizers

A product of nanotechnology, nanofertilizers have attracted interest as a potential means of improving nutrient management in horticulture. These tiny fertilizers are being actively researched and developed since they have a number of advantages over regular fertilizers.

The capacity of nanofertilizers to improve nutrient availability is one of the main advantages of using them in horticulture. In comparison to conventional fertilizers, the nanoscale particles offer a much greater surface area, enabling better contact and interaction with plant roots. Better nutrient absorption is made possible by this expanded surface area, increasing the amount of nutrients that are available to plants.

Nanofertilizers can encourage better plant development, raise agricultural yields, and improve overall productivity by enhancing nutrient uptake. In addition to improved nutrient availability, controlled release properties can be added to nanofertilizers. These fertilizers may be made to release nutrients gradually over time, supplying plants with a steady supply of vital components.

Controlled-release nanofertilizers increase the effectiveness of nutrient utilization and reduce environmental contamination by lowering nutrient losses due to leaching or volatilization. Horticulturists can save time by reducing the frequency of fertilizer applications thanks to the regulated release mechanism.

The potential for customized nutrition distribution is another benefit of nanofertilizers. Nanofertilizers can be made to deliver particular nutrients directly to the appropriate plant tissues or organs through functionalization. This focused strategy can treat particular nutrient shortages in plants and allows for optimal nutrient utilization. Nanofertilizers can boost plant development and increase nutrient uptake by delivering nutrients to the right places. Additionally, nanofertilizers may lessen the environmental impact of conventional fertilizers. Nanofertilizers minimize nutrient runoff and leaching, minimizing environmental contamination and water pollution. They also promote nutrient uptake. Reduced fertilizer consumption overall and a smaller carbon footprint are both results of reducing the frequency of application.

It's crucial to keep in mind that there are still a number of obstacles to overcome in the commercial usage of nanofertilizers in horticulture, which is still in its infancy. It is necessary to conduct more research to determine the long-term impacts of nanofertilizers on plant growth, soil health, and environmental sustainability.

Nanofertilizers for large-scale horticulture applications also need to be assessed for their cost-effectiveness and scalability.

2. Nano-Plant Growth Stimulator

A class of nanotechnology-based product known as nano-plant growth stimulators (NPGS) has demonstrated potential in horticulture for boosting plant growth and enhancing agricultural yields. These stimulators increase plant physiological functions, food absorption, and stress tolerance by using nanoparticles. There have been some noteworthy discoveries involving the use of NPGS in horticulture, while research in this area is currently ongoing.

In one experiment, silver nanoparticles were used to stimulate lettuce plant growth (31). In comparison to the control group, the researchers found that applying silver nanoparticles boosted plant height, leaf area, and fresh weight. The nanoparticles promoted plant growth and photosynthesis by increasing nutrient intake and chlorophyll content.

The use of zinc oxide nanoparticles as a growth stimulator in tomato plants was the subject of a different study (37). The scientists discovered that adding zinc oxide nanoparticles greatly enhanced plant height, branch count, and fruit output. The important elements nitrogen, phosphorus, and potassium were better absorbed by the plants thanks to the nanoparticles, which enhanced plant growth and productivity.

In addition, study looked into how titanium dioxide nanoparticles affected the development and yield of cucumber plants (35). The scientists discovered that adding titanium dioxide nanoparticles to the soil promoted plant development, raised fruit yields, and enhanced fruit quality characteristics like size, color, and nutritional value. The nanoparticles enhanced the plants' antioxidant capacity as well.

It is crucial to highlight that further study is required to fully understand the efficacy, safety, and long-term consequences of nano-plant growth stimulators on plants, soil, and the environment. While these studies offer preliminary evidence of the beneficial effects of nano-plant growth stimulators in horticulture, this is only the beginning of the story. The precise nanoparticles employed, application techniques, dosages, and potential dangers related to their use must all be carefully considered.

3. Nutrient Uptake and Subsequent Translocation in Plant

Research has been done to examine how nanoparticles affect how nutrients are absorbed and transported by plants, offering light on their possible use in horticulture. Numerous researches have examined the function of nanoparticles in promoting nutrient uptake and subsequent translocation inside plants.

In one investigation, zinc oxide nanoparticles' effects on the absorption and translocation of crucial nutrients in wheat plants (25). The researchers discovered that the availability and absorption of nutrients like phosphorus, iron, and zinc were improved by the nanoparticles. They also noticed increased nutrient mobility within the plant system, as evidenced by the increased transfer of these nutrients from the roots to the shoots. The impact of silicon nanoparticles on rice plant nutrient absorption and translocation in a different study (21). According to the research, silicon nanoparticles improved the absorption of macro- and micronutrients like iron, manganese, phosphorus, nitrogen, and potassium. Increased nutrient concentrations were seen in the roots and shoots of the treated plants, indicating enhanced nutrient translocation and redistribution. In addition, (32) investigated the effect of silver nanoparticles on tomato plants' ability to

absorb nutrients. The application of silver nanoparticles considerably improved the uptake of nitrogen, phosphorus, potassium, calcium, and magnesium, the researchers discovered. In order to promote even distribution of nutrients, the nanoparticles made it easier for these nutrients to travel from the roots to the above-ground plant sections.

Collectively, these studies show that nanoparticles can alter nutrient uptake and subsequent translocation inside plants in a way that may enhance nutritional status and promote plant development. To completely comprehend the underlying mechanisms and assess the long-term impacts of nanoparticle application on plant physiology and soil health, additional study is necessary, and this is crucial to keep in mind.

4. Use of Pesticides

Improved pest management in horticulture may be achieved with the use of nano pesticides, which incorporate nanotechnology into pesticide formulations. These formulations at the nanoscale can improve pesticide effectiveness while minimizing dangers to human health and the environment. The use of nano emulsion-based pesticides in managing plant diseases was investigated (42), which showed improvements in their antifungal activity and longer-lasting efficacy. Furthermore, the application of nano pesticides for insect control highlighted the increased insecticidal activity and decreased ecological toxicity of these substances (18). Nevertheless, more investigation is required to guarantee the security and long-term consequences of nano pesticides on unintended organisms and the environment.

5. The Use of Nanomaterials to Extend the Shelf Life of Horticultural Crops

The use of nanomaterials has demonstrated potential in prolonging the shelf

life of horticulture crops by offering a number of advantages including antibacterial activity, improved gas barrier qualities, and controlled release of bioactive substances. In addition to preserving the quality and freshness of fruits and vegetables, these nanomaterials can reduce post-harvest losses.

Silver nanoparticles (AgNPs) are used as an example because of their antibacterial capabilities. Silver nanoparticles were found to be effective at extending the shelf life of strawberries in studies (15). These studies showed that adding silver nanoparticles to packaging materials prevented the growth of bacteria that cause food degradation. A lesser amount of mould and bacterial contamination resulted from the nanoparticles' efficient suppression of microbial activity. Research has also been done on nanocomposite films that contain clay nanoparticles. The introduction of montmorillonite nanoparticles into packaging films enhanced gas barrier qualities, resulting in decreased oxygen and moisture permeability. By reducing the rate of respiration, this regulated gas permeability can help preserve the quality and increase the shelf life of fruits and vegetables (26). Additionally, the utilization of nanomaterials for the regulated release of bioactive substances in horticultural settings has showed promise. For example, natural antioxidants or antibacterial compounds have been enclosed using nanoencapsulation techniques. By shielding the bioactive substances from oxidation, this encapsulation enables their controlled release during storage. study showed that cinnamon essential oil nanoencapsulation increased the shelf life of fresh-cut apples by preventing microbial development and retaining fruit quality features (5).

6. Increasing the Vitality of Cut Flowers

Cut flowers are highly significant commercially and have ornamental value, but their shelf life is quite short because of

increasing microbial contamination (20). Early flower wilting is caused by microbial and stem barrier infection, which results in stem obstruction, inhibits water intake and transport, and creates water imbalances (19, 38). Therefore, it is crucial to manage microbial infections in order to overcome stem obstruction. According to some investigations, nano-silver may be able to extend the vase life of cut flowers (2,3,17,19). The most significant nanoparticle is graphene oxide (GO), a carbon-based NP that resembles graphene and contains a large number of oxygenated groups and a large surface area, which leads to a superior ability to transfer nutrition for slow-release fertilizers (41).

7. Nanomaterials in Food Processing

The use of nanomaterials in the food processing of horticulture crops has the potential to provide advantages such better packaging, greater sensory qualities, increased nutritional content, and prolonged shelf life. To solve a number of problems and improve the quality and safety of horticulture goods, nanomaterials can be used in food processing procedures.

Packaging for food is one use for nanoparticles in the food processing industry. The permeability of barriers to gases and moisture has been improved by the development of nanocomposite films containing nano clays like montmorillonite. Incorporating nano clays into packaging films can improve their mechanical strength, barrier characteristics, and general performance (26). The potential of nanoparticles to enhance the nutritional qualities and fortification of horticulture products has also been explored. Vitamins, antioxidants, and antimicrobial agents are examples of sensitive bioactive substances that can be shielded from deterioration during processing and storage using

nanoencapsulation techniques, maintaining their activity and increasing bioavailability.

It's crucial to remember that the use of nanoparticles in food processing raises questions about safety and legal issues. The use of nanomaterials in food applications must be safe, and this requires thorough research to determine the dangers that might be involved.

8. Nano sensors in Precision Horticulture

A nano sensor is any instrument that has the ability to transmit information and proof about the actions and traits of NPs at the nanoscale level to the macroscopic level (29). Real-time monitoring of field crop, crop growth, and the occurrence of pests and diseases requires the use of nano sensors. Metal nanotubes, nanowires, nanofibers, nanocomposites, nanorods, and nanostructured polymers, as well as various allotropes of carbon, such as carbon nanotubes, graphene, and fullerenes, can all be utilized to make sensors at the nanoscale (22). Real-time monitoring can help to reduce the overuse of pesticides and fertilizers in agricultural production, which helps to lower production costs and environmental damage. Nano sensor technology transforms conventional agriculture into smart agriculture, which is more environmentally and energy-efficient for sustainable agricultural practices. The use of nano formulation-based fertilizers or pesticide delivery systems, which improve the dispersion and wettability of nutrients (10), nano detectors for pesticide or fertilizer residues, and remote-sensing-based monitoring systems for disease incidence and crop growth are all examples of intelligent agricultural practices in the production of horticultural crops. In horticulture, nano sensors are used to measure crop pest detection, nutritional needs, pesticide residues, and soil moisture levels.

CONCLUSION

The application of nanotechnology in horticulture has enormous potential for overcoming a variety of obstacles and improving crop quality and quantity. The controlled release, targeted delivery, and better nutrient availability provided by nanofertilizers support improved plant growth while having a smaller negative environmental impact. With a minimum of ecological harm, nano pesticides offer prospects for efficient pest management. Improved packaging, sensory qualities, nutritional fortification, and an increased shelf life of horticulture products are just a few advantages that nanomaterials in food processing can provide. While using nanotechnology in horticulture, it is crucial to exercise caution and handle any potential issues. To assess the long-term impacts of nanomaterials on plants, soil, non-target creatures, and human health as well as their safety and environmental consequences, more research is required.

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ANALYSIS OF GLADIOLUS (*GLADIOLUS GRANDIFLORUS* L.) CV. PUSA KIRAN FOR ITS YIELD AND ECONOMICS IN WESTERN REGION OF UTTAR PRADESH

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ABSTRACT

Present investigation was carried out to study the analysis of Gladiolus cv. Pusa Kiran for its yield and economics in Western region of Uttar Pradesh. The improved variety of Pusa Kiran was planted along with local variety Tigar Flame as check in 0.8ha each in the fields of six farmers at Pipli Khera and Lawar villages in block of Kharkhoda and Sardhana in Meerut district under the programme of “On Farm Testing (OFT)” during October 2017-18 and 2018-19. Two varieties were used in this experiment and Pusa Kiran gladiolus bulbs were supplied to the farmers under treatment T² was Pusa Kiran whereas T¹ was local variety Tigar Flame. The high yielding variety of Pusa Kiran has been compared with local variety i.e, Tigar Flame. The results revealed that among the varieties Pusa Kiran recorded significantly higher number of spikes per plant (1.45 no. of spikes/plant), number of flowers per spike (8.70 no. of flowers/spike), spike length (44.10 cm), and flower spike yield per hectare (143400 no. of spike/ha). The economic parameters viz., benefit cost ratio (1:3.86), marginal benefit cost ratio (17.24) and relative economic efficiency (28.12) were recorded more in Pusa Kiran than Tigar Flame varieties of gladiolus. The Pusa Kiran variety showed superiority over Tigar Flame and with found suitable for western region of Uttar Pradesh.

Key Words: Corm, Cut spike, Floret, Spike length, Efficiency & Yield.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.), the queen of bulbous flowers, belonging to the family Iridaceae and subfamily Ixioideae, is one of the most popular ornamental bulbous plants grown commercially for its fascinating flowers in many parts of the world. Most of the wild species (approximately 300) of gladioli have their centre of origin in Africa, particularly in and around South Africa, but a few species are also from the Mediterranean

and adjoining areas of Europe. Ploidy in the genus ranges from diploid ($2n = 30$) to dedecaploid ($2n = 12x = 180$). The genus was named by Tournefort and this generic name is derived from the latin word ‘gladius’ meaning ‘sword’ on account of the sword like shape of its foliage. It is commonly called as Sword lily. It is a slender herbaceous perennial with sword shaped phyllode leaves, grown both for gardens and floral decorations. Among the different bulbous plants, the gladiolus tops the list in its beauty, glamour keeping quality,

various colours and shades, shapes, hence it is called as “Queen of Bulb”.

The flower spikes are large and one-sided with bisexual flowers, each subtended by two leathery, green bracts. Adaptation to varying environments makes bulbous plants invaluable in a garden. They can be planted under shrubs or between perennials in the flower border or can be adopted informally in lawns and orchards, or formally in seasonal bedding display (8). The flowers are used in flower arrangement, in bouquets and for indoor decorations. *Gladiolus* is very popular as a cut flower, both with the consumer and the florist alike because of its many spike forms, colours and colour combinations, an advantage in every floral arrangement (2 and 11). It has gained popularity all over the world as one of the main decorative flowers. Demand of its cut flower for bouquet and other floral arrangement is increasing day by day due to its long vase-life and economic value. At present scanty research works are available on recommendations of the suitable *gladiolus* cultivars for growth, floral and economic parameters under agro climatic conditions of Western Uttar Pradesh. It is called queen of bulbous flowers for its excellent aesthetic value and display life (1). This is one of most beautiful flowers blossom from October to March in plains. These plants can be grown both in pots and beds as long as proper sunlight is present (minimum of 10 hours sunlight required for well blooming).

Gladiolus plants grow very well in warm climatic conditions. *Gladiolus* is half-hardy in temperate climatic conditions and these plants grow from rounded, symmetrical corms that are bonded with several layers of brownish tunics. *Gladiolus* flowers are produced in variously colours. Most of the colours are from this variety orange to red. Commercial flower farmers can grow these in poly house or greenhouses as well. One can get decent profits under ideal cultivation

practices. These flowers can be grown in subtropical and temperate climatic conditions. The temperature range of 25°C – 30°C is ideal for its cultivation. Apart from this, this crop demands full exposure to sunlight and performs well with long day conditions of 10 –12-hour photo-period. Avoid any frost during its growth period as this crop is sensitive to frost conditions. Commercial propagation of *Gladiolus* plants is done by corms (a rounded underground storage consisting of a swollen stem base covered with scale leaves). Minimum of 5 cm diameter corms are required for propagation. Make sure these corms are healthy and disease free. When it comes to shape of corms, conical shaped corms gives better flowers when compared to flat shaped corms.

Mostly local varieties are cultivated by the farmers of Meerut district but high yielding varieties is not consideration due to reason of lack of knowledge. Productivity was lesser due to low yielding local varieties. Many varieties have been introduced in *gladiolus* by Indian Institute of Agricultural Research (IARI), New Delhi, Indian Institute of Horticultural Research (IIHR), Bengaluru, National Botanical Research Institute (NBRI), Lucknow and various other Agricultural Institutes. The existing local cultivars are low yielding and give low margin to the farmers. Hence, experiment was conducted to assess suitable high yielding variety ‘Pusa Chandni’ for commercial cultivation in this district. The primary purpose is to produce beautiful cut-flowers which can be marketed to local flower markets or these flowers can be grown for ornamental (decorative) purpose in the garden. However, there are some medicinal health benefits of dried bulb which is ground into a powder. *Gladiolus* flower bulb powder may help in curing common cold, alleviate constipation, relieve from diarrhoea, reduce pain during menstruation in women, curing fungal infections, relieving ulcers and curing

meningitis. These flowers can be grown in subtropical and temperate climatic conditions. The temperature range of 25°C – 30°C is ideal for its cultivation. Apart from this, this crop demands full exposure to sunlight and performs well with long day conditions of 10 – 12 hour photo-period. Avoid any frost during its growth period as this crop is sensitive to frost conditions. Gladiolus plants can be grown in wide range of soils. However, Well-drained sandy loam soil rich in organic matter with pH range of 6.0 – 6.5 are best suitable for their growth and best flower yield. Water-logging soils should be avoided. Gladiolus is one of the most important flower crops cultivated in Meerut district as cut flower for purpose of making bouquets. Flowers with this variety are brilliant colours (moon), attractive shapes, good sizes, excellent keeping quality. The gladiolus is ideal both for garden and floral decoration. The florets open in sequence over a longer duration and hence have a good keeping quality of cut spike. It is ideal as a cut flower, very good for beds, herbaceous border, for making bouquets and does well in pots.

MATERIALS AND METHODS

The experiment has been conducted at farmer's field under Krishi Vigyan Kendra, Hastinapur, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (UP) for two years during 2017-18 and 2018-19 at twelve farmer's field in Pipli Khera and Lawar villages of Meerut district. Two varieties were used and Pusa Kiran gladiolus bulbs were supplied to the farmers under treatment T² was Pusa Kiran whereas T¹ was local variety (Tigar Flame). The high yielding variety of Pusa Kiran has been compared with local variety *i.e.*, Tigar Flame and the characters of gladiolus varieties were given in table 1. Each experimental plot size was 0.1 ha and the planting were taken up during October, 2017-18 and 2018-19 at three

farmer's fields each year. The observations *viz.*, number of spikes per plant, number of flowers per spike, spike length (cm), flower yield per plant (g) and flower yield per hectare (no./ha) and economic character like cost of cultivation, gross income, net income, marginal benefit cost ratio (MBCR), relative economic efficiency (REE), benefit to cost ratio (BCR) were recorded. The soil type was sandy loam, pH 6.4, and EC was 0.8. The available nitrogen, phosphorus, potassium content was 120, 80, 210 kg/ha respectively. The gladiolus bulbs were planted in single row system with spacing of 120 x 20 x 10 cm. Drip emitters were installed for providing irrigation. Before planting of the gladiolus bulbs were treated with Copper oxychloride (COC) (3g/l). Farm yard manure (10 t/ha), recommended dose of fertilizers NPK– 150:100:80 kg/ha, neem cake 250 kg/ha has been applied as a basal dose. The flowers, spikes and yield data obtained were statistically analysed with SPSS and repeated measures mixed ANOVA is carried out for pooled analysis of three years data with two treatments. The Benefit Cost ratio (B:C ratio), Marginal Benefit Cost Ratio (MBCR) and Relative Economic Efficiency (REE) (10) were calculated by using following formula as given below.

- B:C ratio = Net return/ cost of cultivation
- Marginal Benefit Cost Ratio (MBCR) = $\frac{\text{Gross return of new variety} - \text{Gross return of farmers variety}}{\text{Total variable cost of new variety} - \text{Total variable cost of farmer's variety}}$
- Relative Economic Efficiency (REE) = $\frac{\text{Net return of new variety} - \text{Net return of farmers variety}}{\text{Net return of new variety}} \times 100$

RESULTS AND DISCUSSION

From the results (Table 1), it was evident that the improved variety Pusa Kiran showed the highest number of spikes per plant (1.45 no./plant), number of flowers per spike (8.70 no./spike), spike length (44.10 cm), compared to Tigar Flame. In Pusa Kiran flower yield per

hectare (143400 no./ha) were more compared to local variety. Similar results were reported by (9) and (2) in gladiolus. The improved variety Pusa Kiran was well adaptive to different region of the district and there was a significant increase in the yield of the Pusa Kiran compared to that of the local variety i.e. Tigar Flame (Table 2). The flower yield was significantly higher in Pusa Kiran than the local variety as indicated by the greater number of flowers per spike (12.99) with the 28.41 increase percent. The data about interaction effect of year and variety were found non-significant which indicated that during two years both varieties performed in the same way. Further, Pusa Kiran performed well with higher flower yield of 143400 nos./ha than check variety i.e, Tigar Flame 111675 nos./ha. Hence improved gladiolus variety Pusa Kiran was most suitable for cultivation in this region. Similar results were reported by Singh et al (2018). In table 3, economic impact of Pusa Kiran gladiolus variety over Tigar Flame variety was calculated and results revealed that by cultivating Pusa Kiran gladiolus variety farmers got more benefit cost ratio (1:3.86) over Tigar Flame (1:3.16). This may be due to higher yield obtained with Pusa Kiran gladiolus variety compared to farmer's practice. Similar results were obtained by (1). Suitability of new variety was assessed with marginal benefit cost ratio (17.24) and economic efficiency was assessed with Relative Economic Efficiency (28.12). The cultivation of Pusa Kiran gladiolus variety gave higher net return Rs.265700/- over two years as compared to Tigar Flame. The variation in plant height and spike length in different varieties may be due to influence of genetic and environmental factors. As each variety has its own characteristic genetic constitution, which contributes significantly to create variability. Similar observations for

plant height, spike length and rachis length also reported by 7; 12 and 13 in gladiolus and 5 in snapdragon.

Table1. Performance of Gladiolus variety at farmer's field during 2017-18 and 2018-19.

S. Nos.	Parameters	Tigar Flame (T1)			Pusa Kiran (T2)		
		2017-18	2018-19	Mean	2017-18	2018-19	Mean
01.	No. of spike/plant	1.21	1.30	1.26	1.42	1.48	1.45
02.	No. of flower/spike	7.78	7.62	7.70	8.68	8.72	8.70
03.	Spike length (cm)	36.61	35.58	36.09	44.73	43.48	44.10
04.	Flower spike yield (Nos./ha)	110650	112700	111675	138200	148600	143400

Table 2. Comparison of means of the parameters with check variety for two years.

S. Nos.	Parameters	Varieties		Percent increase
		Tigar Flame (T1)	Pusa Kiran (T2)	
01.	No. of spike/plant	1.26	1.45	15.08
02.	No. of flower/spike	7.70	8.70	12.99
03.	Spike length (cm)	36.09	44.10	22.19
04.	Flower spike yield (Nos./ha)	111675	143400	28.41

Table 3. Impact analysis of Economic in Gladiolus.

Gladiolus-Variety	Cost of cultivation (Rs/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B. C. ratio	Marginal Benefit Cost Ratio (MBCR)	Relative Economic Efficiency (REE)
T ¹ -Tigar Flame	88200	279188	190988	1:3.16	17.24	28.12
T ² -Pusa Kiran	92800	358500	265700	1:3.86		

CONCLUSION

Gladiolus improved variety Pusa Kiran with more number of spikes per plant, more flowers per spike and length of spike gave higher yield and B: C ratio. Hence, the farmers were satisfied with the gladiolus variety Pusa Kiran cultivation. Hence, it was concluded that gladiolus variety Pusa Kiran was most suitable variety for Western region of Uttar Pradesh. At present, the area under Pusa Kiran in Western region of Uttar Pradesh is nearly 35 per cent of the total area under gladiolus cultivation.

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CONSUMER PERCEPTIONS OF ADVERTISING APPEALS IN TELEVISION COMMERCIALS: A CRITICAL STUDY

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ABSTRACT

India is currently one of the most preferred business investment destinations. In the recent past, there has been a significant growth in the foreign direct investments across various sectors in India. A positive consumer sentiment has further added to the market potential. Firms have substantially increased their promotional spends, thereby contributing to the overall clutter in the marketplace. In order to improve their return on advertising expenditure, it is imperative that marketers and advertisers revisit their approaches to target their markets. Consumer perceptions and behaviour have been transforming at a rapid pace in India in recent years. Consumer perceptions towards marketing promotion, including advertising, have also been evolving. The purpose of the present research is to study consumer perceptions towards various advertising appeals and to examine the relationship between these perceptions and a set of antecedents, namely consumer demographics, consumer judgements about and feeling from the advertisements. the sample size 195 respondents. Primary data for this study was collected. The data was analysed with the help of SPSS using statistical tools such as t test, mean, s.d. The findings of the study confirm that there is a relationship between the respondents' judgements about the advertisement and their perception towards the advertising appeals used in the commercials.

Keywords: Consumers perception, advertisement, advertisement appeals, emotional and rational

INTRODUCTION

Today, technical products, or consumer electronics are a common part of the everyday life. It is not unusual to use technology at work, at school, or in the free time. Those products can be used for entertainment, for hobbies or several work-related tasks. Whatever the purpose of using technical products may be, the number of users has increased immensely. Those increasing numbers lead to a growing market, which results in growing competition among this

product category. Subsequently, this leads to a change in advertising to stand out on the market.

Targeting the Indian market has always been a challenge for the firms owing to myriad factors. One of them is the changing perceptions of the consumers towards the marketing promotion of the firms. Inadequate information about such changes, often leads to managers finding themselves in difficult situations. The existing firms in the country – Indian as well as foreign – and those that will

enter the Indian market after realising its increased business potential, will have to find out and implement new strategies to tap this evolved market. Marketers have realised that the consumers in India are now better educated and as a result are more aware, and will continue to evolve in the future, more so because of the new and conducive business environment.

There is a need to adopt new bases for segmenting the market. Demographic segmentation may not always be the best method to study consumer perceptions. It is time that marketers in India adopted more bases like consumer personality traits, consumer decision-making styles.

The aforementioned developments with respect to the television medium are positive indicators that this medium is going to remain the advertisers' most preferred one in years to come. However, that re-emphasises the point that there is going to be enough competition and clutter. Advertisers will have to think of new ways to promote their brands and occupy a special place in the consumers' mind. One way could be to revisit and refresh the advertising message strategies as early as possible.

ADVERTISING APPEAL

Different advertising appeals (humor, emotional, musical, rational appeal etc.) used in advertisements to make the advertisement more interesting for the consumers so that they remember the advertisement, think about it thus leading to the buying decision. Different people might have different perception towards the various appeals used in the advertisement. Many researchers have studied the impact of various appeals on the consumer's perception towards T.V. commercials. The ad message strategies or the advertising appeals have evolved over the years. But essentially, they must either elicit positive feelings of the consumers or help them

form positive judgments about the advertisement. Advertising appeal is the approach to seek the attention of consumers and to influence their feelings about the advertised brand or cause. The success of an advertisement depends upon the message strategy and how the message is communicated or the execution style of the message. Companies have, through their advertising, associated with various causes such as gay rights, racial harmony, domestic violence, breast cancer, rape prevention, literacy, AIDS, drug prevention, wetlands and wildlife preservation, and mental and physical disabilities. Such advertising is called company advertising with social dimension. the types of advertising appeal.

EMOTIONAL AND RATIONAL ADVERTISING

Emotional and rational advertising appeals are most commonly and extensively used in most of advertising appeals. As stated "Advertising appeals can be classified as emotional or rational, based on messages in the given context". Then these two broad appeals are further classified into music, humor, fear, sex, romantic, statistic, comparison, adventure, and band wagon appeals etc. A feeling of social approval, respect, excitement, and fear and guilt is stimulated the target audience in **Emotional Appeals**. Emotional appeal is linked up to an individual's right brain thinking, where individual is prompt to satisfy his psychological needs through the advertised product.

CUSTOMER PERCEPTIONS

A customer perception refers to how customer view a certain product based on their own conclusion. These conclusions are derived from a number of factors, such as price and overall experience. A marketing concept that encompasses a customer impression,

awareness or consciousness about a company or its offerings. Customer perception is typically affected by advertising, reviews, public relations, social media, personal experience and other channels. Perception is one of the objects studied by the science of customer behavior. Analyzing the work of scientists studying the customer behavior, it is possible to make a conclusion that perception is presented as one of personal factors, determining customer behavior.

STATEMENT OF THE PROBLEM

Advertising is supposed to create a positive and strong relationship between consumers and advertisers. Consumers are informed about the features, quality, availability and affordability of products and when such products are similar it is obvious that the advertisement include an appeal which based on emotional intangibles through effective brand message. Advertisement is now crucial part of producing a brand position in market as well as in consumers mind. The main purpose of this research is to identify the effects on consumers perception related to brands that are advertised through different advertising appeals.

SIGNIFICANCE OF THE STUDY

With the recent changes in the consumer demographics and the overall business environment, the marketers and advertisers are looking for information about how the consumers in India should be approached and how to combat the rising competition. There is already enough clutter on every medium and the biggest challenge for any advertiser today is to draw the attention of the target audience. While a number of television advertising research studies have been conducted in the developed markets, very little has been done in the area of consumer perceptions towards such advertising in India, more specifically concerning the advertising appeals. As it is, at

present, television is the most preferred medium of the advertisers, and considering the positive developments taking place in the business environment, it is expected that the adspend is only going to grow more in the future at higher rates.

REVIEW OF LITERATURE

(1) Advertising is a marketing activity fundamental that what provides the product / service information related was widely distributed to buyers and persuaded them towards a purchase judgment. Wellness industry compresses beauty sector, fitness & Gym, rejuvenation and AYUSH sectors, here in this segments advertising is one of the best significant and a practice promotional and a common that the promoters of global and local brand are using this for promotional purposes. In advertising, the investors are investing billions and brands and that show the general meaning of this promotional technique. The advertising appeals are a tactic crucial to brand advertisers tilt to regulate the mentality of customers selected. This study tends to examine the impact of four advertising resources used regularly, that is to say, humor, emotion, sex and attractive fear in the consumer the purchase of intention. The present study has been carried out on digital media, determining a sample magnitude of 686 consumers be vested in the capital region of Andhra Pradesh. The outcomes of the study revealed that humor, emotional feeling and fear attract to be the most significant in impacting the purchase intention of consumers. The educational qualification of the respondents is taken into account and its effect on the perception of advertising appeals is observed through the association between them.

(2) The influence of advertising appeals on consumer perceptions of athlete endorser brand image. Analogous to traditional brands, athlete (i.e. personal) brands require

management and maintenance. While the use of athlete endorsers is an effective marketing strategy for companies wanting to increase visibility, research has failed to indicate how advertising influences perceptions of the athlete endorser (i.e. spill-over effects). This research addresses this gap by examining the influence of four advertising appeals on perceptions of an athlete endorser expertise, trustworthiness, attractiveness and likeability. Experimental between-subjects study design. MANOVAs with post hoc analyses were used to examine differences between advertisement appeals. Regression was used to examine the influence of respondent perceptions towards the advertisement on perceptions of the athlete endorser. The results indicate that advertising influences consumer perceptions of athlete endorsers. Consequently, athletes must consider how advertising appeals are applied and consider the residual effects that are generated from product advertisements.

(3) Companies use various appeals in their advertising practice to impact consumers' perceptions and purchase intention by an advertisement. Advertising appeals can be divided into rational or emotional, depending on whether companies want to influence the rational or the emotional motives of the consumer to purchase of the advertised product. Since there is no general pattern for the use of appeals and the success of an advertising message, this study aims to explore the impact of the emotional and rational advertising appeals on the purchase intention. The results of the empirical research, conducted using the focus groups method, are shown in this paper and the focus group participants were members of the student population. The research results indicate that different advertising appeals may have a different impact on the consumer's purchase intention; in case of women, the

emotional appeal has a stronger impact while for men it is the rational appeal, while "fear appeal" proved to be effective to a certain point, after which it causes selective perception and rejection. This implies that depending on the product, its purpose and target group, advertisers can choose the type of appeal, combination of the appeals and their creative presentation, based on the empirical confirmation of the efficiency the approach.

OBJECTIVES OF THE STUDY

1. To study the consumer perceptions towards various advertising appeals used in the television commercials.
2. To study the relationship between judgements-about-the-ad, feelings- from-the-ad, select demographic variables

RESEARCH METHODOLOGY

H_1 : There is a relationship between age and perception-towards-the-advertising- appeal.

HYPOTHESIS

The television commercials based on different appeals were shown to the respondents aged between 15 and above 46 years. The data was collected with the help of a questionnaire in the Haryana. The sample size will be collected 195 respondents. The data analysis was conducted with the help of SPSS, using statistical tools such as t test, mean, S.d, Anova. Data Collection The data will be collected through questionnaire designed particularly for this research. The questionnaire will be administered to people living in different part of the city. The collection of accurate data depends upon the cautious structure of a tool for data group. The descriptive statistics of the respondents? perception- towards-the-advertising-appeals used in the television commercials of the product category cars.

RESULTS AND DISCUSSION

Table 1: Demographic Profile of Respondents

Demographic Variables	Options	Frequency	Percent
Age	15-20	16	8.2
	21-25	80	41.2
	26-30	27	13.8
	31-35	27	13.8
	36-40	14	7.1
	41-45	14	7.1
	Above 46	17	8.5
Gender	Options	Frequency	Percent
	Male	74	37.9
	Female	131	63.1
Education	Options	Frequency	Percent
	Less than 10th	20	10.4
	10-12th	30	15.2
	Graduation	70	33
	Post-Graduation	51	25.4
	Professional Degree	21	10
	Doctorate	1	0.5
	Others	5	3.2
Present Status	Options	Frequency	Percent
	Graduated	78	40
	Working Class	6	3.7
	Home Maker	30	15.8
	Unemployed	7	4.3
	Retired	2	1

Table 1 represents the distribution of respondents across the demographic variables, viz., age, gender, education and present status. Maximum respondents i.e. 41.2% were from the age group of 21-25, 13.8% of respondents were from the age group of 26-30 and equal percentage of respondents were from the age group of 31-35. 9% respondents were above 46 years of age. Three age groups i.e. 15-20, 31-35 and 36-40 had same percentage of respondents, which was 7.1%. Further, the respondents have also been classified based on the educational qualification. Graduates formed 33% of the respondents, while 25.4% respondents were

post-graduate. People with 10 - 12th education qualification formed 15.2% of the total respondents. 10% respondents had professional degree while an equal number of respondents were less than 10th educated. 10.4% respondents had other educational qualification and only 0.5% was doctorate. Table 1 also displays the present status of the respondents. 3.7% of the respondents belong to the working class, while 40% were students. Homemakers formed the 15.8% of the respondents, 4.3% respondents were unemployed, 1% of respondents were retired while there was no respondent from others category.

Table 2 Cars – Feelings-from-the-ad: Descriptive Statistics

Feelings-from-the-ad	TV Commercial with Rational Appeal		TV Commercial with Emotional Appeal	
	Mean	S.D.	Mean	S.D.
Upbeat	1.74	0.69	3.53	0.90
Not-negative	2.38	1.27	3.46	0.93
Warm	1.69	0.87	4.41	1.25
Overall	2.11	0.97	3.80	0.74

For the TV commercial with rational appeal, the mean value of upbeat feelings was 1.74, that of not-negative feelings was 2.37 and that of warm feelings was 1.69. The mean value of overall feelings-from-the-ad for commercial with rational appeal was 2.21. On the other hand, for the commercial with emotional appeal, the mean value of upbeat feelings was 3.13, that of not-negative feelings was 3.06, and that of warm feelings was 4.01. The mean value of overall feelings-from-the-ad for the commercial with emotional appeal was 3.40.

Table 3: Cars – Judgements-about-the-ad and Feelings-from-the-ad: Paired Samples t test

TV Commercial with	Judgements-about-the-ad		Feelings-from-the-ad		t value	Sig.
	Mean	S.D.	Mean	S.D.		
Rational appeal	2.52	.85	2.91	.57	9.77	.000* **
Emotional appeal	3.32	.73	3.40	.34	-1.36	.15

A paired samples t test was conducted to test the difference in the mean value of judgements-about-the-ad and that of

feelings-from-the-ad for each commercial (Table 3) and it was found that the judgements-about-the-ad for the commercial with rational appeal had a significantly higher ($t = 9.772$, $p < .001$) mean value ($m = 2.52$) as compared to that ($m = 2.91$) of its feelings-from-the-ad. However, the feelings-from-the-ad for the commercial with emotional appeal did not have a significantly higher mean value ($m = 3.40$) as compared to that ($m = 3.32$) of its judgements-about-the-ad.

Table 4: Cars – Age-wise Perception-towards-the-Advertising-Appeal: Descriptive Statistics and One-way Analysis of Variance

Age (yrs.)	Perception-towards-the-Advertising-Appeal (Rational)					Perception-towards-the-Advertising-Appeal (Emotional)				
	N	Mean	S.D.	F Value	Sig .	N	Mean	S.D.	F Value	Sig .
15-20	12	3.51	.57	64.20	.000**	16	3.43	.48	6.15	.000**
21-25	84	3.15	.57			85	3.27	.41		
26-30	25	2.72	.52			22	3.36	.54		
31-35	29	2.27	.70			24	3.95	.70		
36-40	12	3.27	.73			17	3.31	.51		
41-45	16	2.43	.72			16	3.20	.45		
Above 46	17	2.78	.63			15	3.01	.65		
Total	195					195				

Table 4 shows that One-way analysis of variance (ANOVA) was conducted to find out if there was a relationship between age and Perception-towards-the-Advertising-Appeal by comparing the means of Perception-towards-the-Advertising-Appeal across different age groups for the two commercials. Hence there is no relationship between the age and Perception-towards-the-Advertising-Appeal.

CONCLUSION

Advertising play a very important role in communicating about the product and service to the consumers. Choosing the correct medium of advertisement for reaching the ultimate consumers is very vital as advertising products and services on any medium incurs cost, which needs to be compensated with increased revenue. Hence,

the advertisers should first find an appropriate and effective medium depending upon the type of product or service and the target consumers. People belonging to different categories of age group, gender, education level, etc. may have different perception towards the T.V. commercials, so the advertisers while designing the advertisements should consider the perception of people and design the advertisements accordingly to make the consumers to perceive the advertisement in a positive way. While the focus on why the car is better than others in the market generates judgements, the execution style also elicits feelings of the respondents, to a certain extent. The respondents, though, may not form very strong judgements or feelings when exposed to such a rational appeal. In the case of the emotional appeal commercial based on joy for the same product category, there is no significant difference found between the judgements-about-the-ad. though both of these responses are more positive as compared to those of the rational appeal commercial. It is possible that the presence of a celebrity endorser motivates the respondents to form equally positive judgements and feelings with respect to such emotional appeals.

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ASSOCIATION OF KNOWLEDGE AND ADOPTION LEVEL OF FARMERS ABOUT MARIGOLD CULTIVATION PRACTICES IN HARYANA

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ABSTRACT

In India marigold is one of the most commonly grown flowers and used extensively on religious and social functions in different forms. Because of their ease in cultivation, wide adaptability to varying soil and climatic conditions, excellent keeping quality, the marigolds have become one of the most popular flowers in our country. The present study was conducted in two districts *viz.*, Gurugram and Jhajjar of Haryana state. From the selected village thirty marigold cultivators were selected randomly for the study. Thus, a total of 120 respondents were finalized from the four randomly selected villages for the present study. The results revealed that majority of the farmers 50.00 per cent were having medium knowledge level regarding marigold cultivation. Regarding concept, importance, harvesting, packing and marketing of marigold majority of the respondents had medium level of adoption. Whereas, in case of agronomic practices and fertilizers application majority of the respondents belonged to low adoption level. Further, from the results it was inferred that, all the selected independent variables together contributed 62.30 per cent variation in the knowledge level of the farmers and 60.50 per cent variation in the adoption level of farmers regarding marigold cultivation.

Keywords: Adoption, Marigold, knowledge, Cultivation, Correlation and Regression

INTRODUCTION

Floriculture has become one of the important high value agricultural industries in many countries of the world. International trade in cut flowers is growing at rate of 25.00 per cent annual growth rate. According to National Horticulture Board report, the area under horticulture grew by about 03.00 per cent per annum and annual production increased by 05.40 per cent. During 2016-17,

the production of horticulture crops was about 295.2 million. Great potentialities exist for cultivation of flowering plants. Increasing trends in area and production of flowers has been observed since 2003-04 onwards. In addition to the beautification of the local landscape, great scope exists for export of flowers; and floriculture is important for beekeeping industry which too provides an alternate source of income to the Indian

farmers. The highest production of Flowers was recorded in Tamil Nadu (416.63 thousand tonnes) followed by Karnataka (280.92 thousand tonnes). In India, area under Marigold in 2015 was 65,000 ha and production was 6,16,000 tonnes (Ministry of Agriculture and Farmers' Welfare, GOI, 2016-17).

The area under marigold cultivation in Haryana during 2014-15 was 5380 ha producing about 62,340 tonnes with an average yield of 11.58 t/ha (Ministry of Agriculture and Farmers' Welfare, GOI, 2014-15). The area under marigold cultivation in Haryana was about 344 ha producing about 1560 tonnes with an average yield of 4.54 t/ha. The annual growth rate of area, production, and yield of marigold for the period from 2007-2008 to 2009-2010 were 12.44 per cent, 11.12 per cent, and -01.32 per cent, respectively. In Haryana, 61.83 thousand tonnes of loose flowers was produced in 2015-16. Regarding cultivation of flower crop, marigold dominated in north Haryana 79.17 per cent.

METHODOLOGY

The study was conducted in two districts *i.e.*, Gurugram and Jhajjar in Haryana state. Further, from each district one block was selected randomly and from each block, two villages were selected, randomly. Purposive sampling and random sampling techniques have been followed for the present study. From each selected village thirty marigold cultivators were selected randomly for the study. Thus, a total 120 respondents were personally interviewed by the investigator at their field/ home. Independent and dependent variables were selected in accordance with the objectives of study while selecting the variables adequate attention was paid to

review of literature collected for the purpose of the study. Respondent's age, education, annual family income, mass media exposure, extension contacts, scientific orientation and motivation were studied as independent variables and these were measured with existing scales with some modifications whenever needed. Whereas, knowledge and adoption level of the respondents regarding marigold cultivation studied under dependent variables and these variables were measured by constructing the interview schedule which is developed especially for the study. The data thus collected was statistically analyzed by using correlation, multiple regression, average score, and knowledge index and adoption index method.

RESULTS AND DISCUSSION

Knowledge level of farmers

Data presented in Table 1 reveals that farmers possess sufficient amount of knowledge regarding method of irrigation and proper harvesting methods of marigold, ranked first with knowledge index 100.00 per cent followed by, had knowledge regarding planting methods ranked second with knowledge index 92.50 per cent and manure and fertilizer application ranked third with knowledge index 82.22 per cent.

Further, diseases/pests and their control ranked fourth, followed by, pinching practices and recommended cultivars ranked sixth, with knowledge index *viz.*, 75.00, 74.44 and 60.56 per cent respectively. These findings found closely resemble to the findings (3) that knowledge of farmers for rice cultivation was medium (54.90%). He revealed in his study that the knowledge of the cultivators regarding seed treatment and plant protection was medium.

Table 1 Distribution of the farmers according to their knowledge level (n=120)

Sr. No.	Practices	Average of response under each category			Total Score	WMS	Knowledge Index	Rank
		Full	Partial	Nil				
1.	Recommended cultivars	16 (13.33)	66 (55.00)	38 (31.67)	218	1.82	60.56	VI
2.	Planting methods	93 (77.50)	27 (22.50)	00 (00.00)	333	2.77	92.50	II
3.	Manure and fertilizer	56 (46.67)	64 (53.33)	00 (00.00)	296	2.47	82.22	III
4.	Methods of Irrigation	120 (100.00)	00 (00.00)	00 (00.00)	360	3.00	100.00	I
5.	Pinching Practices	43 (35.83)	62 (51.67)	15 (12.50)	268	2.23	74.44	V
6.	Proper Harvesting Methods	120 (100.00)	00 (00.00)	00 (00.00)	360	3.00	100.00	I



EXAMINATION OF THE IMPACT OF BOTH RATIONAL AND EMOTIONAL APPEALS IN ADVERTISING ON CUSTOMER BEHAVIOR

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ABSTRACT

In India, the advertising industry first emerged during the British era and has since experienced an exponential growth. The fascinating history of its beginnings and growth supports the Indian marketing industry. In fact, given the current circumstances, it is turning out to be the tertiary sector of the Indian economy that is developing the fastest. The Indian economy has been impacted by changes in monetary policies, technical improvements, and globalization, which has boosted the advertising industry. Every firm now considers public relations to be essential, and sponsors are continuously searching for fresh approaches to develop appealing advertising in order to stand out in the crowded market of today. According to the investigators, the economy will continue to rise, leading to significant financial gains and higher requirements for professionalism and inventiveness. The industry also faces a number of difficulties, including the impact on Indian subcultures and customs, the aging of the workforce, the influence and development of regional India, and commitment to financial turn of events. Whatever the case, the company is geared up and working to get over these challenges. The messaging element is essential to every promotion since it creates effect among the targeted interest groups. Oftentimes, the messaging component is referred to as the “advertising appeal.” Because there is now a range of publicizing appeals thanks to the development of advertising systems, it is crucial for advertisers to choose their appeals carefully. In the field of public relations, “social appeal of promotion” is a fresh and developing idea. By influencing the behavior of the target interest group toward the cause, this promotional appeal is the overall idea that builds a brand within the context of a social purpose. The definition of social appeal in advertising is “an integrated advertising method that combines the benefits of brand advertising with those of social advertising.”

Keywords: Industry, Social Advertising, Social Purpose, Advertising Appeal

INTRODUCTION

Normally, marketers bombard customers with a variety of campaigns, although they do occasionally want things besides the things they see in commercials. Therefore, it becomes necessary to reconnoiter above and beyond anything that might draw notice. The

tendency is shifting away from straightforward advertising and toward appeals in advertising. Companies hope that people would buy their items after seeing the advertising that promote a certain brand and its goods. Businesses spend a significant amount of money developing and monitoring

requests for technological innovations to connect information about their market presence. As a result, creating commercials to sell goods through creative appeals becomes crucial. This would result in strong allusions and leave a lasting impression on potential customers. These variations affect consumer behavior with regard to the product.

The best approach to appeal to consumers has always been a major task for advertising administrators, and the challenge is only getting more difficult as technology develops, the business environment becomes more competitive, and the world becomes more interconnected. Additionally, modern advertising adopts a variety of structures, from traditional paper advertising to targeted online media advertising, which emphasizes and mandates the need for effective advertising correspondence. This is due to the ongoing advancements and expansion of broad communications. An important part of promotion is correspondence marketing. Promoting is, in fact, the most fundamental type of correspondence.

By using advancing trades, businesses try to inform, persuade, and remind customers in a plain or verifiable way about the goods and brands they sell. It is regarded as the brand's voice and a strategy for creating and outlining relationships with customers. Companies may connect their brands to people, places, events, interactions, and emotions by using correspondence marketing. By creating a brand image and imprinting the brand in the buyer's memory, it can also raise brand value.

APPEALS OF ADVERTISING

Appeals can be categorized as rational or emotive. Johnson predicted that appealing consumers and generating increased acquisition intentions will be used in order to safeguard more production material and real-life materials.

According to Coulson, in relation to

emotional appeal, rational appeal awakens and encourages people to make better informed purchase decisions. The consciousness of enjoyment, attachment, pleasure, fear, etc. is linked to emotional appeals. There are affected dreams and convictions that are there in the person that work to purposefully and create a nice impression in the unique essence. Emotions can also be used to distress and control a particular customer's behavior.



FIGURE-1: EMOTIONAL APPEAL IN ADVERTISING

INCREASED ADVERTISER'S ATTENTION TOWARDS THIS FORM OF ADVERTISING

In India, brand promotion that incorporates a social message or a cause is growing in popularity. As was already mentioned, companies are expanding their CSR initiatives, which is precisely why the trend of different marketing contact approaches, including social appeal marketing, is emerging. Another factor contributing to the top management's increased interest in this sort of marketing is that they see it as a crucial theoretical tool that helps them achieve cultural benefits while also enhancing their corporate image both internally and publicly. There is a lot of ambiguity and uncertainty surrounding the

many choice language for cause-related marketing, cause brand alliance, and cause checking, for example, even if social cause publicizing is still in its infancy in India. Various corporate social responsibility programs undertaken by various American associations as “showcasing and corporate social obligation” and have categorised them into two distinct classes: those focused on publicizing and those that express corporate qualities and targets. Additionally, they classified “advertising-driven corporate social endeavors” under the headings “cause progression, cause-related advancement, and corporate social advancement.”

EMOTIONAL APPEALS (EA)

Sponsors commonly use dramatic emotional ads, which are meant to “stun the emotions and make the cerebrum throb,” to boost the specificity and potency of their public relations appeals. Feelings are mental impressions that, when combined with viewpoints and mindsets, can form the “impact” of behavior. The definition of a “feeling” is a “psychological state of being that emerges from intellectual evaluations of events or contemplations, has a phenomenological tone, is regularly communicated authentically, is connected by physiological cycles, and may result in explicit activities to confirm or adapt to the feelings” Emotional appeals should come from the user’s experienced, emotional side. According to & Armstrong, emotional appeal refers to “an attempt to elicit one or more negative or positive sensations conducive to purchase.” These include arguments based on fear, guilt, and shame that influence people to act in a certain way or refrain from acting in a certain way.

Customers’ decisions to purchase things are influenced by emotional appeal. These are people who feel emotionally motivated to buy a certain goods. Two different kinds of emotional attraction are individual appeal

and community appeal. Individual emotions drive people to buy products out of fear, security, comfort, excitement, delight, fulfillment, and joy, whereas friendly appeal drives people to buy things out of alliance, status, acknowledgment, and recognition. The concept of “emotional appeal” describes a person’s social and mental conditions for acquiring particular goods and services. Many customers are either about to make certain purchases or are emotionally stimulated. Sponsors plan to use emotional appeal to their advantage, which is quite effective when there is little difference between different product names and their services. Emotional appeals are often used to convince people to buy anything from a cleanser to a high-end car. Examples of these appeals include fear, blame, humor, and promises of self-improvement or an enhanced life.

RATIONAL APPEALS

These are the systems that were created to satisfy the logical or practical demands of the mass. These are typically linked to sane consumer behavior. Advertisements with justifiable appeals are very educational. The various objective appeals are as follows:

This is done using a method that involves looking at at least two different brands. Typically, a brand will contrast its product with a similar offering from a rival brand in order to show that his product has at least one advantage over the rival’s product.

Value appeal: In this case, the item’s price or value is given first priority. These tactics are more frequently used during the busy seasons, when businesses take into account certain discounts, so enhancing the availability of their goods. Additionally, this is how retailing businesses publicize their promotions and deals. Bharati Axa Life Insurance, which provides affordable term protection, is the model to be used.

The process of drawing consumers’ attention to specific claims or news about a

product is known as news appeal. This is also used to highlight new products on the market and let customers know about specific changes made to the product's present highlights. The name change of Hutch to Vodafone is the most commonly used illustration.

Prevalence appeal: Promotion offices employ this appeal when a message or piece of information needs to be coordinated with a sizable number of people. Here, they give customers information on the product's popularity, such as the number of people who have moved from their more well-known item to this one, the number of national experts who endorse it, or the ranking the product has on the lookout.

OBJECTIVE OF THE STUDY

1. To consider the effect of social appeal versus emotional appeal public relations on brand image.
2. To dissect the appropriateness of social appeal marketing in an Indian context.

RESEARCH METHODOLOGY

We use a scenario-based quasi-experimental strategy to investigate the complex nature of this problem. One study is conducted with limited involvement (sunscreen) and the other with heavy involvement (laptop). Experiment investigated the impact of various advertising appeals (two rational and two emotional appeals) on consumer purchase behavior and advertising attitude for sunscreen, and experiment clarified the impact of various advertising appeals (two rational and two emotional appeals) on the aforementioned variables for laptops.

Table 1. One-Sample Test

		Test Value = 3.5			
Advertising Attitude	Mean	Standard Deviation	t	Df	Sig. (2-tailed)
Emotional Appeals	5.1275	.90526	16.080	79	.000
Rational Appeals	4.1113	1.37932	3.964	79	.000
a < 0.05					

Table 2. Rational and Emotional Appeals on Advertising Attitude: T-Test For Equality Of Means levene's Test For Equality Of Variances

	F	Sig.	t	df
Advertising attitude a < 0.05	12.905	.000	5.509	136.406

In order to compare the impact of rational and emotional arguments on advertising attitude, a T-test was initially performed (see Table 1). There is statistical significance ($P = 0.000, 0.05$) for both emotional and intellectual appeals. According to the findings, intellectual and emotional factors strongly influence how consumers feel about advertisements for minimal participation items.

For H2, a T-test was done to compare how advertising attitudes were affected by emotional versus intellectual arguments. Levene's test for equality of variances is significant, as shown in Table 2, indicating that there are substantial differences between rational and emotional appeals on advertising attitude ($F = 12.905, p = 0.000$). According to Table 1, the emotional appeal's mean was (5.1275), which is higher than the rational appeal's (4.1113). This indicates that stronger advertising attitudes for this product were a result of emotional appeal. As a result, H2a endorsements and emotive appeals have a greater beneficial impact on attitudes toward advertising than do rational ones.

ANOVA post-hoc comparison was used to compare the impact of various advertising pitches. Table 3 demonstrates that there is a significant difference between the appeal to fear and the appeal to quality (0.000 0.05). As a result of the positive upper and lower bound. Quality appeal has less of an impact than fear appeal. Additionally, there is a significant distinction between quality appeal and informational appeal as well as pleasure appeal (0.000, 0.13 0.05). Informational and quality appeal have less of an impact than pleasure appeal. Therefore, H2b is in favor of and there is a notable difference in the appeals to fear, pleasure, knowledge, and quality in advertising.

Table 3. Anova Result And Multiple Comparison Between Appeals With Advertising Attitude

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	49.673	3	16.558	12.498	.000
Within Groups	206.677	156	1.325		
Total	256.350	159			

Together, Study findings showed that both rational and emotional appeals significantly affect advertising attitudes and purchase intentions. Emotional appeals have a greater impact on advertising attitudes toward low involvement products than rational arguments do, even if both have an impact on forming advertising attitudes. In addition, compared to other emotional appeals, pleasurable and frightening emotional appeals have the greatest influence on advertising attitudes. In the end, all hypotheses are confirmed.

Table 4. One-Sample Test

		Test Value = 3.5			
Advertising Attitude	Mean	Standard Deviation	T	df	Sig. (2-tailed)
Emotional Appeals	3.8407	1.45308	4.588	79	.000
Rational Appeals	4.6850	1.57248	9.584	79	.000

Together, study findings showed that while rational appeals have a more dramatic impact on the advertising attitudes of high involvement products, emotional appeals have a more significant impact on creating those attitudes. Additionally, compared to other emotional appeals, the pride appeal has fewer significant effects on the advertising attitude. In the end, all hypotheses are confirmed, with the exception of hypothesis, which is partially confirmed because there were no substantial disparities between the other appeals.

CONCLUSION

Television advertising has changed the communication landscape, making it easier than ever to have a significant impact on a large number of people. Television commercials play a crucial role in influencing consumers' purchasing habits. Advertising is common because the consumer is connected to the media and plans to binge it. Advertising has evolved into a powerful tool that brands may use to influence consumers and enhance their perception of the company. This study aims to understand and analyze how social appeal marketing affects consumers' perceptions of brand persona and buy intent. The increased interest of publicists in social appeal marketing, a budding and inventive trend in the advertising communication sector, points to the need for more research in this area. The results of momentum study have considerably improved the way social appeal promotion is currently set up. In order to show how consumers distinguish between social and emotional appeal in advertising, the analysis created a mathematical model. In conclusion, social appeal advertising offers intriguing shared benefits to the parties engaged, indicating that this public relations technique has a wide and effective reach in India. Appropriate cause-and-effect correlations and efficient application of this strategy may boost profits to the point where

behavior is altered in order to promote cultural inclusiveness and brand esteem. Additionally, considering today's fierce competition and businesses' desire to give back to society, advertising's social appeal ends up being a more effective strategy of publicizing than any other. The current evaluation research has added to the body of information already available in this field and shown areas that need further investigation in order to lay a solid foundation for the application of this technique.

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IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH PARAMETERS OF TURNIP UNDER WESTERN UTTAR PRADESH CONDITIONS

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ABSTRACT

The present experimental work was conducted during the year 2018-19 on turnip cv. Purple Top White Globe to ascertain the effect of integrated nutrient management on growth parameters. The field experiment was conducted at Horticulture Research Farm, Department of Horticulture, Chaudhary Charan Singh University, Campus, Meerut, Uttar Pradesh, India. The experimental field was laid out in randomized block design (RBD) and replicated three times. The treatments involved in the study were eight in numbers i.e. T₁ Control (No fertilizers), T₂ (RDF (120 : 60 : 60) NPK Kg/ha), T₃ (Farm yard manure @ 24 tonnes/ha), T₄ (Vermicompost @ 6 tonnes/ha), T₅ (75%RDF + Farm yard manure @ 6 tonnes/ha), T₆ (75%RDF + Vermicompost @ 1.5 tonnes/ha), T₇ (50%RDF + Farm yard manure @ 12 tonnes/ha), T₈ (50%RDF + Vermicompost @ 3 tonnes/ha). All variable parameters regarding growth attributes were significantly influenced by various combinations of organic and inorganic fertilizers. The present investigation results indicated that application of 50%RDF + Vermicompost @ 3 tonnes/ha gave maximum vegetative growth viz., plant height (39.95cm), number of leaves per plant (17.3), leaf length (38.49cm), fresh weight of plant with root (305.13g), dry weight of plant with root (28.20g), fresh weight of plant without root (114.15g), dry weight of plant without root (16.00g) and yield (277.84q/ha) as compared to other treatments.

Keywords: Turnip, INM, NPK, FYM and Vermicompost

INTRODUCTION

Turnip (*Brassica rapa*; 2n = 20) is a delicious root vegetable crop and one of the most important members of the family Cruciferae. It is extensively cultivated in Bihar, Haryana, Himachal Pradesh, Punjab, Uttar Pradesh and Tamil Nadu. Turnip roots are fleshy thicken underground portion of turnip is actually swollen hypocotyls. The short day length and cool weather favour

proper development of roots, but warm temperature adversely affect root quality and root become woody. The balance consumption of turnip improve heart health, blood circulation and fight against inflammation due to good source of vitamin C and vitamin A. It also helps to boost immune system. As per a study published in International Journal of Cancer (IJC) during 2003, breast cancer risk can reduce by the consumption of Chinese

white turnip. Turnip also helps in bone growth and is used to treatment for visual impairments. Turnip syrup strengthens memory power (6). Purple Top White Globe is an important high yielding variety of turnip. This variety is suitable for growing during *Rabi* season. The roots of this variety are round, bright purple on top, and lower half creamy white. The flesh is white, firm, crisp and mildly sweet in taste.

Integrated nutrient management (INM) strategy is depend on use of judicious combinations of organic, inorganic and biofertilizers. Integrated nutrient management helps to maintain soil health, increase crop productivity and preserves soil productivity for future generation. One of the most important way to increase production of turnip and quality is nutrient management. Although several agronomic factors affect turnip production but the optimum level of organic manures and inorganic fertilizers are the most necessary factors affecting the production and productivity of turnip.

Chemical fertilizers help in increasing the vegetative growth of plants because of the quick availability of the nutrients to the plants. Nitrogen fertilizers are widely adopted to increase crop yield. The organic materials like farm yard manure, crop residues, green manure and vermicompost are commonly used to improve soil condition and soil fertility status reported by several scientists. (8) reported that Organic manures enhance micro and macro nutrient elements in the soil which play an essential role in the plants growing and development, in biosynthesis of the organic substances. Proper nutrient supply through the organic and inorganic fertilizers in turnip plants can inspire the vegetative growth and yield.

METHODS AND MATERIALS

The present investigation was conducted at Horticultural Research Farm, Department

of Horticulture, Ch. Charan Singh University campus, Meerut (U.P.) India, during the year 2018 – 2019. The topography of the field on which the experiment was conducted fairly uniform. The soil of experimental field was well drained, sandy loam and good in nitrogen phosphorus and potassium levels but low in the organic carbon. The treatments involved in the study were eight in numbers *i.e.* T₁ Control (No fertilizers), T₂ (RDF (120 : 60 : 60) NPK Kg/ha), T₃ (Farm yard manure @ 24 tonnes/ha), T₄ (Vermicompost @ 6 tonnes/ha), T₅ (75%RDF + Farm yard manure @ 6 tonnes/ha), T₆ (75%RDF + Vermicompost @ 1.5 tonnes/ha), T₇ (50%RDF + Farm yard manure @ 12 tonnes/ha), T₈ (50%RDF + Vermicompost @ 3 tonnes/ha). The experiment was laid out in Randomized Block Design and each treatment replicated three times. All the organic manure and chemical fertilizers were applied as per treatment. Farm yard manure and vermicompost were applied treatment wise before one week of sowing. Half of the recommended nitrogenous fertilizers was applied as basal dose as per treatment and remaining half dose of nitrogen in two split doses. Phosphate and potassium fertilizers were applied as basal dose during the final preparation of field before the seed sowing. The seeds of turnip cv. Top White Globe were sown by hand dibbling method on 30 cm high ridge by maintaining row to row distance of 45 cm and plant to plant 15 cm. The data on related growth parameters namely: plant height (cm), number of leaves per plant, leaf length (cm), fresh weight of plant with root (g), dry weight of plant with root (g), fresh weight of plant without root (g), dry weight of plant without root (g) and yield (q/ha) were recorded for the analysis. Five plants were randomly selected from each replication to record the data of above mentioned parameters. Appropriate standard and uniform cultural practices viz. irrigation, weeding, thinning, earthing-up etc. and plant protection measures were adopted for raising healthy

crop. The data recorded during the course of investigation were statistically analyzed by using analysis of variance (ANOVA) technique (Fisher, 1958) for drawing conclusion.

RESULTS AND DISCUSSION

Vegetative growth parameters are to be considered as important traits for biomass production. All the vegetative parameters *viz.*, plant height, leaf length, number of leaves per plant, fresh weight of plant, dry weight of plant, and yield were significantly influenced with the various treatments of integrated nutrient management. The present investigation clearly indicated that maximum plant height (39.95 cm), leaf length (38.49cm), and number of leaves per plant (17.3), were observed with T₈ (50%RDF + Vermicompost @ 3 tonnes/ha) which was found statistically higher than all other treatments. These findings of the study confirmed with the findings of (10), (9), (11) and (7). This positive response in vegetative parameters might be due to the integrated effect of chemical fertilizers and organic manures. Chemical fertilizer when apply in soil, they are fast release and available to plant for initiation of growth of seedling. Better supply of nitrogen and organic carbon through optimum mineralization due to presence of organic sources of nutrients. Organic manure such as vermicompost and FYM promote nitrogen fixation and microorganism activity which help to provide nitrogen for manufacturing food through the photosynthesis reaction. Better moisture holding capacity, supply of micronutrients and availability of major nutrients in soil due to favorable conditions created by vermicompost. Vermicompost is one of the best organic manure which contains growth promoting hormones (3). The soil enriched with vermicompost provides the additional substances that are not found in chemical fertilizers (1) are responsible for high vegetative growth.

Similarly, the maximum fresh weight of plant with root (305.13g), dry weight of plant with root (28.20g), fresh weight of plant without root (114.15g), dry weight of plant without root (16.00g) and minimum number of days taken to harvest (61.33) were recorded under soil application of treatment T₈ (50%RDF + Vermicompost @ 3 tonnes/ha) which was found statistically higher over all other treatments. It also seams from the experiment study that vermicompost had more positive impact to increase the fresh weight of plant with root and without root, dry weight of plant with root and without root as compared to farmyard manure. These findings are in closely comparison with findings of (9) and (7). Integrated nutrient use of half dose of compost and half dose NPK by chemical fertilizer increase fresh weight of root, dry weight of root and yield of radish crop has been reported by (5). This might be due to better nutrient elements present in the root zone for growth and development of the plant. (2) reported that use of organic sources of nutrients such as vermicompost in INM options induced better root system of potato resulting greater uptake of nutrients than sole application of chemical fertilizers. N, P and K are considered as major nutrients required for maintaining proper metabolism of the plant. Besides this, nitrogen is the main constituent of protoplasm, nucleic acids, amino acids, proteins, chlorophyll and other metabolic products. Phosphorus is an important constituent of nucleic acid, and phytin. Phosphorus at early stage of growth may be involved in stimulation of root system through efficient translocation of certain growth stimulating compounds formed on account of protoplasmic leading to better absorption of nitrogen and other nutrients and their utilization. The addition of vermicompost to the soil increases water-holding capacity and beneficial microbial activity in the soil.

integrated nutrient management treatments on vegetative parameters of turnip (*Brassica rapa* L.). cv. Purple Top White Globe

Treatments	Notation	Plant height (cm)	Number of leaves per plant	Leaf length (cm.)	Fresh weight of plant with root (g)	Dry weight of plant with root (g)	Fresh weight of plant without root (g)	Dry weight of plant without root (g)	Number of days taken to final harvest
Control (no fertilizers)	T ₁	29.24	14.56	28.60	212.39	21.48	81.20	10.87	90.66
RDF (120 : 60 : 60) NPK Kg/ha	T ₂	34.07	15.82	34.60	268.67	25.35	97.17	13.77	82.66
Farm yard manure @ 24 tonnes/ha	T ₃	35.13	15.93	35.50	282.33	25.49	106.44	13.86	76.00
Vermicompost @ 6 tonnes/ha	T ₄	35.93	16.06	35.96	289.01	25.57	107.76	13.96	75.00
75%RDF + Farm yard manure @ 6 tonnes/ha	T ₅	36.66	16.33	36.32	291.65	25.69	108.63	14.41	72.66
75%RDF + Vermicompost @ 1.5 tonnes/ha	T ₆	38.26	16.73	37.51	298.13	26.69	111.12	15.29	67.33
50%RDF + Farm yard manure @ 12 tonnes/ha	T ₇	37.2	16.66	36.65	294.26	26.25	110.25	14.48	70.33
50%RDF + Vermicompost @ 3 tonnes/ha	T ₈	39.95	17.3	38.49	305.13	28.20	114.15	16.00	61.33
CD at 5%		1.07	0.57	0.91	3.08	1.47	2.26	0.70	3.21
SEm (±)		0.35	0.18	0.29	1.00	0.48	0.73	0.23	1.05

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ANALYZING THE EFFICIENCY OF PHOSPHATE SOLUBILIZING BACTERIA (*PSEUDOMONAS*) ISOLATED FROM RHIZOSPHERE SOIL ON THE GROWTH OF *VIGNA RADIATA* L.

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ABSTRACT

Phosphate Solubilizing Bacteria (PSB) present in the rhizosphere play a vital role in increasing the bioavailability of soil phosphate for plant through solubilization and mineralization. The present study aimed at analysing PSB from different rhizospheres and testing isolates on growth of mung bean plant at different medium with the future prospects. PSB were isolated by spread plate technique using Pikovskaya's medium (PVK) and further identified using appropriate biochemical test. Pot experiments were using for green gram plant rhizosphere soil to determine the efficiency of the isolated PSB on growth of mung bean. The total number of 6 microbial isolates with halo-zone of phosphate solubilization more than 5mm were isolated from the various rhizosphere soils samples. All of the 6 isolates showed in the efficiency to phosphate solubilizing bacteria (*Pseudomonas*). All over the results were significantly. Therefore, they can be used as biofertilizer to enhance the availability of P in the soil and improving the efficiency of mung bean and other crops as like black gram, pea and gram.

Key words: Soil, PSB, *Vigna radiata*, efficiency

INTRODUCTION

Mung bean (*Vigna radiata* L.) is one of the most widely cultivated legume crops after Chickpea and Pigeon pea. It is native to India and Central Asia. The major pulse producing states in India are Andhra Pradesh, Orissa, Maharashtra, Madhya Pradesh and Rajasthan accounting for 70% of total production (11). It has been grown in these regions since prehistoric times and as an important legume crop in India throughout

the year (14). As a low input, short duration, high value crop, mung bean fits very well into rice, wheat cropping system and in other crop rotations. While green gram cultivation spread over to many countries, especially in tropical and sub-tropical Asia, the progenitor of this pulse is believed to be *Vigna radiata* (L.) which grows wild in India (8). Pulses are mostly grown in two seasons Kharif and Rabi. Mung bean (*Vigna radiata* L.) is one of the protein rich major pulse crops. Mung bean is a popular pulse in the diet and consumed in

combination with cereals because it is easily digestible, free from flatulence, rich in protein and iron and easy to cook (2).

Phosphorous play a key role in balanced nutrition of plants. Indian soils having rich chemicals, that cannot be absorbed by plants (12). Phosphate solubilizing micro-organisms are a group of organisms that convert the unavailable forms of phosphorous to available forms in the soil (3). An important group of PSB which includes several genera like *Pseudomonas*, *Bacillus*, *Serratia* etc. PSB isolates play an important role in making the P available to crop plants and thereby increase the growth of crop plants (6). These organisms in addition to supplying soluble P to plants also facilitate the growth of plants by several other mechanisms. For instance, improving the agricultural yield in harmony with ecological concerns, improving the uptake of nutrients and stimulating the production of some phytohormones (10). PSB are likely to serve as an efficient bio-fertilizer especially in areas deficient in P to increase the overall performance of crops by playing a vital role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and several other processes in plants.

MATERIALS AND METHODS

Collection of Sample:

The soil samples were collected from depth of 6-15cm from different location of Department of Pathology and Microbiology, Sardar Patel University of Agriculture and Technology, Meerut. Samples were collected from rhizosphere of plant like, green gram, black gram, gram, pea.

Efficiency of phosphate solubilizing bacteria:

Present study has been carried out by performing an experiment of halo zone formation around the bacterial growth after

inoculated on Pikovskaya's agar and incubated for 24hr and 48hr at 28°C continuous observation, indicates phosphate solubilizing ability which observed by checking diameter of zone which were in increasing order at every day incubation. The zones were found phosphate solubilization efficiency. **Table 1 and Figure 4** shows the efficiency of PSB in 6 different samples.

$$\text{PSE\%} = \frac{\text{Solubilizing diameter (mm)} - \text{Colony diameter (mm)}}{\text{Colony diameter (mm)}} \times 100$$

RESULTS AND DISCUSSION

In the present study, the collected soil samples were evaluated for Phosphate solubilizing efficiency in PVK agar plates. After 7 days of incubation, isolates showed good clear halo-zone of solubilization on solid PVK medium. Similar finding has been reported by 9) Phosphate solubilization efficiency of the isolates was confirmed by quantitative analysis of available phosphorus in the PVK medium (Table 1). All the isolated micro-organisms solubilized tri-calcium phosphate (TCP) though they increased in their ability and the growth period for highest phosphate solubilizing efficiency (PSE). Among the isolates *Pseudomonas* sp. shows highest PSB efficiency. The phosphate solubilization ability of the isolated micro-organisms increased from 40%-76.9%. On the basis of the halo-zone and isolate diameter PSE % was calculated and shows maximum PSE% PSB3, PSB4, PSB5 and PSB6 isolates and minimum efficiency % was shown by PSB1 in agar plates. The PSE measurement was shown in the **Table 1** (13). The capacity of bacterial isolates to solubilize phosphate depends upon the zone of their origin. The large number of Phosphate solubilizing bacteria efficiency observed in the rhizosphere region might be due to the favourable influence of root exudates, containing amino acids, organic acids, sugars,

growth promoting substances. All strains significantly increased soil available P and crop growth. The increase in growth may be attributed to auxin production (5), phosphate solubilising efficiency (Naik et al., 2008), production of organic acids (4). Previous studies have shown that *Pseudomonas* sp. enhanced phosphate solubilising efficiency (1).

Table 1. Estimation of phosphate solubilizing bacteria by measurement of clear zone formation around their colony on Pikovskaya's agar medium

S. No.	PSB isolates	Solubilizing diameter (mm)	Colony diameter (mm)	Solubilizing efficiency (%)
1.	PSB 1	2.1	1.5	40
2.	PSB 2	2.5	1.7	47
3.	PSB 3	2.7	1.8	50
4.	PSB 4	2.1	1.4	57.1
5.	PSB 5	2.6	1.6	62.5
6.	PSB 6	2.3	1.3	76.9

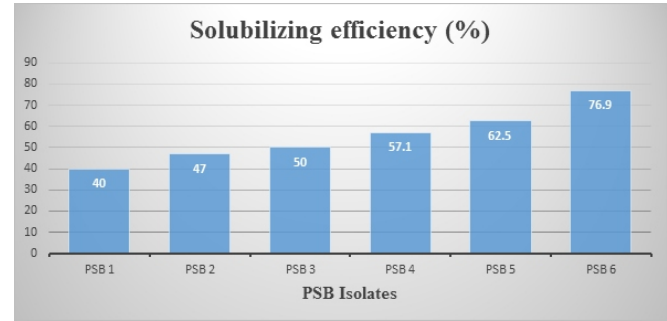


Figure 1: PSB Solubilizing Efficiency shows in percentage



Figure 2: PSB isolates from rhizosphere soil in green gram

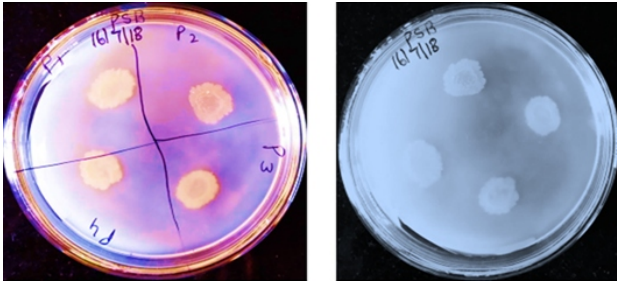


Figure 3: Phosphate solubilization by PSB Bacteria

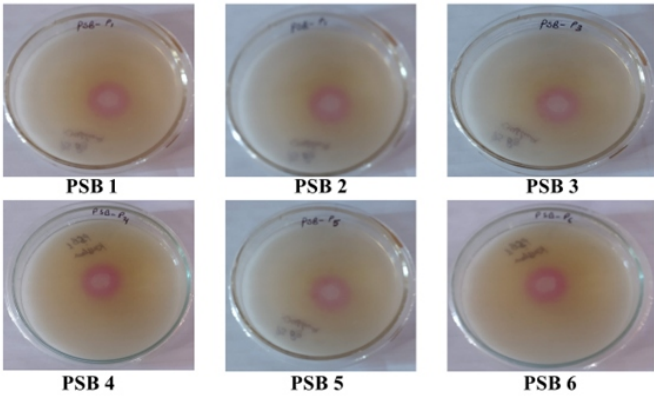


Figure 4. Efficiency of Phosphate solubilizing bacteria (*Pseudomonas*) on PVK medium

CONCLUSION

It may be concluded that the present study Phosphate solubilizing bacteria isolates were effective in solubilizing phosphate in the soil. The PSB (*Pseudomonas*) increased the higher phosphate solubilization efficiency. This biofertilizer enhanced the efficiency of phosphorus fertilizer in the soil for green gram plant production. Additionally, phosphate-solubilizing micro-organisms support plant growth by increasing the efficiency of nitrogen fixation. These Phosphate solubilizing bacteria (*Pseudomonas*) can be applied in the form of biofertilizer to promote sustainable agriculture as well as to improve world food production and environmental conditions.

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EFFECT OF PLANT BIOREGULATORS ON VEGETATIVE GROWTH PARAMETERS OF OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) CV. ARKA ANAMIKA

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ABSTRACT

A field experiment was conducted during the year 2019 on okra cv. Arka Anamika to ascertain the effect of different plant bioregulators on growth and yield parameters. The field experiment was carried out at Horticulture Research Farm, Department of Horticulture, Chaudhary Charan Singh University, Campus, Meerut, Uttar Pradesh, India. The experimental field was laid out in randomized block design (RBD) and replicated three times. The treatments involved in the study were ten in numbers viz. T₁ Control (distilled water), T₂ (NAA @ 50 ppm), T₃ (NAA @ 100 ppm), T₄ (NAA @ 150 ppm), T₅ (IAA @ 50 ppm), T₆ (IAA @ 100 ppm), T₇ (IAA @ 150 ppm), T₈ (GA₃ @ 50 ppm), T₉ (GA₃ @ 100 ppm) and T₁₀ (GA₃ @ 150 ppm). All variables parameters regarding growth attributes were significantly influenced by foliar application of different plant bioregulators. Results revealed that among all the treatments, the foliar application of GA₃ @ 150 ppm gave the better effect on vegetative parameters viz. plant height (146.56 cm), leaf length (16.90 cm), leaf width (17.10 cm), root length (31.66 cm), number of leaves per plant (28.46), number of branches per plant (4.80), number of nodes main stem per plant (31.30), fresh weight of plant (342.33 g), dry weight of plant (100.33 g), fruit yield (159.11q/ha) as compared to other treatments. However, maximum root length (31.66 cm) was recorded under the foliar application of IAA @ 150 ppm.

Keywords: Okra, growth, NAA, IAA, and GA₃

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is one of the most important and popular fruit vegetable in India. Okra is frequently known as Bhindi or Lady's Finger. It is an important warm season and rainy season crop which is cultivated in tropical and subtropical Africa (2). In the world, India has occupied largest area and production followed by the Nigeria. In India, okra is cultivated in an area of 509

thousand hectares with an annual production of 6095 thousand tonnes. Leading okra producing states in India are Gujarat, West Bengal, Bihar, Madhya Pradesh, Odisha, Chhattisgarh and Uttar Pradesh (1).

Okra is a short duration crop. Its green tender fruits are used as cooked vegetable. It is also used in curry and soup, dehydrated or frozen forms for off-season consumption (13). Its mature fruits, stems and roots are used in

paper industry and clearing sugarcane juice for jiggery making (2). Its ripe roasted seeds used as a substitute for coffee in Turkey (12). Okra is used in curing diabetes, chronic dysentery and genitor urinary disorder (14).

In India, okra has occupied a prominent position among the export oriented vegetables because of its high nutritive value and good palatability. It has an enormous potential as the foreign exchange earner crops and accounts for 70 per cent of the export of fresh vegetables (5). At present, it is being exported to the neighboring countries *viz.* Gulf and South-East Asia, particularly Singapore, Mauritius, Malaysia, Sri Lanka and Bangladesh.

Vegetative growth of vegetables can be increased by various ways such as proper nutrient management, use of high yielding varieties, better use of agronomical practices etc. But at the same time by considering all these factors constant, growth and yield of vegetable can be also increased by using plant growth regulators. Many researchers reported that plant growth regulators play a vital role in growth and development of plants. Plant growth regulator can modify plant physiological process using in small amounts and plays an essential role in plant growth and development, elongation and flower development (10 and 21).

Naphthalene acetic acid (NAA) is a synthetic form of auxin that plays key role in cell elongation, cell division, vascular tissue, differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, prevent fruit dropping, promote flower sex ratio and flowering in various crops (6, and 3). Naphthalene acetic acid (NAA) is also a potential antifungal agent (13).

Plants produce natural auxin such as Indole-3-acetic acid (IAA). Natural auxin is found in growing stems and roots from where they migrate to their site of action. Some observations on natural levels of auxin

protectors might suggest that, their low levels are coupled with root initiation, but high levels with root growth. Indole-3-acetic acid (IAA) can also be synthesized artificially in laboratory, which is used as exogenously application, for regulating growth and development of various vegetable as reported by many researchers.

Gibberellin plays an important role in elongation, bolting and flowering. Probably, the most conspicuous and well known effect of GA₃ is stem elongation. Gibberellins are noted for their ability to overcome dwarfism in plants allowing compact plants to develop heights. Based on various observations, researchers believe that gibberellins play a major role in cell division and cell elongation in plants. (4) reported that foliar application of GA₃ had positive impact on vegetative and reproductive parameters of okra *viz.*, plant height, number of leaf and pod yield etc. So, keeping in view the above facts in mind, the present investigation was carried out to analysis the effect of plant bioregulators on okra (*Abelmoschus esculentus* L. Moench).

METHODS AND MATERIALS

The experiment was carried out during 2019 at the Horticultural Research Farm, Department of Horticulture, Chaudhary Charan Singh University Campus, Meerut, Uttar Pradesh. The climate of this track is humid subtropical and characterized by hot summers. The topography of the field on which the experiment was conducted fairly uniform. The soil of experimental field was good in nitrogen phosphorus and potassium levels but low in the organic carbon. The experiment was laid out in randomized block design with three replications. A total number of ten treatments *viz.* T₁ Control (distilled water), T₂ (NAA @ 50 ppm), T₃ (NAA @ 100 ppm), T₄ (NAA @ 150 ppm), T₅ (IAA @ 50 ppm), T₆ (IAA @ 100 ppm), T₇ (IAA @ 150 ppm), T₈ (GA₃ @ 50 ppm), T₉ (GA₃ @ 100 ppm) and T₁₀ (GA₃ @ 150 ppm)

were involved in the study. Two sprays of each treatment were applied at 30 and 60 days after sowing with hand sprayer. Okra cultivar Arka Anamika was used in the experiment. The harmonized seeds of okra were sown treatment wise by hand dibbling method and maintain 45 cm distance between row to row and 30 cm distance between plant to plant. The data on related growth parameters namely: plant height (cm), leaf length (cm), leaf width (cm), root length (cm), number of leaves per plant, number of branches per plant, number of nodes on main stem, fresh weight of plant (g), dry weight of plant (g), root length (cm) and fruit yield (q/ha) were recorded for the analysis. Six plants were randomly selected from each replication to record the data of above mentioned parameters. The data recorded during the course of investigation were statistically analyzed by using analysis of variance (ANOVA) technique (7) for drawing conclusion. Appropriate standard and uniform cultural practices viz. irrigation, weeding, thinning, earthing-up etc. and plant production measures were adopted for raising healthy crop.

RESULTS AND DISCUSSION

A perusal of data revealed that application of plant bioregulators significantly affected the vegetative growth attributes of okra. It was observed that the plant height was significantly increased by various treatments of plant bioregulators. Maximum plant height (146.56 cm) was recorded under T₁₀ (GA₃ 150 ppm) followed by T₉ (GA₃ 100 ppm). The minimum plant height (111.16 cm) was observed under control treatment. Similarly, the maximum leaf length (16.90 cm) and leaf width (17.10 cm) were recorded under the foliar application of GA₃ at the rate 150 ppm which was found statistically at par with GA₃ at the rate 100 ppm. Foliar application of IAA also showed good response for increase leaf

length and leaf width as compared to NAA. In case of NAA a lower concentration that is NAA @ 100 and 50 ppm performed better as compared to higher one i.e. NAA @ 150 ppm. The findings are also in the line of the findings of (4) who evaluated the impact of foliar application of bioregulators on the vegetative parameters of okra cv. Prabhani Kranti reported maximum leaf length (27.35 cm) and leaf width (21.56 cm) under the foliar application of GA₃ @ 75 ppm.

In the present findings the plant bioregulators significantly influenced root length. The maximum root length (31.66 cm) was found under foliar spray application of IAA @ 150 ppm, which was statically at par with GA₃ @ 150 ppm (30.16 cm) and IAA @ 100 ppm (30.00 cm). The increase in root length might be due to the effect of auxins (IAA) as establish root primordial and for increase the total root length. This statement is confirmed with the statement of (19) who reported that IAA promotes root initiation and induces both growth of pre-existing roots and adventitious root formation. Since, auxins has a tight connection with the root development, IAA may regulate root elongation through regulation of glutathione content in tomato seedling reported by (18).

Among different treatment of plant bioregulators, more number of leaves per plant (28.46), number of branches per plant (4.80) and number of nodes main stem per plant (31.30) were obtained with the foliar spray of GA₃ @ 150 ppm, which was found statistically similar with T₉ (GA₃ @ 100 ppm). These findings are closely conformed with the findings of (11), who reported maximum number of leaves per plant (49.00) and maximum number of branches (5.50 per plant) under the application of GA₃. Similarly, (9) recorded the maximum number of branches per plant (3.10) and maximum number of nodes per plant (25.85) under the application of GA₃ @ 150 ppm. The possible reason for the

initiation of more number of leaves, number of nodes and number of branches per plant might be due attributed to high metabolic activity and precise pattern of the epidermal cells of the developing leaf which controlled by the accumulation of auxins and gibberellic acid in plant. (8) reported that gibberellic acid stimulate the activity of the sub-apical meristem during new growth and the apical meristem during vegetative bud development. GA₃ and auxins help to increase the number of branches and number of nodes reported by (15).

In the present observation fresh weight per plant and dry weight of plant were also significantly influenced by foliar application of plant bioregulators. The significantly maximum fresh weight per plant (342.33 g)

and dry weight of plant (100.33 g) were recorded under foliar spray application of GA₃ @ 150 ppm, which was found statistically similar with the GA₃ @ 100 ppm (324.93 g). The findings of the study confirmed with findings of (4) reported that twice foliar sprays of GA₃ @ 75 ppm gave the maximum fresh weight (365.34 g) and dry weight (61.22 g) of okra cv. Prabhani Kranti.(11) also reported the maximum fresh weight of plant (84.5 g) and dry weight of plant (10.9 g) under the GA₃ @ 150 ppm. The increase in fresh weight and dry weight of plant is directly related to the biomass production by the plant through the process of photosynthesis of uptake of nutrients. GA₃ increased carbohydrate accumulation and dry mater, reported by (16).

Table-1 Effect of plant bioregulators on vegetative growth parameters of okra (*Abelmoschus esculentus* L. Moench) cv. Arka Anamika

Treatments	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Length of root (cm)	Number of leaves per plant	Number of branches per plant	Number of nodes main stem per plant	Fresh weight of plant (g)	Dry weight of plant (g)	Yield (q/ha)
Control (Distilled water)	111.16	13.60	13.73	20.83	24.73	2.80	27.67	202.46	67.70	120.14
NAA @ 50 ppm	136.73	14.06	14.86	23.33	26.00	3.53	30.20	292.36	88.46	148.53
NAA @ 100 ppm	137.86	14.16	14.93	24.16	26.33	3.70	30.56	303.80	92.56	151.56
NAA @ 150 ppm	134.60	13.85	14.40	21.00	25.85	3.20	29.70	281.56	85.53	144.50
IAA @ 50 ppm	118.13	14.23	14.36	27.33	25.20	3.30	29.30	252.26	72.56	134.92
IAA @ 100 ppm	125.63	14.66	15.30	30.00	25.36	3.60	30.00	258.96	76.50	138.86
IAA @ 150 ppm	128.20	15.61	15.96	31.66	25.73	3.80	30.43	272.30	81.60	141.47
GA ₃ @ 50 ppm	139.10	15.13	15.40	26.66	27.46	3.83	29.73	312.46	94.50	151.18
GA ₃ @ 100 ppm	144.06	16.46	16.53	29.66	28.06	4.43	30.73	324.93	96.93	155.96
GA ₃ @ 150 ppm	146.56	16.90	17.10	30.16	28.46	4.80	31.30	342.33	100.33	159.11
CD at 5%	3.081	0.538	0.669	1.805	0.855	0.350	1.865	3.177	1.800	1.689
SEm (±)	1.029	0.180	0.223	0.603	0.286	0.117	0.623	1.061	0.601	0.564

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CLIMATE-RESILIENT AND SUSTAINABLE DEVELOPMENT IN HORTICULTURE: CULTIVATING A GREENER FUTURE

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ABSTRACT

Climate-resilient and sustainable development in horticulture holds immense importance in addressing climate change, ensuring food security, and promoting environmental sustainability. By integrating innovative approaches, such as climate-smart agriculture, vertical farming, and water- efficient practices, the horticulture industry can adapt to climate challenges while minimizing resource consumption. Sustainable development principles, including biodiversity conservation, fair trade practices, and community empowerment, contribute to a more inclusive and equitable agricultural system. Success stories from the Netherlands, Costa Rica, and India highlight the transformative potential of climate-resilient and sustainable horticulture, inspiring further action. By investing in research, collaboration, and market incentives, we can create a greener future and pave the way for a resilient and sustainable horticulture industry. Climate change is a global threat to the food and nutritional security of the world. As greenhouse-gas emissions in the atmosphere are increasing, the temperature is also rising due to the greenhouse effect. The concentration of CO₂, which accounts for a major proportion of greenhouse gases, is increasing at an alarming rate, and has led to higher growth and plant productivity due to increased photosynthesis, but increased temperature offsets this effect as it leads to increased crop respiration rate and evapotranspiration, higher pest infestation, a shift in weed flora, and reduced crop duration.

Keywords: Climate-resilient, climate-smart agriculture; diseases; economics; pest; weeds

INTRODUCTION

In an era defined by escalating climate change concerns and the urgent need for sustainable development, the horticulture sector stands at the forefront of a green revolution. With its potential to address food security, environmental preservation, and economic growth, horticulture plays a pivotal role in shaping a climate-resilient and sustainable future. This article explores the

critical significance of integrating climate resilience and sustainability principles into horticultural practices, highlighting the transformative potential it holds for our planet.

Climate change is a global threat to the food and nutritional security of the world. As greenhouse-gas emissions in the atmosphere are increasing, the temperature is also rising due to the greenhouse effect. The average

global temperature is increasing continuously and is predicted to rise by 2 °C until 2100, which would cause substantial economic losses at the global level. The concentration of CO₂, which accounts for a major proportion of greenhouse gases, is increasing at an alarming rate, and has led to higher growth and plant productivity due to increased photosynthesis, but increased temperature offsets this effect as it leads to increased crop respiration rate and evapotranspiration, higher pest infestation, a shift in weed flora, and reduced crop duration [8]. Climate change also affects the microbial population and their enzymatic activities in soil (9).

The integration of climate resilience and sustainability in horticulture requires a multi-faceted approach. This involves harnessing innovative technologies and research to develop resilient crop varieties, implementing efficient irrigation systems, adopting precision farming techniques, and promoting organic and regenerative agriculture. Furthermore, collaborative efforts among stakeholders, including farmers, policymakers, researchers, and consumers, are crucial in fostering knowledge exchange, capacity building, and the adoption of best practices.

As we confront the pressing challenges of climate change and strive for a sustainable future, investing in climate-resilient and sustainable horticulture becomes imperative. This article delves deeper into the various strategies, success stories, and potential barriers associated with this transformative journey [1]. By recognizing the invaluable role of horticulture and committing to its climate-resilient and sustainable development, we pave the way for a greener and more prosperous future for generations to come.

Mitigation and Adaptation to Climate Change

Farmers' perceptions of climate change's threat and severity have the most important

motivational factor in voluntary mitigation. However, the adaptation depends on the availability of related information. Moreover, there will be a reduction in the number of people exposed to water stress with mitigation strategies, but the remaining people will need adaptation strategies due to their exposure to increased stress. The usage of traditional management systems and agro ecological management systems, namely bio diversification, soil management, and water harvesting, can help farmers adopt climate-resilient technologies. These management practices ensure increased carbon sequestration, increased soil health, increased soil quality and reduced soil erosion, leading to resilient soils and cropping systems, ultimately ensuring food security during climate change. These educational interventions, which focus on local, tangible, and actionable aspects, and could be monitored by individual behavior, are the most successful in providing climate-change education for ecological development. The farmers were basically in support of adaptations, but the GHG reduction is endorsed by only a few, which shows the need to focus on interventions having both the features of adaptation and mitigation [4]. The main adaptation methods of mitigation can be broadly classified into resource-conservation technologies, cropping-system technologies, and socio-economic or policy interventions. Small and marginal farmers are not able to cope with climate change due to less awareness, which makes them more susceptible to losses.

Concept of Climate Resilient Horticulture / Climate Smart Horticulture (CSH)

1. CSH has emerged as a way forward to consolidate and strengthen the climate change adaptation and mitigation regime at the global level.
2. CSH integrates the economic, social and environmental dimensions of sustainable

development by jointly addressing food security and climate change challenges.

3. To be more specific, CSH is an approach to develop the technical, policy and investment conditions to achieve sustainable agricultural development through an integrated approach that is responsive to local conditions.
4. CSH brings together practices, policies and institutions that are not necessarily new but are used in the context of climatic changes, which are unfamiliar to farmers

The Importance of Climate-Resilient Horticulture

Horticulture is the most vulnerable sector to climate change, owing to its huge size and sensitivity to weather parameters, thereby causing huge economic impacts. The changes in climatic events such as temperature and rainfall significantly affect the yield of crops. The effect of rising temperatures, precipitation variation, and CO₂ fertilization varies according to the crop, location, and magnitude of change in the parameters. The temperature increase is found to reduce the yield, while the precipitation increase is likely to offset or reduce the impact of increasing temperature. As influenced by climatic variables when witnessed in Iran, crop productivity depends on adaptation abilities and crop type, climate scenario, and CO₂ fertilization effect.

Climate change poses unprecedented challenges to global food security and agricultural practices. As temperatures rise, weather patterns become more erratic, and extreme events become more frequent, the horticulture industry faces significant risks. However, the adoption of climate-resilient practices in horticulture is crucial for ensuring the availability of nutritious food, sustaining livelihoods, and preserving the environment. Horticulture, which includes the cultivation of fruits, vegetables, flowers, and ornamental plants, plays a vital role in human well-being. Fruits and vegetables are rich sources of essential nutrients, contributing to a healthy

diet and reducing the risk of chronic diseases. Moreover, horticulture provides economic opportunities for farmers, contributes to rural development, and fosters local and global trade. Climate change impacts horticulture in several ways. Rising temperatures can affect crop growth and development, leading to reduced yields and compromised quality. Changes in precipitation patterns and increased water scarcity pose challenges for irrigation, a critical component of horticultural practices. Extreme weather events, such as storms, floods, and droughts, can cause substantial damage to crops and infrastructure. Additionally, pests and diseases can proliferate under changing climatic conditions, affecting plant health and productivity. By adopting climate-resilient practices, horticulture can adapt to the changing climate while minimizing risks and maximizing productivity. Climate-resilient horticulture focuses on strategies that enhance the capacity of plants and farming systems to withstand climate stresses. This includes the use of climate-resilient crop varieties, efficient water management techniques, improved soil health practices, and integrated pest management. Climate-resilient horticulture not only safeguards food production but also contributes to environmental sustainability. By adopting practices that conserve water, reduce greenhouse gas emissions, and promote biodiversity, horticulture can play a crucial role in mitigating climate change. Agroforestry, intercropping, and sustainable soil management practices help sequester carbon and enhance soil fertility, contributing to climate change mitigation. Furthermore, preserving and restoring biodiversity in horticultural systems improves ecosystem services, such as pollination, pest control, and nutrient cycling. The life cycle of pathogens such as *Puccinia striiformis* f.sp. *tritici* is projected to be limited by increasing temperature, while an increase in the

concentration of atmospheric CO₂ is estimated to provide advantageous conditions for *Fusariumpseudo graminearum*. Climate change impacts the geographical distribution and growth rate of populations, along with increasing the number of generations. Climate change can extend the development season of the pests and change the synchronization of crop and pest. It can also increase the risk of migrant pest invasion [6]. The efficiency of plant protection measures such as host plant resistance, natural enemies, transgenic plants, synthetic chemicals, or biopesticides are also likely to be reduced due to climate change.

Sustainable Development in Horticulture

Sustainable development in horticulture involves the implementation of practices that prioritize environmental, social, and economic sustainability. It aims to minimize the negative environmental impacts of horticultural activities while promoting the efficient use of resources, biodiversity conservation, and community well-being. One key aspect of sustainable development in horticulture is resource management. This includes adopting efficient water management techniques, such as drip irrigation, to minimize water usage and reduce the strain on freshwater sources. Additionally, implementing soil health and conservation practices, such as composting and cover cropping, helps maintain soil fertility, prevent erosion, and reduce the need for synthetic fertilizers. Another crucial element is biodiversity conservation. By embracing agro ecology and perma culture principles, horticulturists can create habitat corridors, incorporate native plants, and promote beneficial insects, leading to enhanced biodiversity and ecosystem services. Such practices not only support pollinators but also contribute to natural pest control, reducing the need for chemical interventions. Integrated Pest Management (IPM) is another

key component of sustainable development in horticulture. IPM involves using a combination of cultural, biological, and chemical control methods to manage pests and diseases effectively while minimizing environmental impact. By utilizing natural predators, crop rotation, and resistant crop varieties, horticulturists can reduce reliance on synthetic pesticides and foster a healthier ecosystem. Furthermore, sustainable development in horticulture recognizes the social and economic aspects of the industry. Fair trade practices, responsible sourcing, and supporting small-scale farmers empower local communities and promote equitable economic growth. Education and knowledge-sharing initiatives play a vital role in empowering farmers with sustainable practices and enhancing their productivity and income.

Innovative Approaches and Technologies

As the world faces the challenges of climate change, the horticulture industry is embracing innovative approaches and technologies to ensure climate-resilient and sustainable development. By integrating cutting-edge solutions, horticulturists are finding ways to adapt to changing climatic conditions while minimizing their environmental impact. These innovative approaches hold the key to cultivating a greener and more sustainable future. One of the notable innovations in climate-resilient horticulture is the concept of climate-smart agriculture. This approach combines advanced farming techniques with data-driven technologies to optimize resource efficiency and increase productivity. Precision farming and sensor technologies enable farmers to monitor and manage soil moisture, temperature and nutrient levels, allowing for targeted and precise application of water and fertilizers. Additionally, the use of drones and satellite imagery provides valuable insights into crop health and can help identify areas of stress or disease outbreaks.

Another significant innovation is the development of drought-tolerant and heat-resistant crop varieties. Plant breeders are actively working on developing resilient plant varieties that can withstand extreme temperatures and water scarcity. These new cultivars have the potential to improve yields and reduce the vulnerability of horticultural systems to climate-induced stresses. Through genetic engineering and marker-assisted breeding techniques, researchers are accelerating the development of climate-resilient crops [7].

Vertical farming and controlled environment agriculture are revolutionizing horticulture by enabling year-round production in urban settings. These technologies utilize indoor spaces, such as high-rise buildings or greenhouses, to grow crops under controlled conditions. By providing optimized lighting, temperature, and nutrient delivery systems, vertical farming minimizes the reliance on natural resources and reduces the carbon footprint associated with transportation. It also mitigates the risks posed by extreme weather events and pests, as the crops are grown in a controlled and protected environment.

Water-efficient practices are another crucial aspect of sustainable horticulture. Drip irrigation systems, for example, deliver water directly to the plant roots, minimizing wastage and improving water-use efficiency. Rainwater harvesting and storage systems are employed to capture and store rainfall, ensuring a sustainable water supply during dry periods. Aquaponics and hydroponics, which involve growing plants in nutrient-rich water without soil, further reduce water consumption and enable year-round cultivation [5].

Agro ecology and permaculture are innovative approaches that promote ecological balance and biodiversity conservation in horticulture. By employing natural pest

control methods, such as beneficial insects and companion planting, farmers can reduce the reliance on chemical pesticides and enhance ecosystem resilience. Organic practices, including the use of compost and cover crops, improve soil health, sequester carbon, and minimize the release of greenhouse gases [3]. Ecological landscaping and sustainable urban agriculture initiatives contribute to urban greening and enhance the overall sustainability of horticultural systems. To

Promote sustainable horticulture, it is crucial to establish sustainable supply chains and facilitate market access for farmers. Direct farmer-consumer relationships and short food supply chain ensure fair prices for farmers and reduce the environmental impact associated with long-distance transportation. Certification and labeling schemes for sustainable horticulture products enable consumers to make informed choices, supporting growers who adhere to environmentally friendly practices.

Success Stories and Initiatives

Climate-resilient and sustainable development in horticulture has gained traction worldwide, with numerous success stories and initiatives demonstrating the potential for positive change. These stories highlight the transformative power of innovative practices, technologies, and collaboration in building a more sustainable and resilient horticulture industry.

One such success story is found in the Netherlands, where sustainable horticulture innovation has flourished. In India, community-based organic farming initiatives have taken root, fostering sustainable horticulture practices. These initiatives promote organic cultivation methods, minimizing the use of synthetic inputs and protecting soil health. Through the establishment of farmer producer organizations and market linkages,

small-scale farmers have gained access to fair markets, ensuring economic viability. Women-led initiatives have also played a crucial role in promoting sustainable horticulture and empowering rural communities.

These success stories exemplify the transformative potential of climate-resilient and sustainable development in horticulture. By adopting innovative approaches, fostering collaborations, and empowering farmers, these initiatives not only mitigate climate change impacts but also enhance biodiversity conservation, ensure food security, and promote equitable socio-economic development. These examples serve as beacons of hope, inspiring further action and providing a roadmap for a greener and more sustainable future in horticulture.

CONCLUSION

Climate-resilient and sustainable development in horticulture is not only essential for the future of food production but also for environmental conservation and economic prosperity. By adopting innovative approaches and technologies, implementing sustainable practices, and fostering collaborations across sectors, the horticulture industry can mitigate the impacts of climate change while ensuring the long-term viability of its operations. Governments, international organizations, researchers, farmers, and consumers must collectively work towards creating an enabling environment that supports climate-resilient and sustainable horticulture. Investing in research, providing

technical assistance to farmers, and creating market incentives for sustainable products are key steps in this direction. By cultivating a greener future through climate-resilient and sustainable horticulture, we can pave the way for a more resilient, equitable, and environmentally friendly world.

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INDUSTRIAL INFRASTRUCTURE DEVELOPMENT, ECONOMIC GROWTH AND REGIONAL INDUSTRIAL DISPARITY WITH SPECIAL REFERENCE TO HARYANA

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ABSTRACT

The growth of an economy can be seen as a progression of its many sectors moving upwards from current levels to higher levels of performance. The physical structure of facilities required to offer goods and services to the general public is referred to as infrastructure. Empirical investigations and theoretical analysis have been conducted on infrastructure development and provision. Infrastructure is inextricably related to the growth of the economy. Infrastructure consists of long-term structures that provide economic inputs such as road networks, train facilities, power, schools, colleges, and hospitals, among others. Haryana, following its creation on November 1, 1966, began its development process later than the other states in the country. Infrastructure is viewed as a forerunner or pace setter for economic progress, and it is one of the most important determinants of economic development. Infrastructure can be considered the bedrock or foundation of the economy because of its impact on economic development. A large building, for example, cannot stand on a shaky foundation, and agricultural and industrial development cannot be conceived without adequate and robust infrastructure. Agriculture and industry have a direct impact on a country's or region's growth. If sufficient infrastructure facilities are provided, economic progress becomes easier and faster. For agricultural development, essential infrastructure facilities such as an appropriate supply of water for irrigation, storage and transportation facilities, a well-organized marketing network, financial institutions for short and long-term finance, and relevant information are required. With the use of these facilities, agricultural productivity can be enhanced at a cheaper cost, and production can be more diverse. However, additional production will be useless if it is unable to reach the market. As a result, integrated transportation infrastructure is required to carry agricultural products to local, national, and international markets.

Keywords: Infrastructure, Transportation, Economy, Agriculture, Sectors.

INTRODUCTION

Infrastructure is critical for all countries' development, but notably for underdeveloped countries. Economic and social infrastructure is required for India's development, and it is

urgently needed. To benefit colonial matters, the economic structure that India inherited was designated to some of the favoured industries and Industrial Centers at the time of independence. The pattern and progression

of industrialization also revealed a distorted picture. There was growth in the sector of manufacturing and raw materials, but there was a scarcity of banking institutions, a lack of entrepreneurship, and a lack of transportation infrastructure on the other hand. India's economy possessed the majority of the necessary characteristics of a developing economy. Soon after independence, the Indian government planned to give the economy a 'great push,' which was seen as necessary for achieving economic self-sufficiency and minimizing inter-regional inequities.

Economic development is defined as a process in which the various sectors of the economy progress from their current state to higher levels of performance. Economic development principles have become more comprehensive in recent years. "Development must be understood as a multi-dimensional process comprising changes in structure, attitude, and institutions, as well as acceleration of economic growth, reduction of inequities, and decrease of absolute poverty," remarked M. Todaro in 1977. In essence, development must depict an integrated spectrum of changes via which the state's social structure, individual states, and social groups progress away from sadness and misery, and it must guarantee social justice to all."

Infrastructure is a broad term that refers to the physical framework of facilities that deliver products and services to the general public. Because it directly influences production and consumption, causes positive and negative spillover effects, and involves enormous inflows of expenditure, its economic ties are numerous and complex. Large capital intensive natural monopolies such as motorways, other transportation facilities, water and sewer lines, and communications systems are examples of infrastructure that makes greater economic sense. Infrastructure is defined as the tangible capital stock owned

by the public sector in an alternate version that focuses on ownership (Goel, 2003). Infrastructure stock is divided into economic or physical infrastructure and social infrastructure, according to the World Development Report (WDR, 1994). Electricity, transportation, roads, water systems, communications, irrigation, and other services are included in the former, while education and health facilities are included in the latter. Other types of infrastructure, such as banking and civil administration, can be classified as institutional infrastructure. The term "infrastructure" can be divided into three distinct categories:

1. Physical Infrastructure: consists of transportation, telecommunications, power, irrigation, and other facilities without which an integrated autonomous modern economy cannot function.
2. Human capital's standard of living is represented by social infrastructure, which includes housing, education, public health, sanitation, and drinking water supply, among other things.
3. Financial Infrastructure: covers money and capital markets and represents the spread of monetization and other commercial operations across the region.

NEED OF THE STUDY

Haryana is a state in northern India with a population of 2.5 million people (as per Census of India, 2011). The working population of Haryana is 7015283 (main workers), with 5860600 men and 1154683 women. Haryana has a population of 1901255 marginal workers. In the 1970s, agriculture was the mainstay of Haryana's economy. Agriculture and related industries were the largest contributors to GSDP at the time of formation, accounting for 60.7 percent. However, the economy structure has shifted in 2018-19, with the tertiary sector contributing the most, accounting for 50.2 percent of Haryana's overall GSDP. The secondary sector's contribution has also climbed to 32.3 percent, up from 21.7 percent at the time of creation.

According to the data above, economic and social infrastructure development is critical for economic growth. Economic (transport, storage, communication, trade, hotel, tourism, banking, and insurance services) and social services are included in the tertiary sector (Education, Health and Administration). Many economists have emphasized the need of improving economic infrastructure. Infrastructure is regarded as a requirement for economic growth. Haryana has placed a greater priority on the development of the aforementioned services in order to facilitate the state's rapid economic development. As a result, the state has made symbolic progress in the field of economic infrastructure, but people's wellbeing is dependent on facility construction and distribution. As a result, it is necessary to assess the levels of development of socioeconomic indicators of infrastructure at the state and district levels. Simultaneously, it is necessary to determine the inter-district discrepancies in several infrastructure metrics. We can identify developed, moderately developed, and less developed districts based on many variables. This necessitates taking significant steps to develop policies for improving that specific metric.

SCOPE OF THE STUDY

The study's scope is extremely broad. The study's findings will aid planners, policymakers, academics, and government officials in framing appropriate policy measures that will aid in the development of underdeveloped areas.

Future scholars will be able to use the findings to do more research on the same topic in this way as a result of the study. The Haryana government may also take into account the findings and take required steps toward the development of less developed regions in order to eliminate inter-district gaps in various economic and social infrastructure indices.

OBJECTIVES OF THE STUDY

Following are the objectives of the present study.

1. To examine the growth of industrial infrastructure development facilities over time.
2. To examine inter-district disparities in industrial infrastructure development in Haryana.

REVIEW OF LITERATURE

(1) researched the social infrastructure development in Assam on state as well as district level variations. The Composite Index was built for thirty factors for delivering ranks to the districts based on index value. Principal Component Analysis was used for data reduction. It was hypothesised that there was no significance difference in social infrastructure development among the districts of Assam. But this hypothesis was found incorrect because widespread disparities were found in the districts of concerned state. The area of Assam suffered drastically from migration and districts were diversified geographically and in context of natural boundary, religion, ethnicity and population.

(2) attempted to study the role of economic and social infrastructure in economic development of Punjab. Multiple regression models were used to find the impact of social and economic infrastructure on NSDP per capita. Secondary data sources had been used from 2000-01 to 2015-16 for NSDP per capita. It was found that significant impact of economic and health infrastructure index existed on economic development of state. But education infrastructure index didn't impact much on economic development. Health infrastructure growth was found negative during study period; this indicated that the state needs to work towards health infrastructure. It was recorded that economic infrastructure had shown better growth than social infrastructure.

(3) One of the most important components in driving economic growth is infrastructure. Economic growth will be good and stable in a location with adequate infrastructure. As one of the disaster-prone areas, West Nusa Tenggara Province faces considerable development challenges, particularly in terms of infrastructure and economic growth. The economy of West Nusa Tenggara Province has experienced a significant contraction to a negative value following the disaster in 2018. As a result, the purpose of this study is to use panel data analysis to examine the prospects for infrastructure development in the province of West Nusa Tenggara in order to improve economic growth. The findings demonstrate that power, water infrastructure, schools, health facilities, and capital spending all have positive and significant benefits on economic growth, whereas road length has no such effect. The non-mining and non-quarrying sector must be prioritised in efforts to improve economic growth and infrastructural development. In addition, areas with a high earthquake risk should consider building earthquake-resistant infrastructure. It is necessary to improve the quality of the road rather than the quantity.

(4) Equitable development is being pursued through rapid infrastructure development and the provision of high-quality infrastructure facilities and services. The government continues to stimulate the improvement of deteriorated infrastructure in order to boost economic growth, particularly in places where access is limited. The goal of this research is to examine the impact of infrastructure development on Papua Province's economic growth. Panel data regression with the Random Effect Model is used in this study. Road infrastructure, educational infrastructure, and health infrastructure data from 29 districts / cities

from 2011 to 2018 were used in this study. The findings show that transportation and educational infrastructure have a positive and considerable impact on economic growth in Papua Province, while health infrastructure has a good but little impact. In remote areas, the regional administration must boost the amount and quality of educational staff, services, and health facilities.

RESEARCH METHODOLOGY

The current research is empirical in nature and relies exclusively on secondary data. All 21 districts have been included and taken into account in order to highlight inter-district discrepancies. Secondary data is gathered from a variety of sources to meet the objectives, including:

- Statistical Abstract of Haryana, Various Issues
- Census of India, 2001 and 2011
- Economic Survey of Haryana, Various Issues
- Statistical Abstract of Districts, Various Issues
- National Human Development Reports
- Planning Commission of India
- Districts Census Handbook, Government of Haryana
- Directorate of Telecommunication, Government of India

Data from 2000-01 to 2017-18 was used to show the growth and development of economic and social infrastructure at the state and district levels. This time period has been broken into two sections: the first from 2000-01 to 2010-11 (decadal growth), and the second from 2011-12 to 2017-18 (interim growth). Data from 18 indicators of economic and social infrastructure were utilized at three times in time, 2000-01, 2010-11, and 2017-18, to discover inter-district differences and find development ranks of Haryana's 21 districts.

RESULTS AND DISCUSSION

HARYANA'S ECONOMIC INFRASTRUCTURE IS GROWING (AT STATE LEVEL)

In this section, statistics such as total metalled road length, metalled road per 100 sq km of land, metalled road per lakh of population, and percentage of villages connected with metalled roads have been used to explain the evolution of economic infrastructure.

Table-1: Haryana's Road Transport Sector

Year	Total Metalled Road Length (In km.)	Per 100 sq. km. of Area	Per Lakh of Population	% of Villages Connected with Metalled Road
2000-01	22960	51.93	109.00	98.99
2001-02	23012	52.05	109.00	98.99
2002-03	23050	52.14	109.00	99.62
2003-04	23098	52.24	109.00	99.62
2004-05	22941	51.89	108.00	99.70
2005-06	23013	52.05	109.00	99.88
2006-07	23090	52.22	109.00	99.88
2007-08	24093	54.49	114.00	99.89
2008-09	24317	55.00	115.00	99.89
2009-10	24202	54.74	114.00	99.89
2010-11	26888	60.82	106.00	99.90
LSGR (%)	1	1	0	0
2011-12	26930	60.91	106.00	99.90
2012-13	26930	60.91	107.00	99.90
2013-14	25793	58.34	102.00	99.92
2014-15	26001	58.81	103.00	99.92
2015-16	26023	58.86	102.65	99.87
2016-17	26085	59.00	102.77	99.87
2017-18	26085	59.00	103.26	99.87
LSGR (%)	-1	-1	-1	0

Table-1 shows the growth of Haryana's economic infrastructure in terms of road transport from 2000-01 to 2017-18. The length of metalled road has increased little from 22960 km in 2000-01 to 26888 km in 2010-11 with an LSGR of only 1%, but has since decreased somewhat in 2017-18 with an LSGR of -1%, remaining at only 26085 km. In 2000-01, the length of metalled roads was 51.93 km per 100 sq km of land and 109 km per lakh of population. The data for metalled road per 100 sq. km. of area increased over time, from 60.82 km in 2010-11 to 59 km in 2017-18,

with an LSGR of 1%, but declined to 59 km in 2017-18, with an LSGR of -1%. In 2010-11, the number of metalled roads per lakh of people fell to 106, indicating a zero percent LSGR, and then fell to 103.26 in 2017-18, indicating a negative one percent LSGR. The percentage of villages connected to metalled roads has steadily climbed from 98.99 percent in 2000-01 to 99.90 percent in 2010-11 with an LSGR of 0%, however there was a little decline in 2017-18 with a recorded percentage of 99.87 percent and an LSGR of 0%. This indicates that practically all of the villages are connected by metalled roads, which explains why there has been no major rise in this metric.

INFRASTRUCTURE DEVELOPMENT INDEX-DISTRICT WISE

The infrastructure development index is calculated by subtracting the average of composite index values for each district. The rankings for each district are listed in descending order of value.

Table-2: District-Wise Infrastructure Development Index Calculated from Composite Index Values

Districts	2000-01		2010-11		2017-18	
	IDI	Rank	IDI	Rank	IDI	Rank
Ambala	0.4631	2	0.4191	5	0.4173	9
Panchkula	0.4076	6	0.4211	4	0.4369	7
Yamuna Nagar	0.4361	3	0.3790	13	0.4138	10
Kurukshetra	0.3792	10	0.4283	3	0.4441	6
Kaithal	0.3448	13	0.4155	9	0.3904	13
Karnal	0.3057	18	0.3643	14	0.3777	16
Panipat	0.3927	8	0.2959	19	0.3478	18
Sonapat	0.3064	17	0.3918	11	0.4535	4
Rohtak	0.5260	1	0.4806	2	0.3783	15
Jhajjar	0.3197	15	0.4176	7	0.4605	3
Faridabad	0.4334	4	0.5063	1	0.3985	11
Palwal	0	-	0.2605	20	0.2804	21
Gurugram	0.3267	14	0.3345	18	0.4784	1
Nuh	0	-	0.1917	21	0.3245	20
Rewari	0.4289	5	0.4177	6	0.4363	8
Mahendergarh	0.3544	12	0.3369	16	0.3957	12
Bhiwani	0.3993	7	0.3993	10	0.4474	5
Jind	0.2971	19	0.3353	17	0.3427	19
Hisar	0.3866	9	0.4159	8	0.3744	17
Fatehabad	0.3556	11	0.3792	12	0.4607	2
Sirsa	0.3089	16	0.3577	15	0.3815	14

Table-2 shows the district-level infrastructure development index, which is calculated from the average of three different types of infrastructure composite index data (Economic, Education and Health). Rohtak district was first in 2000-01, second in 2010-11, and then 15th in 2017-18 due to poor performance in both economic and social infrastructure. Ambala district has similarly steadily slipped from second place in 2000-01 to fifth place in 2010-11 to ninth place in 2017-18. Faridabad district dropped from first place in 2010-11 to eleventh place in 2017-18. Gurugram district improved dramatically from 18th place in 2010-11 to first place in 2017-18. Fatehabad District likewise fared admirably, rising from 12th place in 2010-11 to second place in 2017-18. Palwal, Nuh, and Jind, on the other hand, stayed in last place throughout the research period.

CLASSIFICATION OF DISTRICTS ON THE BASIS OF INFRASTRUCTURAL DEVELOPMENT INDEX

Using the average and standard deviation values of the Infrastructure development index, districts were divided into three categories: developed, moderately developed, and less developed.

Table-3: District-Wise Classification Based on Infrastructure Development Index Values

Districts	2000-01		2010-11		2017-18	
	IDI	Catego ry	IDI	Catego ry	IDI	Catego ry
Ambala	0.4631	D	0.4191	D	0.4173	MD
Panchkula	0.4076	MD	0.4210	D	0.4369	D
Yamuna Nagar	0.4361	D	0.3790	MD	0.4138	MD
Kurukshet ra	0.3792	MD	0.4283	D	0.4441	D
Kaithal	0.3448	LD	0.4155	D	0.3904	MD
Karnal	0.3057	LD	0.3643	MD	0.3777	MD
Panipat	0.3927	MD	0.2959	LD	0.3478	LD
Sonipat	0.3064	LD	0.3918	MD	0.4535	D

Rohtak	0.5260	D	0.4806	D	0.3783	MD
Jhajjar	0.3197	LD	0.4176	D	0.4605	D
Faridabad	0.4334	D	0.5063	D	0.3985	MD
Palwal	0	-	0.2605	LD	0.2804	LD
Gurugram	0.3267	LD	0.3345	LD	0.4784	D
Nuh	0	-	0.1917	LD	0.3245	LD
Rewari	0.4289	D	0.4177	D	0.4363	D
Mahender garh	0.3544	MD	0.3369	LD	0.3957	MD
Bhiwani	0.3993	MD	0.3993	MD	0.4474	D
Jind	0.2971	LD	0.3353	LD	0.3427	LD
Hisar	0.3866	MD	0.4159	D	0.3744	LD
Fatehabad	0.3556	MD	0.3792	MD	0.4607	D
Sirsa	0.3089	LD	0.3577	MD	0.3815	MD

For three research periods, 2000-01, 2010-11, and 2017-18, Table-3 displays the classification of districts based on the Infrastructure Development Index. In 2000-01, five of the nineteen districts were classified as developed, seven were classified as moderately developed, and seven were classified as less developed. As a result, there are more less developed districts than developed and moderately developed districts. However, the number of developed districts climbed to nine in 2010-11. In 2010-11, the number of low-developed districts fell from seven to six. The number of moderately developed districts climbed in 2017-18, while the number of low-developed districts fell. This graph depicts the evolution of districts from 2000-01 to 2017-18.

Throughout the study period, the Rewari district was classified as developed. Sonipat, Kurukshetra, Karnal, Jhajjar, Bhiwani, Fatehabad, and Gurugram are among the districts that have improved their development from 2000-01 to 2017-18, whilst Jind has remained less developed. Since their creation, the districts of Nuh and Palwal have been on the list of the least developed. Rohtak was a developed district in 2000-01 and 2010-11, but it worsened in 2017-18, falling into the moderately developed category.

Table-4 : Disparities In Different Infrastructures

Type of Infrastructure	Economic	Education	Health
S.D. values for selected variables for 2000-01	27.24	9.55	0.25
	10.96	1.5	0.11
	2.64	3.52	0.39
	17.78	7.23	2.62
	1.66	29.49	0.44
	1.74	2.37	40.48
S.D. values for selected variables for 2010-11	34.5	19.67	0.16
	10.17	7.9	0.14
	2.91	15.08	0.5
	22.45	42.28	2.66
	6.54	25.58	0.5
	4.52	7.71	26.91
S.D. values for selected variables for 2017-18	33.4	8.75	0.11
	9.56	12.81	0.15
	2.91	13.28	0.54
	12.65	14.72	2.87
	12.96	12.5	0.49
	9.16	3.97	11.77
Mean	12.43	13.22	5.06
S.D.	10.59	10.50	11.02
C.V.	85.19	79.41	217.74

The S.D. values of all selected economic and social infrastructure indicators are shown in Table-4. Economic infrastructure has a C.V. of 85.19, while social infrastructure has a C.V. of 79.41 (education) and 217.74 (healthcare) (health). These figures show that social infrastructure is more important than economic infrastructure. As a result, we accept the hypothesis that social infrastructure gaps are greater than economic infrastructure differences.

CONCLUSION

The growth of an economy can be seen as a progression of its many sectors moving upwards from current levels to higher levels of performance. The physical structure of facilities required to offer goods and services to the general public is referred to as infrastructure. Empirical investigations and theoretical analysis have been conducted on

infrastructure development and provision. Infrastructure is inextricably related to the growth of the economy. Infrastructure consists of long-term structures that provide economic inputs such as road networks, train facilities, power, schools, colleges, and hospitals, among others. Haryana, following its creation on November 1, 1966, began its development process later than the other states in the country.

Infrastructure is viewed as a forerunner or pace setter for economic progress, and it is one of the most important determinants of economic development. Infrastructure can be considered the bedrock or foundation of the economy because of its impact on economic development. A large building, for example, cannot stand on a shaky foundation, and agricultural and industrial development cannot be conceived without adequate and robust infrastructure. Agriculture and industry have a direct impact on a country's or region's growth. If sufficient infrastructure facilities are provided, economic progress becomes easier and faster.

For agricultural development, essential infrastructure facilities such as an appropriate supply of water for irrigation, storage and transportation facilities, a well-organized marketing network, financial institutions for short and long-term finance, and relevant information are required. With the use of these facilities, agricultural productivity can be enhanced at a cheaper cost, and production can be more diverse. However, additional production will be useless if it is unable to reach the market. As a result, integrated transportation infrastructure are required to carry agricultural products to local, national, and international markets.

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SPACE FARMING : NEED FOR FRESH VEGETABLE CROP

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ABSTRACT

Space farming, like moon farming, involves cultivating crops in space for food and other uses. Feeding space stations and other long-term missions takes time and money. Producing food in flight is intriguing because restocking is expensive and interplanetary expeditions are impossible. Space greenhouses distribute water, nutrients, and oxygen to plant roots using LED lighting, a porous clay base, and controlled-release fertilizer. The station's APH is a plant research growth chamber. Colonists who desire to farm off-Earth will face technical obstacles. Numerous companies want to lead the food production industry to space. Space agriculture could change farming on Earth with higher yields, more efficient production methods, and closed-loop fertilizer and water recycling technologies that maximize resource utilization.

Keywords: LED lighting, Resource use efficiency, Spread harvesting

Introduction

Similar to agriculture on Earth, “space farming” involves the growing of plants for food and other resources in outer space or on extra-terrestrial celestial objects. There are numerous parallels between farming on a space station or space colony and farming on a celestial body like the Moon or Mars. It's a big expense to keep astronauts and space travellers fed during extended voyages. (12). The notion of producing food in flight is extremely tempting due to the high expense of restocking and the impracticality of resupplying interplanetary missions. As plants may be used to recycle wastewater, produce oxygen, continually filter the air, and recycle excrement, having a space farm aboard a space station or spacecraft would be helpful in creating a sustainable ecosystem (15).

Production of food is essential in order to realize successful space missions for extended periods of time. As staple crops can be preserved dried for a long time, a priority is production of fresh vegetables, which has also been shown to have beneficial psychological effects for the crew members (7, 9). The purpose of the EU-funded EDEN ISS project (Ground Demonstration of Plant Cultivation Technologies and Operation in Space) is to develop a growing system for fresh vegetables, that can operate under the constraints of a space mission build a testing in mobile test facility (MTF). However, plant cultivation during space missions must cope with factors like gravity and radiation, which are difficult to properly address in plant cultivation on earth.

Therefore, it is necessary to define growth conditions and crop management that maximise the productivity of both space and energy, that is electricity to power artificial light and air conditioning. For instance, in order to maximize light use efficiency (LUE) of lettuce, (12) made use of targeted lighting, illuminating only the photosynthetic plant tissue. This was achieved by having the plants in fixed spots, which entails a large fraction of unused space during the early stage of the crops. Space is also a very limited resource in space missions, and to mimic this, the cultivation space in the MTF will be 40 racks of 40×60 cm, of which 22 are 30 cm high (cultivation space between the top of the rack and lamp), 16 are 80 cm and 2 are 160 cm. The issue is therefore to develop crop growing and management recipes that maximise productivity of both electricity and space. This requires some knowledge of the marginal value (in term of additional production) of both. That was the purpose of the work described here, which was carried out in climate rooms equipped similarly to the growing cabinets of the MTF (4). The development of these crop growth recipes may also be employed in vertical farming

Therefore, the overall objectives of this work were;

1. Determine the “marginal” value of resources (light and temperature) in terms of [fresh] yield.
2. Collect suitable information for crop management planning that maximises productivity of the unit and ensures a varied diet.

The first step is, rather obviously, the selection of suitable crops. While the aspect of human nutrition is obviously an important element in space farming, it has been expressed in earlier studies. Due to the fact that the physical space for plant growth is very limiting in space missions, the focus was placed on the psychological component of a limited amount of fresh food. The desirable characteristics of ready-to-eat fresh vegetable

products for their well-being have been expressed by former astronauts and crews that have over-wintered on Antarctica, we developed an objective selection method that differently prioritizes “hard” constraints (for instance, space) and “soft” constraints (such as harvest index or even spiciness). The method resulted in a diverse set of vegetable crops, each with their own specific requirements for optimal growth and production, like light intensity, light spectrum, temperature and humidity.

What is Space Farming?

Space farming is the practice of growing crops for food and other purposes in space or on extra-terrestrial bodies, like moon farming. There are numerous parallels between farming on a space station or colony and farming on celestial bodies such as the Moon or Mars. Farming on celestial bodies may not be as complex as farming in microgravity, depending on body size. The availability of inputs for the space agricultural process would vary depending on the environment, including the relative availability of carbon dioxide, nitrogen, and oxygen, soil medium, and insolation. (12).

Why Space Farming is necessary?

Food delivery to space stations and other long-duration missions is time-consuming and expensive. Due to the high cost of restocking and the impossibility of resupplying interplanetary missions, the idea of producing food in flight is very appealing. A space farm would help create a sustainable environment because plants can be used to recycle wastewater, produce oxygen, continuously filter the air, and recycle faces aboard the space station or spaceship (15).

Used in Vegetable crop on space Farming

Their limited size and high harvest index, ensure that leafy greens are always at the top

of any list for “space vegetables” for fresh food. Our list was not an exception, although it did include a dwarf variety of tomato and a cocktail cucumber (as fruit crops) and radish as root crop. Besides different cultivars of lettuce, spinach, red mustard, Swiss chard and herbs were included for more taste and quality aspects (6). Two experiments were conducted to determine the influence of light intensity, and the influence of temperature at 2 different light levels on the growth of the vegetables and regrowth of some crops, harvested during or at the end of the growth period.

What are the benefits of growing plants in space?

Because during future long-duration missions, life in space may depend on it. The ability of plants to provide a source of food and recycle carbon dioxide into breathable oxygen may prove critical for astronauts who will live in space for months at a time. In addition, plants provide a sense of well-being. Space-based technology is of value to farmers, agronomists, food manufacturers and agricultural policymakers who wish to simultaneously enhance production and profitability. Remote sensing satellites provide key data for monitoring soil, snow cover, drought and crop development (5). Rainfall assessments from satellites, for example, help farmers plan the timing and amount of irrigation they will need for their crops. Accurate information and analysis can also help predict a region’s agricultural output well in advance and can be critical in anticipating and mitigating the effects of food shortages and famines.

Space Farming: 3 Space-Based Technologies That Are Changing How We Grow Food

Agriculture and space. The ground and the sky. One of the most ancient human activities paired with our dreams for the future. While agriculture and space at first may not appear

to have much in common, space-based technologies are helping us grow food and monitor crops more efficiently. As the population grows, water becomes precious, and the climate becomes more variable, space-based technologies will be critical in helping us solve our greatest challenges here on Earth. Here are three such technologies that are changing the way we grow food.

1. Controlled Environment Agriculture (CEA) helps grow more food with fewer resources.

As more people move into urban centers and the need to conserve water and energy increases, we need new ways to grow food with fewer resources, closer to the people who consume it. We also need ways to cultivate healthy crops in an increasingly volatile climate. Thanks to decades of research by NASA, we don’t have to start from scratch. The need to grow fresh food, generate oxygen and promote astronaut well-being in space led NASA to develop indoor farming techniques that are now taking root on Earth.

Growing food in a space station or spacecraft demands specialized, fully contained systems that can reuse a limited water supply and don’t require soil or sunlight. This tall order led NASA to build the first vertical farm in the U.S.—and plant the seeds for today’s Controlled Environment Agriculture (CEA) sector.

CEA creates and maintains ideal growing conditions for crops within a closed structure. Plants are fed a precise mixture of nutrients and receive the optimal duration and intensity of LED lighting. Environmental controls keep the temperature and humidity at ideal levels for the particular crop. There is no threat of drought or pests. Crops can be grown in vertical stacks, making the most of every square inch and acre.

CEA is a growing industry ripe with opportunity. NASA continues to develop CAE

techniques and makes patents available for commercialization. One example is the Veggie Plant Growth System, available through the NASA Technology Transfer Program. It is a suite of technologies used to plant, feed and harvest plants in microgravity with minimal human intervention. Nutrients are delivered directly to the plant roots via capillary action. This system could have applications on Earth for vertical farming and green walls.

2. Earth observing data helps farmers see the future.

For millennia, farmers have put seeds into the ground with the faith that the rains would come and their crops would grow. Unpredictability comes with the profession. However, space technology is now helping farmers, scientists, resource managers and policymakers see into the future and plan ahead. Satellite programs such as Landsat have been used for decades to gather remote sensing data and monitor cropland from space. Now, Earth observation data is combined with high-end computer modelling to:

- Remotely monitor crop development and health
- Plan the timing and amount of irrigation needed based on predicted rainfall and soil moisture
- Predict water shortages, droughts and floods
- Spot the early signs of a struggling crop
- Identify problem areas in a field
- Estimate crop yields
- Create custom irrigation and fertilizer recommendations

The benefits extend far beyond individual farms and economic factors. This data and analysis can help predict the agricultural output of entire regions, so the effects of food shortages can be mitigated before people go hungry. For example, steps can be taken early to transport food to regions predicted to have a major crop failure. Farmers in areas predicted

to experience drought may be able to choose a more drought-resistant crop or adjust irrigation patterns.

3. GNSS helps make farming more precise and efficient.

Global navigation satellite systems (GNSS) are satellite constellations that provide positioning, navigation and timing services here on Earth. Examples include GPS (United States), Galileo (European Union) and BeiDou (China).

GNSS-enabled programs and applications are increasingly used today to make farming more efficient. Agricultural machinery equipped with onboard navigation can be programmed to run on optimal routes distributing seeds, fertilizer or pesticides without overlapping or skipping. This helps farmers make the most of their time while significantly reducing fuel consumption. Farmers can even upload field maps and only apply fertilizer and pesticides to areas that need them. Other applications include crop monitoring, livestock tracking and auto-guidance for steering (9). The overall Crop Monitoring Market, which includes remote sensing systems and imagery, AI and robotics, variable rate technology (VRT) and more, is projected to reach \$4.4 billion by 2025.

FARMING IN SPACE

The goals of the space farmer are to provide food for human crews living in microgravity aboard spacecraft or in planetary bases. Thus, Earth-based cultural practices and crops must be adapted to grow optimally in new environments with new biophysical combinations (e.g. microgravity, low atmospheric pressures, and supra-elevated CO₂ concentrations) encountered only in space. The process of adaptation to new environments will be no different than what farmers have done in the past as new environments on Earth were colonized. The

space farm modules will be built as flight hardware because they will be used by manned-crews in space. However, there are vast differences between spacecraft and planetary bases in terms of the resources available for farming and in the constraints that must be accommodated. Therefore, farming in space will be conducted in controlled environment chambers of varying sizes and power demands depending on the amount of local resources available. These chambers will provide programmable levels of light, air temperature, relative humidity, and carbon dioxide. They will also provide adequate ventilation and automated water/nutrient delivery systems to sustain plant growth.

1. Space Farms on Spacecraft

Space farms in microgravity will most likely be constrained to supplementing the dietary requirements of crews during short-term missions. Spacecraft like the ISS offer limited volume, mass and power for farming. Small payload launch masses of current heavy lift vehicles and an inefficient power supply by arrays of solar cells impose spartan resources for food production. Thus, resources are primarily used for crew life support and maintaining the spacecraft in a stable orbit. Little crew time for processing and cooking crops is likely so that initial efforts at space farming will probably provide just a few fresh foods; this concept has often been referred to as a salad machine (8). Salad crops (i.e. lettuce, radish, tomato, carrots, onions, and cabbage) that can be picked by hand and eaten fresh are prime candidates for supplementing crew diets in microgravity. The Vitacycle is a prototype greenhouse concept for microgravity (3). It consists of a rotating inner cylinder containing ten plant troughs where plants are seeded periodically and harvested after 30 days. The rotating cylinder is contained within a lamp bank housing arranged in the shape of a spiraling

cylinder, which holds lamps 8cm over the first plant trough and 30cm over the tenth trough. The light level is $270 \mu\text{mol m}^{-2} \text{s}^{-1}$, the lighting area is 1.1 m^2 and the planted area is 0.48 m^2 .

2. Space Farms on Planetary Surfaces

In contrast to space vehicle systems, planetary bases are envisioned as being composed of large modules where larger growing areas and potentially larger power budgets could be available. In this case, more conventional controlled environment farming of staple crops (wheat, soybean, potato, sweet potato, and rice) could be sustained, provided there is adequate lighting either from direct solar light, or electric lighting systems. However, use of electric lighting systems would require sufficient power, which may be supplied by nuclear power plants. These bases would have the added benefit of some gravity, e.g., $1/6 \text{ g}$ on the Moon or $1/3 \text{ g}$ on Mars. Gravity makes the use of hydroponic systems more feasible by providing gravity-driven drainage capabilities, alleviating such problems as the degassing of fluids in microgravity and the need for triple containment of water in space vehicles, and allows better moisture distribution near the roots of the crops. In addition, planetary bases can make use of important local resources such as regulate, water (on Mars and possibly the poles of the Moon), and CO_2 (Mars), which all defray some of the energy and mass costs required for farming in space. Regardless of the location, the future space farm will have to accommodate many of the mass and volume constraints imposed on current flight experiments and technologies designed for STS and ISS missions. Another environmental factor that must be considered for space farming systems is the total atmospheric pressure. Reduced pressures can reduce gas leakage and structural mass costs for both vehicle and surface systems (1), but the ability to manage environments at low pressure and thorough understanding of its effects on plants

(crops) are needed. Several studies have shown that plants can grow well at reduced pressures, but that transpiration rates can increase. If very low pressures are used, e.g., <50 kPa, then human access to the plant growing areas would likely require some protective suits or assistance. In spite of this, it still might be advantageous to use such low pressure for economic reasons, and lower pressure structures may use transparent materials for direct solar lighting; in other words, increase the potential for building “greenhouse” like structures (15). Maintaining adequate O₂ levels for the plants at reduced pressures may pose a challenge, particularly for managing the rootzone. Likewise, the tendency for higher evaporation rates and reduced ability to convectively transfer heat may pose challenges for maintaining acceptable humidity and temperature control.

Working of Space Farming

Agriculture in space is still in its early stages. On the ISS, there are currently small, specialized space greenhouses that carefully regulate the plant environment to allow plants to grow. To deliver water, nutrients, and oxygen to the plant roots, it employs LED lighting, a porous clay substrate, and controlled-release fertilizer (13). When a crop is ready for research, the crew collects plant samples, freezes, or chemically preserves them, and returns them to Earth for scientists to examine so they can learn more about how space influenced their growth and development (11).

Advanced Plant Habitat in Space

The Advanced Plant Habitat (APH) is a plant research growth chamber on the station. It uses LED lights and a porous clay substrate with controlled release fertilizer to deliver water, nutrients, and oxygen to the plant roots. Because it is enclosed and automated with cameras and more than 180 sensors that are in constant interactive contact with a team

at Kennedy, it does not require much daily maintenance from the crew. It has automatic temperature, atmospheric content, moisture levels, and water distribution controls. It has more LED light colors than Veggie, such as white, far red, infrared, and even red, green, and blue lights for night imaging (10).

Can it Transform Agriculture?

Some of the knowledge and innovations developed for space agriculture may find widespread application and success on Earth. Such developments would result in higher-yielding food production and harvests, which would benefit the entire food system. Space agriculture research has already resulted in several innovations that are now used all over the world and have fundamentally changed the way agriculture is practiced. We may be able to better regulate root zones for both water and nutrients as we learn more about how root systems function when crowded closely together (as they naturally do in low-gravity conditions). As a result, it is critical to continue this research (15, 16).

Future of Space Farming

As the amount of arable land on Earth continues to decline, some scientists and businesspeople are looking to the stars as the next big agrarian frontier. The notion that producing palatable, nutritious food is critical to humanity's ability to survive in space dates to the first science fiction story. Several companies are now stepping forward, hoping to lead the food production industry up the runway to space. (Figure: Plant growth samples from NASA's Martian Garden) (10).

What are the Challenges?

Race in Space - The more diverse the group of minds working on growing food in space, the better the chances of humanity solving critical food-related problems on Earth and in space. Future food production challenges include

resource depletion and food security, both of which are exacerbated by the climate crisis. Many people believe that for humanity to successfully grow food in space, we must first learn how to produce food sustainably on Earth (13).

CONCLUSION

Crop growing and management recipes were developed to maximise productivity of energy and space. Different light, temperature and cultivation (spread harvest) regimes were tested and edible yield was determined. To summarize, space farming research is still very specialized and unique, with a primary focus on developing tools that astronauts can use to maintain their autonomy while travelling to and from Mars in the future. This type of research will help NASA in its efforts to improve long-distance travel and understand how to keep plants flourishing in space. With higher yields, more efficient production methods, and closed-loop nutrient and water recycling systems that maximize the use of every resource available, space agriculture has the potential to significantly influence farming practices on Earth (2). Increasing the plant density increases the light use efficiency and applying spread harvesting increases fresh food production. Increasing plant density is only possible in combination with spread harvesting, and this combination results in a higher biomass production, but at the cost of extra work by crew members and the availability of seeds.

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ARTIFICIAL INTELLIGENCE IN HORTICULTURE CROPS

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ABSTRACT

Artificial intelligence is the process by which humans create intelligent machines. It falls under the broad category of computer science that emphasizes the development of physical and intangible systems that not only behave intelligently but also exhibit behavior on a par with how people think and behave, achieving human-like performance in all cognitive tasks through the use of only logical reasoning. AI having wide application in horticulture; By this we can detect diseases, enhance the yield, can control the weed, detect the required nutrient to the plant, by this we can control the use of fertilizers. Learning from prior data and making rapid, efficient decisions are the fundamental building blocks of AI. A part of artificial intelligence called machine learning is where the tools are developed. For the purpose of determining the most mature fruits or vegetables an AI-based automatic method has been created and developed. This method uses an algorithm based on computer vision and machine learning that uses Hear-like features. AI technology is quickly fixing the issues and advising precise steps that need be taken to solve them. AI is effective at keeping track of information and promptly finding solutions. The digital transformation of the agriculture and horticulture sector offers both producers and consumers enormous potential. The next great agricultural and farming revolution is about to begin thanks to the introduction of digital agriculture, industrialization and mechanization of production processes, networking, and data management.

Key Word: AI (Artificial Intelligence), Digital agriculture and Industrialization

INTRODUCTION

India has the opportunity to grow a wide variety of horticulture crops due to its various soil, climate, and agro-ecological zones. Horticultural crops, which comprise fruits, vegetables, medicinal, aromatic, and decorative plants, are important components of a balanced diet, sources of medication and fragrance, as well as possessing a variety of aesthetic benefits for people.

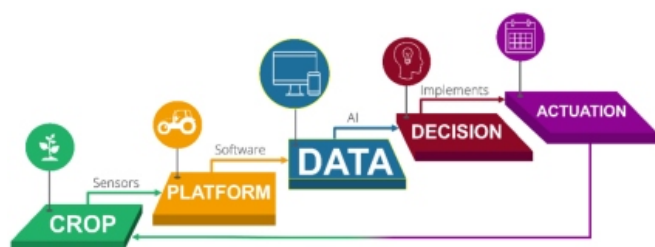
Fruits and vegetables contribute to 90% of

all horticulture production in the nation. Our nation currently produces 10% of the fruits and 14% of the vegetables consumed worldwide, placing us second only to China in terms of acreage and production of these commodities. Horticulture crops contribute significantly to India's economy by raising rural residents' incomes along with generating jobs for young people.

The development of intelligent systems has increased the potential to improve the cultivation and management elements of

horticulture crops on the basis of advances in technology and information analysis methodologies. Surprisingly, horticulture has seen an increase in agricultural technology research and commercialization while having the least amount of digitalization. The sector is nevertheless exposed to a wide spectrum of biotic and abiotic stress, which affects the yield and quality of the produce. In such cases, implementing the most recent technical advancements and solutions can result in better and more effective manufacturing methods.

The field of computer science known as artificial intelligence (AI), also referred to as machine intelligence, teaches machines how to mimic human physical movements and respond in human-like ways. The term ‘**Artificial Intelligence**’ was coined by John McCarthy in 1950. How come artificial intelligence? It is viewed as a chance, particularly in challenging circumstances or issues that standard computing systems and humans are unable to adequately resolve. It has many uses in the horticulture sector. Machines may frequently be made to perform tasks more effectively than people, including planting, watering, and harvesting as well as testing new systems. In order to increase yield, the horticulture sector needs workers with expertise in artificial intelligence. Artificial intelligence (AI) technologies help produce healthier crops, provide information on current weather conditions, such as temperature, rain, wind speed, wind direction, solar radiation, pest control, and soil and growing conditions, organise data for farmers, lessen their workload, and enhance the food supply chain (Manaware, 2020).



Cycle of data management

Advntages of AI in Horticultural Sector

The following are some significant advantages of AI in horticulture:

- AI provides more efficient ways to produce, harvest and sell essential crops.
- AI implementation emphasis on checking defective crops and improving the potential for healthy crop production.
- The growth in AI technology has strengthened agro-based businesses to run more efficiently.
- Used in applications such as automated machine adjustments for weather forecasting and disease or pest identification.
- AI can improve crop management practices.
- AI solutions have the potential to solve the challenges farmers face such as climate variation, an infestation of pests and weeds that reduces yields.
- It wouldn't eliminate jobs of human farmers rather it will improve their processes.

APPLICATIONS

Produce maturity identification:

Identifying the stage of fruit ripeness requires taking pictures of various crops under white/UV-A light. Particularly in the case of extremely perishable horticultural products, farmers might develop multiple maturity grades based on the crop/fruit category and place them into separate stacks before delivering them to the market. Harvesting at the right maturity would also increase post-harvest shelf life.



Fruit Maturity Identification

Automation system in Irrigation

The Internet of Things (IoT)-based smart irrigation system is a device that can automate the irrigation process by monitoring the soil's moisture content and meteorological conditions. Irrigation is one of the most labor-intensive processes in farming which can be avoided by artificial intelligence because it is aware of historical weather patterns, soil quality, and the type of crops to be grown.

AI in Shaping the Future of Farms

- Drones; Through in-depth field analysis, long-distance crop spraying, and high-efficiency crop monitoring, this technology is offering new ways to increase agricultural yields and is quickly turning into an indispensable tool for farmers. Drones inspect the soil's condition and decide whether it needs watering or planting. Vegetables and fruits are monitored by cameras that are being trained to spot anomalies or issues like dehydration and undesirable insects. The best time to harvest the crop can be predicted using all of this information. Agriculture has undergone a high-tech transformation thanks to drone technology. More drones can scan the ground and spray evenly in real-time. When using drones instead of traditional technology, the outcome of aerial spraying is five times faster.



- Raising pots inside the greenhouse; variety of robotics-based solutions can be created to simplify the growing and transportation of potted plants while increasing production.

The incredible benefit of a robotic arm is that it can complete many tasks in a 3D environment, such as placing plants in a carrier and then removing them from the carrier and placing them on tables or in trays in the following motion. This is performed with the greatest precision, even if the plants are not located precisely in the right place.

- Fruit harvesting robot: These robots require picking up fruits without damaging the branches or leaves of the tree. The robots must be capable to access all areas of the tree being harvested and distinguish between fruits and leaves by using video image capturing. The camera is mounted on the robot arm and the colours detected are compared with properties stored in the memory. If a match is obtained, the fruit is harvested. If the fruit is hidden by leaves, an air jet can be used to blow leaves out the way for a clearer view. The pressure applied to the fruit is sufficient for removal from the tree, but not enough to bash the fruit. The shape of the gripper relies on the fruit being picked. A drone is used to pick apples and the company Bx recently showed a video robot 'dog' Spot from Boston Dynamics walking through an apple orchard with a camera and sensors.
- These robots have to pick up fruit without damaging the tree's leaves or branches. The robots must be able to access all parts of the tree being harvested and distinguish between fruits and leaves by using video image capturing. The camera is installed on the robot arm, and the colour it detects is compared to data stored in memory. The fruit or vegetable is collected if a match is detected. An air jet can be used to blow leaves out of the way to provide a clearer view if the fruit is obscured by foliage. The pressure exerted to the fruit is sufficient to remove it from the tree but insufficient to bash it. The fruit or vegetable being plucked determines the gripper's form.



FRUIT HARVESTING ROBOT

- A robot for lettuce weeding and thinning is used to boost lettuce productivity. Each plant is carefully inspected by its vision system, which then applies cutting-edge artificial intelligence algorithms that decide which plants to keep and which to get rid of in order to maximize productivity.



AUTONOMOUS ROBOT FOR WEED CONTROL

- Automated tractors; farmers will soon be able to pass this 100-year-old machine over to robots by combining ever-more complex software with “off-the-shelf” technologies like sensors, radars, and GPS systems.

Table.1 Artificial intelligence (AI)-based opportunities in Horticulture (14.)

AI-based opportunities	Description
Agronomic decisions	Implementation of AI in farming decisions such as soil management, pest and weed management, disease management, crop management, and water-use optimization.
Economic performance	Cost-benefit assessment to improve profits based on local/tacit farming knowledge and recommendation actualized through digital platforms. Predictions and recommendations driven by AI models can help farmers reduce fertilizer overuse, forecast uncertainties such as plant and livestock-based diseases, and monitor soil conditions to prevent yield loss.

alphaSupporting inclusive growth in developing economies	AI-based agricultural technologies can prevent market and information asymmetries in food value chains at the local and global level if data is shared transparently and responsibly.
Social mobility	AI-based agriculture can benefit from availability and development of skilled workforce in the domains of computer science, agronomy and plant science, animal science, and social sciences.
Social and environmental impact	Sustainability of food and water systems, food-security for global population, and resource optimization.

AI in horticulture: current approaches & achievements:

Blue River Technology –

- **Weed Control:** Given that an estimated 250 kinds of weeds have developed resistance to herbicides, controlling weeds is one of farmers’ main priorities. A startup business in California created a robot named “See & Spray” that purportedly uses computer vision to track and precisely spray on weeds. Herbicide resistance can be avoided with precise spraying. It accurately sprays fertilizers where they are needed, on the plant. This might reduce the amount of herbicide needed to spray the entire field by around 90%.
- **Crop Harvesting** – It has reportedly resulted in millions of dollars’ worth of income losses due to a labour shortage. To assist strawberry growers with picking and packing their products, Florida-based Wish Farms stated that they would use a Harvest CROO Robotics strawberry harvester in the summer of 2017.
- **AI for Monitoring Crop and Soil Health**
PEAT – A machine Vision for Diagnosing Pests / Soil Defects: Berlin-based agricultural tech startup PEAT has created a deep learning programme called Plantix that according to reports, detects probable flaws and nutrient deficits in soil. Agricultural technology business PEAT in Berlin has created a deep learning programme called Plantix that according to reports, detects probable flaws and nutrient deficits in soil.

Software algorithms analyse data and tie certain foliage patterns to specific soil issues, plant pests, and plant illnesses. The company claims that its software can quickly discover patterns with up to 95% estimated accuracy.

- **Trace Genomics-** Machine Learning for Diagnosing Soil Defects; Trace Genomics, a California-based company, provides soil analysis services to farmers in a manner similar to the Plantix app. Illumina, the system's lead investor, assisted in developing provides clients with an understanding of the strengths and weaknesses of their soil using machine learning. Users are said to obtain an in-depth overview of their soil's components from Trace Genomics after sending them a sample of their soil.
- **Farm Shots,** a Raleigh, North Carolina-based firm, also specializes in the analysis of agricultural data generated from satellite and drone imagery. The company's specific goal is to "detect diseases, pests, and poor plant nutrition on farms." The business claims that their software can help consumers understand exactly where fertilizer is required and can reduce fertilizer use by about 40%. With the spatial resolution to distinguish individual plots and/or plants and the temporal advantage of monitoring changes over the course of the growth cycle, hyperspectral imaging and 3D laser scanning are capable of quickly giving improved information and plant metrics across thousands of acres.
- **"aWhere":** The Colorado-based company "aWhere" makes use of satellites and machine learning algorithms to assess farms for the detection of diseases and pests, forecast the weather, and analyse the sustainability of crops. The business gives its customers access to more than a billion points of agronomic information every day. Temperature, precipitation, wind speed, and sun radiation are among the variables that are measured, "along with comparisons to historic values for anywhere on the agricultural Earth." (1)
- **Expert Systems Implemented at CLAES:**

Agriculture has developed into a sophisticated industry that calls for the acquisition and integration of knowledge and data from a wide range of sources. In order to make decisions and stay competitive, modern farmers frequently rely on information from agricultural experts and advisers. Unfortunately, when a farmer needs support, agricultural specialists are not always around to provide it. Expert systems were found to be an effective instrument with enormous potential in agriculture for resolving this issue. An expert system, also known as a knowledge-based system (KBS), is a computer programme created to mimic the problem-solving methods of a subject-matter expert in a particular field or subject. In the field of agriculture, expert systems combine the collective knowledge of several disciplines, such as plant pathology, entomology, horticulture, and agricultural meteorology, into a framework that most effectively responds to the unique demands of farmers individually. Some of the expert systems developed for the specific crops are; Cuptex: An Expert System for Cucumber Crop Production, Citex: An Expert System for Orange Production, Tomatex: An Expert System for Tomatoes, and Limex: A Multimedia Expert System for Lime Production, etc.

- **Artificial intelligence and protected cultivation;** Greenhouse production processes are already highly automated and controlled but, similar to what is occurring in many sectors, AI systems are now taking control to unprecedented levels. Because of their potential ability to process large amounts of data and make tiny continuous adjustments, AI systems are beginning to provide greenhouse operators with myriads of production-related benefits (22) AI in protected horticulture can predict yield, ensure product quality from starting material to harvest, help decide on the planning of time-to-market and resources used and improve efficiency. It can, therefore, contribute to the economic profit of growers and the sustainability of their production. Both are important factors in

industrialised production processes with large greenhouse compartments at different locations, a lack of skilled labour and increased demand for high-value food close to urban areas. In addition, the link between growing conditions and shelf-life processes needs to be elaborated, such that information from the end point (the consumer acceptance) is used as feedback to alter growing conditions.

- **Plant phenotyping of horticultural crops and the use of crop sensors;** Plant phenotyping can be defined as the set of methodologies and protocols used to measure plant growth, architecture and composition with a certain accuracy and precision at different scales of organisation, from plant organs to complete crop canopies. The term is often restricted to plant breeding purposes, but it can also be used for plant production, specifically where measured plant features are used for precise crop maintenance and crop control in a controlled environment, such as (autonomous) greenhouses and vertical farms.
- **Digitalisation and artificial intelligence for crop morphology measurements;** The shape and morphology of plants is related to variety, the underlying genetics and environmental factors (light, temperature, irrigation). Digital plant phenotyping refers to the use of computers for plant phenotyping where digital sensors are used to measure plant characteristics. One of the most common digital phenotyping methodologies is image analysis, where cameras are used to record images and software is used to automatically extract the measurements from the images to access plant morphology (the shape of a plant), in a reproducible and accurate way (23). Currently, many different types of cameras are available for measuring important plant features to characterise plant morphology. The most used camera is the RGB colour camera, which produces images in the visible spectrum, mimicking the human eye. To relate the images to real dimensions, 3D information is often needed, which resulted in RGB camera-based 3D

sensors. The Intel Realsense RGBD sensor is an affordable example of a RGB 3D sensor and is often used in horticultural phenotyping, e.g., for tomato fruit detection and counting (2). Other examples are LiDAR sensors. All of these might become low cost because of the development of smart phone cameras for consumers. In greenhouse crop production, the plants may be intertwined, and so they cannot be easily imaged from all sides. This leads to occlusion and hampers the possibility of imaging important plant traits with a 3D camera. To overcome this problem, more advanced imaging solutions are needed. This can either be achieved by a moving trolley system with a mounted camera, flying drones inside the greenhouse or a robot that scans the plant with a 3D camera from many viewpoints. Using artificial intelligence algorithms, the point clouds from different single viewpoints are converted into a robust representation of the crop (6).

- **Digitalisation and artificial intelligence for crop physiology performance;** Next to plant morphology, plant physiological processes are important for crop monitoring. In crop production, photosynthesis in the leaves yields important biochemicals, such as sugars, starch, chlorophyll and nutrients that are transferred to the plant organs, flowers and fruits (9). Therefore, measuring the efficiency of plant photosynthesis directly and non-destructively is a desirable way for obtaining information on crop performance and for the early detection of deviations from optimal physiological conditions. Technologies like chlorophyll fluorescence imaging and thermal imaging are promising, especially if they can be applied to other parts of crop canopies, as well as individual leaves. The chemical composition of the crop can be determined by sampling leaves or fruits, sending them to a laboratory and waiting for the analysis. Recent imaging spectroscopy was tested on a laboratory scale, to determine the composition of biochemicals in crops, with promising results (10). Imaging spectroscopy is an imaging technique for images taken using many

narrow wavelength bands over a range extending across the visible spectrum (from ultraviolet to shortwave infrared) and compared to a standard camera, which only records red, green and blue light. In doing so, it creates an extremely detailed image of the reflection of light on plants or other objects. Imaging spectroscopy provides a lot of information on plant pigments, sugars, proteins, fats and water, as well as their distribution over the leaves or organs. Regions of interest, such as the fruits or leaves, can be automatically extracted from the image. This opens the possibility of using this technique on mobile platforms (17). Currently, a lot of research and development effort is going into the development of spectral cameras, making them less bulky, more robust, faster, and less costly. Currently, AI techniques are explored to extract useful information from the massive amount of data collected by the spectral cameras (18, 24). These developments suggest an outlook for the future, providing more information on different important plant features. Until now, most plant features could only be measured manually, destructively and/or very locally with scarce datapoints. Digitalisation of the measurement and use of modern sensors and camera systems will help to collect more data points. AI methods will largely help in the interpretation of variable data output. AI algorithms will also help to transform and combine the output of multiple sensors into useful information for growers.

Limitation of artificial intelligence in horticulture

- Lack of familiarity with high tech machine learning solutions in farms across most parts of the world
- Cost is a big challenge
- AI systems also need a lot of data to train machines and to make precise predictions

Challenges and future scope

Horticulture has been tackling significant difficulties like absence of irrigation system,

change in temperature, density of groundwater, food scarcity and wastage and substantially more. The fate of cultivating depends to a great extent on reception of various cognitive solutions. When it comes to handling realistic challenges faced by farmers and using autonomous decision making and predictive solutions to solve them, farming is still at a nascent stage.

The AI technology will be useful to predict the weather and other conditions related to agriculture like land quality, groundwater, crop cycle, and pest attack, etc. AI empowered sensors can also be installed in the robotic harvesting equipment in order to get the data. It is speculated that AI-based advisories would be useful to increase production by 30%. However, the farmers cope up with changing scenario to bring digital transformation in the agriculture by implementing AI. It's only one example of AI transforming agriculture, an emerging trend that will help spur an agricultural revolution. We will have to be more resourceful this time around.

CONCLUSION

Artificial intelligence in agriculture not only assists farmers in automating their operations but also changes to precise cultivation for increased crop production and better quality while consuming fewer resources. For horticulture, labour is a significant expense. In comparison to large-scale farming, intensive horticultural crops require a significantly more skilled labour force. Hiring labour for various tasks is responsible for over 50% of manufacturing expenditures. With the help of AI, you can control labour use, making effective use of herbicides and fertilizers and minimizing crop losses by harvesting at the right time. Artificial intelligence (AI) can assist farmers in increasing production capacity and decreasing production costs. The application

of AI in all application domains will also bring an ideal shift in the way we do research and development in horticulture now. Artificial intelligence-based goods and services, such as training data for drones, automated manufacturing, and agriculture, will progress technologically in the future and offer more valuable applications to this industry, for increasing efficiency. Artificial intelligence can be technological revolution and boom in horticulture to feed the increasing human population of world. Artificial intelligence will complement and challenge to make right decision by farmers.

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GENETIC ANALYSIS IN MUSKMELON (*CUCUMIS MELO* L.) SUBJECTED TO NORTH CAROLINA MATING DESIGN-III

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ABSTRACT

Muskmelon (*Cucumis melo* L.) is an important cucurbitaceous crop relished for its sweet taste. Before starting any breeding programme it is pertinent to know the inheritance of horticultural traits. By studying the genetics of some horticultural traits and the precise estimation of components of genetic variation, the appropriate breeding strategy can be formulated for their improvement. The present investigation was aimed at the mode of inheritance of some horticultural traits in muskmelon by evaluating biparental progenies (BIPs) which were developed and statistically analyzed by North Carolina Design-III. The sixteen BIPs of two crosses, MM-28 $\times$ NDM-21 and Hara Madhu $\times$ NDM-21 were evaluated. For node at which first pistillate flower opens, the BIPs of cross MM-28 $\times$ NDM-21 showed that additive genetic variance was significant but variance due to dominance was non-significant. The average degree of dominance was less than one. For polar diameter of fruit, both additive genetic variance and dominance variance were highly significant but the value of additive genetic variance was higher than the dominance variance. The average degree of dominance was more than one. Similarly, both additive genetic variance and dominance variance were significant but the value of additive genetic variance was more than double to that of dominance variance for equatorial diameter of the fruit. The average degree of dominance was near to one. For vine length, additive genetic variance was highly significant but variance due to dominance was non-significant. The average degree of dominance was less than one. Similarly, the BIPs of cross Hara Madhu $\times$ NDM-21, exhibiting additive genetic variance was significant and dominance variance was highly significant for node at which first pistillate flower opens. For polar diameter of fruit and equatorial diameter of fruit additive genetic variance was significant but variance due to dominance was non-significant. The value of additive genetic variance was four times more to dominance variance. However, the results showed that both additive genetic variance and dominance variance were highly significant but the value of additive genetic variance was twice to that of dominance variance for vine length. The average degree of dominance was more than one for node at which first pistillate flower opens, which hinted at exploitation of over-dominance for heterosis but other traits have the degree of dominance less than one, these traits can be improved by simple selection methods.

Keywords: Muskmelon, additive genetic variance, dominance variance, average degree of dominance

INTRODUCTION

Cucumis melo L. (Reticulatus group), commonly called as cantaloupe or muskmelon, is a member of the Cucurbitaceae family (4). It has gained commercial importance due to its short duration and high production potential. It is also the good source of Carbohydrates, phenols, polyphenols, ascorbic acid, carotenoids, total antioxidant activity (13). Muskmelon is a member of *Cucumis* genus and is a diploid species with $2n=2x=24$ chromosomes. The centre of origin is probably East Africa. (16). In the world, total production of muskmelon is 29.23 mtonnes and area 12.6 lakh ha with an average productivity of 23.15 t ha^{-1} (1). The important muskmelon producing countries are China followed by Turkey, Iran, Spain and USA. In India, it is cultivated in an area of 31.5 thousand ha with production of 6.45 lakh tonnes and the productivity is 20.48 t ha^{-1} (2). In India, the major cultivation of muskmelon is done on riverbeds of Yamuna, Ganga and Narmada in the North and Kaveri, Krishna and Godavari in the South. In Punjab state, area under this crop is 4950 ha and production is 86100 metric tonnes with an average productivity of 19.69 t ha^{-1} (3).

The economic importance of the crop has stimulated the breeding work which is aimed at the improvement of qualitative and quantitative characteristics. In the past, nature of the mode of inheritance of horticultural traits had been reported by applying different biometrical techniques (17, 21, 5, 7, 15, 24 and 23) but the accurate information was lacking. The information from different sources of literature indicated that there was lack of genetic information regarding important economic traits. However, before starting any breeding programme it is pertinent to know the inheritance of important economic characteristics. By studying the genetics of economic traits and the precise estimation of

components of genetic variation, the appropriate breeding strategy can be formulated for their improvement. Keeping this in view, the present studies on inheritance of economic characteristics was envisaged by involving biparental progenies. As biparental mating design especially North Carolina Design-III (12) serves two purposes, It tends to increase genetic variation within a population and it provides most precise estimate of additive and dominance components of genetic variation. The objectives of this study were to estimate components of genetic variation such as additive genetic variance and dominance variance which help in estimation of degree of dominance, heritability and genetic advance of different characteristics which is pre-requisite for suggesting an appropriate breeding strategy in this crop.

Considerable efforts have been made in past to improve the productivity and quality of muskmelon as per consumers' choice of a specific area. High heterotic response observed in F_1 persisted to a considerable extent in the F_2 and subsequent advanced generations. Thus, mating of randomly selected plants in the segregating generations of the heterotic crosses needs exploitation. This will not only be helpful in creating greater variability by breaking tight and unfavourable linkages for effective selection over a longer period but also create new populations with high frequencies of rare recombinants (11, 14). Before such populations can be used for the genetic improvement, an efficient breeding methodology has to be formulated. For this purpose, information would be required on the relative proportion of additive and non-additive variances. In the present investigation, the approach of North Carolina Design-III was tried because of lack of such information in muskmelon.

MATERIALS AND METHODS

The present investigation was carried out at Department of Vegetable Crops of Punjab Agricultural University, Ludhiana during the spring-summer season of year 2008 and 2009. The crosses were attempted during spring-summer season of 2008. The crosses were attempted by emasculating the hermaphrodite flowers in evening at 5.00-7.00 p.m., bagging it and pollinating it in the next morning at 6.00-8.00 a.m. After pollination, the flowers were covered with parchment paper bags and the bags were removed after setting of fruits. The biparental progenies (BIPs) were developed by backcrossing the randomly sampled F_2 plants with parents designated as L_1 and L_2 . For crossing the F_2 plants were used as males and parents as females. F_2 generations were developed in the previous year from crossing parents, L_1 and L_2 and selfing F_1 generation. The inbred lines, L_1 and L_2 were maintained by selfing in the department. Nursery of BIPs was sown in polythene bags on February and transplanting was done on March during 2009. The biparental progenies (BIPs) of following four crosses thus raised were evaluated in spring-summer season of 2009. The experiment was laid out in Randomized Block Design (RBD). The standard package of practices was followed for raising the crop. (2).

STATISTICAL ANALYSIS

The data recorded were subjected to the statistical analysis as suggested by (12).

i) Analysis of variance

Source of variation	df	M S S	F Value	Expected mean squares
Testers (T)	t-1	MST	MST/MSS	$^2_w + D + nrk^2T$
F_2 (s) Additive	n-1	MSS	MSS/MSS _w	$^2_w + 2r^2_s$
TxS (Dominance)	n-1	MSTS	MSTS/MSS _w	$2w + 2r^2_d$

Within families	FS	2n(r-1)	MSw		^2_w
Total		2nr-1			

Where

^2_s = Variance due to sums

^2_d = Variance due to differences

^2_w = Variance with in full sib families

ii) Components of variance and degree of dominance

The estimates of additive genetic variance (σ^2_A) and dominance variance (σ^2_D) were calculated from the variance due to sums and variance due to differences as follows.

$$^2_s = \frac{1}{4} V_A \quad \quad \quad ^2_d = \frac{1}{2} V_D$$

$$V_A = 4 \quad ^2_s \quad \quad \quad V_D = 2 \quad ^2_d$$

V_A = Additive genetic variance

V_D = Dominance variance

The average degree of dominance was calculated by following methods.

$$\sqrt{\frac{2V_D}{V_A}}$$

iii) Heritability

Heritability estimates in the narrow sense were calculated as follows

$$h^2_{ns(\%)} = \frac{^2_A}{^2_A + ^2_D + ^2_E} \times 100$$

^2_A = Additive genetic variance

and ^2_D = Dominance variance

^2_E = Error variance

iv) Estimation of Genetic advance

Expected genetic advance from full sib families was calculated by the procedure outlined by (6). Genetic advance was estimated at 5% selection intensity.

$$\text{Genetic advance (GA)} = \frac{1}{2} i V_A / FS$$

i = Selection intensity at 5 % is 2.06

FS = Phenotypic standard deviation of full sibs

V_A = ^2_A = Additive genetic variance

FS was calculated from full sib phenotypic variance, FS .

Genetic advance in percentage for all the characters calculated is as

$$(GA\%) = GA/\bar{x} \times 100$$

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) for North Carolina Design –III is presented in Table: 1 for crosses MM-28 x NDM-21 and Hara Madhu x NDM-21, respectively. In respect of node at which first pistillate flower opens in case of cross MM-28 × NDM-21, analysis of variance showed that variance due to sums was significant but variance due to differences was non-significant. In cross Hara Madhu × NDM-21, variance due to sums was significant and variance due to difference was highly significant. For polar diameter of fruit, analysis of variance for cross MM-28 × NDM-21 indicated that both variances due to sums and differences were highly significant. However, in case of cross Hara Madhu × NDM-21, variance due to sums was significant but variance due to differences was non-significant. For equatorial diameter of fruit, analysis of variance of cross of MM 28 × NDM-21 demonstrated that both variances due to sums and differences were significant. However, in case of cross Hara Madhu × NDM-21, variance due to sums was significant but variance due to differences was non-significant. For flesh thickness, the analysis of variance revealed that variance due to sums was non-significant and variance due to differences was significant in cross-MM-28 × NDM-21. However, in case of cross Hara Madhu × NDM-21, variance due to sums was highly significant and variance due to differences was significant. For the character of vine length, analysis of variance for cross MM-28 × NDM-21 indicated that variance due to sums was highly significant but variance due to differences was non-significant. In case of cross Hara Madhu × NDM-21, both variances due to sums and differences were highly significant.

Components of variance in North Carolina Design-III for various characters of different crosses are presented Table: 2, For node at which first pistillate flower opens, data of cross MM-28 × NDM-21 showed that additive genetic variance was significant but variance due to dominance was non-significant. An estimate of D (variance due to additive genetic effects) was significant for number of nodes on which first female flower appeared (21). The average degree of dominance was less than one (0.58). In cross Hara Madhu × NDM-21, additive genetic variance was significant and dominance variance was highly significant. Dominant component of variance was found to be important for node at which first female flower appears (20). The average degree of dominance was more than one (1.61) which hinted at exploitation of over dominance for heterosis. In cross MM-28 × NDM-21, both additive genetic variance and dominance variance were highly significant but the value of additive genetic variance (2.222) was higher than the dominance variance (1.634) for polar diameter of fruit (cm). (18) also observed the dominance variance is significant for this character. The average degree of dominance was more than one (1.21). Contrary to above the cross Hara Madhu × NDM-21 displayed that additive genetic variance was significant but variance due to dominance was non-significant. The average degree of dominance was less than one (0.43). In cross MM-28 × NDM-21, both additive genetic variance and dominance variance were significant but the value of additive genetic variance (0.764) was more than double to that of dominance variance (0.327) for Equatorial diameter of fruit (cm). The average degree of dominance was near to one (0.92). In contrast to the above, cross Hara Madhu × NDM-21 revealed that additive genetic variance was significant but variance due to dominance was non-significant. The value of additive genetic variance (0.476) is about four times to that of dominance variance (0.119). The average

degree of dominance was less than one (0.71). In cross-MM-28 $\times$ NDM-21, dominance variance was found significant but additive genetic variance was non-significant for flesh thickness (cm). The average degree of dominance was more than one (1.84). The involvement of dominance variance for flesh thickness of the fruit was also reported earlier by (19, 9). However, in cross Hara Madhu $\times$ NDM-21, additive genetic variance was highly significant and dominance variance was significant but the value of additive genetic variance (0.094) was more than dominance variance (0.021). (5) also reported that additive gene effects are significant for this character. The average degree of dominance was less than one (0.67). For Vine length, results of cross MM-28 $\times$ NDM-21 revealed that additive genetic variance was highly significant but variance due to dominance was non-significant. The average degree of dominance was less than one (0.40). However, results of cross Hara Madhu $\times$ NDM-21 showed that both additive genetic variance and dominance variance were found highly significant but the value of additive genetic variance (0.080) was twice to that of dominance variance (0.035). The average degree of dominance was less than one.

Heritability is the only component which is transmitted to the next generation. The ratio of genetic variance to the total variance i.e., phenotypic variance is known as heritability. Heritability estimates gives a measure of transmission of characters from one generation to the next and the consistency in the performance of progeny in succeeding generations and depends mainly on the magnitude of heritable portion of variation (8).

The estimates of heritability (Table 2) were of high magnitude ($>60\%$) in cross MM-28 $\times$ NDM-21 (74.78%) for vine length, (60.27%) for equatorial diameter of fruit and in cross Hara Madhu $\times$ NDM-21 (65.72%) for vine length

and (80.29%) for flesh thickness. Low magnitude ($<30\%$) for 20.04% for flesh thickness in cross MM-28 $\times$ NDM-21 and moderate magnitude (30-60%) (54.76%) for polar diameter of fruit and (59.12%) for node at which first pistillate flower opens in cross MM-28 $\times$ NDM-21 and 59.74 % for equatorial diameter of fruit, 55.83% for polar diameter of fruit and 41.55 % for node at which first pistillate flower opens in cross Hara Madhu $\times$ NDM-21. High values of heritability for vine length, for equatorial diameter of fruit and flesh thickness indicated that though the characters are least influenced by the environmental effects, the selection for the improvement of such characters may not be useful, because broad sense heritability is based on total genetic variance which includes both fixable (additive) and non-fixable (dominance and epistatic) variances. The high heritability, therefore, implies that these yield attributes are controlled genetically, signifying high potential for improvement through selection. The moderate estimates of heritability for polar diameter of fruit, for node at which first pistillate flower opens and for equatorial diameter of fruit, indicating that these characters are moderately influenced by environmental effects and genetic improvement through selection will be moderately difficult due to masking effects of the environment on the genotypic effects. The estimates of heritability alone fail to indicate the response to selection. Therefore, heritability estimates appear to be more meaningful when accompanied by estimates of genetic advance and genetic advance as percentage over mean (10). The estimates of genetic advance (Table 2) were of high magnitude ($>20\%$) for vine length (21.66 %) in cross MM-28 $\times$ NDM-21, of moderate magnitude (10-20%) for vine length (14.54%) and (12.66%) for flesh thickness in cross Hara Madhu $\times$ NDM-21 and of low magnitude ($<10\%$), for node at which first pistillate flower appears, polar diameter of fruit and

equatorial diameter of fruit in cross MM-28 × NDM-21 and Hara Madhu × NDM-21. High estimates of heritability (>60%) coupled with high genetic advance (>20%) for vine length revealed that most likely the heritability is due to additive gene effects and selection may be effective. Such value of high heritability and high genetic advance may be attributed to the action of additive genes (16). The characters like vine length recorded high genetic coupled with high heritability estimates, indicating that these traits were under the strong influence of additive gene action, and hence simple selection based on phenotypic performance of these traits would be more effective. Low heritability and low genetic advance values were observed for the characters flesh thickness. This indicates the character is highly influenced by environmental effects and selection would be ineffective. Similar results were also reported by other researcher in muskmelon. (22).

Table 1: Analysis of variance of North Carolina Design –III in crosses MM-28 × NDM-21 and Hara Madhu × NDM-21

Source of variation	Degree of freedom	Node at which first pistillate flower opens		Polar diameter of fruit		Equatorial diameter of fruit		Flesh thickness		Vine length	
		MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21
Tester	1	21.82	2.47	232.63	13.19	13.97	27.06	1.46	0.09	0.62	0.42
F ₂ (S) (Additive)	7	0.34*	0.75*	4.71**	0.71*	1.68*	1.09*	0.06	0.18**	0.30**	0.17**
T×S (Dominance)	7	0.18	1.47**	6.29**	0.36	1.51*	0.74	0.10*	0.09*	0.11	0.15**
Within FS families	32	0.11	0.30	1.39	0.29	0.53	0.38	0.04	0.04	0.08	0.05
TSS	47										

*Significant at 5% level

**Significant at 1% level

Table 2: Components of variance, average degree of dominance, heritability and genetic advance obtained from North Carolina Design-III of crosses MM-28 × NDM-21 and Hara Madhu × NDM-21

Character	Additive genetic variance (σ _{2A})		Dominance variance (σ _{2D})		Environmental variance (σ _{2E})		Average degree of dominance		Heritability (%)		Genetic advance (%)	
	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21	MM-28 × NDM-21	Hara Madhu × NDM-21
Node at which first pistillate flower opens	0.135*	0.299*	0.023	0.389**	0.148	0.032	0.59	1.61	59.12	41.55	9.69	8.82
Polar diameter of fruit	2.222**	0.284*	1.634**	0.026	0.010	1.21	0.199	0.43	57.46	55.83	9.36	4.31
Equatorial diameter of fruit	0.764*	0.476*	0.327*	0.119	0.177	0.201	0.92	0.71	60.27	59.74	7.59	5.47
Flesh thickness	0.012	0.094**	0.021*	0.021*	0.028	0.002	1.84	0.67	20.04	80.29	2.37	12.66
Vine length	0.146**	0.085**	0.012	0.035**	0.037	0.009	0.40	0.91	74.78	65.72	21.66	14.54

* Significant at 5% level

** Significant at 1% level

CONCLUSIONS

The predominance of dominance variance and average degree of dominance being more than one suggests the possibility of high yielding and superior F₁ hybrids. Therefore, the heterosis breeding remains suitable option of breeding for the characters such as number of fruits per vine, fruit weight, total fruit yield per vine, rind thickness and total soluble solids (TSS) content

where F_1 hybrids are expected to give better performance than inbred lines. In this crop, both types of genetic variances were recorded in different magnitudes among different cross combinations. By adopting population improvement methods, superior inbred line can be developed after accumulating additive gene effects for different characters and high yielding possess high total soluble solids (TSS) inbred lines can be utilized to develop superior hybrids (6). The bi-parental progenies should be evaluated at multi-locations to assess their performance properly by minimizing the genotypic-environment interaction. The population improvement programmes should be carried out to improve the economically important quantitative characters in this crop. In population improvement, undesirable linkages are needed to be broken, releasing potential genetic variability and forming new recombinants, which can be used in breeding programme of muskmelon.

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EFFECT OF DIFFERENT FLORAL PRESERVATIVES ON THE VASE LIFE OF CUT FLOWER OF GERBERA (GERBERA JAMISONII BOLUS EX. HOOKS F.) cv. RUBY RED

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ABSTRACT

An experiment was conducted under Completely Randomized Design (CRD) to study the effect of different floral preservatives on the vase life of cut gerbera flower cv. Ruby Red. Uniform sized stalks of gerbera at the outer ray florets completely elongated were harvested and kept in 10 different holding solutions comprised of (T₀) Distilled water (control), (T₁) Sucrose (2%), (T₂) Sucrose (4%), (T₃) Acetic acid (100 ppm), (T₄) Acetic acid (200 ppm), (T₅) Sucrose (2%) + Al₂(SO₄)₃ (200 ppm), (T₆) Sucrose (4%) + Al₂(SO₄)₃ (300 ppm), (T₇) Sucrose (2%) + Citric acid (100 ppm), (T₈) Sucrose (4%) + Citric acid (200 ppm), (T₉) Sodium thiosulphate (300 ppm). It was observed that treatment (T₆) Sucrose (4%) + Al₂(SO₄)₃ (300 ppm) was found best than rest of the treatments and resulted in minimum weight loss (26.46 %) and maximum value for solution uptake (68.80 ml/L), number of days took to freshness (13.76 days), vase life (18.29 days), head and disc diameter (7.43 cm) (4.73 cm) respectively. Although, other treatments show better result than control.

Key words: Gerbera, vase life, sucrose, Al₂(SO₄)₃, acetic acid, sodium thiosulphate.

INTRODUCTION

Gerbera (*Gerbera jamesonii*) cv. Ruby Red popularly known as Transvaal daisy is one of the nature's beautiful creations belongs to Asteraceae family having colourful flowers of exquisite shape, size and bewitching colour. They are very attractive in the garden with their star like flower of varying colour and shades. It is one of the ten most popular commercial cut flowers in the world and according to the global trend in floriculture; it occupies the 4th place among cut flowers. It is named in honour of Traugott Gerber, a German naturalist. Gerbera flower are in considerable

demand in both domestic and export market. The exact stage of harvesting varies with the variety, grower, weather conditions and market distance. The flowers are generally cut when the outer ray florets are completely elongated or when outer two rows of disc florets are perpendicular to the flower stem. Enhance vase life of cut flowers depends on their water relation and retarding rate of senescence, which can be achieved by using certain chemicals. Therefore, the present study was undertaken to develop appropriate method for prolonging the post-harvest life of gerbera cut stalk cv. Ruby Red.

METHOD & MATERIALS

The present experiment was carried out at P.G. laboratory of the Department of Horticulture, R.B.S. College Bichpuri, Agra during 2021-22. Cut flower of Gerbera cv. Ruby Red partially open stalk freshly harvested in the morning at 8.00 to 9.00am was used for the experiment. The freshly cut flower stalk were placed in pre-conditioned solution after pre-cooling for 12 hr at $21 \pm 2^{\circ}\text{C}$ room temperature. Flowers of uniform shape and size were selected for the experiment and the stems were cut leaving 40 cm. The basal 2 cm portion of the stalk was re-cut under water to expose fresh tissue and stalks were put in different vase solution. Then these were transferred to 500 mL beakers containing different vase solutions i.e. (T₀) Distilled water (control), (T₁) Sucrose (2%), (T₂) Sucrose (4%), (T₃) Acetic acid (100 ppm), (T₄) Acetic acid (200 ppm), (T₅) Sucrose (2%)+Al₂(SO₄)₃(200 ppm), (T₆) Sucrose (4%)+Al₂(SO₄)₃(300 ppm), (T₇) Sucrose (2%)+Citric acid (100 ppm), (T₈) Sucrose (4%)+Citric acid (200 ppm), (T₉) Sodium thiosulphate (300 ppm). The experiment was laid out in Completely Randomized Design with 3 replication and 10 treatments. Different observations like fresh weight, head and disc diameter, uptake of solution, freshness & turgidity, neck bend and vase life of stalk were taken and subjected to analysis of variance. The stalk placed in vase solution cut 2 cm on every alternate day to remove vascular blockage. All the process repeated till the end of vase life. The fresh weight was recorded in the initial day when the stalk placed in holding solution and the final weight recorded at the end of vase life. The head and disc diameter of the stalk were recorded at different interval during the vase life (1st day, 4th day, 9th day, 15th day and at the end of vase life). The total uptake of solution was recorded at the end of vase life while other parameters like freshness & turgidity, neck bend and vase life were recorded daily on the

basis of physical appearance.

RESULT & DISCUSSION

The data presented in **Table 1** shows that the different holding solution had significant influence on the vase life of cut gerbera. The minimum loss of fresh weight (26.46%) was recorded with treatment (T₆) Sucrose (4%)+Al₂(SO₄)₃(300 ppm) followed by Treatment (T₉) Sodium thiosulphate (300 ppm) (28.80%) which was statistically significant than control (58.02%) **Figure 2**. The reduced transpiration loss leads to increase in stalk weight. Similar findings were also found by (2,3,4, and 7).

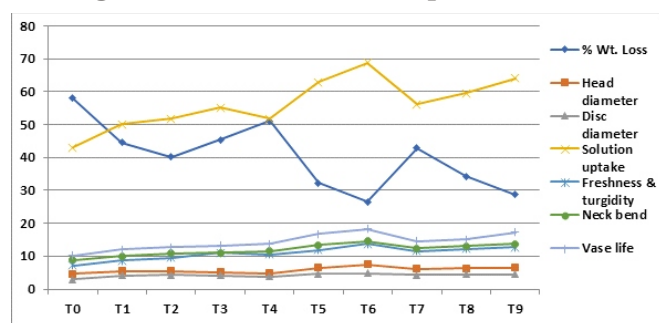
The flower head diameter was influenced by all floral preservative solutions but maximum flower diameter (7.43 cm) was found in treatment (T₆) Sucrose (4%) +Al₂(SO₄)₃(300 ppm) which was significantly superior over rest of the treatments. Treatment (T₅) and (T₉) were statistically at par with treatment (T₆) however, the minimum flower diameter (4.60 cm) was observed in treatment (T₀) (control). On the other hand, similar finding regarding the disc diameter, maximum value for flower disc diameter in vase solution was observed in treatment (T₆) Sucrose (4%) +Al₂(SO₄)₃(300 ppm) statistically at par with (T₅) Sucrose (2%) +Al₂(SO₄)₃(200 ppm) **Table 1**. The increase in flower diameter by chemical formations might be due to the fact that sucrose provided energy for growth and helped in higher uptake of vase solution. All treatments were found significantly superior in terms of extending vase life over control **Table 1**. The maximum vase life (18.29 days) and solution uptake (68.80 ml/L) were observed in treatment (T₆) Sucrose (4%)+Al₂(SO₄)₃(300 ppm) **Figure 1**. However, the minimum vase life (10.23 days) was observed in treatment (T₀) (control). The possible reason for increase in vase life is that sucrose act as a carbon source for maintaining mitochondrial structure, function and

improved water balance in flower stalk. The present findings are in close conformity with the observations made by (5, 6 and 9) in tuberose, (4) in cut gerbera flower, (1) in cut chrysanthemum and (8, 9 and 10) in tuberose cut flower. Hence, the present study clearly shows that treatment (T₆) Sucrose (4%) + Al₂(SO₄)₃(300 ppm) can be used to enhance the keeping quality/ vase life of cut flower of gerbera cv. Ruby Red.

Figure 1: Effect of holding solution on different post harvest parameters of Gerbera jamesonii

Treatment	% Wt. Loss
Distilled water	58.02
Sucrose 2.0%	44.53
Sucrose 4.0%	40.20
Acetic acid 100 ppm	45.40
Acetic acid 200 ppm	51.13
Sucrose 2% + Al ₂ (SO ₄) ₃ 200 ppm	32.25
Sucrose 4% + Al ₂ (SO ₄) ₃ 300 ppm	26.46
Sucrose 2%+Citric acid 100 ppm	42.94
Sucrose 4%+Citric acid 200 ppm	34.26
Sodium thiosulphate 300 ppm	28.80
Sem±	3.00
CD at 5%	8.85

Table 2: Graphical representation of effect of holding solution on different parameters



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TO STUDY OCCUPATIONAL ROLE STRESS AMONG TEACHER IN RELATION TO THEIR ORGANIZATIONAL COMMITMENT AND COPING STRATEGIES

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ABSTRACT

Experience of occupational stress is inevitably involved in the execution of any type of work. Stress has an adaptive value. It motivates the individual to attend to the task and get rid of the tension or demand the unattended task produced. “Workplace stress” is the harmful physical and emotional responses that can happen when there is a conflict between job demands on the employee and the amount of control an employee has over meeting these demands. In general, the combination of high demands in a job and a low amount of control over the situation can lead to stress. Stress in the workplace can have many origins or come from one single event. This study revealed the relationship between the coping strategies and organizational commitment of teacher educators. Result showed that their exist significant relationship between the coping strategies and organizational commitment of teacher educators. Study further showed significant difference between the male and females occupational stress.

Keywords: Occupational role stress, stress coping strategies, Teaching

INTRODUCTION

It is often said that the teachers are the backbone of any society as they guide and help the future generations in realizing their full potential. All students have the potential to become future leaders and it is the responsibility of the teachers to make the students ready for their future. Students carry what they learn and experience in their formative years throughout their lives and hence teachers play a very important role in shaping their views and attitude towards life. As Dr.A.P.J. Abdul Kalam mentioned, no profession in the world is more mportant to the society than that of a teacher.

Stress is a reality and its unavoidable.

Present day living has brought plenty of stressors, incalculable methods for comfort, as well as a plenty of requests that assessment human body and psyche. Presently a-days stretch is everyone’s piece of each one’s life. It is cutting overall financial gatherings of the populace and turning into the colossal leveler. High- pressure officials are confronting worry as well as corporate workers, working women, businessmen, expertsin various field, and even kids. Stress is an inevitable part of day to day life because of growing competition and dynamicity of the environment. Even many a times its because of increasing expectations for everyday comforts. In the dynamic work environment, no individual is free from stress and no calling is free from stress. Everybody

has to encounter pressure whether it is at the domestic end, business, academics, professional, or some other social or financial action. Stress has become centre point of attention because of its negative consequences. Everyone wants peaceful life but Stress is unavoidable factor and no one can stay away from it. Every day one has to encounter stressful situation. Stressful situation can arise may be accidentally or purposefully.

Occupational role stress

Occupational stress is stress related to one's job. Occupational stress often stems from unexpected responsibilities and pressures that do not align with a person's knowledge, skills, or expectations, inhibiting one's ability to cope. Occupational stress can increase when workers do not feel supported by supervisors or colleagues, or feel as if they have little control over work processes. Teachers, as a part of their professional role, are always seen as the center of attention in any classroom, but when it comes to address their needs, concerns or problems, it is obvious that they do not attract the same amount of attention. In spite of the fact that stress can have a negative effect on teachers in terms of many aspects (physical, mental and/or emotional/psychological) and this may consequently affect the institutions and students negatively, research into stress as an affective factor for teachers is limited.

Sources of occupational role stress come from:

- a toxic work environment
- negative workload
- isolation
- financial pressures
- types of hours worked
- role conflict & role ambiguity
- lack of autonomy, career development barriers

Organizational commitment

It is an individual's psychological attachment to the organization. The basis behind many of these studies was to find ways to improve how workers feel about their jobs so that these workers would become more committed to their organizations. Organizational commitment predicts work variables such as turnover, organizational citizenship behavior, and job performance. Some of the factors such as role stress, empowerment, job insecurity and employability, and distribution of leadership have been shown to be connected to a worker's sense of organizational commitment.

Coping strategies

Psychological coping techniques are sometimes known as coping skills or coping strategies. tactics that are unconscious or non-conscious, such as defense mechanisms. Adaptive or constructive coping mechanisms, which lower stress levels, are typically referred to by the word "coping." However, some coping mechanisms may be deemed maladaptive, leading to an increase in stress. In essence, non-coping can be used to indicate maladaptive coping. Additionally, the term "coping" typically refers to "reactive coping," which is coping that occurs after the stressor. In contrast, proactive coping seeks to prevent a stressor from occurring in the future.

Significance of the study

Workings conditions or academics have changed considerably over the last decade. It has been argued that institution lecturers and researchers currently experience similar pressures of professionals in any large organisation (Thorsen, 1996). Compared to other occupational groups, however, little research has focused on the job stressors experienced by academics. Even less is known about the extent of strain in the higher education sector, and how job stressors are related to the health, wellbeing and satisfaction of employees.

Statement of the problem

Occupational Stress is the study of all those aspects of work that either have or threaten to have bad effects on the organism such as physical properties of working environment, pollution, extreme heat or cold, humidity, pressure, noise, bad man machine design, time pressures, deadlines, non-standard working hours, organizational or administrative irrationality, poor management relations, demotion, transfer, non-availability of extrinsic rewards (increase pay scale), conflict with boss or subordinates, ambiguity about job security and many more. The present study is attempted to know the source of occupational role stress among teacher in relation to their organizational commitment and coping strategies.

REVIEW OF LITERATURE

(1) The level of stress among academics in higher education institutions has significantly increased over the past decade. Mental health and well-being of academics can be affected once they are exposed to stressful work conditions and use negative coping strategies. This study was set against the backdrop of the pandemic disease, COVID-19, which has challenged the daily work of academics and risen to the various new stressors. This study aims to investigate the current status of occupational stress, coping styles, mental health and emotional well-being of university academics during the COVID-19 outbreak in Northern Ireland, and examine the effect of stress and coping strategies on mental health and emotional well-being. A cross-sectional online survey was conducted using a sample size of 87 academic staff working in a university in Northern Ireland. SPSS version 25 was used to analyse the collected data. The results showed academics experienced moderate stress levels, and distraction behaviours were the most common form of coping mechanism. Academics were in the

moderate status of mental health and poor emotional well-being. Occupational stress has a significant effect on mental health and emotional well-being. Positive reframing and acceptance coping styles have an impact on emotional well-being. This study contributes to the understanding of occupational stress, coping strategies, mental health and emotional well-being of academics in higher education in Northern Ireland. The findings can help to develop reliable methods to inform policy on health and well-being for university academics, which in turn lead to increased productivity at work.

(2) report that work related stress among teachers is associated with Teaching experience, educational level, high job demand and poor relationships. In order to reduce stress levels among teacher, they recommend that action need to be taken to balance work demand and experience. Further, teachers should be given opportunities to enhance their skills by upgrading their educational qualifications. Good relationships among teachers also help them reduce the stress related to work.

(3) state that occupational stress is a major concern among urban school teachers in India. They further suggest that by constantly evaluating the stress levels and proving proper counseling, stress levels of teachers can be considerably reduced and their quality of life can be improved. Kumar et.al (2019) in their study "Organizational Commitment and Hardiness personality in relation to occupational stress of Primary School Teachers" reveal that both men and women in the teaching profession have the same amount of occupational stress. They further add that organizational commitment and hardiness personality, combined together, play a very important role in managing job stress. They also suggest that future research should focus on finding the regional, cultural and occupational factors for predicting and

managing job stress.

OBJECTIVES OF THE STUDY

1. To study the difference between the occupational stress with respect to gender.
2. To study the relationship between occupational stress and organizational commitment of the teacher.

Hypothesis

H1:- There will be no significant difference between the occupational stress with respect to gender.

H2:- There will be no significant relationship between the occupational stress and organizational commitment of the teachers.

RESEARCH METHODOLOGY

The goal of the current study is to understand the level occupational role stress among teacher in relation to their organizational commitment and coping strategies. The present study is descriptive in nature. The questionnaire was developed for collecting primary data and was administered to 160 college teachers and their responses were collected through filled up questionnaire. The collected data were tabulated and analyzed. The statistical tools used for analysis include Frequency and Percentage analysis.

Statistical techniques

1. Pearson product moment correlation was used to calculate the relationship between the variables.
2. T-ratio was used to find out the significant difference between the variables.

RESULTS AND DATA INTERPRETATION

This evaluates the key data gathered

throughout the study process. This chapter offers an objective analysis to make it simpler to read and comprehend. Tables and graphs were used by the researcher to present the data. The tables have highlighted significant findings. According to the needs, many statistical methods have been utilized, including percentage, mean, mode, and median.

Table 1: Gender group of the respondents

Particulars	No. of respondents	Percentage
Male	70	43.75%
Female	90	56.25%
Total	160	100%

The above data shows that 56.25% of respondents are females. And 43.75% of respondents are male.

Table-2: Distribution on the basis of courses

Courses	Number of Respondents	Percentage
MBA	32	20.0%
MCA	36	22.8%
Dental	28	17.14%
Engineering	40	25.7%
pharmacy	24	14.28%
Total	160	100%

Source: Primary Data

According to the data above, 20% of respondents attended MBA institutions. And MCA Streams College is represented by 22.8% of respondents. Dental, engineering, and pharmacy schools respectively account for 17%, 14%, and 25.7% of responders

Table-3: Showing the difference between the occupational stress of male and female teacher educators

Gender	Sample	Mean	SD	SED	t-ratio	Significant
Male	70	41.59	13.796	1.738	3.8423	Significant at both levels
Female	90	46.53	14.765			

T-value is more than the obtained value so this hypothesis is accepted. There exists significant difference between the occupational stresses with respect to the

gender.

Table-4: Showing the relationship between the occupational stress and organizational commitment of male and female teacher educators

Variables	Sample	Mean	SD	SED	t-ratio	Significant
Occupational stress	70	54.96	15.720	3.1312	4.5514	Significant at both levels
Organizational commitment	90	47.39	18.309			

t-value is more than the obtained value so this hypothesis is accepted. There exists significant relationship between the occupational stress and organizational commitments.

CONCLUSION

From this study, it can be concluded that faculty members of management institutes mostly exhibit defensive style (as dominant coping style) in coping stress. This style calls for avoidance of aggression or blame by use of defence mechanisms. The high involvement of the self and of others in the stress makes superego more active and therefore, defensive behavior is stimulated. The faculty members try to rationalize the stressful situation, avoid the aggression because their job demands more of patience, tolerance, as they have to deal with students with whom they have to be more tactful and convincing. An individual nor an organization can remain in a continuous state of tension. Even if a deliberate and conscious strategy is not utilized to deal with the stress some strategy is adopted. It is useful for individual and organization to examine what strategies they are using for coping. If no coping strategy is adopted lack of effectiveness may result. The act of coping itself as opposed to non-coping is related to satisfaction and is more important

than any other coping strategy.

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ADVANCES IN OMICS (TRANSCRIPTOMICS, PROTEIOMICS, METABOLIOMICS, IONOMICS AND PHENOMICS) IN RELATION TO ABIOTIC STRESSES IN POTATO

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ABSTRACT

Human population on Earth is increasing day by day and crossed 8 billion recently. Food security for such a huge population in climate change era is a big challenge because climate change severely intensifies the effect of abiotic and biotic stresses on plants. The stresses such as drought, heat, salt, elevated CO₂, temperature (low and high), waterlogging, rainfall and sunshine intensity, chemical factors (heavy metals and pH) etc. will threat the global food security, if not properly managed. Potato (*Solanum tuberosum* L.) is the fourth most important food crop after wheat, rice and maize with an estimated annual tuber production of 370 million tonnes. Environmental stresss affects the alteration of genomics, transcriptomics and proteomics in plants, as well as secondary metabolites. Multi-omics data integration is a powerful approach that combines information from multiple high-throughput omics technologies, such as genomics, transcriptomics, proteomics, metabolomics, ionomics, phenomics, epigenomics, etc., to investigate the molecular mechanisms underlying abiotic stress tolerance responses and ultimately pave a path to make stress tolerant crop varieties. The methodology for multiomics studies include Experimental design in specific abiotic stress treatment with control, collection of samples for multiple omics platforms, Data generation using high-throughput omics technologies such as whole genome sequencing (WGS) for genomics, RNAseq for transcriptomics, Mass Spectrophotometry (MS) for proteomics and metabolomics profiling for metabolomics, Data pre-processing and data Data integration.

Keywords: Genomics, Transcriptomics, Proteomics, Metabolomics, Ionomics, Phenomics, Epigenomics

INTRODUCTION

Human population is increasing worldwide and crossed 8 billion. Food security for such a huge population in climate change era is a challenge not only for governments of various countries but farmers and agricultural scientists also. It is estimated that between

691 and 783 million people in the world faced hunger in 2022. Global hunger, measured by the prevalence of undernourishment affecting around 9.2 percent of the world population in 2022 compared with 7.9 percent in 2019. Agrifood systems are highly vulnerable to climate variability and extremes (1).

Potato (*Solanum tuberosum* L.) is the fourth most important food crop after wheat, rice and maize with an estimated annual tuber production of 370 million tonnes (2). However, for potato as for other crops, abiotic stresses including water stress, heat stress and salt stress presents a serious threat. Potato has shallow root system, thus more susceptible to water stress (3). Drought or low water stress decrease crop growth and yield more than any other abiotic stress (4).

Abiotic Stresses Response At physiological Level

At morphological level potato cultivars exhibit an increase in root/shoot ratio due to the extensive and large root architecture in response to drought stress (5). At the whole plant and physiological levels, potato plants improve instantaneous WUE by minimizing transpiration water loss and conserving leaf water status through the decrease in stomatal conductance, leaf number, and leaf area (6,7).

Abiotic Stresses Response At Biochemical Level

At the biochemical level, potato plants display an increased accumulation of compatible solutes in response to drought stress (8). These solutes have been believed to decrease the leaf water potential without affecting turgor pressure. As a result, leaf cells are capable of taking up more water from the soil to maintain leaf water status and survive drought. For instance, the elevated accumulation of sugar alcohol and proline levels (9,24) has been observed in potato leaves following drought stress. In another study, the increased accumulation of glycine betaine has been reported in higher plants in response to drought, salinity, and low-temperature stress (10). Knowledge regarding these gene functions can be used to generate potato cultivars that are tolerant to

unfavourable conditions. A key goal is therefore to develop stress resistance varieties which can prevent 18-32% global yield losses.

Abiotic Stresses Response At Molecular Level

At molecular and genomic levels, drought tolerance has been conferred by the expression of various stress-related genes that encode proteins including transcription factors and enzymes involved in drought stress tolerance. The products of drought-related genes play a key role in stimulating initial stress response and in inducing stress tolerance at the cellular level. (14) Drought stress initiates the synthesis and deprotonation of abscisic acid (ABA), a well-known phytohormone (11). Synthesis of ABA induces transcriptional reprogramming leading to a variety of outcomes, including accumulation of osmo-protectants and stomatal closure (12). ABA serves as signaling molecules that induce the expression of several stress-related genes including those involved in closing stomata (13). Drought-related genes are believed to be governed through both ABA-dependent and ABA-independent mechanisms (14). Although the application of exogenous ABA has confirmed the ABA-induced expression of stress-related genes, several drought-induced genes are insensitive to exogenous ABA application (25).

Phenomics

Phenomics deals with omics of phenotype (phenotypes), a product of genes and utilizes high-throughput analysis of organismal phenotype by evaluating the morphological, physiological, and biochemical traits [17]. In the case of plants, phenomics correlates growth, performance and composition with genetic, epigenetic and environmental factors. Therefore, phenomics integrated with other omics unveils cellular biochemical or bio-physical networks that result in the final

desirable phenotype [16]. As most phenotypic traits are determined by the interactions between genes and the environment (G E), collections of large numbers of phenotypic data across multiple environmental conditions revealed the relationships between phenotypic traits and prevailing abiotic stresses. Both forward and reverse phenomics strategies were employed for the analysis of various traits. Forward phenomics uses high-throughput and fully automated phenotyping tools for the rapid identification of interesting, unique or desired traits(18), whereas the reverse phenomics method investigates the selected traits in detail and subsequently discovers the underneath mechanism [19]. In fact, phenomics can be used at the cellular and tissue level and also used on a bigger scale, i.e., plant organ, whole plant, plant community in the field, the vegetation of the particular area and ecosystem basis.

Multionics Data Collection and Data Integration

The methodology for multionics studies initiates with setup an Experimental design that expose crops to specific abiotic stress conditions while considering appropriate control sets for a quick compare. It needs to ensure the collection of samples for multiple omics platforms, including DNA, RNA, proteins and metabolites. 'Data generation' utilizes high-throughput omics technologies such as whole genome sequencing (WGS) for genomics, RNAseq for transcriptomics, Mass Spectrophotometry (MS) for proteomics and metabolomics profiling for metabolomics, to generate large-scale datasets for each omics layer. Data pre-processing' performs quality control. Data integration is a very vital step which can apply computational methods to integrate the multi-omics datasets. Such big-data-driven analysis requires high statistical significance to integrate different omics layers.(28)

Genomics

A genome is an organism's comprehensive collection of nucleic acids (DNA or RNA), which contains all of its genes. Genomic science or genomics is the study of the genome's structure, function, evolution, mapping and modifications. Functional genomics is concerned with the function of genes and their interactions while structural genomics is concerned with determining the three-dimensional structure of genes to identify, locate and determine their order along the chromosome. (20) Recent breakthroughs in molecular biological techniques have accelerated the pace of high-throughput genome sequencing, genomic characterization and gene expression analysis. (21)The technique of decoding the genome using high throughput next-generation sequencing (NGS) technology comprises the isolation of genomic DNA, the multiplication of DNA using polymerase chain reaction (PCR), the sequencing of the DNA and the assessment of the sequence's integrity (22). The sequencing and assembly of DNA, followed by the structural and functional annotation of the gene, permits large-scale investigations into the activities of genes and elucidates the interactions of gene products at the cellular and organismal levels (23).Functional genomics analyzes the data generated by complete or partial genome sequencing to describe gene functions and interactions and employs two complementary approaches to the determination of individual genes, viz., forward and reverse genetics[20].

Transcriptomics

Transcriptome is the whole collection of transcripts that are present in a cell or organism. The study of transcriptome is called transcriptomics (26). It helps in finding gene transcripts or RNA that are associated with a plant's phenotypic expression under different

environmental conditions. Several methods, including DNA microarrays, SAGE or high-throughput technologies relying on NGS, may be used in the process of conducting a transcriptome study such as RNA sequencing (RNAseq) and digital gene expression (DGE). Recently transcriptomic analysis has identified many stress-responsive genes, and their mode of expression under abiotic stress conditions in many plants including wheat, maize, rice, barley, sorghum, cotton and soybean (35). Moreover, transcriptome analysis in tomatoes has revealed the discovery of regulators of SGA pathways (22).

To date, several transcriptomic studies have been documented in potato governing response to abiotic/biotic stress and quality traits (34). In one of the earliest transcriptomic studies of potato in response to abiotic stresses, 20,756 ESTs from a complementary DNA (cDNA) library were constructed by pooling messenger ribonucleic acid (mRNA) from heat-, cold-, salt-, and drought-stressed potato leaves and roots (Rensink et al., 2005a). Later, to intensify potato transcriptomic analysis, the Potato Oligo Consortium (POCI) array was formed with 44,000 probes representing 42,034 potato unigenes (Kloosterman et al., 2008). The array was integrated into the functional genomics program of a Canadian consortium to improve disease resistance and tuber quality traits of potato.(30) Recent developments in high-throughput sequencing technologies of the whole transcriptome, known as RNA-Seq, permit the analysis of all transcripts in a sample for mRNA and miRNA abundance in potato. In a study of potato under drought stress, the transcripts that are differentially expressed under water with holding and rewatering were identified to deepen the understanding of the molecular mechanism of potato stolon responding to water stimulus. By analyzing the RNA-Seq data generated from stolon tips of potato plants in each of the three

groups, the researchers identified 3189 and 1797 differentially expressed transcripts under only drought treatment and treatment of drought followed by rewatering, respectively.(27) Several of these genes are homologs of known drought-responsive genes in Arabidopsis, including a dehydrin, protein phosphatase, auxin-responsive protein, gibberellic acid-stimulated gene, calmodulin-like protein, abscisic acid 80-hydroxylases, and calcium-transporting ATPase.(29)

miRNAs in potato

MicroRNAs (miRNAs) are small (21_24 nt), endogenous, nonprotein-coding RNAs that play important gene regulatory roles in animals and plants by pairing to the mRNAs of protein-coding genes to mediate posttranscriptional repression. The first attempt to identify the miRNAs that function in development and their targets in potato was done in 2009 (32). In this study, 48 potential miRNAs were identified in *S. tuberosum* by in silico comparisons of known miRNAs from other plants against potato EST, and nucleotide databases.(42). Several microRNAs have been known to regulate abiotic and biotic stresses, yield, and nutritional components in crops. High-throughput DNA sequencing allowed researchers to identify various miRNA families affected under biotic, abiotic stresses and quality.(36) A total of 458 known and 674 new miRNAs in control samples were identified in a recent comprehensive deep-sequencing miRNA analysis, while 471 known and 566 novel miRNAs were predicted in drought samples (31).

Proteomics

The study and characterization of the whole sequence of proteins that are present in a cell, organ or species at a particular point in time are referred to as proteomics. Various stages, such as development, cellular

differentiation and the cell cycle, as well as distinct environmental factors, such as abiotic stressors, may cause the same genes to express themselves in a variety of different ways. Some proteins might be regarded to be unique biomarkers for certain environmental factors such as abiotic stressors (37). Under environmental stresses, proteomics allows for the detection and characterization of proteins, as well as their activity profiles, post-translational modifications (PTMs) and protein–protein interactions. The two most common laboratory techniques are used extensively in proteomics studies—protein electrophoresis and protein identification using mass spectrometry. Conventional gel-based protein electrophoresis methods include techniques such as two-dimensional electrophoresis (2-DE) and Difference In-Gel Electrophoresis(DIGE). So far, various proteomic studies revealed abiotic stress tolerance of the plant, such as in drought, heat, chilling, salinity and waterlogging (33).

Two-dimensional (2D) gel electrophoresis was used to analyze potato treated with salt stress by applying 90-mM NaCl. A total of 322 and 305 differentially expressed proteins were detected in shoots of Kennebec and Concord, respectively.(42) These proteins differentially expressed under NaCl treatment were involved in protein synthesis, metabolism/energy, and photosynthesis.

Metaboliomics

Metabolites are concerned with the quantitative, qualitative and dynamic study of all endogenous, low molecular weight compounds (less than 1000–1500 dalton) within the organismal cells, tissue or organs and perform essential activities in a spatio-temporal manner. The most promising method to decipher abiotic stress tolerance in plant species has emerged from metabolomics.(38) Metabolomic approaches

are already in use for phenotyping the available species, lines, and varieties, as well as for assessing the tolerance of potato plants to environmental challenges and for detecting changes in tubers during storage. The use of metabolomics to research biotic/abiotic stress will help us to elucidate underlying molecular mechanisms associated with stress and would surely lead to developing tolerant potato plants with enhanced yield. (40) Metabolites can be classified into two classes—primary and secondary metabolites. Primary metabolites are essential for plant growth and play a wide role in physiological activity, while secondary metabolites are essential for defence response under a wide range of abiotic stresses. Plants have been studied for their ability to adapt to a variety of environmental conditions by looking at how they modify metabolites such as osmoprotectants (proline, glycine betaine, trehalose, etc.) and antioxidant enzymes (superoxide dismutase, peroxidase, ascorbate peroxidase, catalase, glutathione reductase, guaiacol peroxidase, etc.)(33). Primary metabolites such as sugars, amino acids and TCA (Krebs) cycle intermediates (citric acid, -ketoglutarate) are directly involved in plants' normal growth and development; whereas the secondary metabolites are genera-specific and condition-specific. Thus, the total metabolite profile of a given plant species indicates how many regulatory systems, such as gene expression and gene–protein interaction, have been integrated. Under any adverse environmental conditions, plants exhibit an array of responses that lead the particular stress tolerance, all of which are associated with metabolic modifications. Therefore, the study of stress-associated changes in metabolites is given particular attention in the 21st century (39).

Ionomics

In plants, ions are classified into two categories i.e. essential nutrient ions (macro and micronutrients) and non-essential nutrient ions. Some non-essential ions have negative role by harming normal physiological conditions in the plant. For example, the sodium ion (Na⁺) is a well-reported causal factor of salinity stress in many crop plants including rice. (41) There is also a positive role of an essential ion such as Ca²⁺ that antagonizes the salt stress (Na⁺) effect in rice salt-tolerant landraces Nona Bokra and sensitive cultivar IR-64 [15]. In ionomics, elements are profiled in a high-throughput manner and deal with the studies of inorganic components, mineral nutrients and trace element composition of a living being. Recent reports showed that ionomics studies revealed the mechanisms of ion uptake under abiotic stresses in plants. Moreover, transport, compartmentalization and exclusion of ions during adverse environmental conditions were also monitored by ionomics.

Bioinformatics

Bioinformatics is a wide multidisciplinary field that encompasses both theoretical and practical methods to comprehend, generate, analyze and disseminate biological information. Bioinformatics is the first link between biological data and the application of computational methods. Thus, with time, the field of bioinformatics has evolved and provides the platform for interactive “Omics” technologies.

Conclusion

Environmental stress affects the alteration of transcriptomics and proteomics in plants, as well as secondary metabolites. Transcriptomic studies in potato have identified a number of abiotic stress-related genes, providing new candidate genes for

future studies of abiotic stress responses in potato. Metabolic features that explain variation of yield under stress condition also become a strong instrument in breeding program to abiotic stress tolerance. Various secondary metabolites are known to be increased in response to drought stress, such as galactose, inositol, galactinol, proline and proline analogues and a number of drought-tolerance metabolite markers have also been proposed. These all advances in omics (Genomics, Transcriptomics, Proteomics, Metabolomics, Ionomics Phenomics) will pay the path for development of stress resistance varieties of potato suitable for climate change environment.

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