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5. Chandola, R.P., Bhatnagar, C.P. and Sah, Sudha 1971. Nature of variability induced by radiations, In : Proc. Int. Symp on use of Isotopes, Radiations in Agriculture and Animal Husbandary Research, New Delhi 46-50.

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CONTENTS

RESEARCH/REVIEW PAPERS

1. Role of Plant Tissue Culture in Improvement of Horticultural Crops 1-6
Ruchi Vir and Vipin Kumar
2. Studies on Influence of Pre-Sowing Treatments, Sowing Positions and Age of Stones After Extraction on Germination of Mango 7-13
U. R. Reshma and S. Simi
3. Study on Germination Percentage of Coffee (*Coffea arabica* Cv. Chandragiri) Seeds Grown in Portray and Raised Bed Using Different Rooting Media in Primary Nursery 14-16
D. D. Srigandha and Sudeesh Kulkarni
4. Dominance- Diversity and Distribution Pattern Along an Altitudinal Gradient of Garhwal Himalaya 17-21
Smriti Kukshal and Sarika Maheshwari
5. Assess the Extent of Path Coefficient Analysis for Fruit Yield and It's Contributing Traits in Cucumber (*Cucumis sativus* L.) 22-26
Deepesh Keshari, B. Singh, Rajat Singh, Satya Prakash
6. Growth and Yield of Cauliflower (*Brassica oleracea* L. Var. Botrytis) as Influenced by Integrated Sources of Nutrients and Mulching 27-32
Amit Kumar, Mukesh Kumar, Rajat Singh, Satya Prakash and Satvaan Singh
7. Study the Effect of Disbudding on Growth and Yield on Chrysanthemum (*Chrysanthemum morifolium*) Cv. Snowball 33-40
Mohammad Almas Amiri, Satya Prakash, Mukesh Kumar, Sunil Malik and Khursheed Alam
8. Impact of Front Line Demonstrations on Yield and Economics of Tomato in Ambala District of Haryana 41-45
Amit Kumar, Guru Prem, Upasana Singh, Vikram D. Singh, Kapil Kumar, Vikas Chaudhary and Neeraj Pal Malik
9. Integration of Different Sources of Nutrients on Growth and Yield of Potato (*Solanum tuberosum* L.) Cv. Kufri Chipsona. 46-50
Arvind Kumar, Vipin Kumar, S K Tripathi, Satya Prakash and Bijendra Singh

10. Extent of Correlation Coefficient Between Yield and its Contributing Traits in Onion (*Allium cepa* L.) Under Dhampur (Bijnor) Condition 51-54
Priyanshu, S. L. Pal, Ravi, Shoraj Singh and Vipin Kumar
11. Effect of Chemical Substances on Post-Harvest Vase-Life of Cut Gladiolus (*Gladiolus grandiflorus* L.) 55-60
Vikas Chaudhary, Rajveer Singh, Kapil Kumar, Vimal Chaudhary, Amit Kumar and Neeraj Pal Malik
12. Performance of Wheat Cultivars Under Different Spacing of Poplar (*Populus Deltoides* Bartr. Ex Marsh.) Based Agroforestry System in Semi-Arid Ecosystem of Northern India 61-67
Parvinder Kumar, Chhavi Sirohi, Sushil Kumari, R.S. Dhillon and Ishu Redhu
13. Genetic Variability Studies in Cherry Tomato for Quality Traits in Protected Conditions 68-71
Sameena Lone, K. Hussain, Ajaz Malik, Khalid Z. Masoodi, Z.A. Dar, Nageena Nazir, Zahedullah Zahed and Gowher Ali
14. Genetic Variability, Heritability and Genetic Advance in Bottle Gourd (*Lagenaria siceraria* (Mol.) Standl) 72-78
Rajat Singh, B. Singh, Satya Prakash, Mukesh Kumar, Vipin Kumar, Pooran Chand and Vaishali
15. Engineering Properties of Chewable Size Moringa Pods 79-83
I.P. Sudagar, P. Aruna and P. Rajkumar
16. Effect of Water Stress on Tuber Quality (Dumbel, Pointed, Cracks and Total Deformed Tubers) in Potato (*Solanum tuberosum* L.) 84-88
Subhash Kumar, Devendra Kumar, B. Singh, Yash Pal Singh, Pushpendra Singh and Akshya Kumar



ROLE OF PLANT TISSUE CULTURE IN IMPROVEMENT OF HORTICULTURAL CROPS

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Abstract

Plant tissue culture comprises variety of in vitro techniques, methods and strategies that are used to improve many economically important plants. Tissue culture can be used to create genetic variability through somaclonal variations that can further be exploited by using techniques like micropropagation, embryo culture, somatic embryogenesis, meristem culture and protoplast fusion for improvement of horticultural crops. Several traits, like stress resistance, increasing shelf life, virus free plants have been incorporated in horticultural plants raised by tissue culture techniques. The applications of various tissue culture approaches like micropropagation, somaclonal variations, somatic embryogenesis, anther culture, meristem culture, Protoplast fusion and embryo culture in horticultural crops are reviewed in this article.

Keywords: Tissue culture, Micropropagation, somaclonal variations, somatic embryogenesis, anther culture, meristem culture, protoplast fusion, embryo culture, Horticultural crops.

Introduction

Conventional plant breeding involves selection, hybridization, backcrosses, composite crosses are dependent and affected by environmental conditions like relative humidity, temperature and rainfall. However, genetic engineering along with plant tissue culture has revolutionised conventional plant breeding methods by providing new genotypes for breeding purposes that are healthy, disease free plant material resulting in improved fruit quality, increased shelf life, impacted availability of biopesticides, biofertilizer and more. Tissue culture techniques are part of a large group of strategies and technologies ranging from molecular genetics, recombinant DNA studies, genome characterization, gene transfer techniques, aseptic growth of cells, tissues, organs and in vitro regeneration of plants

called plant biotechnology. Genetic engineering involves identification of useful genes that are used to make gene constructs, which can be integrated into the genome of desired horticultural crop. Furthermore, tissue culture technique especially micropropagation helps in mass multiplication of genetically modified plants.

A plant tissue culture technique provides a substitute for vegetative propagation of various horticultural crops (Krishna et al. 2005, (2). The applications of various tissue culture approaches like micropropagation, somaclonal variations, somatic embryogenesis, anther culture, meristem culture and embryo culture in horticultural crops are reviewed in this article.

Plant tissue culture can be defined as culture of all types of plant cells, tissues and organs under aseptic conditions and controlled

environment. It involves culturing of excised embryos and protoplast too. Several plant tissue culture techniques like embryo culture, meristem culture, micropropagation somatic embryogenesis, somaclonal variations, in vitro selection, anther culture and protoplast culture have played important role in breeding, production and improvement of horticultural crops. More importantly, the present role of tissue culture is in production of pathogen free plants, virus elimination and germplasm storage of recalcitrant horticultural crops. The tissue culture techniques have been applied to the plant species to produce new genotypes with improved characteristics including tolerance to salt, drought and many other biotic and abiotic stresses. As these stresses affect the secondary metabolite production and therefore in turn declines crop yield and productivity and quality.

Micro Propagation

Micropropagation or in vitro clonal propagation is multiplication of genetically identical copies of a cultivar by asexual means under aseptic conditions and controlled environment. Micropropagation allows the production of large number of plants from small pieces of stock (shoot tip, leaf, lateral bud, stem or root tissue) plants in short period of time (9). It is most useful in propagation of horticultural crops that reproduced asexually. In addition, micropropagation is particularly useful in horticultural crop, where there is problem with seed germination and propagation of recalcitrant seeds. Micropropagation is reported in several horticultural crops like Citrus, Pineapple, Carnations, Gerbera. In these horticultural crops, micropropagation helped in higher and rapid rate of multiplication within a very limited space (Krishna et. al. 2008; 11), provided freedom from seasonal constraints, required less raw material consumption,

labour saving and help in production of disease-free plants. Also, the uniformity of individual plants within a clone population is a major advantage of clonal cultivars in commercial production (Krishna and Singh, 2013). Micropropagation of horticultural crops (Banana, Grape, Bougainvillea, Chrysanthemum, Lilies) has been successfully reported in relation to disease-free planting material generation with reference to specific pathogens. Micropropagation has been applied successfully to the production of self-rooted trees of four columnar apple tree selections from a breeding programme. Three of these selections had been released as commercial cultivars in the form of grafted trees on rootstocks under the cultivar names of 'Tuscan', 'Trajan' and 'Telemon', respectively (Marin et. al. 2015).

Somatic Embryogenesis

Somatic embryogenesis is a developmental process of somatic cells, which resembles morphologically zygotic embryogenesis. Somatic embryogenesis in fruit crops is emerging as an attractive option and most of the times necessary exercise it along with plant breeding. It is not only an ideal system for investigation of whole process of differentiation in plants but also used to observe mechanisms of expression totipotency in plant cells. It has several distinct advantages over conventional micropropagation (Litz & Gray, 1995). It is generally used in large scale production of plants and synthetic seeds. In most of the important fruit crops it is promising in plant regeneration (Kamle et. al. 2011). It is a process that shows advancement over vegetative propagation technology and micropropagation in high value horticultural crops. It finds application in mass multiplication of new and elite varieties within a short span of time with limited resources. Somatic embryogenesis finds application in production of plants with secondary metabolites, transgenic plants and somatic cell genetics (Litz & Gray, 1992). Along with conventional breeding, somatic

embryogenesis has accelerated the pace of genetic improvement programs of crops (Stasolla and Yeung, 2003). Further, Somatic embryogenesis find application in crop improvement through genetic transformation (Giri et. al. 2004; Gomez-Lim & Litz, 2009), virus elimination and germplasm conservation. Also, regeneration of fruit trees through somatic embryogenesis particularly in Banana, Guava, Mango, Papaya etc. are of great commercial importance for industry. Somatic embryogenesis has been reported in several polyploid varieties of Mango and somatic embryos were developed from nucellar cells of two monoembryonate Indian Varieties namely 'Amrapali' and 'Chausa' ((3).

Embryo Culture

Critical requirement for crop improvement programs is introduction of new genetic material into cultivated lines which can be effectively done via wide hybridization. However, due to pre and post zygotic barriers in most of the cases wide hybridization is not successful. One of the common reasons behind this is embryo abortion due to poor endosperm development. Embryo culture is not only helpful in overcoming abortion of the embryo but also solves the problem of low seed set, seed dormancy, poor seeds germination and viability. Production of monoploids in barley (Raghavan 1980, 1994 Yeung et. al. 1981; Zenkteler, 1990), shortening of breeding cycle in iris (Randolph, 1945) and interspecific and inter generic hybrids of number of agriculturally important crops (8, Palmar & Keller 1994) have been reported by using embryo culture. In Banana, commercially popular varieties are seedless owing to their triploid status. Interspecific hybrids between *Musa acuminata* and *M. balbisiana* were developed using embryo rescue techniques (10,6). Embryo rescue is also used to recover crosses between diploids and tetraploid species. Embryo culture techniques played role in improvement of fruit quality in seedless Lime (Prasad et. al. 1996). Also, double haploids of Carnation (*Dianthus caryophyllus*) were obtained by pseudofertilized ovule

culture (Sato et. al. 2000) through embryo culture.

Somaclonal Variations

Culturing of an explant in aseptic and controlled environment may also generate genetic variability known as somaclonal variation. These variations have provided a new and alternative tool to breeders for obtaining genetic variability especially in horticultural crops which are difficult to breed or have narrow genetic base (Krishna et. al. 2016). Several instances of usage of somaclonal variations in improvements of horticultural crops like Banana (Sahijram et. al. 2003), Apple (7), Brinjal (Ferdausi et. al. 2009), chrysanthemum (Miller & Zalewska, 2014) Carnations (Esmail et. al. 2012) have been reported. Somaclonal variants, which are dependent on natural variation in the population of cells may be genetic or epigenetic and are usually observed in regenerated plantlets (Larkin & Scowcroft, 1981). Somaclonal variations are same as variations induced with help of mutagens (Jain, 2001) and offers natural variability in cell lines for their potential exploitation in crop improvement. These are generated through several types of nuclear chromosomal rearrangements, chromosomal aberrations, gene amplification, transposon activation (Larkin et. al. 1984, Scowcroft et. al. 1987, Karp 1994). Most of the changes observed in plants generated from in vitro cultures possess variations are of potential agricultural and horticultural significance, like plant pigmentation, seed yield, plant vigour and size, leaf and flower morphology, essential oil and disease resistance (5). The prominent example is of Banana in which occurrence of off-types from tissue cultured plantlets ranged from 6 to 38 % in Cavendish cultivars (Sahijram et al. 2003); however, it could be as high as 90 % (Smith 1988).

Anther Culture

Anther culture is one of the ways of

producing haploid plants. Double haploids produced by treatment of haploids with colchicine allow expression of simple genetic traits or mutated recessive genes. These plants generated work as homozygous breeding lines and are useful in in vitro selection schemes (Smith & Drew, 1990) and have been successfully used to produce plant resistant to various metabolic inhibitors, environment stresses, herbicides and phytopathotoxins (Chaleff 1983, Mazur & Falco 1989). More than hundreds of plant species have been used to produce haploids by pollen, microspore and anther culture (Evans et. al. 1984, Hu & Zeng 1984, Bajaj 1990). These include horticultural crops like Grapes, Strawberry, Gerbera etc. Using this technique five to seven years were saved in producing and inbred line in different horticultural crop Freesia (5).

Meristem Culture

Medicine culture (Morel, 1960) involves culturing apical meristem after removal of two to three leave primordia from shoot apex. Together with micropropagation techniques, large number of disease-free plants can be produced through meristems. It has been used successfully in elimination of viruses from several horticultural crops (Nemeth, 1984, Waterworth & Hadidi 1998, Venkat Raman et. al. 2015). Chilean Strawberry is one of the progenitors of the cultivated strawberry (*Fragaria x ananassa* Duch.) and grows naturally in Chile, Hawaii, and the west coast of the United States. In Chilean Strawberry (*Fragaria chilensis*), meristem culture demonstrated to be an efficient tool for eliminating virus from infected plants, giving the possibility to produce disease free propagation material (Quiroz et. al. 2017).

Protoplast Fusion

Protoplast fusion is a tissue culture

technique that is used to produce unique hybrid plants that cannot be produced by conventional sexual hybridization. Protoplast can be produced from many plants including most crop species (Gamborg et. al. 1981; Evans & Bravo 1983; Lal & Lal 1990). However, the protoplast of two plants can be fused by chemical or physical means, the technique is limited by ability of fused products to regenerate and sterility in the interspecific hybrids (Evans et. al. 1984, Gleddie et. al. 1986; Evans & Bravo 1988). The restoration of regeneration capacity is observed through complementation and the problem of sterility can be eliminated by backcrossing the regenerated hybrids. The use of protoplast fusion for hybridization in crop plants has been reported in Brassicas, Citrus, Rice, Tomato, Carrots and Clover ((1,4) Vardiet. al. 1989; Kao et. al. 1991). Evans & Bravo (1988) suggested that production of novel hybrids through protoplast fusion should focus on 1. Agriculturally important traits; 2. Achieving combinations that only be accomplished by protoplast fusion; 3. Somatic hybrids integrated into conventional breeding program; 4. The extension of protoplast regeneration to a wider range of crop species. In Citrus, protoplast fusion has been widely used for scion and rootstock improvement (Grosser et. al. 2000; Guo & Deng, 2001; Grosser, 2003). The genus Citrus includes a range of species, varieties and cultivars. novel allotetraploid hybrids for use as parents in crosses with diploids to produce easy-peel, seedless, triploid citrus cultivars. The protoplasts of 'Encore' mandarin and 'Valencia' sweet orange, and of 'Encore' and 'Caffin' clementine mandarin in which protoplasts of each of the donors were isolated from embryogenic callus. Forty plants were confirmed as tetraploid by flow cytometry and chromosome counting. Three (less than 10% of all regenerants) were non-hybrid diploids. DNA fingerprinting confirmed that both parents contributed DNA to the hybrids, which were therefore allotetraploid. The hybrids showed morphological features typical

of other tetraploid Citrus, including broad, thick, dark green leaves (Wuet. al.2005).

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STUDIES ON INFLUENCE OF PRE-SOWING TREATMENTS, SOWING POSITIONS AND AGE OF STONES AFTER EXTRACTION ON GERMINATION OF MANGO

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Abstract

The present investigation was conducted at College of Agriculture, Vellayani during the year 2017-2018 to assess the effect of pre-sowing treatments, sowing positions and age of stone after extraction from the fruit on germination of mango stones. Mango stones of different age groups viz., freshly extracted stones, 10 and 20 days after extraction of pulp were soaked for 24 hours in aqueous solutions of GA₃ (100 and 200 ppm), KNO₃ (1 and 2 ppm), cow dung slurry, water and control (without treatments) and sown in flat and stalk end up (plumule up) positions in polythene bags. The freshly extracted mango stones which were soaked in 200 ppm GA₃ solution and sown in plumule up position recorded the least number of days for initiation of germination (13 days) and 50 % germination (23 days), the highest rate of germination (0.74), seedling length (27.35 cm) and dry weight (10.70 g) whereas freshly extracted mango stones which are soaked in 100 ppm GA₃ solution and sown in plumule up position recorded the highest germination (82.22 %), seedling vigour index -I (2142.03 cm) and seedling vigour index-II (791.48 g).

Key words: Mango stones, sowing positions, age, pre sowing treatments, germination

Introduction

Mango is commercially propagated by veneer, stone, approach and softwood grafting in different parts of the India. In most of the fruit crops, rootstock influences the vigour, longevity, tree size, yield and quality. For successful graft union, it is imperative to have healthy, strong and actively growing rootstocks. Mango stones are usually available during the drier parts of the year (April-May) because of which the germination percentage and vigour are very low (8). The viability of mango stones is also low since the stones are recalcitrant in nature. Germination percentage of mango stones is only 12 to 50 per cent when sown within a month of extraction.

Pre-sowing treatments with chemicals viz., gibberellic acid (GA₃) and KNO₃ have a significant effect on initiation of germination to boosting up of growth and vigour stimulation. Pre sowing treatments also protect seeds from biotic and abiotic factors during critical phase of seedling establishment. Synchronization and rapid seedling emergence are the commonly reported benefits of pre-sowing treatments on germination.

The orientation of seeds on seed bed has a great role in boosting up of the process of germination. It has a positive influence on altering the energy levels which are needed for the radicle and plumule emergence required

for completion of germination process. This is mainly due to the quantity of stored nutrients as well as the positioning of micropyle. The stalk end up position of sowing helps to place the micropyle in the most appropriate position and resulted in minimum requirement of energy for germination and stimulate the metabolic process that release energy for radicle emergence (2). Age of stone also has a crucial impact on germination and subsequent growth. Moisture content is the key factor that determines the viability of recalcitrant seeds. Loss of critical moisture content as the age advances can cause the alterations in a series of metabolic processes and can cause accumulation of free radicals, which result in onset of the deterioration process (16).

An experiment was therefore undertaken to assess the effect of pre-sowing treatments, sowing positions and age of stones after extraction from the fruit with the main objectives of increasing germination percentage and producing vigorous rootstocks in order to meet the ever rising market demand and to evolve the best technology for producing high quality mango planting material in a short period of time. The study aims to obtain information about seed germination and seedling development that could facilitate nursery production of mango seedlings for orchard establishment.

Materials and Methods

The present study was carried out during 2017-2018 at the College of Agriculture, Vellayani, Thiruvananthapuram. The experiment was laid out in Factorial Completely Randomized Block Design with 42 treatments. The treatments comprise of different combinations of 2 sowing positions (flat and stalk end up), 3 different age group of stones after extraction from fruit (freshly extracted stone, 10 days after extraction and 20 days after extraction) and 7 pre-sowing treatments (GA3- 100 and 200 ppm, KNO₃ -1 and 2 ppm, cow dung slurry, water and

control). Fruits of 'Kotookonam Varikka' variety of mango were selected for stone extraction and were procured from southern tracts of Thiruvananthapuram, district of Kerala and washed thoroughly to remove extraneous material adhering to it. The stones were immersed in water and allowed to settle at the bottom of the container. Stones floating on the surface of water were discarded and those which settled at the bottom were used for experimentation. The mango stones were soaked in the above solutions for 24 hours prior to sowing during different times after extraction based on age group. The resultant forty two treatments were replicated thrice. Treated mango stones of different age groups were sown in two different methods viz., stalk end up and flat positions.

The germination percentage was calculated using the formula given below;

$$\text{Germination percentage} = \frac{\text{Number of germinated stones}}{\text{Total stones}} \times 100$$

The rate of germination was determined by dividing the germination percentage with number of days taken for attaining the germination. The seedling vigour index-I was calculated by multiplying germination % and seedling length, while the seedling vigour index II was determined by multiplying germination % and dry weight of seedling.

Five mango seedlings were selected at random from each replication for recording observations related to germination. The germination of stones started 15 days after sowing and continued upto 55 days. Observations were recorded daily for germination parameters; and vegetative parameters like seedling length, dry weight and seedling vigour index I & II were recorded 4 months after sowing. The experimental data recorded was subjected to statistical analysis as per the method suggested by (14). Treatment means were separated using F test values at 5% level of significance.

Results and Discussion

Significant differences were observed among the pre-sowing treatments, sowing position and age of stone after extraction from the fruit for germination characters. Statistically analysed results are given in Table 1&2 and are explained under following subheadings.

Effect of Sowing Positions

There was a significant impact of sowing positions on all the parameters chosen for this investigation (Table 1). The stones which were sown with stalk end up position resulted in the highest germination, minimum number of days for initiation of germination, high rate of germination and seedling vigour indices (on growth and weight basis). Sowing of seeds at proper depth and position was one of the most important nursery operations because it affects germination and subsequent growth.

To ensure good germination, rapid emergence and good performance, seeds must be placed in a position and in an environment that ensures the availability of nutrients and water from the soil. Seed orientation affects seedling emergence greatly. The results are in conformity with (6) and (7) in cashew.

Germination commences with the uptake of water by the dry seed (imbibition) and is completed when embryonic shoot and root, i.e., plumule and radicle, respectively, emerged. The amount of energy required to accomplish this task varies with genotype and orientation of the seed at sowing because of the quantity of stored nutrients, especially endosperm and positioning of micropyle. Mango stones with stalk-end up places the micropyle in the most suitable position, i.e., pointing downward, and therefore require less germination energy for the radicle to emerge from the embryo. Moreover, stalk-end facing up might enhance accessibility to required oxygen for the initial metabolic process that produces energy for radicle emergence (2). Improper orientation of

stones could deprive the emerging embryo of needed oxygen which could lead to high ethanol and pyruvate production in the system and finally death of the emerging embryonic (plumule and radicle) plants. This probably resulted in the reduced germination percentages and poor quantitative plant vigour.

Effect of Age of Stones After Extraction from the Fruit

The highest germination percentage, minimum number of days for initiation of germination, rate of germination, seedling vigour indices on growth basis and weight basis were the best for the freshly harvested stones (Table 1.). Germination characteristics of freshly harvested stones were the best compared to other ages of stones (1). Germination became progressively slower as the age advances. The highest germination percentage, minimum number of days for initiation of germination and for 50 % germination, rate of germination, seedling length, dry weight of seedling, seedling vigour index- I and seedling vigour index- II were found best for the freshly harvested stones. The results are in conformity with (10) in jamun.

Effect of Pre-sowing Treatments

The stones pre-treated with GA₃ 100 ppm recorded the highest germination, whereas GA₃ (200 ppm) required minimum number of days for initiation of germination (Table 1.). Early stone germination in GA₃ 200 ppm treatment might be due to increased endogenous auxin content due to application of GA₃. The pre-soaking treatment of GA₃ might have affected and altered the enzymatic reaction, protein synthesis and conversion of starch to sugars involved in the germination process (13). Gibberellic acid induces *denovo* synthesis of proteolytic enzymes like -Amylase and ribonuclease. Amylases in turn hydrolyse starch in the endosperm,

providing essential sugars for the initiation of growth processes and liberate chemical energy which is used in the activation of embryo as well as suppression of inhibition along with synthesis of RNA which resulted in higher germination (4). GA₃ treatment is also known to overrule the photo dormancy, thermo-dormancy, dormancy imposed by incomplete embryo development, mechanical barriers and presence of germination inhibitors (5). Similar results in case of GA₃ were reported by (18) in mango and (11) in papaya

The highest rate of germination was observed in the treatment GA₃ 200 ppm followed by GA₃ 100 ppm and KNO₃ 1 ppm and the lowest in control. The difference in rate of germination may be attributed to the differential ability of the pre sowing treatment of these chemicals for reducing the time taken for germination and to remove the obstruction in embryo growth (12). The stones treated with GA₃ 200 ppm took the least time for initiation and 50 % of germination, while maximum days was reported in control. The variation in respect of days required for potential germination might be due to stimulative effect of chemicals on emergence of seedling and the rate of different growth processes like cell elongation, cell division and cell multiplication (16).

Among the various treatments, the maximum seedling length was recorded in GA₃ 200 ppm followed by KNO₃ (1 %). This might be due to the fact that the GA₃ stimulates vegetative growth by increased osmotic uptake of nutrients, cell multiplication and cell elongation which might have reflected in the maximum height of seedlings in this treatment. These results are in accordance with results obtained by (19) and (9). The regulation of growth by gibberellins and KNO₃ relates almost extensively to its stem elongation properties. Influence of gibberellic acid and potassium nitrate on stem elongation is achieved by inducing the cell wall extensibility, stimulating cell wall synthesis, reducing the

rigidity of cell wall and by increasing cell division as well as increasing the synthesis of IAA leading to more growth.

Among the treatments, the highest dry weight was found highest in GA₃ 200 ppm followed by KNO₃ 1 ppm while the lowest was in control. The increased weight of seedling was mainly attributed to enhanced germination, early seedling emergence and better seedling growth. The higher vigour indices may be due to the higher germination percentage induced by these chemicals. Seedling Vigour Index is a product of germination percentage and seedling length. Higher the seedling vigour index, more vigorous the seedlings are considered to be (1). In the current trial, maximum Seedling Vigour Index-I was observed when mango stones which were treated with GA₃ 100 ppm followed by GA₃ 200 ppm whereas minimum was noticed in control. This can be ascribed to the cumulative effect of higher shoot length, root length and germination percentage under GA₃ treatments. These results are in agreement with an earlier report by (12) in citrus.

Interaction Effect

The freshly extracted mango stones which were soaked in 200 ppm GA₃ solution and sown in plumule up position recorded the least number of days for initiation of germination and 50% germination, highest rate of germination, seedling length and dry weight whereas freshly extracted mango stones which are soaked in 100 ppm GA₃ solution recorded the highest germination, seedling vigour index- I and seedling vigour index- II. As the interaction effect of the factors viz., sowing positions, age of stones after extraction from the fruit and pre-sowing treatments on germination of mango stones concerned, there were no significant effect obtained for days taken for 50 % germination, germination percentage, Seedling Vigour Index- I and Seedling Vigour Index- II (Table 2).

Conclusion

From the present investigation, it is evident that the freshly extracted mango stones which are soaked in 200 ppm GA3 solution and sown in stalk-end up position recorded the least number of days for initiation of germination, and 50 % germination, highest rate of germination, seedling length and dry weight whereas the stones soaked in 100 ppm GA3 solution recorded the highest germination, seedling vigour index- I and seedling vigour index-II. The pre-sowing treatments, sowing positions

and age of stones need to be taken into consideration to attain a noticeable difference in enhancing germination, rapid emergence and stimulating growth and vigour.

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Table 1: Germination Characters of Mango as Influenced by Different Sowing Positions, Age of Stones After Extraction from the Fruit and Pre-sowing Treatments on Germination of Mango Stones

Parameters	Days taken for initiation of germination	Days taken for 50 % germination	Germination (%)	Rate of germination	Seedling length (cm)	Dry weight of seedling (g)	Seedling vigour index -I Growth basis (cm)	Seedling vigour index- II Weight basis (g)
Effect of Sowing Positions								
Flat	29.15	40.91	40.95	0.26	18.34	7.46	27.33* (746.93)	17.44* (304.15)
Stalk end up	22.95	31.75	60.85	0.47	21.84	8.64	36.39* (1324.23)	22.84* (521.67)
SE(m)	0.046	0.166	0.690	0.001	0.054	0.026	0.226	0.143
CD	0.130	0.466	1.940	0.004	0.152	0.073	0.637	0.402
Effect of Age of Stone After Extraction from Fruit								
Freshly extracted stone	18.56	31.29	59.84	0.47	22.76	8.60	36.80* (1354.24)	22.60* (510.76)
10 days after extraction	24.56	36.50	52.38	0.36	21.07	8.07	33.05* (1092.30)	20.45* (418.20)
20 days after extraction	35.03	41.20	40.48	0.28	16.45	7.48	25.74* (662.55)	17.37* (301.72)
SE(m)	0.057	0.203	0.845	0.002	0.066	0.032	0.277	0.175
CD	0.160	0.571	2.376	0.005	0.186	0.090	0.780	0.492
Pre Sowing Treatments								
GA3 - 100 ppm	23.89	33.94	62.59	0.43	21.16	8.47	36.37* (1322.78)	22.99* (528.54)
GA3 - 200 ppm	22.62	31.78	55.19	0.47	22.69	9.58	35.30* (1246.09)	22.95* (526.70)
KNO ₃ - 1 ppm	24.49	34.17	52.96	0.42	22.14	9.15	34.09* (1162.13)	21.92* (480.49)
KNO ₃ - 2 ppm	25.69	35.56	50.00	0.36	20.14	8.00	31.60* (998.56)	19.85* (394.02)
Cow dung slurry	25.78	35.78	55.19	0.35	19.94	7.64	33.10* (1095.61)	20.46* (418.61)
Water	28.84	40.11	42.96	0.31	18.11	7.01	27.81* (773.40)	17.28* (298.60)
Control (no treatment)	31.01	42.94	37.40	0.25	16.45	6.49	24.76* (613.06)	15.51* (240.56)
SE(m)	0.087	0.310	1.291	0.003	0.101	0.049	0.424	0.267
CD at 5 %	0.244	0.872	3.630	0.008	0.285	0.137	1.192	0.751

Transformed values*Table 2: Interaction Effect of Sowing Positions, Age of Stones After Extraction from the Fruit and Pre-sowing Treatments on Germination of Mango Stones**

Sl. no.	Treatments	Days taken for initiation of germination	Days taken for 50 % germination	Germination (%)	Rate of germination	Seedling length (cm)	Dry weight of seedling (g)	Seedling vigour index -I Growth basis (cm)	Seedling vigour index- II Weight basis (g)
1	S ₁ A ₁ T ₁	19.13	31.33	62.22	0.51	21.83	8.65	36.86* (1358.60)	23.22* (538.50)
2	S ₁ A ₁ T ₂	17.73	30.33	53.33	0.58	23.92	9.60	35.69* (1276.57)	22.62* (511.44)
3	S ₁ A ₁ T ₃	18.33	31.67	51.11	0.51	23.38	9.17	34.49* (1191.39)	21.634* (469.13)
4	S ₁ A ₁ T ₄	21.00	33.67	46.67	0.40	21.41	7.88	31.58* (999.91)	19.17* (367.49)
5	S ₁ A ₁ T ₅	22.20	33.33	53.33	0.41	20.10	7.70	32.73* (1073.47)	20.26* (410.25)
6	S ₁ A ₁ T ₆	23.73	38.34	40.00	0.26	19.04	7.36	27.55* (761.82)	17.13* (293.35)
7	S ₁ A ₁ T ₇	25.73	42.33	35.55	0.21	16.07	6.89	23.89* (570.54)	15.66* (244.59)
8	S ₁ A ₂ T ₁	26.00	37.34	51.11	0.24	20.47	8.00	32.35* (1046.73)	20.24* (408.90)
9	S ₁ A ₂ T ₂	24.00	36.33	42.22	0.25	22.17	8.55	30.60* (937.13)	19.01* (360.99)
10	S ₁ A ₂ T ₃	26.53	41.33	40.00	0.24	22.11	8.37	29.69* (885.15)	18.28* (334.71)
11	S ₁ A ₂ T ₄	27.67	41.67	35.55	0.26	19.23	7.68	26.16* (685.56)	16.54* (273.32)
12	S ₁ A ₂ T ₅	26.87	39.33	44.45	0.26	19.65	7.24	29.55* (873.29)	17.96* (322.17)
13	S ₁ A ₂ T ₆	31.60	45.34	33.33	0.21	16.67	6.70	23.53* (556.84)	14.93* (223.27)
14	S ₁ A ₂ T ₇	33.27	47.66	31.11	0.15	14.99	6.22	21.58* (466.33)	13.93* (193.53)
15	S ₁ A ₃ T ₁	36.80	44.67	44.45	0.14	14.98	7.17	25.81* (666.65)	17.87* (319.08)
16	S ₁ A ₃ T ₂	35.47	41.00	37.78	0.21	16.90	7.99	25.28* (640.29)	17.39* (302.30)
17	S ₁ A ₃ T ₃	37.40	44.33	35.55	0.16	16.27	7.62	24.04* (577.96)	16.46* (270.34)
18	S ₁ A ₃ T ₄	37.94	45.34	31.11	0.14	14.60	6.91	21.30* (454.25)	14.68* (215.35)
19	S ₁ A ₃ T ₅	37.20	47.00	37.78	0.14	15.30	6.33	24.05* (579.32)	15.47* (238.70)
20	S ₁ A ₃ T ₆	40.27	51.00	28.90	0.11	13.86	5.58	20.00* (400.01)	12.72* (161.52)
21	S ₁ A ₃ T ₇	43.20	55.67	24.45	0.11	12.17	4.95	17.24* (297.41)	11.03* (121.15)
22	S ₂ A ₁ T ₁	13.53	26.34	82.22	0.66	26.05	9.62	46.29* (2142.03)	28.14* (791.48)
23	S ₂ A ₁ T ₂	13.00	23.00	73.33	0.74	27.35	10.70	44.75* (2003.42)	28.00* (784.27)
24	S ₂ A ₁ T ₃	14.67	24.33	73.33	0.60	27.26	10.31	44.69* (1998.67)	27.49* (755.38)
25	S ₂ A ₁ T ₄	16.40	27.34	68.90	0.42	24.85	8.80	41.37* (1710.92)	24.64* (606.16)
26	S ₂ A ₁ T ₅	16.07	28.66	75.56	0.42	23.89	8.55	42.44* (1806.03)	25.40* (646.50)
27	S ₂ A ₁ T ₆	18.33	32.00	64.45	0.45	22.20	7.89	37.83* (1430.94)	22.57* (508.97)
28	S ₂ A ₁ T ₇	19.93	35.33	57.78	0.33	21.20	7.21	34.98* (1224.40)	20.42* (416.37)
29	S ₂ A ₂ T ₁	19.53	30.00	75.55	0.56	23.77	8.83	42.38* (1795.72)	25.85* (667.58)
30	S ₂ A ₂ T ₂	18.53	28.33	66.67	0.60	24.67	10.53	40.54* (1644.89)	26.48* (700.47)
31	S ₂ A ₂ T ₃	20.87	30.00	68.90	0.58	24.08	9.84	40.67* (1658.92)	26.01* (678.26)
32	S ₂ A ₂ T ₄	21.27	30.33	73.33	0.50	23.15	8.46	41.18* (1696.92)	24.92* (621.33)
33	S ₂ A ₂ T ₅	20.40	31.34	71.11	0.45	23.05	8.12	40.50* (1639.88)	24.04* (577.17)
34	S ₂ A ₂ T ₆	22.47	35.00	55.55	0.41	21.12	7.53	34.25* (1172.97)	20.47* (418.65)
35	S ₂ A ₂ T ₇	24.73	37.00	44.45	0.33	19.80	6.96	29.67* (880.53)	17.60* (309.75)
36	S ₂ A ₃ T ₁	28.33	34.00	60.00	0.42	19.85	8.51	34.51* (1193.87)	22.59* (510.35)
37	S ₂ A ₃ T ₂	27.00	31.67	57.78	0.44	21.15	10.13	34.97* (1222.87)	24.21* (585.77)
38	S ₂ A ₃ T ₃	29.13	33.33	48.89	0.42	19.72	9.61	30.98* (962.18)	21.66* (470.11)
39	S ₂ A ₃ T ₄	29.87	35.00	44.45	0.41	17.59	8.25	27.95* (781.25)	19.17* (367.07)
40	S ₂ A ₃ T ₅	32.00	35.00	48.89	0.41	17.64	7.90	29.31* (862.45)	19.63* (386.25)
41	S ₂ A ₃ T ₆	36.67	39.00	35.56	0.40	15.79	7.06	23.70* (562.14)	15.85* (250.81)

42	S ₂ A ₃ T ₇	39.20	39.67	31.11	0.34	14.47	6.69	21.20* (449.67)	14.44* (208.39)
SE(m)	0.212	N/A	N/A	0.007	0.248	0.119	N/A	N/A	
CD at 5 %	0.597	N/A	N/A	0.019	0.698	0.335	N/A	N/A	

S1: Flat S2: Stalk end up A1: Freshly extracted stone A2: 10 days after extraction

A3: 20 days after extraction

T1: GA3- 100 ppm T2: GA3 - 200 ppm T3: GA3- 300 ppm T4: KNO₃- 1ppm T5: KNO₃ - 2 ppm

T6: Cow dung slurry T7: Water T8: Control (No treatment)

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STUDY ON GERMINATION PERCENTAGE OF COFFEE (COFFEA ARABICA CV. CHANDRAGIRI) SEEDS GROWN IN PORTRAY AND RAISED BED USING DIFFERENT ROOTING MEDIA IN PRIMARY NURSERY

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Abstract

This study was conducted with an objective to find out the most suitable media for better germination of coffee seeds sown in portray and raised bed. Coffee seedlings were grown in portray and raised bed using 7 different media for a period of 45 days in primary nursery. It was revealed from the study that, the germination percentage of coffee seeds was greatly influenced by different media used. Coffee seeds sown in raised bed using the media red soil+ sand+ vermicompost (C1M3) recorded maximum germination percentage (61 and 87.80) at 30 and 45 days after sowing.

Keyword: Coffee, portray, raised bed, media.

Introduction

Coffee is the second important commodity in international trade, next to petroleum products in trade volume and value. Coffee (*Coffea* sp.) belongs to family Rubiaceae. As per 2019-20 data Karnataka leads in production (2, 03, 445 MT) next top producer states are Kerala and Tamilnadu (1). India exports 70-80 per cent of its produce. Commercially coffee is propagated through seeds. There are various factors that influence the initial development of coffee growing in the field, such as the seedlings production process and, specially, the container and substrate used (4). Regarding the substrate, conventionally Forest soil: FYM: Sand (6:2:1) is used, but the availability of forest soil is difficult because of diminishing of forest area.

Materials and Methods

An experiment was conducted during 2016-17 at the College of Horticulture, Mudigere to know the germination percentage of coffee seeds grown in portray and raised bed using different rooting media for large scale plantation programme. The required seeds were collected from Central Coffee Research Institute, Balehonnur.

An experiment was laid out in a two factorial randomized block design. Coffee cultivar Chandragiri was used. Seeds were sown in portrays, 2 seeds per well and raised bed of 15 cm height and 1 m wide size at a distance of 2 cm between seeds and 10 cm between rows in primary nursery for a period of 45 days.

Treatments Detail

Factor I: Container		Factor II: Media	
Treatment	Container	Treatment	Media
C ₁	Raised bed [Control]	M ₁	Red soil + sand + FYM in 3:1:1 ratio (Control)
C ₂	Protrays (2" × 2")	M ₂	Red soil + cocopeat + FYM in 3:1:1 ratio
		M ₃	Red soil + sand + vermicompost in 3:1:1
		M ₄	Red soil + sand + pressmud in 3:1:1
		M ₅	M1+ <i>Pseudomonas fluorescens</i> (5g/ kg)
		M ₆	M5+ VAM – <i>Gigaspora gigantea</i> (10g/kg FYM)
		M ₇	M5+ PSB – <i>Bacillus megaterium</i> (10g/kg FYM) + Nitrifying Bacteria – <i>Azospirillum</i> (10g/kg FYM)

Table 1: Effect of portray, raised bed, rooting media and their interactions on germination percentage of coffee seeds at 30 days after sowing

	M ₁	M ₂	M ₃	M ₄	M ₅	M ₆	M ₇	Mean
C ₁	41.50	45.80	61	51.50	56.40	59.40	59.80	53.62
C ₂	31.60	37.20	59.30	39.80	32.90	37.50	38.70	39.57
Mean	36.55	41.50	60.15	45.65	44.65	48.45	49.25	
	SEm±				CD @ 5%			
Container(C)	0.154				0.476			
Media(M)	0.288				0.884			
Interaction (C×M)	0.408				1.241			

Table 2: Effect of portray, raised bed, rooting media and their interaction on germination percentage of coffee seeds at 45 days after sowing

	M ₁	M ₂	M ₃	M ₄	M ₅	M ₆	M ₇	Mean
C ₁	65.60	70.90	87.80	75.40	81.40	82.80	83.40	78.18
C ₂	62.50	65.80	78.10	70.00	63.10	64.50	65.60	67.08
Mean	64.05	68.35	82.95	72.70	72.25	73.65	74.50	
	SEm±				CD @ 5%			
Container (C)	0.219				0.674			
Media (M)	0.410				1.259			
Interaction (C×M)	0.580				1.770			

C: ContainerM: Media

Results and Discussion

Germination percentage of coffee seeds found to be significant among the containers, media and with their interactions. The maximum germination percentage was found in the seeds sown in raised bed prepared by using red soil + sand+ vermicompost (C₁ M₃) which was on par with C₁M₇ i.e., raised bed prepared by using Red soil + sand + FYM+ *Pseudomonas fluorescens* + PSB+ Nitrifying Bacteria and the least was recorded in C₂M₁ at 30 days after sowing. Similarly at 45 days after sowing maximum germination was found in C₁ M₃ followed by C₁ M₇ and C₁ M₆ and the least was recorded in C₂ M₁.

This maximum germination could be attributed to the fact that well decomposed vermicompost maintains optimum moisture and in addition sand provides good aeration and oxygen for better respiration and red soil supports better anchorage, this integrated condition favours for better germination of seeds. (2) recorded highest percentage of germination (95.27) in papaya cv. Red lady in similar media of vermicompost: sand: pond soil (1:1:1) with cocopeat. In portray surface area is less and drainage is inadequate whereas in raised bed ample surface area, better moisture availability and good aeration which facilitated better germination of seeds.

Similar findings was recorded by (3) in *Albizia procera* which attained 95% germination within 14 days after sowing in traditional nursery bed.

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DOMINANCE- DIVERSITY AND DISTRIBUTION PATTERN ALONG AN ALTITUDINAL GRADIENT OF GARHWAL HIMALAYA

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Abstract

In this study, we examined the species composition, distribution pattern and diversity of tree and shrub species along an altitudinal gradient of Garhwal Himalaya. Vegetational analysis was analyzed along four forest stands at an altitude of 750m-1000m a.s.l. The total tree density ranged from 340-610 tree/hac. *Pinus roxburghii* displayed maximum density and IVI at all four sites. *Carissa apaca* showed maximum density and IVI amongst shrubs. Trees were distributed randomly while shrubs displayed contagious distribution. Species diversity ranged from 0-1.87 amongst trees while .98-1.36 values are reported for species diversity of shrubs..

Key words: altitude, distribution pattern, diversity.

Introduction

The Himalayan forest ranges from tropical dry deciduous forest in the foot hill to timber line forest are the main source of livelihood of the people living Uttarakhand, Western Himalaya a forest of this region are mainly dominated by *Pinus roxburghii* and *Quercus leucotrichophora*. In forest ecosystems, trees are responsible for the overall physical structure of habitats, and thus, they define fundamentally the templates for structural complexity and environmental heterogeneity (15). Knowledge of species composition and diversity of tree species is of utmost importance not only to understand the structure of a forest community but also for planning and implementation of conservation strategy of the community (16, 12).

Species is one of the major analytical characteristics of the plant community (16). The *Pinus roxburghii* is the most common resin producing pine species of India and also

provide alternate source of fuel wood and leaves for bedding materials (8). The region between 1000 - 1800m above m.s.l. is mainly dominated by chir- pine, (*Pinus roxburghii*) forest representing densely populated zone of the region. In Garhwal Himalaya a pine forest are situated between 300m - 2000m above m.s.l.

The lower elevation of the temperate forest is occupied by Oak and pine mixed forest and other coniferous at higher altitudes normally from the climatic vegetation (3). Forest resources of the Himalaya are shrinking in size due to over-exploitation and there is increased interest to protect, manage and make them more productive. These forests have been under severe biotic pressure (Lopping, grazing and firewood collection) from human and livestock population which influence the rapid and frequent changes in land and resource use, reduction in species number, change in the climate pattern. These changes directly affect biodiversity (9).

The main aim of the present paper was to observe dominance-diversity and distribution pattern of forests along an altitudinal gradient. The present study provides a quantitative information and distribution pattern of species of the study sites.

Materials and Methods

The study area was conducted in Srinagar region situated in Pauri Garhwal (30° 12' 15"-30° 15'N Lat. and 80° 50' E Long.), temperate part of the western Himalaya in the altitudinal range of 700-1000m.a.s.l, divisible in four different study sites. The climate of study site was typically monsoonic. The soil is derived from weathering of phyllite rocks as a result of physical, chemical and biological activities. Phytosociological analysis in the area was done by laying 10 quadrats of 10x10m size in each site. The size and number of quadrat was determined on the basis of species area curve method. All the occupying individuals of each species and their types (tree and shrubs) were noted. Trees were considered to be individuals > 30cm cbh (circumference at breast height) (22). The phytosociological data were analyzed quantitatively for percentage frequency,

abundance, density according to the formulae given by (5). Importance value index for trees was determined as the sum of the relative density relative frequency, relative dominance (6). Abundance to frequency ratio was done following (4) Distribution patterns were considered to be <0.025 regular distribution, 0.025-0.05 random distribution and >0.05 contagious distribution. Species richness or evenness was determined following (25) by tabulating the number of species in each site. Species diversity was computed by using (23). Concentration of dominance (CD or) was computed using Simpson's index (24)

Results

Phytosociological analysis of vegetation at different study sites are given in table1 and 2. A total of 12 species of Trees and 7 species of shrubs were recorded from the study sites. Among the Trees, the maximum density was that of *Pinus roxburghii* (410tree/hac) at site III and least density was occupied by two species i.e. *Terminalia* spp and *Pyrus pashia* (20 tree/ha) in site I. Among trees, *Pinus roxburghii* was the dominant species (IVI-300) at site II While least dominant species was *Terminalia* spp (IVI=10.80) at site I (Table 1).

Species	Stand I (800m)		Stand II (1000m)		Stand III (950m)		Stand IV (750m)	
	Density (Tree/ha)	IVI	Density	IVI	Density	IVI	Density	IVI
<i>Mallotus philippensis</i> (Lam.) Muell.-Arg.	240	79.69	—	—	—	—	—	—
<i>Terminalia</i> sp. L.	20	10.80	—	—	—	—	—	—
<i>Eucalyptus globulus</i> Labbil	50	31.07	—	—	—	—	—	—
<i>Pyrus pashia</i> Buch.-Ham.exD.Don	20	11.58	—	—	—	—	—	—
<i>Bauhinia vahlii</i> Wight&Arn.	30	17.59	—	—	—	—	—	—
<i>Pinus roxburghii</i> Sarg.	60	69.28	410	300	300	264.6 2	400	192.26
<i>Dalbergia sisso</i> Roxb.	60	32.88	—	—	—	—	—	—
<i>Lannea coromandelica</i> (Houttuyn) Merrill	—	—	—	—	40	35.38	—	—
<i>Syzygium</i> sp.L.	—	—	—	—	—	—	50	22.10
<i>Cassia fistula</i> L.	—	—	—	—	—	—	100	38.47
<i>Phyllanthus emblica</i> L.	—	—	—	—	—	—	40	15.54
<i>Mangifera indica</i> L.	50	47.11	—	—	—	—	30	31.63
Total	530		410		340		610	

Among Shrubs, *Carissa apaca* displayed maximum density and IVI (2680 Shrubs/hac; 178.75) at site II while minimum density and IVI was shown by *Zanthoxylum armatum* (80shrubs/hac; 4.09) at site I (Table 2).

Table2: Phytosociological Attributes of Shrubs at all Study Sites

Species	Stand I(800m)		Stand II (1000m)		Stand III (950m)		Stand IV (750m)	
	Density (Shrubs/ha)	IVI	Density (Shrubs/ha)	IVI	Density (Shrubs/ha)	IVI	Density (Shrubs/ha)	IVI
<i>Asparagus adscendens</i> Buch.-Ham	160	47.73	1040	43.28	1280	90.26	1720	53.36
<i>Berberis aristata</i> DC.	280	10.04	—	—	—	—	—	—
<i>Carissa apaca</i> Stapf.	2080	158.97	2680	178.75	1720	126.24	2120	152.84
<i>Euphorbia royleana</i> Boiss.	280	13.26	—	—	400	26.92	400	40.03
<i>Lantana camara</i> L.	1880	55.55	2360	77.98	1280	56.58	1680	53.77
<i>Rhus parviflora</i> Roxb.	280	10.35	—	—	—	—	—	—
<i>Zanthoxylum armatum</i> DC.	80	4.09	—	—	—	—	—	—
<i>Total</i>	4960		6080		4680		5920	

Among trees, the distribution pattern of study site indicates that mostly species are in random distribution while few of them distributed contagiously (Table3). While shrubs are distributed contagiously. Only one shrub species distributed randomly (Table 4)

Table 3: Distribution Pattern (%) of Tree Species at all Sites

Sites	Distribution pattern (%)		
	Regular	Random	Contagious
I	—	62.5 (5)	37.5(3)
II	—	100(1)	0
III	—	100(2)	0
IV	—	60(3)	40(2)

Table 4: Distribution Pattern (%) of Shrubs at all Sites

Sites	Distribution pattern (%)		
	Regular	Random	Contagious
I	—		100(7)
II	—		100(3)
III	—		100(4)
IV	—	25(1)	75(3)

Table 5 and 6 showed alpha diversity, total diversity, evenness and dominance value along four different sites. The minimum diversity of trees was found at site 2nd (as only single tree was present there) and the highest diversity value at site 1st (1.87). It ranged from 0-1.87, respectively. Among Shrubs, the maximum diversity ranged from 0.89-1.36 (Table 6).

The concentration of dominance values ranged from 0.44 - 1 at all sites among trees. Among the shrubs, the maximum dominance at site 1st being 0.344 and minimum at site III being 0.31 (Table 6).

The maximum evenness value was recorded at site 1st being 2.070 and lowest at site 2nd with 0 score. Among the shrubs, the maximum evenness of 2.08 was recorded at site 3rd and minimum of 1.61 at site 1st (Table 5 & 6).

The alpha diversity represents the species richness of the community. Among trees, the highest alpha diversity was at site 1st (8) and the lowest value at site 2nd (1). The alpha diversity ranged from (1-8) at all site. Among the shrubs, the alpha diversity was maximum at site 1st (7) and minimum at site 2nd (3) (Table 5 & 6).

Table 5: Alpha diversity, evenness, total diversity index (H) and concentration of dominance (cd) of trees at all sites

Sites	Alpha diversity	Evenness	Total diversity (H)	Conc. of Dominance (cd)
I	8	2.07	1.87	0.18
II	1	0	0	1
III	2	1.20	0.36	0.79
IV	5	1.62	1.13	0.44

Table 6: Alpha diversity, evenness, Total diversity index (H) and concentration of dominance (cd) of shrubs at all sites

Sites	Alpha diversity	Evenness	Total diversity index (H)	Conc. of Dominance (cd)
I	7	1.61	1.36	0.344
II	3	2.05	0.98	0.44
III	4	2.08	1.25	0.31
IV	4	2.03	1.22	0.34

Discussion

The total tree density value of the present study sites ranged from 340-610 tree/ha, these values were within the range values reported earlier by (21, 18) and, Dhaulakhandi et.al. (2008). The total tree density value ranged from 140-750 trees/ha in Pindari catchments forest (18), 820 trees/ha in natural forest of Gangotri, ((7) and for temperate forests of Kumaun Himalaya ranged from 420-1640 trees/ha. (21).

Total shrub density value ranged from 4680-6080 shrub/hac. The distribution pattern of trees displayed most of species are distributed randomly, while few of them were in contagious distribution. Shrubs are distributed contagiously. Regular distribution was totally absent among trees and shrubs. The contagious distribution of species at all

sites indicated interaction between plant and climate which allows the individual to establish in some area and climate then other. Contiguous pattern is also reported for the grazinglands of Garhwal Himalaya (10, 2, 17, 3, 19, 11).

Dominance increases the productivity capacity of the ecosystem and diversity makes the system stable. Shannon-wiener index (H) is expressed as species evenness and species richness; this is a simple layer of biodiversity pattern of site. Likewise Simsons index (cd) showed dominance pattern among the stands.(1) reported value for diversity index was 0.00 to 1.70 for moist temperate forest of Garhwal Himalaya. The present findings for diversity index (0.00-1.87) fall well within the range of other temperate forest.

In the present study cd value for tree strata was higher at site II (1.00) and minimum at site I (0.18). The maximum value of cd indicates a monospecific forest type. The shrubs showed dominance at site II (0.44) followed by site I, IV and III. The result of the present investigation varied within a range of (0.10-0.99) as reported for temperate forests by several workers (20).

Anthropogenic activities such as constructions of hill roads, forest fires, overgrazing, lopping of trees for fodder and fuelwood, and removal of leaf and wood litter from the forest floor are also affecting plant diversity in the Garhwal Himalayan region, India (15). Conversion of forest land to agricultural land, lopping for fuelwood, deforestation for household purposes have severely threatened the plant biodiversity. The coniferous dominant forest have high economic value but due to close proximity to human interference these forest suffer various level of disturbances which would be the causative factor regarding loss of plant biodiversity. The forest fire, lopping and cutting of stem for terpentine are some other factor for poor regeneration and degradation. Irregular felling of tree boles not only reduces number of trees per hectare but also decreases

wood production each year. Therefore it is expected that the forest will be under great stress in years to come. Present investigation was an attempt to study the structure of these forests. These data's may be helpful for conservation and monitoring of new management approaches to the forest of Garhwal region.

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ASSESS THE EXTENT OF PATH COEFFICIENT ANALYSIS FOR FRUIT YIELD AND IT'S CONTRIBUTING TRAITS IN CUCUMBER (*CUCUMIS SATIVUS* L.)

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Abstract

Present investigation was carried out at the Horticulture Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut during summer season- 2018-2019. Analysis of variance revealed significant differences among the strains for all characters studied viz, vine length, number of primary branches, days to 50% flowering, days to first fruit harvest, number of fruits per plant, fruit length, fruit diameter, average fruit weight, fruit yield. Path analysis provided a clear picture about direct and indirect effects, days to first fruit per plant (0.439) had maximum direct positive effect, followed by average fruit weight (0.375) while, days to 50% flowering (-0.543) had maximum direct negative effect, followed by fruit diameter (-0.333). The Phenotypic path coefficient revealed that days to first fruit per plant (0.420) had maximum direct positive effect, followed by average fruit weight (0.375) while, days to 50% flowering (-0.526) had maximum direct negative effect, followed by fruit diameter (-0.330). Thus, while conducting selection for yield improvement in cucumber, a breeder will have to emphasize on the genotypes which mature early having more average fruit weight, longer fruits, more fruit diameter, a greater number of marketable fruits and primary branches plant, longer vine.

Key words: Genotypic path coefficient, phenotypic path coefficient, direct effects, indirect effects etc.

Introduction

Cucumber (*Cucumis sativus* L.) is an important salad vegetable crop developed both under open field and protected conditions all through India. In Asia, it is considered as fourth most important vegetable harvest after tomato, cabbage, and onion (6). It is essentially monoecious, thermophilic, frost susceptible, day-natural having climbing or trailing habit through axillary unbranched tendrils. Immature fruits believed to possess cooling impacts on our body and are considered useful for individuals experiencing constipation, jaundice, and indigestion. Throughout India is the primary center of origin

of cucumber, but almost very less attention has been paid to its improvement. Fruit yield is a complex character contributed by many characters. A study of the correlation between different quantitative characters provided an idea of association that could be effectively exploited to formulate selection strategies for improving yield and quality of a crop to have a clearer picture of the yield components for an effective selection program it would be desirable to consider the relative magnitude of association of various characters with yield. The path coefficient technique created by (7) helps in assessing the direct and indirect contribution of different parts in developing the total correlation towards yield. Based on

these studies the quantum importance of individual character is marked to facilitate the selection program for better genetic gains.

Materials and Methods

An experiment was conducted at Horticultural Research Center, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during the summer season 2018-2019. Total Twenty genotypes of cucumber (*Cucumis sativus* L.) were used as an experimental material in the present experiment. The genotypes were different as for morphological and important economical attributes. The experiment was laid out in Randomized Block Design (RBD) with three replications. Each genotype were spacing of 1.5 meters $\times$ 0.60 cm during the evening hours of during March-June, 2019. The crops were grown with a standard package of practices to get great yield the observation on various, growth and qualitative characters viz. vine length, number of primary branches, day to 50% flowering, day to first fruit harvest, number of fruits per plant, fruit length, fruit diameter, Average fruit weight observed highly significant differences for all the traits under study.

Results and Discussion

Path Coefficient Analysis

Genotypic Path Coefficient Analysis

Direct Effect

The direct and indirect effect of different characters on fruit yield at the genotypic level is presented in table 1. The highest positive direct effect on yield per plant was observed by days to first fruit harvest (0.439) via, average fruit weight (0.375), number of fruits per plant (0.106) and vine length (0.034). whereas negative direct effect was exerted by days to 50% flowering (-0.543) followed by fruit diameter (-0.333), fruit length (-0.082) and the number of primary branches (-0.050).

Indirect Effect

various traits are described below

Vine length

Vine length exhibited indirect and negative effect towards fruit yield (-0.048) and average fruit weight (0.121), while it had indirect negative effect towards on days to 50% flowering (-0.089), days to first fruit harvest (-0.015), number of fruits per plant (-0.038), fruit length (-0.049), fruit diameter (-0.016) and fruit yield (-0.049), respectively.

Number of Primary Branches

The number of primary branches exhibited an indirect and negative effect of (-0.297) on fruit yield via, days to first fruit harvest (0.056), and it had negative indirect effect towards days to 50% flowering (-0.110), fruit diameter (-0.128), fruit yield (-0.297), average fruit weight (-0.033) and fruit length (-0.015), respectively.

Days to 50% Flowering

Days to 50% flowering exhibited the indirect and negative effect of (-0.036) on fruit yield via, days to first fruit harvest (0.307), average fruit weight (0.158), and fruit diameter (0.074), while it had negative indirect effect towards fruit yield (-0.036), the number of fruits per plant (-0.021) and the number of primary branches (-0.010), respectively.

Days to First Fruit Harvest

Days to first fruit harvest had the indirect and positive effect of (0.156) on fruit yield via, fruit yield (0.156), average fruit weight (0.094), fruit diameter (0.028) and fruit length (0.016), whereas it exhibited negative indirect effect towards days to 50% flowering (-0.380), number of fruits per plant (-0.032), number of primary branches (-0.006), respectively.

Number of Fruits Per Plant

Number of fruits per plant showed the indirect and positive effect of (0.098) on fruit yield via, days to 50% flowering (0.105), fruit yield (0.098), fruit diameter (0.030), and

number of primary branches (0.006), it also exhibited negative and indirect effect towards days to first fruit harvest (-0.133), vine length (-0.012) and average fruit weight (-0.009), respectively.

Fruit Length

Fruit length exhibited the indirect and negative effect of (-0.137) on fruit yield via, average fruit weight (0.149) and vine length (0.020), while it had negative indirect effect towards fruit yield (-0.137), fruit diameter (-0.075), days to first harvest (-0.084), days to 50% flowering (-0.050), number of primary branches (-0.009), respectively.

Fruit Diameter

Fruit diameter exhibited the indirect and negative effect of (-0.330) on fruit yield via, days to 50% flowering (0.121) and vine length (0.002), while it had negative indirect effect towards fruit yield (-0.330), average fruit weight (-0.036), fruit length (-0.018), the number of fruits per plant (-0.010), days to first fruit harvest (-0.037) and the number of primary branches (-0.019), respectively.

Average Fruit Weight

This character showed indirect and positive effect of (0.269) on fruit yield via, fruit yield (0.269), fruit diameter (0.032), days to first fruit harvest (0.109), vine length (0.011) and number of primary branches (0.004), while it exhibited negative indirect effect towards days to 50% flowering (-0.228), fruit length (-0.032) and number of fruits per plant (-0.002), respectively.

Phenotypic Path Analysis

Direct Effect

The direct and indirect effect of different characters on fruit yield at the phenotypic level is presented in table 2. The highest positive direct effect on yield per plant observed with days to first fruit harvest (0.420) via, average fruit weight (0.375), number of fruits per plant (0.99) and vine

length (0.029). The negative direct effect was exerted with days to 50% flowering (-0.526) followed by fruit diameter (-0.330), fruit length (-0.086) and the number of primary branches (-0.051).

Indirect Effect

Vine Length

Vine length exhibited indirect and negative effect towards fruit yield (-0.048) and positive indirect effect via, an average fruit weight (0.121), while it had indirect negative effect towards on days to 50% flowering (-0.086), days to first fruit harvest (-0.015), number of fruits per plant (-0.035), fruit length (-0.052), fruit diameter (-0.017) and fruit yield (-0.048), respectively.

Number of Primary Branches

The number of primary branches exhibited an indirect and negative effect (-0.281) on fruit yield via, days to first fruit harvest (0.050), whereas it had negative indirect effect towards days to 50% flowering (-0.101), fruit diameter (-0.119), fruit yield (-0.281), average fruit weight (-0.031) and fruit length (-0.015), respectively.

Days to 50% Flowering

Days to 50% flowering exhibited an indirect and negative effect of (-0.036) on fruit yield via, days to first fruit harvest (0.291), average fruit weight (0.157), fruit diameter (0.073), however it had negative indirect effect towards fruit yield (-0.036), the number of fruits per plant (-0.019) and the number of primary branches (-0.010), respectively.

Days to First Fruit Harvest

Days to first fruit harvest showed the indirect and positive effect of (0.155) on fruit yield via, fruit yield (0.155), average fruit weight (0.093), fruit diameter (0.027) and fruit length (0.016), while it exhibited negative indirect effect towards days to 50% flowering (-0.365), number of fruits per plant (-0.029), number of primary branches (-0.006), respectively.

Number of Fruits Per Plant

The number of fruits per plant had the indirect and positive effect of (0.095) on fruit yield via, days to 50% flowering (0.100), fruit yield (0.095), fruit diameter (0.029), number of primary branches (0.005), while it exhibited negative and indirect effect towards days to first fruit harvest (-0.124), vine length (-0.010) and average fruit weight (-0.008), respectively.

Fruit Length

Fruit length exhibited an indirect and negative effect of (-0.137) on fruit yield via, average fruit weight (0.149) and vine length (0.018), as well as showed while it had negative indirect effect towards fruit yield (-0.137), fruit diameter (-0.075), days to first harvest (-0.081), days to 50% flowering (-0.048), the number of primary branches (-0.009), respectively.

Fruit Diameter

Fruit diameter exhibited an indirect and negative effect of (-0.330) on fruit yield via,

days to 50% flowering (0.116) and vine length (0.001), while it had negative indirect effect towards fruit yield (-0.330), average fruit weight (-0.036), fruit length (-0.019), the number of fruits per plant (-0.009), days to first fruit harvest (-0.035) and the number of primary branches (-0.019), respectively.

Average Fruit Weight

Average fruit weight had the indirect and positive effect of (0.269) on fruit yield per plant via, fruit yield (0.269), fruit diameter (0.032), days to first fruit harvest (0.104), vine length (0.009) and the number of primary branches (0.004), while it exhibited negative indirect effect towards days to 50% flowering (-0.220), fruit length (-0.034) and the number of fruits per plant (-0.002), respectively.

Such positive and high direct effects of these variables had also been reported in earlier finding by (4, 2, 5, 1), whereas significant and negative direct effects of these variables were noticed by (3).

Table 1: Direct and Indirect Effect of Genotypic (GC) Path Coefficient for 8 Characters in 20 Genotypes of Cucumber

Parameters	Vine length (cm)	Number of primary branches	Days to 50 % flowering	Days to 1st fruit harvest	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Fruit yield q/ha
Vine length (cm)	0.034	0.006	-0.089	-0.015	-0.038	-0.049	-0.016	0.121	-0.048
Number of primary branches	-0.004	-0.050	-0.110	0.056	-0.012	-0.015	-0.128	-0.033	-0.297*
Days to 50 % flowering	0.006	-0.010	-0.543	0.307	-0.021	-0.007	0.074	0.158	-0.036
Days to 1st fruit harvest	-0.001	-0.006	-0.380	0.439	-0.032	0.016	0.028	0.094	0.156
Number of fruits per plant	-0.012	0.006	0.105	-0.133	0.106	0.004	0.030	-0.009	0.098
Fruit length (cm)	0.020	-0.009	-0.050	-0.084	-0.006	-0.082	-0.075	0.149	-0.137
Fruit diameter (cm)	0.002	-0.019	0.121	-0.037	-0.010	-0.018	-0.333	-0.036	-0.330**
Average fruit weight (g)	0.011	0.004	-0.228	0.109	-0.002	-0.032	0.032	0.375	0.269*

Table 2: Direct and Indirect Effect of Phenotypic (PC) Path Coefficient for 8 Characters in 20 Genotypes of Cucumber

Parameters	Vine length (cm)	No. of primary branches	Days to 50 % flowering	Days to 1st fruit harvest	No. of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Fruit yield q/ha
Vine length (cm)	0.029	0.005	-0.086	-0.015	-0.035	-0.052	-0.017	0.121	-0.048
No. of primary branches	-0.003	-0.051	-0.101	0.050	-0.010	-0.015	-0.119	-0.031	-0.281*
Days to 50 % flowering	0.005	-0.010	-0.526	0.291	-0.019	-0.008	0.073	0.157	-0.036
Days to 1st fruit harvest	-0.001	-0.006	-0.365	0.420	-0.029	0.016	0.027	0.093	0.155
No. of fruits per plant	-0.010	0.005	0.100	-0.124	0.099	0.004	0.029	-0.008	0.095
Fruit length (cm)	0.018	-0.009	-0.048	-0.081	-0.005	-0.086	-0.075	0.149	-0.137
Fruit diameter (cm)	0.001	-0.019	0.116	-0.035	-0.009	-0.019	-0.330	-0.036	-0.330*
Average fruit weight (gm)	0.009	0.004	-0.220	0.104	-0.002	-0.034	0.032	0.375	0.269*

Conclusion

The path coefficient analysis for different character in the study showed the positive indirect effect towards fruit yield per plant via, days to first fruit harvest, average fruit weight, number of fruits per plant. Thus, the selection of these traits can be considered as a guideline in further breeding programme for selection of better genotype.

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GROWTH AND YIELD OF CAULIFLOWER (*BRASSICA OLERACEA* L. VAR. BOTRYTIS) AS INFLUENCED BY INTEGRATED SOURCES OF NUTRIENTS AND MULCHING

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Abstract

Field experiments were conducted at the Horticulture Research Center (HRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut during 2018-19 and 2019-20. The experiment consists of eleven treatment combinations with integrated sources of nutrients and mulching (Black and Paddy straw) in Randomized Block Design with three replications. The results showed that plants fortified and mulched with T8 50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5mm) had been significantly registered for largest leaf plant⁻¹ (16.73 cm²) and maximum average specific gravity of the curd (1.17), polar diameter of curd (17.87 cm), curd size index (19.13 cm²) and maximum marketable curd yield (179.09 q ha⁻¹). The same treatment was also found superior in terms of minimum days taken to first curd initiation (47.62), days taken to 50% curd initiation (64.57), days taken to 50 % curd maturity (99.35) and days taken to first curd maturity duration from initiation to harvest (18.67).

Keywords: Vermicompost, Azotobacter, bio- fertilizer,

Introduction

Cauliflower (*Brassica oleracea* L. var. botrytis) is an important member of cole crops and contributes about 35% area and production in the world. After originating in Cyprus the cauliflower got established around Mediterranean regions, particularly in Italy (13). Like other vegetable crops of the family, cauliflower are a heavy feeder of mineral elements, it removes large amount of macronutrients and micronutrients from the soil. Heavy manuring has been recommended for proper growth and good yield in cauliflower (17). Among the different sources of nutrients application in crop, Integrated sources of nutrients have been proved very effective in

various growth and yield of vegetables (8, 7, 9, 15, 16, 21, 22) and (20). Various research reports exhibited that continuous use of inorganic fertilizers deteriorates the environment and soil fertility. Therefore, organic and inorganic fertilizers are used for better growth and yield of vegetable crops. Bio-fertilizers that are derived product of living microorganism capable of fixing atmospheric nitrogen and also convert insoluble phosphorous to soluble phosphorous for uptake of plants (11). Need for use of bio-fertilizer has been raised due to excess use of chemical fertilizer which causes lots of harmful effects both on environment and soil condition such as damage to soil texture.

Mulching also play a significant role in organic farming and are used for many beneficial reason in the agriculture sector such as for soil temperature modification, weed control and for soil conservation but water conservation and erosion control are the most important objectives. Besides this, mulching also add essential plant nutrient into the soil after decomposition which improve the soil physical, chemical and biological properties and leads to increase both the quality as well as quantity of the crop (1). Therefore, the present investigations were undertaken to study the effect of different sources of nutrients with mulching on growth and yield of cauliflower.

Materials and Methods

The present investigation entitled "Growth and yield of cauliflower (*Brassica oleracea* L. var. botrytis) as influenced by integrated sources of nutrients and mulching" was carried out at Horticulture Research Center (HRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut during during Rabi season 2018- 2019 and 2019-2020. The experiment was laid out in Randomized Block Design (RBD) and replicated thrice with eleven treatment combinations. The black polythene sheet of 200 gauge thickness and paddy straw were covered into bed size 1.8 x 1.8 m. In polythene sheet, the holes of 1 x 1 inch were made as per the plant and row to row distance similarly. Spread of above 1 cm thickness as mulch on top soil of the beds and thereafter, transplanting of the seedling was done at appropriate distance in beds. All the parameters were collected from five randomly selected plants of each treatment. Last significant difference at 5% level was used for finding the significant differences among the treatment means. The pooled data obtained from both years from selected plants were subjected to analysis of variance (14).

Results and Discussion

Growth Parameters

Largest Leaf Plant⁻¹ (cm²)

Cauliflower leaf size plant was significantly affected by integrated sources of nutrients and mulching after 60 days of transplanting (Table- 1). Plants treated with T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm) resulted in largest leaf plant⁻¹ (16.73 cm²) followed by, (15.83 cm²) with the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), however, least size of leaf plant⁻¹ (13.03 cm²) produced by control T₁. It was due to treatments having organic manure and bio-fertilizers might have improved the growing environment by providing better aeration, water holding capacity and might have increased the fertilizer use efficiency (6). The present results are close conformity with the findings of (6 and (10) in cauliflower, (12) in tomato. Another reason may be due to mulching which help in improving the microclimatic condition of the soil which might have provided a suitable condition for better plant growth. Similar results were reported by (10) in cauliflower.

Average Specific Gravity of the Curd

Average specific gravity of the curd was significantly affected by integrated sources of nutrients and mulching materials (Table-1). The maximum average specific gravity of curd (1.17) was noted under the treatment T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm), followed by (1.13) under the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), while minimum average specific gravity of curd (0.56) had been registered with control T₁. The specific gravity is highly correlated with dry matter content as reported by (3). Similar results were also reported by (4) in cauliflower.

Days Taken to First Curd Initiation

The data presented to the days taken to first curd initiation in cauliflower was significantly differed each other with the integrated application of nutrients and mulching (Table 1). Among the treatments, treatment T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm) took minimum days took to first curd initiation (47.62), followed by (56.82 days) in the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), while control T₁ emerged late curd initiation (78.14). The beneficial role of Azotobacter, PSB and vermicompost provide better nutrients absorption by plants which ultimately higher values for growth and emerged earlier curd initiation.

Days Taken to 50% Curd Initiation

Days taken to 50% curd initiation were significantly affected by integrated sources of nutrients and mulching materials (Table-1). Treatment T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm) resulted in minimum days taken to 50% curd initiation (64.57) followed by, (85.33 days) under the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch) while maximum days took to 50% curd initiation (107.02) were recorded under control T₁.

Days Taken to 50% Curd Maturity

The data presented in (Table-1) clearly indicates that days taken to 50 % curd maturity showed variable effect as influenced by integrated sources of nutrients and mulching. Plants fortified and mulched with T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm) had minimum days taken to 50% curd maturity (99.35) which was minutely less days (104.60) took by the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), while minimum days taken to 50 % curd maturity (120.18) had been

registered under control T₁. It might be due to that required nutrients necessary for curd development was available to the plant by combined application of chemical fertilizers + bio fertilizers and organic manures which fascinated for the development of the curd in a faster rate and thereby, the marketable maturity was earlier. Similar results have been reported by (19) in sprouting broccoli, (5) and (18) in cauliflower.

Days Taken to Curd Maturity Duration from Initiation to Harvest

Days taken to first curd maturity from initiation to harvest was significantly affected by integrated sources of nutrients and mulching (Table-1). Minimum days taken to curd maturity duration from initiation to harvest (18.67) noted with T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm) followed by (24.56 days) under the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), while minimum days took to first curd maturity n from initiation to harvest (25.56) had been registered with control T₁. The probable reason for early curd maturity duration from initiation to harvest might be due to higher dose of N which was not effective as excess of N resulted in lodging by including an undue lengthening of stem internodes which delays the maturation of curds and also affects the curd quality. On the other hand, P nutrient could not be exerting significant effect on days taken for curd formation. Bio-fertilizers secreted hormones which enhances early curd initiation and curd maturity. Similar results have been reported by (19) in sprouting broccoli and (18) in cauliflower.

Yield Parameter**Polar Diameter of Curd (cm)**

The data pertaining to polar diameter of curd (cm) was significantly affected by different sources of nutrients and mulching (Table-1). The maximum polar diameter of

curd (17.87 cm) was recorded under the treatment T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm), followed by (16.16 cm) with the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), while minimum polar diameter of curd (9.80 cm) had been produced by control T₁. The increase in polar and equatorial diameter of curd (cm) might be due to increased photosynthetic ability of plants.

Curd Size Index (cm²)

The data in regards the curd size was significantly affected by different sources of nutrients and mulching materials are presented in (Table 1) The maximum curd size index (19.13 cm²) was produced by the treatment T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm), followed by (16.65 cm²) under the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), while minimum curd size index (10.70 cm²) had been recorded with control T₁. Increased in curd size index can also be attributed to sustained availability of nutrient throughout the growing season also efficacy of inorganic fertilizers is much pronounced when they were combined with organic manure and bio-fertilizers. Such beneficial effects of bio-fertilizers and inorganic fertilizers have been recorded by (2) in cabbage.

Marketable Curd Yield (q ha⁻¹)

The marketable curd yield of cauliflower was significantly affected by different sources of nutrients and mulching. Soil treated with T₈ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5 mm)

produced maximum marketable curd yield (179.09 q ha⁻¹) followed by, (172.72 q ha⁻¹) under the treatment T₉ (50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch), while minimum marketable curd yield (153.26 q ha⁻¹) had been recorded under control T₁. It might be due to reduce the losses of nitrogen (nitrification and denitrification) by increasing cation and anion exchange capacity of soil thereby, enhancing the curd yield attributing traits of cauliflower. Increased in marketable curd weight (g plant⁻¹) could be attributed due to increase in plant height, number of leaves and diameter of curd which might have increased the photosynthetic surface and lead to more synthesis and translocation of photosynthetase toward the curd formation. Soil application by mulch is also beneficial in minimize water losses through evaporation; enhance soil organic carbon status in soil, minimizing the nitrogen loss by nitrification and denitrification from soil Similar results were also reported by (18) in cauliflower.

Conclusion

On the basis of results obtained from the study, It can be concluded that treatment T₈ 50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5mm) was found significantly superior for getting maximum growth and yield of cauliflower production. It is further advised that poor farmers who are unable to apply full dose of recommended fertilizer may apply 50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5mm) and almost save the 50% per cent of the cost of fertilizers.

Table.1: Growth and Yield Parameters as Influenced by Integrated Sources of Nutrients and Mulching (Pooled data 2018-19, 2019-2020)

Treatments		Largest leaf plant ¹ (cm ²)	Average specific gravity of the curd	Days taken to first curd initiation	Days taken to 50% curd initiation	Days taken to 50% curd maturity	Days taken to curd maturity duration from initiation to harvest	Polar diameter of curd (cm)	Curd size index (cm ²)	Marketable curd yield (q ha ⁻¹)
T ₁	Control	13.03	0.56	78.14	107.02	120.18	25.56	9.80	10.70	153.26
T ₂	100% RDF + Black mulch (2.5mm)	13.55	0.63	70.73	94.15	116.14	21.76	13.77	14.91	165.57
T ₃	100% RDF + Paddy straw mulch	15.33	0.64	63.16	92.64	111.02	22.30	14.98	15.40	167.75
T ₄	100% RDF+ 5 t/ha VC + Black mulch (2.5mm)	15.62	0.72	76.02	87.87	111.16	22.08	12.03	13.74	170.41
T ₅	100% RDF + 10 t/ha FYM + Paddy straw mulch	13.87	0.67	73.98	96.06	103.84	22.77	14.47	16.35	171.08
T ₆	75% RDF + 10 t/ha VC + Black mulch (2.5mm)	14.62	0.78	66.68	89.25	115.06	22.22	15.84	16.47	168.97
T ₇	75% RDF + 10 t/ha VC + Paddy straw mulch	15.49	0.83	77.16	88.91	117.89	21.93	13.40	14.99	166.80
T ₈	50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + PSB (5kg/ha) + Black mulch (2.5mm)	16.73	1.17	47.62	64.57	99.35	18.67	17.87	19.13	179.09
T ₉	50% RDF + 15 t/ha VC + Azotobacter (5kg/ha) + Paddy Straw mulch	15.83	1.13	56.82	85.33	104.60	24.56	16.16	16.65	172.72
T ₁₀	25% RDF + 20 t/ha VC + Azotobacter (6kg/ha) + Black mulch (2.5mm)	14.57	0.87	62.66	87.13	103.89	22.65	15.16	15.62	167.48
T ₁₁	25%RDF + 20 t/ha VC + Azotobacter (7kg/ha) + Paddy Straw mulch	14.07	0.86	64.50	88.88	109.77	21.92	14.77	15.67	166.72
	SE(m)	0.11	0.022	0.42	1.17	0.66	0.19	0.30	0.17	0.77
	C.D	0.34	0.067	1.26	3.50	1.98	0.56	0.90	0.51	2.28

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STUDY THE EFFECT OF DISBUDDING ON GROWTH AND YIELD ON CHRYSANTHEMUM (*CHRYSANTHEMUM MORIFOLIUM*) CV. SNOWBALL

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Abstract

Experiment to investigate the effect of disbudding on growth and yield on Chrysanthemum (*Chrysanthemum morifolium*) cv. Snowball which was carried out on the field during August, 2020 at the Horticulture Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Modipuram, Meerut-250110. The experimental materials comprised of sixteen treatments were planted in Randomized Block Design (RBD) with three replications. Data showed the significant variation among all characters. The result indicated that maximum plant height (53.76 cm), number of branches per plant (7.61), number of leaves per plant (92.68 plant⁻¹), leaf area (57.90cm²), days to first flower bud initiation (60.36 days), stalk length (cm) (9.54 cm), diameter of flowers (94.92 mm), average flower yield per plant (g) (236.59), average flower yield per plot (kg ha⁻¹) (9.26), average Yield (t ha⁻¹) (35.46) from T4 No disbudding (control).

Introduction

The chrysanthemum (*Chrysanthemum morifolium*) was first introduced into the Western world during the 17th Century. In 1753 Karl Linnaeus renowned Swedish botanist, combined the Greek words chrysos, meaning gold with anthemion, meaning flower. Chrysanthemum flower is one of the most versatile flowers and is the second most popular flower, after roses in the world having a various type, size and colour that is why in more recent times, growers within several countries began to propagate chrysanthemums. Hybridizers in England, France, Japan, and the United States have developed a wide range of floral colours, shapes, and sizes. Today, its colours include various shades of pink, purple, red, yellow, bronze or orange, and white.

Chrysanthemum is among the more popular flowers grown in our country for its diversified beauty of colours, shapes, shades and keeping quality. Flowers of standard varieties are produced on long, sturdy stems and have a good keeping quality. These characters make it highly suitable for flower arrangements. Flower of spray varieties is highly suitable as loose flowers for making Garland, Veni and Gajara. It is highly suitable for beds, pots and a floral arrangement. Its bloom lasts over a short period of 1 to 2 months. Hence, they command a remunerative price in the market. On account of its good, keeping quality flowers can be transported to a distant market easily. Now a day, large number of varieties are available and these varieties have a natural blooming period of November to December but it can be extended from September to December by just

selecting suitable types and planting on different dates. Disbudding is the second important operation is mostly performed for large-flowered and decorative type of chrysanthemum.

The method of disbudding varies according to the type of chrysanthemum grown. Many of the varieties are disbud or standard types, in which the largest terminal bud is retained and all axillary buds are removed. Disbudding of spray varieties is very easy because in this case only the large epical buds removed and the axillary buds are allowed to develop.

Materials and Methods

An experiment was carried out at Horticultural Research Centre (HRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh during August, 2020. The experiment was laid out in a randomized block design with three replications. The seeds were sown in a well-prepared seedbed in open condition of 2 x 3 m size nursery beds in broad cost method on July 1st 2020. Healthy seedlings with uniform growth having 3-4 leaf, having a size 8 cm height were transplanted at spacing of 45cm×30cm in 1.35×2.10 m plots. After transplanting light irrigation was given in field. The experiment was planned out in Randomized Block Design with 16 treatments.

Treatment

Sl. No	Notation	Treatment
1.	T ₁	No pinching(control)
2.	T ₂	Pinching at 20 DAT
3.	T ₃	Pinching at 30 DAT
4.	T ₄	No disbudding(control)
5.	T ₅	Complete disbudding
6.	T ₆	Untreated with ethephon (control)
7.	T ₇	250 ppm ethephon
8.	T ₈	500 ppm ethephon
9.	T ₉	Pinching at 20 DAT + Complete disbudding
10.	T ₁₀	Pinching at 30 DAT+ Complete disbudding
11.	T ₁₁	Pinching at 20 DAT+250 ppm ethephon

12.	T ₁₂	Pinching at 30 DAT+250 ppm ethephon
13.	T ₁₃	Pinching at 20 DAT+500 ppm ethephon
14.	T ₁₄	Pinching at 30 DAT + 500 ppm ethephon
15.	T ₁₅	Complete disbudding+250 ppm ethephon
16.	T ₁₆	Complete disbudding+500 ppm ethephon

Results and Discussion

Plant Height (cm)

The plant height was significantly influenced by disbudding. Among the treatments, the maximum plant height recorded T₄ No disbudding (control) (53.76 cm) at 120 days. Whereas, lowest plant height was recorded under the Pinching at 30 DAT+ Complete disbudding (T₁₀) at 30 days stage and show the same pattern at 60 and 90 days stage. Similar results were observed by (7) and (8). These results are in close conformity with the findings of (11, 12) and (9).

Number of Branches Per Plant

Number of branches significantly influence by concentration and disbudding. The highest number of branches per plant (7.61 plant⁻¹) showed by treatment T₄ No disbudding (control). And the lowest number of branches per plant was observed under the Pinching at 30 DAT+ Complete disbudding (T₁₀) at 30 days stage and show the same pattern at 60 and 90 days stage. Similar results were observed by (7) and (8).

Number of Leaves Plant⁻¹

Number of leaves plant⁻¹ significantly influenced by concentration and disbudding. The highest number of leaves (92.68 plant⁻¹) was recorded with the treatment T₄ No disbudding (control) and the lowest number of leaves plant⁻¹ was observed under the Pinching at 30 DAT+ Complete disbudding (T₁₀) at 30 days stage and show the same pattern at 60 and 90 days stage. Similar results were observed by (11) and (12).

Leaf Area (cm²)

Leaf area significantly influences by concentration and disbudding. The highest leaf area (57.90 cm²) was recorded with the treatment T₄ No disbudding (control) and the lowest leaf area was observed under the Pinching at 30 DAT+ Complete disbudding (T₁₀) at 30 days stage and show the same pattern at 60 and 90 days stage. Similar results were observed by (10, 14) and (13).

Table 1. Effect of Pinching and Disbudding on Plant Height (cm) of Chrysanthemum Crop at Different Stages

Treatments		Average Plant height (cm)			
		30 DAT	60 DAT	90 DAT	120 DAT
T ₁	No pinching (control)	13.48	28.68	48.26	54.31
T ₂	Pinching at 20 DAT	11.58	26.18	45.68	52.40
T ₃	Pinching at 30 DAT	11.28	25.81	45.38	51.84
T ₄	No disbudding (control)	13.25	28.36	47.86	53.76
T ₅	Complete disbudding	9.51	25.01	44.51	50.61
T ₆	Untreated with ethephon (control)	12.80	27.76	47.46	53.43
T ₇	250 ppm ethephon	13.68	29.42	48.76	54.81
T ₈	500 ppm ethephon	13.81	29.95	50.26	55.36
T ₉	Pinching at 20 DAT + Complete disbudding	11.02	24.88	44.20	50.36
T ₁₀	Pinching at 30 DAT+ Complete disbudding	8.25	23.25	40.34	45.63
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	11.82	26.37	46.08	52.71
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	12.34	26.91	46.83	52.90
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	12.62	27.33	47.22	53.12
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	12.10	26.68	46.42	52.69
T ₁₅	Complete disbudding+250 ppm ethephon	10.34	25.19	44.78	51.24
T ₁₆	Complete disbudding+500 ppm ethephon	10.81	25.46	45.10	51.52
SEm±			0.97	1.69	1.97
CD (p=0.05)			2.77	4.81	5.61

Table 2. Effect of Pinching and Disbudding on Number of Branches plant ¹ of Chrysanthemum Crop at Different Stages

Treatments		Average No. of branches plant ¹		
		30 DAT	60 DAT	90 DAT
T ₁	No pinching(control)	1.31	6.74	7.75
T ₂	Pinching at 20 DAT	1.33	6.77	7.81
T ₃	Pinching at 30 DAT	1.28	6.71	7.68
T ₄	No disbudding(control)	1.25	6.68	7.61
T ₅	Complete disbudding	1.13	6.48	7.33
T ₆	Untreated with ethephon (control)	1.22	6.64	7.55
T ₇	250 ppm ethephon	1.35	6.80	7.85
T ₈	500 ppm ethephon	1.38	6.82	7.89
T ₉	Pinching at 20 DAT + Complete disbudding	1.10	6.42	7.25
T ₁₀	Pinching at 30 DAT+ Complete disbudding	0.96	5.52	6.47
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	1.45	6.87	8.02
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	1.42	6.84	7.95
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	1.50	7.02	8.20
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	1.48	6.93	8.10

T ₁₅	Complete disbudding+250 ppm ethephon	1.18	6.61	7.49
T ₁₆	Complete disbudding+500 ppm ethephon	1.16	6.56	7.39
	SEm±	0.05	0.24	0.27
	CD (P=0.05)	0.13	0.68	0.78

Table 3. Effect of Pinching and Disbudding on Number of Leaves Plant ¹ of Chrysanthemum Crop at Different Stages

Treatments		Average No. of leaves plant ¹			
		30 DAT	60 DAT	90 DAT	120 DAT
T ₁	No pinching(control)	25.16	70.66	94.16	83.54
T ₂	Pinching at 20 DAT	25.51	71.54	95.01	84.73
T ₃	Pinching at 30 DAT	24.90	68.11	93.52	81.42
T ₄	No disbudding(control)	24.71	67.55	92.68	79.51
T ₅	Complete disbudding	23.50	61.58	87.38	74.10
T ₆	Untreated with ethephon (control)	24.43	65.56	91.16	78.41
T ₇	250 ppm ethephon	25.76	72.70	96.41	86.91
T ₈	500 ppm ethephon	26.20	73.32	97.15	87.12
T ₉	Pinching at 20 DAT + Complete disbudding	23.21	60.18	85.10	71.48
T ₁₀	Pinching at 30 DAT+ Complete disbudding	20.40	49.42	58.12	54.20
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	26.84	74.79	100.18	91.45
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	26.51	74.23	98.45	89.62
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	27.54	76.90	105.77	94.65
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	27.28	75.10	103.62	92.60
T ₁₅	Complete disbudding+250 ppm ethephon	24.11	64.31	90.57	76.62
T ₁₆	Complete disbudding+500 ppm ethephon	23.79	62.61	88.21	75.54
	SEm±	0.91	2.49	3.39	2.99
	CD (P=0.05)	2.59	7.09	9.65	8.52

Table 4. Effect of Pinching and Disbudding on Leaf Area (cm²) of Chrysanthemum Crop at Different Stages

Treatments		Average Leaf area (cm ²)			
		30 DAT	60 DAT	90 DAT	120 DAT
T ₁	No pinching(control)	28.62	33.54	43.49	58.48
T ₂	Pinching at 20 DAT	28.80	33.84	43.85	58.78
T ₃	Pinching at 30 DAT	28.26	33.22	43.16	58.27
T ₄	No disbudding(control)	27.90	32.76	42.90	57.90
T ₅	Complete disbudding	26.86	31.48	41.58	56.57
T ₆	Untreated with ethephon (control)	28.62	32.49	42.65	58.72
T ₇	250 ppm ethephon	29.14	34.26	44.25	59.34
T ₈	500 ppm ethephon	29.43	34.63	44.50	59.56
T ₉	Pinching at 20 DAT + Complete disbudding	26.42	31.10	41.35	56.34
T ₁₀	Pinching at 30 DAT+ Complete disbudding	25.02	30.08	40.10	55.17
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	30.18	35.10	45.14	60.25
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	29.78	34.91	44.72	59.74
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	30.86	35.72	45.68	60.79
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	30.51	35.42	45.41	60.53
T ₁₅	Complete disbudding+250 ppm ethephon	27.70	32.30	42.32	57.36
T ₁₆	Complete disbudding+500 ppm ethephon	27.38	31.88	41.80	56.78
	SEm±	1.02	1.20	1.56	2.10
	CD (P=0.05)	2.91	3.41	4.43	5.96

Table 5. Effect of Pinching and Disbudding on Days Required for First Flowering and Stalk Length (cm) of Chrysanthemum Crop

Treatments		Days for First Flowering	Stalk length (cm)
T ₁	No pinching (control)	63.81	9.81
T ₂	Pinching at 20 DAT	64.26	10.01
T ₃	Pinching at 30 DAT	62.20	9.72
T ₄	No disbudding (control)	60.36	9.54
T ₅	Complete disbudding	54.32	8.74
T ₆	Untreated with ethephon (control)	58.42	9.31
T ₇	250 ppm ethephon	65.10	10.12
T ₈	500 ppm ethephon	66.34	10.21
T ₉	Pinching at 20 DAT + Complete disbudding	52.49	8.59
T ₁₀	Pinching at 30 DAT+ Complete disbudding	49.51	7.64
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	68.49	10.42
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	67.11	10.34
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	71.35	10.96
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	70.42	10.86
T ₁₅	Complete disbudding+250 ppm ethephon	57.48	9.18
T ₁₆	Complete disbudding+500 ppm ethephon	55.27	8.91
SEm±		2.26	0.35
CD (P=0.05)		6.44	1.01

Table 6. Effect of Pinching and Disbudding on no. of Flowers Plant⁻¹ and Diameter of Flower (mm) of Chrysanthemum Crop

Treatments		No. of flowers plant ⁻¹	Diameter of flower (mm)
T ₁	No pinching(control)	75.36	96.35
T ₂	Pinching at 20 DAT	76.48	97.41
T ₃	Pinching at 30 DAT	74.81	95.10
T ₄	No disbudding(control)	73.54	94.92
T ₅	Complete disbudding	67.46	92.46
T ₆	Untreated with ethephon (control)	72.40	94.51
T ₇	250 ppm ethephon	77.15	98.68
T ₈	500 ppm ethephon	78.92	99.62
T ₉	Pinching at 20 DAT + Complete disbudding	65.38	92.10
T ₁₀	Pinching at 30 DAT+ Complete disbudding	58.14	90.36
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	81.46	102.16
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	80.77	101.04
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	83.64	104.48
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	82.72	103.28
T ₁₅	Complete disbudding+250 ppm ethephon	71.76	93.72
T ₁₆	Complete disbudding+500 ppm ethephon	69.52	93.18
SEm±		2.72	3.50
CD (P=0.05)		7.73	9.96

Table 7. Effect of Pinching and Disbudding on Flower Yield Plant⁻¹, Flower Yield Plot⁻¹ (kg) and Flower Yield (t ha⁻¹) of Chrysanthemum Crop

Treatments		Flower yield plant ⁻¹ (g)	Flower yield plot ⁻¹ (kg)	Flower yield (t ha ⁻¹)
T ₁	No pinching(control)	261.95	9.66	36.13
T ₂	Pinching at 20 DAT	272.59	9.88	36.58
T ₃	Pinching at 30 DAT	249.32	9.44	35.78
T ₄	No disbudding(control)	236.59	9.26	35.46
T ₅	Complete disbudding	202.38	8.30	33.16
T ₆	Untreated with ethephon (control)	224.52	9.04	34.68
T ₇	250 ppm ethephon	285.48	10.04	37.28
T ₈	500 ppm ethephon	296.25	10.16	37.81
T ₉	Pinching at 20 DAT + Complete disbudding	196.38	8.02	32.35
T ₁₀	Pinching at 30 DAT+ Complete disbudding	130.54	4.68	30.51
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	321.57	10.51	38.74
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	307.51	10.32	38.41
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	352.68	10.94	39.48
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	335.78	10.75	39.12
T ₁₅	Complete disbudding+250 ppm ethephon	218.59	8.78	34.37
T ₁₆	Complete disbudding+500 ppm ethephon	210.33	8.55	33.48
SEm±		9.58	0.34	1.30
CD (P=0.05)		27.26	0.95	3.71

Table 8. Effect of Pinching and Disbudding on Nitrogen, Phosphorus, Potassium (kg ha⁻¹) and Organic Carbon (%) of Chrysanthemum Crop

Treatments		Available nutrients (kg ha ⁻¹)			Organic carbon (%)
		Nitrogen	Phosphorus	Potassium	
T ₁	No pinching (control)	136.88	18.16	119.42	0.35
T ₂	Pinching at 20 DAT	136.48	17.91	118.88	0.35
T ₃	Pinching at 30 DAT	137.14	18.43	119.76	0.36
T ₄	No disbudding (control)	137.59	18.72	120.24	0.36
T ₅	Complete disbudding	139.65	20.17	121.75	0.38
T ₆	Untreated with ethephon (control)	138.21	19.28	120.58	0.37
T ₇	250 ppm ethephon	135.74	17.62	118.62	0.35
T ₈	500 ppm ethephon	135.39	17.30	118.33	0.34
T ₉	Pinching at 20 DAT + Complete disbudding	140.10	20.42	122.45	0.38
T ₁₀	Pinching at 30 DAT+ Complete disbudding	140.36	20.68	122.86	0.39
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	134.31	16.47	117.73	0.34
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	134.68	16.78	118.10	0.34
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	130.52	15.18	115.71	0.32
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	133.79	16.10	117.36	0.34
T ₁₅	Complete disbudding+250 ppm ethephon	138.72	19.54	120.85	0.37
T ₁₆	Complete disbudding+500 ppm ethephon	139.32	19.88	121.38	0.37
SEm±		1.31	0.65	4.28	0.01
CD (P=0.05)		3.73	1.86	12.19	NS

Table 9. Effect of Pinching and Disbudding on Economics Analysis of Chrysanthemum Crop

Treatments		Cost of cultivation (? ha-1)	Gross return (? ha-1)	Net return (? ha-1)	B: C ratio
T ₁	No pinching (control)	114292	433560	319268	2.79
T ₂	Pinching at 20 DAT	114440	438960	324520	2.84
T ₃	Pinching at 30 DAT	113868	429360	315492	2.77
T ₄	No disbudding (control)	113590	425520	311930	2.75
T ₅	Complete disbudding	112578	397920	285342	2.53
T ₆	Untreated with ethephon (control)	113262	416160	302898	2.67
T ₇	250 ppm ethephon	114789	447360	332571	2.90
T ₈	500 ppm ethephon	115086	453720	338634	2.94
T ₉	Pinching at 20 DAT + Complete disbudding	112242	388200	275958	2.46
T ₁₀	Pinching at 30 DAT+ Complete disbudding	110728	366120	255392	2.31
T ₁₁	Pinching at 20 DAT+250 ppm ethephon	115945	464880	348935	3.01
T ₁₂	Pinching at 30 DAT+250 ppm ethephon	115472	460920	345448	2.99
T ₁₃	Pinching at 20 DAT+500 ppm ethephon	116860	473760	356900	3.05
T ₁₄	Pinching at 30 DAT + 500 ppm ethephon	116336	469440	353104	3.04
T ₁₅	Complete disbudding+250 ppm ethephon	113020	412440	299420	2.65
T ₁₆	Complete disbudding+500 ppm ethephon	112746	401760	289014	2.56
SEm±		—	15508	11426	0.10
CD (p=0.05)		—	44121	32509	0.28

Days Taken to First Flower Bud Appearance

The days taken to first flowering bud appearance was significantly affected by different disbudding. The treatment, T10 Pinching at 30 DAT+ Complete disbudding recorded first flower bud initiation (49.51 days) Similar results have also been reported by (11, 12) and (9).

Stalk Length (cm)

Stalk length was significantly affected by pinching and disbudding. The highest stalk length (9.54 cm) was taken under treatment T4 No disbudding (control) The present results are clear confirmed with the review of (7) and (8).

Diameter of Flower (mm)

The highest diameter of flowers (94.92 mm) recorded under the treatment T4 No disbudding (control). Whereas, lowest diameter of flowering (90.36 mm) was observed in Pinching at 30 DAT+ Complete

disbudding (T10). The present results are clear confirmed with the review of (9)

Average Flowers Yield Plant¹

The flower yield plant¹ was significantly influenced by the application of different disbudding. Among the treatments applied, the highest flowers yield plant¹ (236.59 g) was obtained from the plant treated with T₄ No disbudding (control). Similar observations have been recorded by (5, 3, 1) and (6).

Average Flower Yield Per Plot (g)

The flower yield per plot was significantly affected by the application of different disbudding. Among the treatments T₄ No disbudding (control) gave highest flower yield per plot (9.26 kg) and lowest flower yield per plot (4.68 kg ha⁻¹) were noted under Pinching at 30 DAT+ Complete disbudding (T10). Similar observations have been recorded by (3), (2), (1) and (4).

Average Yield (t ha⁻¹)

Flower yield was significantly affected by the application of different disbudding compared to pinching at 30 DAT+ Complete disbudding (T₁₀). Among the treatments, the maximum flower yield per hectare (35.46 t ha⁻¹) had been recorded under the T₄ No disbudding (control) and the lowest flower yield per hectare (30.51 t ha⁻¹) was found under Pinching at 30 DAT+ Complete disbudding (T₁₀). Similar observations have been recorded by (1, 2).

Conclusion

The observations recorded from the present investigation revealed that the budding effect in the growth and yield characters in chrysanthemum flower crop. Timely planting and budding effect in all the traits. Among all the treatment, budding the plants showed the highest growth and yield.

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IMPACT OF FRONT LINE DEMONSTRATIONS ON YIELD AND ECONOMICS OF TOMATO IN AMBALA DISTRICT OF HARYANA

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Abstract

Tomato is a major vegetable crop in Ambala district of Haryana. One of the major constraints of low productivity of this vegetable may be due to partial adoption of recommended package of practices by the tomato growers. The present study was undertaken to address the yield gap through FLDs on Tomato crop. Krishi Vigyan Kendra, Ambala (Haryana) conducted 35 demonstrations on tomato since 2015-16 and 2018 in different locations of the districts. Front line demonstrations tomato recorded the higher yield in the year 2015 (357q/ha) than farmers practice (305 q/ha), year 2016 (268q/ha) than farmers practice (240 q/ha) and the year 2018 (340.75q/ha) than farmers practice (295 q/ha). The Percentage increase in the yield (17.04), (11.66) and (15.50) respectively the year (2015-16) and 2018 over farmers practice was recorded. The cost of cultivation (Rs/ha) during year 2015-16 and 2018 was 60000, 65000 and 60000 respectively in demonstration sown tomato. While it was 66000, 72000 and 56000 in farmers sown fields. The BCR was 7.14, 4.93 and 4.54 in the demonstrated technology, which was higher than in farmers sowing 5.54, 3.00 and 2.834.21.

Key words: Tomato, Yield, Extension gap, Technology gap, Technology index and B:C ratio

Introduction

The main aim of the Krishi Vigyan Kendra is to reduce the time lag between generation of technology at the research institution and its transfer to the farmers for increasing productivity and income from the agriculture and allied sectors on sustained basis. KVKs are grass root level organizations meant for application of technology through assessment, refinement and demonstration of proven technologies under different 'micro farming' situations in a district (2). Front line demonstration (FLD) is an appropriate tool to demonstrate recommended technology among the farmers. The technologies developed at the

agricultural universities and research stations through research activities are demonstrated in farmer's field through FLDs. This is one of the most powerful tools of extension because farmers in general are driven by the perception that 'seeing is believing'. The main objective of FLDs is to demonstrate newly released crop production and protection technologies and its management practices at the farmer's field under different agro-climatic regions and farming situations.

Tomato (*Lycopersicon esculentum* Mill.) is an important vegetable crop grown almost throughout the world including tropical and

temperate regions. It is cultivated both in the green houses on protective structures as well as under natural conditions. It ranks first among processed vegetables. It is consumed fresh in salad, fried in culinary preparations and processed in various forms viz. ketchup's auces, puree, paste, powder, juice soup and chutney etc. The fast foods such as pizza, burger, noodles etc. will not taste the same without addition of tomato sauces. Tomato is a rich source of vitamins A and C and is referred to as "poor man's orange". It adds variety of colours to the food. Tomato is a very good appetizer and its soup is said to be a good remedy for patients suffering from constipation. Lycopene that imparts red colour to ripe tomatoes is reported to possess anticancerous properties. It also serves as a natural anti-oxidant as the Beta-carotene functions to help prevent and neutralize free radical chain reaction and ascorbic acid is an effective scavenger of superoxide, hydrogen peroxide, singlet oxygen and other free radicals (3). It is one of the most sensitive vegetable crops and fails miserably if growing conditions are too harsh. It is highly sensitive to frost. Dry and hot weather results in flower drops and poor fruit set. It can be grown in almost all states of India except in higher altitudes. Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh, Punjab, Haryana and Assam are important tomato growing states in India.

The main objective of front line Demonstration (FLD) is to introduce suitable agriculture practices like high yielding varieties, seed treatment, spacing, timely sowing, nutrient management including micronutrients, growth hormones, pest and disease management etc. among the farmers accompanied with organizing extension programmes (field day) for horizontal dissemination of the technologies. FLD is playing a very important role for transfer of

technologies and changing scientific treatment of the farmers by seeing and believing principle. In order to have better impact of the demonstrated technologies for farmers and field level extension functionaries, Front Line Demonstrations were conducted at farmer's field, in a systemic manner, to show case the high yielding new varieties, to convince them about the potential of improved production technologies to enhance yield of tomato. Generally, the agricultural technology is not accepted by the farmers as such in all respects. There is always a gap between the recommended technology by the scientist and its modified form at the farmer's level which is a major absentee in the efforts of increasing agricultural production in the country. It is need of the hour to reduce this technological gap between the agricultural technology recommended by the scientists or researchers and its acceptance by the farmers on their field. In view of the above facts, front-line demonstrations were undertaken in a systematic manner on farmer's field to show the worth of improved practices and convince the farmers to adopt in their farming system.

Materials and Methods

The present study was carried out at Krishi Vigyan Kendra, Ambala Haryana for three consecutive years from 2015-16 & 18 in the farmer's field in different locations of Ambala district through front line demonstration. The front line demonstration on Role of front line demonstration on Each demonstration was of 0.4 ha area and Mancozeb, Cypermethrin, Pendamethalin and PGR (Plant growth regulator) was given as critical input for inputs were applied as per the recommendation of CCS HAU, Hisar. and Tomato variety Namdhari-524 was most commonly grown at their fields. The total 35 front line demonstrations in 14 hectares were conducted at farmers' field in different

villages of district Ambala. Along with front line demonstrations (FLD), practicing farmer training was also imparted. The nutrient and pest management were properly followed under demonstrated plots where these were not taken into consideration at farmers' fields. The data on production cost and returns were collected by KVK, scientists with frequent field visits during 2015-16 & 18 from front line demonstration plots and farmers practice plot and finally extension gap, technology gap, and technology index were calculated as given below. In the present study, technology index was operationally defined as the technical feasibility obtained due to implementation of Front line Demonstrations in tomato. To estimate the technology gap, extension gap and technology index following formula used by Samui et al., (2000), Sagar and Chandra 2004 have been used.

Technology Gap = Potential Yield - Demonstration Yield

Extension Gap = Demonstration Yield - Farmers yield

Technology index = $\left[\frac{\text{Potential Yield} - \text{Demonstration yield}}{\text{potential yield}} \times 100 \right]$.

Results and Discussion

A comparison of productivity levels between demonstration and farmers practice is shown in Table 1. It is evident from results that under the demonstrated plots, performance of tomato (yield) was sustainable higher than in the local check. During the period of study, it was recorded that front line demonstrations tomato recorded the higher yield in the year 2015 (357 q/ha) than farmers practice (305 q/ha), year 2016 (268 q/ha) than farmers practice (240 q/ha) and the year 2018 (340.75 q/ha) than farmers practice (295 q/ha). The Percentage increase in the yield (17.04), (11.66) and (15.50) respectively the year

(2015-16) and 2018 over farmers practice was recorded. Similarly, yield enhancement in different crops in front line demonstrations were documented by (7, 9, 8, 14) and (2, 3). From these results it is evident that the performance of the technology demonstrated was found to be better than the farmers practice under same environment conditions. The farmers were motivated by seeing the results in term of productivity and they are adopting the technologies. The yield of the front line demonstrations and potential yield of the crop was compared to estimate the yield gaps which were further categorized into technology index and Technology gap. The technology gap shows the difference between potential yields over demonstration yield of the technology. The potential yield of the variety is 550 q/ha. The Technology gap 193 q/ha, 282 q/ha and 209.25 was recorded (Table 1). The front line demonstration was laid down under the supervision of Krishi Vigyan Kendra specialists at the farmer's field, there exist a gap between the potential yield and demonstration yield. This may be attributed to dissimilarities in soil fertility, salinity and to erratic rainfall and other vagaries of weather in the demonstration area. Hence, location specific recommendations may become necessary to narrow down the gap. Comparative high Extension gap (52), (28) and (45.75) (Table 1) emphasizes the need to educate the farmers and help them for optimizing the yield by adopting improved practices. Greater use of the latest improved production technologies applied to high yielding varieties can subsequently bridge this extension gap between demonstration yield and farmer's yield. New technologies, may, eventually lead farmers into discontinuing obsolete package of recommended dose of weedicide, fungicide, insecticide and plant growth regulator. Technology index shows the feasibility of the Package of

practice/technology at the farmer's field. The lower the value of technology index (35%), (51.27) and 38.04) respectively the year 2015-16 and 2018 more is the feasibility of the particular technology (Table 1).

It means the technology is suitable for the Ambala district of Haryana. The results of the present study are in consonance with the finding and (5) in onion, (3) in coriander.

Table 1. Tomato Yield and Gap Analysis of FLDs and Farmer Practices

Year	No. of demons	Area (ha)	Yield (qtl/ha)		Increase (%)	Extension gap (q/ha)	Technology gap (qtl/ha)	Technology index (%)
			Demo	F.P.				
2015	5	2	357	305	17.04	52	193	35
2016	10	4	268	240	11.66	28	282	51.27
2018	10	4	340.75	295	15.50	45.75	209.25	38.04

Economic Analysis

The cost of cultivation (Rs/ha) during year 2015-16 and 2018 was 60000, 65000 and 60000 respectively in demonstration sown tomato. While it was 66000, 72000 and 56000 in farmers sown fields (Table 2.). Due to recommended dose of weedicide, fungicide, insecticide and plant growth regulator higher crop yield, the gross and net return was also higher in Demonstration yield as compared to the farmers sowing method or un judicious use of technology. The BCR was 7.14, 4.93 and 4.54 in the demonstrated technology, which was higher than in farmers sowing 5.54, 3.00 and 2.834.21 respectively.

Table 2. Economic Analysis in Demonstrated Plots and Farmers' Practice

Year	Cost of cultivation (Rs./ha)		Gross returns (Rs./ha)		Net return (Rs/ha)		B:C ratio	
	Demo	F.P.	Demo	F.P.	Demo	F.P.	Demo	F.P.
2015	60000	66000	428400	366000	368400	300000	7.14	5.54
2016	65000	72000	321600	288000	256000	216000	4.93	3.00
2018	60000	56000	272600	236000	212600	180000	4.54	4.21

Conclusion

The FLD produced a significant positive result and provided an opportunity to demonstrate the productivity potential and profitability of the latest technology

(intervention) under real farming situation. This could circumvent some of the constraints in the existing transfer of technology system in the Ambala district of Haryana. The productivity gain under FLD over existing practices of tomato cultivation has created greater awareness and motivated other farmers to adopt the demonstrated technologies for tomato production in the district.

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INTEGRATION OF DIFFERENT SOURCES OF NUTRIENTS ON GROWTH AND YIELD OF POTATO (*SOLANUM TUBEROSUM* L.) CV. KUFRI CHIPSONA.

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Abstract

Field experiment was conducted during rabi seasons of 2009-10 and 2010-11, to study the effect of application of different sources of nutrients on growth and yield of Potato (*Solanum tuberosum* L.). The different sources of organic and inorganic fertilizers were integrated into 6 possible treatments viz. T₁: 90 Kg N + 37 Kg P₂O₅ + 68 Kg K₂O + 75 Q NADEP/hac, T₂: 60 Kg N + 25 Kg P₂O₅ + 45 Kg K₂O + 100 Q NADEP/hac, T₃: 30 Kg N + 12Kg P₂O₅+22 Kg K₂O +125 Q NADEP/hac, T₄: RDF (120 Kg N + 50 Kg P₂O₅ + 90 Kg K₂O) T₅: 200 Q NADEP /Ha and T₆: Control. All the treatments resulted in improvement of growth and tuber yield characters in Potato, out of these treatments where organic sources of nutrient were integrated registered significantly maximum effect. Highest growth and tuber yield in potato were recorded in the treatment T₄: 30 Kg N + 12Kg P₂O₅+22 Kg K₂O +125 Q NADEP/hac, while the lowest was observed in control treatment where none of the fertilizer was applied by any source. Nutrient supplied through integrated source are showed significant higher yield and growth in comparison to nutrient supplied through chemical fertilizers alone.

Introduction

The growth and yield of potato largely depends on the soil, climatic condition and different production practices. Potato production can be increased by the adoption of improved cultural practices, among them use of different types of fertilizer is important. Inorganic fertilizer also increases the production of crops. But continuous use of inorganic fertilizers in Crop cultivation is causing health hazards, and creating problems to the environment including the pollution of air, water & soil, etc.

The external input oriented agriculture, which was part of our green revolution strategy, has depleted soil environment considerably in all major agricultural production systems. This is reflected in the declining trend of total production from same

land diminishing response of food grain increase to applied fertilizer nutrients, reduction in organic matter content of fertile soils. The physical, chemical and microbial environment of the soil has slowly but steadily deteriorated (10). Continuous removal of micronutrients from soil by the recently introduced fertilizer responsive improved varieties of crops particularly cereals which produce high biomass on fertilizer application, reduced the concentration of micronutrient in soil solution below that required for the plant growth.

In order to feed the burgeoning population, food production has to be increased manifold. However, with the declining cultivable land area, it is certain that we will end up our what-so-available resources and ultimately compromising with a vulnerable and unsafe

environment. Given a per income growth of 3.5% or more per annum, India may need nearly 300 million tons (MT) of cereals by 2020 (1). But the country's production capacity is not likely to exceed 260 MT by that time. This implies a cereal gap of 40 MT or more per year after 2020. Importing huge amount of cereals is an option, but this could be a heavy burden on India's trade balance.

The other alternative would be to diversify from non-traditional foods. Root, tuber crops and short duration crops like potato, cassava, sweet potato etc can be major contribution, if not principal, alternative source of food and nutrition (11). Attempts to improve productivity of this crop were initiated by the various provinces of pre-independent century. It has however, great favor with the farmers as a cash crop because of its ability to grow under varied agro-ecologies, nutritive value and marketable qualities.

Organic fertilizer and micronutrients are essential for crop production both in plain and hills. It has a direct influence on soil nutrient availability from soil native pool and applied fertilizers, water retention capacity and bulk density. Availability of micronutrients in soil depends upon the organic matter present in it. In this context, use of organic matter and micronutrients is an excellent option owing to low cost and environment friendly nature. It helps to maintain long-term soil fertility and ecological sustainability required for crop production. Potato plants require micronutrients to produce optimum yield. Micronutrients help to increase the rate of photosynthesis and translocation of photosynthates leading to increased size and number of tubers. Even though the micronutrient elements are required in very small quantity, many of Indian soils may not supply them in sufficient quantity needed for healthy growth and optimum yield of any crops. It is observed that a very small amount

of nutrients is absorbed, if the nutrient is supplied through chemical fertilizers. However the same amount of nutrients was supplied to plants through NADEP compost it was observed in very large amount. The cost of nutrients from value added NADEP compost is not only cheap but also safer for the sustainability of agriculture and environment. (9). Therefore, keeping the above points as guideline, the present study was undertaken to investigate the effect of application of different sources of nutrients on growth and yield of potato.

Materials and Methods

The experiment was conducted during rabi seasons of 2009-10 and 2010-11 at Horticultural Research Center, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP). The soil is having sandy loam in texture. The field experiment was laid out in Randomized Block Design with three replication, having 6 treatments viz. T₁: 90 Kg N + 37 Kg P₂O₅ + 68 Kg K₂O + 75 Q NADEP/hac, T₂: 60 Kg N + 25 Kg P₂O₅ + 45 Kg K₂O + 100 Q NADEP/hac, T₃: 30 Kg N + 12Kg P₂O₅ + 22 Kg K₂O + 125 Q NADEP/hac, T₄: RDF (120 Kg N+ 50 Kg P₂O₅ + 90 Kg K₂O) T₅: 200 Q NADEP /Ha and T₆: Control.

The crop was grown during Nov-Feb following recommended package of practices under irrigated condition. The seed tubers having minimum two eyes were planted on raised bed at a distance of 45 cm x 20 cm. Both the organic and inorganic fertilizers were applied to different plots according to the treatment. A basal dose of half of nitrogen, full doses of phosphorous and potassium were applied through urea, single super phosphate and murate of potash respectively, in furrows of each plot and thoroughly mixed with the soil before planting of seed tubers. The rest half of the nitrogen was top dressed at 30 days after planting.

Data were collected on 17 growth and yield characters viz: Days to germination, Plant height (cm), Number of leaves plant⁻¹, Number of shoot plant⁻¹, Length of shoot (cm), Leaf area (cm²), Tuber length (cm), Tuber diameter (cm), No. of tubers per hill, Per tuber weight (gm), Tuber weight per hill (gm), Small size tuber yield (t/ha), Medium size tuber yield (t/ha), Large size tuber yield (t/ha), Extra large size tuber yield (t/ha), Gross yield (t/ha) and Marketable yield (t/ha).

Table 1. Mean Performance of Potato Var. Kufri Chipsona for 17 Characters

Sl No	Treatments	Days to germination	Plant height (cm)	Number of leaves plant ⁻¹	Number of shoot plant ⁻¹	Length of shoot (cm)	Leaf area (cm ²)	Tuber length (cm)	Tuber diameter (cm)
T ₁	90 Kg N+37 Kg P ₂ O ₅ +68 Kg K ₂ O+75 Q NADEP/hac	9.66	32.10	30.97	6.20	35.40	232.27	7.55	4.10
T ₂	60 Kg N+25 Kg P ₂ O ₅ +45 Kg K ₂ O+100 Q NADEP/hac	9.84	33.70	32.97	6.43	36.20	234.57	7.64	4.32
T ₃	30 Kg N+12Kg P ₂ O ₅ +22 Kg K ₂ O+125 Q NADEP/hac	9.91	35.90	35.87	7.20	39.13	240.27	7.88	4.59
T ₄	RDF 120 Kg N+ 50 Kg P ₂ O ₅ + 90 Kg K ₂ O	9.82	33.73	33.03	6.70	36.97	236.00	7.50	4.02
T ₅	200 Q NADEP /Ha	9.86	33.27	30.80	6.13	36.07	233.13	7.48	3.84
T ₆	Control	9.73	29.33	28.37	5.90	33.23	227.13	7.27	2.83
	CV	0.250	1.331	2.246	1.811	0.733	0.211	0.676	2.237
	CD at 1%	0.635	1.336	1.850	0.301	0.686	1.274	0.132	0.229
	CD at 5%	0.446	0.799	1.300	0.212	0.482	0.896	0.093	0.161

Table 1 Continued.....

Sl No	Treatments	No. of tubers per hill	Per tuber weight (gm)	Tuber weight per hill (gm)	Small size tuber yield (t ha ⁻¹)	medium size tuber yield (t ha ⁻¹)	large size tuber yield (t ha ⁻¹)	Extra large size tuber yield (t ha ⁻¹)	Gross yield (t ha ⁻¹)	Marketable yield (t ha ⁻¹)
T ₁	90 Kg N+37 Kg P ₂ O ₅ +68 Kg K ₂ O+75 Q NADEP/hac	6.52	25.21	211.37	3.31	7.18	9.63	3.43	23.55	21.39
T ₂	60 Kg N+25 Kg P ₂ O ₅ +45 Kg K ₂ O+100 Q NADEP/hac	6.77	26.55	213.64	3.20	7.32	9.93	3.72	24.17	22.71
T ₃	30 Kg N+12Kg P ₂ O ₅ +22 Kg K ₂ O+125 Q NADEP/hac	7.18	29.40	240.69	4.07	8.45	12.82	4.32	29.67	28.03
T ₄	RDF 120 Kg N+ 50 Kg P ₂ O ₅ + 90 Kg K ₂ O	6.44	25.79	221.55	3.57	7.26	10.52	3.91	25.25	23.25
T ₅	200 Q NADEP /Ha	6.14	23.66	217.37	3.34	7.12	9.33	3.70	23.50	21.53
T ₆	Control	5.62	21.79	205.63	2.86	6.74	8.54	3.12	21.25	19.24
	CV	1.441	1.904	0.471	2.912	1.184	3.277	2.022	0.656	1.982
	CD at 1%	0.240	1.251	2.662	0.256	0.225	0.859	0.193	0.417	1.164
	CD at 5%	0.169	0.880	1.871	0.180	0.158	0.604	0.136	0.293	0.818

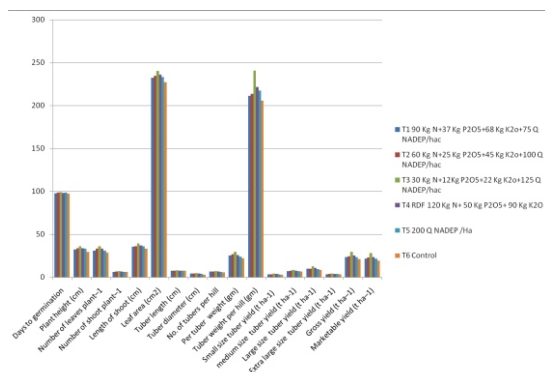


Fig 1. Growth and yield of Potato influenced by different source of fertilizations

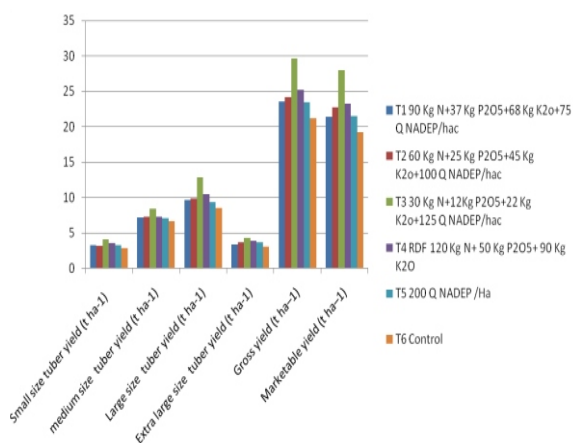


Fig 2. Tuber yield of Potato influenced by different source of fertilizations.

Results and Discussion

Growth and Yield

Proper combination of organic and inorganic source of nutrients to the potato crop very much influenced all the growth and yield characters. It was clearly indicated in Table 1 that maximum days to germination (99.16) was observed in T₃ : 30 Kg N + 12Kg P₂O₅ + 22 Kg K₂O + 125 Q NADEP/hac, followed by T₄:200 Q NADEP/ha (98.63), whereas it was minimum in control treatment (97.30). Maximum plant height (35.90) were recorded in the treatment which were supplied with 30 Kg N + 12Kg P₂O₅ + 22 Kg K₂O +125 Q NADEP/hac, whereas it was minimum in control treatment. Maximum Number of leaves per plant (35.87), was found in T₃: 30 Kg N + 12Kg P₂O₅+22 Kg K₂O +125 Q

NADEP/hac, followed by T₄ : RDF 120 Kg N+ 50 Kg P₂O₅ + 90 Kg K₂O (33.03) and minimum number of leaves were observed in Control treatment (28.37). Maximum Number of shoot plant-1 (7.20), was observed in T₃: 30 Kg N + 12 Kg P₂O₅ + 22 Kg K₂O +125 Q NADEP/hac, followed by T₄ : RDF 120 Kg N+ 50 Kg P₂O₅ + 90 Kg K₂O (6.70) and minimum was observed in control treatment (5.90). Other growth and yield related characters like Length of shoot (93.13) and Leaf area (240.27), were also found in T₃: 30 Kg N + 12Kg P₂O₅ + 22 Kg K₂O +125 Q NADEP/hac. These were significantly higher than control and RDF treatments. Minimum values in most of the treatment were observed in control treatment.

Better effect of these treatments on growth and yield parameters of potato might be attributed to combined effect of organic manure and inorganic fertilizers in building up plant tissues, resulting to better vegetative growth which plays a vital role in photosynthesis, carbohydrate transport and other physiological process of the plant. This finding was in agreement with those of (3, 4, 7) and (8). Similar finding of higher crop growth parameters in organic matter integrated treatments were reported by (14).

Organic manure and chemical fertilizers in proper combination influenced significantly in yield attributes and yield of potato tubers. The total yield of tubers was significantly affected by application of various organic sources of nutrients and absolute control with recommended package of practices. Organic integrated treatments were in favour of higher tuber size and total yield. As a result the Tuber length (7.88), Tuber diameter (4.59), No. of tubers per hill (7.18), Per tuber weight (29.40), Tuber weight per hill (240.69), Small size tuber yield (4.07), Medium size tuber yield (8.45), Large size tuber yield (12.82), Extra large size tuber yield (4.32), Gross yield (29.67) and Marketable yield (28.03) were also

be observed in T3: 30 Kg N + 12 Kg P_2O_5 + 22 Kg K_2O + 125 Q NADEP/hac. The higher yield of tubers have been achieved which might be due to higher yield attributes obtained viz., number of A, B, C and D grades and weight of A, B, C and D grades of tubers. The another scientific explanation for achieving higher yield of tubers might be due to balanced supply of N P & K through chemical fertilizers alone and N P K and other nutrients provided through combination of NADEP compost.

Integrated use of recommended dose of NPK through inorganic fertilizers and remaining RDN through organic sources produced higher numbers of tubers and total tuber yield than application of 100% RDNPK through inorganic fertilizers, which were at par with the crop receiving RDNPK through inorganic fertilizers or inorganic fertilizers alone.

The results were in agreement with the finding of (13). (15, 5, 2) and (12) also reported higher number large sized tubers in organic and inorganic integrated treatments.

Conclusion

Thus, we came to a conclusion that the integration of different organic and inorganic manures can greatly contribute towards the yield of potato cultivation, yielding attributes and different properties of soil. INM also reduces heavy burden of costly fertilizers application and their more hazardous environmental effects.

Acknowledgment

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EXTENT OF CORRELATION COEFFICIENT BETWEEN YIELD AND ITS CONTRIBUTING TRAITS IN ONION (*ALLIUM CEPA* L.) UNDER DHAMPUR (BIJNOR) CONDITION

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Abstract

The experiment was conducted at Horticulture Research Farm of RSM PG, College, Dhampur, Bijnor (UP), during winter season 2019-2020. The onion variety Agrifound Light Red was used for the study. The periodical observations on growth yield and yield attributes was recorded to find out the correlation coefficient of different growth and its attributing characters. Plant height showed positive and highly significant correlations with Diameter of stem (0.766), Fresh Bulb weight (0.828), Dry Bulb weight (0.913), and per plant equal diameter (0.804). Number of leaves/plant showed positive and highly significant correlations with Total soluble sugar (0.802). Height of leaves/plant showed positive and highly significant correlations with Height of stem (0.951). Height of stem/plant showed positive and highly significant correlations with protein (0.918). Diameter of stem /plant showed positive and highly significant correlations with fresh bulb weight (0.932). Fresh bulb/plant weight showed positive and highly significant correlations with dry bulb weight (0.978). Dry bulb weight showed positive and highly significant correlations with, protein (0.943). Polar diameter showed positive and highly significant correlations with, protein (0.845). Equal diameter showed positive and highly significant correlations with Protein (0.817). Yield /plot showed positive correlations with yield/hectare (1.000). Yield/hectare showed positive correlations with T.S.S (0.401).

Introduction

Onion (*Allium cepa* L, 2n = 16) is one of the most important bulbous crop grown all over the world. It belongs to the family Alliaceae, and originated in central Asia. As a nutritious vegetable, it contains carbohydrates (11 gm), protein (1.2gm), calcium (180 mg), phosphorus (50 mg), iron (0.7 mg), in each 100 gm of edible portion (3). The average productivity of onion in India is 16.3 MT/ha, which is low as compared to other onion

producing countries of the world. It is cultivated in India in an area of 1320.13 Thousand (ha.). (1). After the green revolution, production of vegetable has increased to a great extent due to use of chemical fertilizer and improved varieties. But there is wide scope of improvement in superior variety by using several method of crop improvement. Correlation study in any crop may play an important role in this direction.

Materials and Methods

The field experiment was conducted at Horticulture Research Centre (HRC) of R.S.M (PG) College Dhampur Bijnor Uttar Pradesh, India. Geographically it is situated between 29° 17' 27" latitude in the north and 78° 30' 12" longitudes in the eastern elevation of about 235 m above mean sea level. The experiments were laid down in a Randomized Block Design with three replications. Agrifound Dark Red variety of onion was planted at a distance of 15 cm row to row and 10 cm plant to plant as per spacing of transplanting. Total 8 treatments were undertaken i.e. T₁ Control, T₂ 100% NPK, T₃ 100% FYM, T₄ 100% NEEM CAKE, T₅ 50% NPK + 50% NEEM CAKE, T₆ 50% NEEM CAKE + 50% FYM, T₇ 33% NPK + 33% NEEM CAKE + 33% FYM and T₈ 50% NPK + 50% FYM. The following observations were recorded during the course of experimentation on following characters- Plant height (cm), Number of leaves/plant, Height of leaves (cm)/plant, Height of stem (cm)/plant, Diameter of stem (mm)/plant, Fresh bulb weight (g)/plant, Dry bulb weight (g)/plant, Polar Diameter of bulb/plant (cm), Equal Diameter of bulb/plant (cm), Yield (kg)/plot, Yield q/ha, T.S.S. (Brix°) and Protein (%). The observations were recorded on five randomly selected plants of each plot. Average of data from the sampled plant of each treatment was used for statistical analyses in order to draw valid conclusions. The statistical parameters like mean, range were calculated as per the standard methods of analysis.

Result and Discussion

Correlation coefficient was highly significant for most of the characters. Plant height showed positive and highly significant correlations with height of stem (0.951), dry bulb weight (0.913), protein (0.885) fresh bulb weight (0.828), equal diameter (0.804), diameter of stem (0.766) and significant and

positive correlation with Polar diameter (0.554) whereas negative correlation with number of leaves (-0.162). Number of leaves/plant showed positive and highly significant correlations with Total soluble sugar (0.802) and negative correlation with height of leaves (0.162), equal diameter (0.110) and Height of stem (0.089). Height of leaves/plant showed positive and highly significant correlations with Height of stem (0.951), dry bulb weight (0.913), protein content (0.885), Fresh bulb weight (0.828), equal diameter (0.804) and diameter of stem (0.766). Height of stem/plant showed positive and highly significant correlations with protein content (0.918), dry bulb weight (0.889), fresh bulb weight (0.798) and diameter of stem (0.657). Diameter of stem /plant showed positive and highly significant correlations with fresh bulb weight (0.932), dry weight of bulb (0.882), protein (0.706), whereas significant positive correlation with equal diameter (0.620), yield/plot (0.579), yield/hectare (0.565) and T.S.S (0.521) significant. Fresh bulb weight /plant showed positive and highly significant correlations with dry bulb weight (0.978), protein (0.882) and equal diameter (0.739) and it was significantly positive with polar diameter (0.700), yield/plot (0.519), yield/hectare (0.505) and T.S.S (0.498). Dry bulb weight showed positive and highly significant correlations with, protein (0.943), equal diameter (0.820) and polar diameter (0.736). Polar diameter showed positive and highly significant correlations with, protein (0.845), and significant with equal diameter (0.638), and T.S.S (0.565). Equal diameter showed positive and highly significant correlations with Protein (0.817). Yield /plot showed positive correlations with yield/hectare (1.000), T.S.S (0.413) and protein (0.385). Yield/hectare showed positive correlations with T.S.S (0.401), and protein (0.376). This indicated that strong intrinsic associations were somewhat masked at phenotypic level due to

environmental effects. Yield kg per plot expressed significant and positive correlation with per plant fresh bulb weight (gm) at phenotypic level. (6, 2) and Morsy, et al (2011), (5), were find similar trends in their investigation.

A wide range of variation in qualitative characters provides the basis for performance of manure and fertilizer dose. Diameter of stem has highly significant and positive correlation with per plant dry bulb weight has highly significant and positive correlation with per plant polar diameter, whereas positive and significant correlation with protein expressed highly significant and positive correlation with per plant equal diameter and significant and positive correlation with T.S.S. Correlation coefficient analysis measures the mutual relationship between plant characters and determines the

component character on which selection can be made for phenotypic improvement of yield. Investigation regarding the presence of component and nature of association among themselves is essential and prerequisite for improvement in yield. Correlation coefficient provides a clear picture of the extent of association between a pair of traits and indicates whether simultaneous improvement of the correlated traits may be possible or not. The knowledge of phenotypic association between yield and its component characters help in improving the efficiency of selection for yield by making proper choice and balancing one component with another. Thus, it can be inferred that selection based on any one of these characters either alone or in combination, will result in identifying high yielding strains.

Table 1. Correlation Study in Onion (*Allium Cepa* L.) Var. Agrifound Dark Red for 13 Characters

Character	Plant height(cm)	Number of leaves/plant	Height of leaves(cm)/plant	Height of stem(cm)/plant	Diameter of stem(mm)/plant	Fresh bulb weight(gm)/plant	Dry bulb weight(gm)/plant	Polar diameter (mm)/plant	Per plant equal diameter (mm)	Yield (kg)/plot	Yield (quintal)/hectare	T.S.S Brix %	Protein %
Plant height(cm)	1.00	-0.162	1.000	0.951*	0.766**	0.828**	0.913**	0.554*	0.804**	0.257	0.247	0.054	0.885*
Number of leaves/plant		1.000	-0.162	-0.089	0.352	0.320	0.181	0.359	-0.110	0.221	0.211	0.802*	0.060
Height of leaves(cm)/plant			1.000	0.951*	0.766**	0.828**	0.913**	0.554*	0.804**	0.257	0.247	0.054	0.885*
Height of stem(cm)/plant				1.000	0.657**	0.798**	0.889**	0.641*	0.714*	0.177	0.169	0.000	0.918*
Diameter of stem(mm)/plant					1.000	0.932**	0.882**	0.482	0.620*	0.579*	0.565*	0.521*	0.706*
Fresh bulb weight(gm)/plant						1.000	0.978**	0.700*	0.739**	0.519*	0.505*	0.498*	0.882*
Dry bulb weight(gm)/plant							1.000	0.736**	0.820**	0.415	0.402	0.392	0.943*
Polar diameter (mm)/mm								1.000	0.638*	0.323	0.314	0.565*	0.845*
Equal diameter (mm)/plant									1.000	0.124	0.112	0.332	0.817*

Yield (kg)/plot										1.000	1.000	0.413	0.385
Yield (quintal)/hectare											1.000	0.401	0.376
T.S.S. (Brix %)												1.000	0.297
Protein (%)													1.000

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EFFECT OF CHEMICAL SUBSTANCES ON POST-HARVEST VASE-LIFE OF CUT GLADIOLUS (*GLADIOLUS GRANDIFLORUS* L.)

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Abstract

The experiment was carried out during April 2007 in the Laboratory of Department of Horticulture, Janta Vedic College Baraut (Baghpat), Ch. Charan Singh University, Meerut (U.P.) India. Gladiolus was brought into cultivation from its native habitat from South Africa, perhaps during the ancient Greek period. The exact date of introduction in India is not confirmed but the development of gladiolus in India started only in the rarely years of the century after the discovery of *primulinus gladioli* (*G. primulinus*). The different types of gladiolus show marked distinction in various characters and it is impossible to place them under one or another group. The data 6th day was showed significant effect the maximum No of floret open/spike (10.00) was recorded on 6th day treated with Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm and followed by (9.66) treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (9.33) treated with Sucrose 10% + AgNO₃ 200ppm and Sucrose 10% + 8HQC- 400ppm, (9.00) treated with Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (8.66) Sucrose 10% + 8HQC- 200ppm (8.33) treated with Sucrose 10% and (7.66) was minimum floret open/spike from Sucrose 10% + AgNO₃ 100ppm and control. The maximum Uptake of Solution (31.60) was recorded on 3rd day treated with Sucrose 10% + 8HQC- 400ppm and followed by (31.00) treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (30.00) Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm, (28.30) treated with control, (27.30) Sucrose 10% + 8HQC- 200ppm, (27.00) treated with Sucrose 10% + AgNO₃ 100ppm, (26.30) treated with Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (24.00) treated with Sucrose 10% + AgNO₃ 200ppm, (23.66) Sucrose 10% was minimum Uptake of Solution. The data 6th day was significantly. Vase-life of cut spike of gladiolus. Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm was most effective in floret opened/spike. Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm was most effective in percentage of opened floret. Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm was most effective in longevity of individual floret.

Key words: Sucrose, AgNO₃, 8HQC, Vase-life, Spike, Floret.

Introduction

The word gladiolus is derived from the Latin, gladiolus means a sword, Leaves of gladiolus resemble the sword and hence, it is commonly known as "Sword lily". The genus gladiolus comprises about 300 species of half hardly bulbous flowering

plants in which 250 are wild and 50 of garden origin. Most of the species are native of South Africa, west and central Europe, Mediterranean to south, Westland central Asiatic regions. Gladiolus was brought into cultivation from its native habitat from South Africa, perhaps during

the ancient Greek period. The exact date of introduction in India is not confirmed but the development of gladiolus in India started only in the rarely years of the century after the discovery of *primulinus gladioli* (*G. primulinus*). The different types of gladiolus show marked distinction in various characters and it is impossible to place them under one or another group. In India, there is an impressive collection and maintenance of wide array to indigenous and exotic cultivars and species at various places like-IARI New Delhi, NBRI Lucknow, IIHR Bangalore, IBG Calcutta, HAU Hissar, PAU Ludhiana and BCKVV Kalyani and other private nursery men particularly in Darjeeling and elsewhere too. The gladiolus is mainly propagated vegetative by corms, cormels or from corm division. It can be propagated sexually by seed to evolve a new variety by hybridization. Gladiolus can also be proposed successfully by tissue culture technique in vitro inflorescence, cormel, corm stem tip, vegetative shoot and axillary's bud etc. The spikes of gladiolus have longer vase-life and can be transported for long distance when the spikes are harvested open the first floret (the lower most) shows colour. Whereas for local markets spikes are harvested when basal floret is fully opened. For enhancement the vase life of spikes, pulsing with 20% sucrose and biocide for 24 hrs is good cut spikes can be successfully stored for two weeks at 1 - 2 C.

About 50% losses occurs during the transportation which ultimately decline the quality of cut spike and farmers get not good fetch returns to avoid this situation we use different type of chemical preservative for enhancing the vase-life of cut spike. Generally we used biocide and sucrose for enhancing vase-life of cut spike of gladiolus because biocide remove the microorganism which

present in the spike and sucrose provide energy. However, it is important to remember that a sucrose solution is also perfect for the growth of microorganism, so that a biocide should be added to the vase solution. Ag No₃ and 8HQC is a biocide to inhibit the growth of microorganism.

Materials and Methods

The present investigation was carried out in the laboratory of Department of Horticulture Janta Vedic College, Baraut (Baghpat)-250611 U.P. Baraut is situated at the western boundary of U.P. 57 km. to the north of Delhi; the capital of India, on Delhi-Saharanpur road, i.e. 20.60 N and 77.150E longitude at an elevation of 236.6 m. above the sea level. The maximum temperature range between 18°C- 46°C and minimum range between 4°C- 27°C. The relative humidity is high in winter and rainy season, some cyclonic showers, however are also revealed during December-January late spring. AgNO₃ and 8-HQC both were used in two different concentrations and their treatment were tried as holding solution which are as follows:

(T₁)Control (Distilled Water), (T₂) Sucrose 10%, (T₃) Sucrose 10% + AgNO₃ 100ppm, (T₄) Sucrose 10% + AgNO₃ 200ppm, (T₅) Sucrose 10% + 8HQC- 200ppm, (T₆) Sucrose 10% + 8HQC- 400ppm, (T₇) Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm, (T₈) Sucrose 10% + AgNO₃ 200ppm + 8HQC - 400ppm and (T₉) Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm. The cut spikes were kept in Control (Distilled Water), Sucrose 10%, Sucrose 10% + AgNO₃ 100ppm, Sucrose 10% + AgNO₃ 200ppm, Sucrose 10% + 8HQC- 200ppm, Sucrose 10% + 8HQC- 400ppm, Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm, Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm and solution keep under ambient condition of 24 ± 9 C temperature 55 + 65 %

relative humidity. There were 9 treatments, replication thrice in completely randomized design (C.R.D.). The cut spike taken per replication were 9 and finally the vase lives of cut spike of Gladiolus were evaluation the flask containing of 200 ml holding solution.

Experimental Findings

The present investigation entitled "**Effect of Chemical substances on post-harvest vase-life of cut Gladiolus (*Gladiolus x grandiflorus* L.) cv. Local red**" was carried out during April 2007 in the Laboratory of Department of Horticulture, Janta Vedic College Baraut (Baghpat), Ch. Charan Singh University, Meerut (U.P.) India.

Florets Opened/Spike

The data 3rd day was not significantly but the maximum No of floret open/spike (5.00) was recorded on 3rd day treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm and followed by (4.66) treated with Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm and Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (4.33) treated with Sucrose 10% + AgNO₃ 100ppm and Sucrose 10% + 8HQC- 400ppm, (3.66) treated with Sucrose 10% + 8HQC- 200ppm and Sucrose 10% + AgNO₃ 200ppm, (3.33) treated with Sucrose 10% and (3.00) was minimum floret open/spike from control with respectively. The data 6th day was showed significant effect the maximum No of floret open/spike (10.00) was recorded on 6th day treated with Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm and followed by (9.66) treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (9.33) treated with Sucrose 10% + AgNO₃ 200ppm and Sucrose 10% + 8HQC- 400ppm, (9.00) treated with Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (8.66) Sucrose 10% + 8HQC- 200ppm (8.33) treated with Sucrose 10% and (7.66) was minimum floret open/spike from Sucrose 10% + AgNo3 100ppm and

control. The data senescence day was not significantly in spite the maximum No of floret open/spike (4.66) was recorded on senescence day treated with Sucrose 10% + 8HQC- 400ppm and followed by (4.33) treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (4.00) treated with Sucrose 10% and Sucrose 10% + AgNO₃ 200ppm and Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (3.66) Sucrose 10% + AgNO₃ 100ppm and Sucrose 10% + AgNo3 100ppm + 8HQC- 200ppm, (3.33) was minimum floret open/spike from control. All the treatment influenced the floret opening of cut spike of gladiolus over the control. Maximum floret opening have been obtained with sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm and the minimum floret opened/spike in case of control. Similar results have been reported by (1) and (9).

Effect of Chemical Substances on Floret Opened/spike and Floret Diameter (cm) of Cut Gladiolus.

Treatment	Floret opened spike			Floret diameter (cm)		
	3rd day	6td day	Senes cence day	3rd day	6td day	Senes cence day
T ₁	3.00	7.66	3.33	6.33	4.66	3.60
T ₂	3.33	8.33	4.00	6.70	4.80	3.73
T ₃	4.33	7.66	3.66	7.26	5.30	4.00
T ₄	3.66	9.33	4.00	7.66	5.76	3.96
T ₅	3.66	8.66	3.33	7.50	5.56	3.56
T ₆	4.33	9.33	4.66	7.9	5.93	3.73
T ₇	4.66	10.00	3.66	6.76	4.76	3.56
T ₈	5.00	9.66	4.33	7.43	6.03	3.73
T ₉	4.66	9.00	4.00	7.46	5.80	3.50
S.E.		0.68			0.41	
C.D.		1.43			0.87	

Floret Diameter

The data 6th day was significantly. The maximum Floret diameter (6.03) was recorded on 6th day treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm and followed by (5.93) treated with Sucrose 10% + 8HQC- 400ppm, (5.80) Sucrose 20% + AgNO₃ 200ppm + 8HQC-

400ppm, (5.76) treated with Sucrose 10% + AgNO₃ 200ppm, (5.56) treated with Sucrose 10% + 8HQC- 200ppm, (5.30) treated with Sucrose 10% + AgNO₃ 100ppm, (4.80) treated with Sucrose 10% and (4.66) was minimum Floret diameter from control. The data senescence day was not significantly. The maximum Floret diameter (4.00) was recorded on senescence day treated with Sucrose 10% + AgNO₃ 100ppm and followed by (3.96) treated with Sucrose 10% + AgNO₃ 200ppm, (3.73) Sucrose 10% + 8HQC- 400ppm and Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm and Sucrose 10%, (3.60) treated with control, (3.56) treated with Sucrose 10% + 8HQC- 200ppm and Sucrose 10 % + AgNO₃ 100ppm + 8HQC- 200ppm, (3.50) was minimum Floret diameter from Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm. All the treatment influenced the floret diameter of cut spike of gladiolus over the control. The maximum diameter has been obtained with sucrose 10% + 8HQC- 400ppm and the minimum floret diameter in case of control. Similar result obtained by (2).

Percentage of Opened Floret

The data Percentage of opened floret was significantly. The maximum percentage of opened florets (91.59) was found when cut-spike treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm followed by (87.45) Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm, (86.62) treated with Sucrose 10% + 8HQC- 400ppm, (85.71) Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (80.83) treated with Sucrose 10% + AgNO₃ 200ppm, (79.68) treated with Sucrose 10% + 8HQC- 200ppm, (74.60) treated with Sucrose 10% + AgNO₃ 100ppm, (74.52) treated with control, (72.22) was minimum percentage of opened florets from Sucrose 10%. The percentage of opened floret spike of gladiolus showed variation on treatment sucrose, AgNO₃, 8HQC, control. The maximum percentage of opened floret

(91.59 %) treated with sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm and the minimum percentage of opened floret (72.22 %) treated with sucrose 10%. These results confirm the findings of (1).

Uptake of Solution (ml)

The data 3rd day was significantly. The maximum Uptake of Solution (31.60) was recorded on 3rd day treated with Sucrose 10% + 8HQC- 400ppm and followed by (31.00) treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (30.00) Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm, (28.30) treated with control, (27.30) Sucrose 10% + 8HQC- 200ppm, (27.00) treated with Sucrose 10% + AgNO₃ 100ppm, (26.30) treated with Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (24.00) treated with Sucrose 10% + AgNO₃ 200ppm, (23.66) Sucrose 10% was minimum Uptake of Solution. The data 6th day was significantly. The maximum Uptake of Solution (54.00) was recorded on 6th day treated with Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm and followed by (53.60) treated with Sucrose 10% + 8HQC- 400ppm, (51.66) Sucrose 10% + 8HQC- 200ppm, (51.00) treated with Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (49.00) Sucrose 10% + AgNO₃ 200ppm, (47.60) treated with Sucrose 10% + AgNO₃ 100ppm, (47.00) treated with control, (45.60) treated with Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (45.33) Sucrose 10% was minimum Uptake of Solution. The data senescence day was significantly. The maximum Uptake of Solution (97.00) was recorded on senescence day treated with Sucrose 10% + 8HQC- 400ppm and followed by (94.33) treated with Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm, (91.66) Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (87.60) treated with Sucrose 10% + 8HQC- 200ppm, (81.00) treated with Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (77.66)

treated with Sucrose 10% + AgNO₃ 200ppm, (72.00) treated with Sucrose 10% + AgNO₃ 100ppm, (64.33) Sucrose 10 % and minimum Uptake of Solution from control. The uptake of solution by the cut spikes of gladiolus showed variation on treatment sucrose, AgNO₃, 8HQC and control. Uptake of solution was the maximum with sucrose 10% + 8HQC- 400ppm and the minimum uptake of solution by control. Similar results reported in gladiolus by Shaman et al. (2002) and Rekha et al. (2001).

Longevity of Individual Floret

The data Longevity of individual floret was significantly the maximum Longevity of individual floret (6.38) was found when cut-spike treated with Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm followed by (6.02) Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm and Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (5.38) treated with Sucrose 10% + 8HQC- 400ppm, (5.17) Sucrose 10% + 8HQC- 200ppm, (4.91) treated with Sucrose 10% + AgNO₃ 200ppm, (4.33) treated with Sucrose 10%, (4.25) treated with control, (3.83) was minimum Longevity of individual floret from Sucrose 10% + AgNO₃ 100ppm. All the treatment influenced Longevity of individual floret of cut spike of gladiolus. Maximum Longevity of individual floret has been obtained with sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm and the minimum Longevity of indusial floret treated with sucrose 10% + AgNO₃ 100ppm. Similar results reported in gladiolus.

Effect of Chemical Substances on Percentage of Opened Florets, Uptake of Solution (ml), Longevity of Indusial and Floret Vase Life (days) of Cut Gladiolus.

Treatm ent	Percent age of opened florets	Uptake of solution (ml)			Longev ity of indusia l floret	Vase life (days)
		3rd day	6td day	Senesc ence day		
T ₁	74.52	28.30	47.00	54.30	4.25	6.33
T ₂	72.22	23.66	45.33	64.33	4.33	7.33
T ₃	74.60	27.00	47.60	72.00	3.83	9.00
T ₄	80.83	24.00	49.00	77.66	4.91	10.00
T ₅	79.68	27.30	51.66	87.60	5.17	8.33
T ₆	86.62	31.60	53.60	97.00	5.38	12.00
T ₇	87.45	30.00	54.00	94.33	6.02	11.33
T ₈	91.59	31.00	51.00	91.66	6.02	10.00
T ₉	85.71	26.30	45.6	81.00	6.38	8.33
S.E.	3.59	2.28	1.83	3.11	0.30	0.64
C.D.	0.80	4.70	3.86	6.54	0.74	1.36

Vase-life (days)

The maximum Vase-life (days) (12.00) was found when cut-spike treated with Sucrose 10% + 8HQC- 400ppm followed by (11.33) Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm, (10.00) Sucrose 10% + AgNO₃ 200ppm and Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm, (9.00) Sucrose 10% + AgNO₃ 100ppm, (8.33) Sucrose 10% + 8HQC- 200ppm and Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm, (7.33) treated with Sucrose 10% and (6.33) was minimum Vase-life (days) from control. Sucrose and biocide at both the concentration significantly influenced the vase life of cut spike of gladiolus. Maximum vase-life (12 days) has been obtained with sucrose 10% + 8HQC- 400ppm followed by sucrose 10% + AgNO₃ 100ppm. The minimum vase life showed by control. Sucrose provides the energy of spikes and biocides prevent the vesicular blockage results enhanced the vase-life which are confirm to the report.

Conclusion

It can be concluded from the results obtained that sucrose 10% + 8 HQC- 400ppm was most effective in promoting uptake of solution, floret diameter (cm), vase-life of cut spike of gladiolus. Sucrose 10% + AgNO₃ 100ppm + 8HQC- 200ppm was most effective in floret opened/spike. Sucrose 10% + AgNO₃ 200ppm + 8HQC- 400ppm was most effective in percentage of opened floret. Sucrose 20% + AgNO₃ 200ppm + 8HQC- 400ppm was most effective in longevity of individual floret.

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PERFORMANCE OF WHEAT CULTIVARS UNDER DIFFERENT SPACING OF POPLAR (*POPULUS DELTOIDES* BARTR. EX MARSH.) BASED AGROFORESTRY SYSTEM IN SEMI-ARID ECOSYSTEM OF NORTHERN INDIA

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Abstract

The experiment was conducted to evaluate the performance of three wheat varieties under different spacing geometry (3×3, 4×3, 5×3, 6×3, 7×3 and 8×3 m) of already established two-years old poplar plantation during 2019-20. Growth of poplar was found significantly higher in 3×3 m spacing. Growth and yield attributing parameters of wheat varieties (WH- 1105, HD-2967 and WH-711) were reduced significantly under different spacing geometry of poplar plantation in comparison to sole crop. The maximum grain yield (4.68 t/ha) was recorded in variety HD-2967, followed by WH-711 (4.25 t/ha) in wider spacing (8×3 m) of poplar. On an average, the highest per cent reduction in grain and straw yield over control was recorded in variety WH-1105 (23.9 and 18.2%), followed by WH-711 (16.02 and 17.01%) and HD-2967 (10.7 and 11.69%) under 3×3 m spacing. The rate of decrease in straw yield was comparatively lower than grain yield under different spacing of poplar. The overall reduction in grain and straw yield was more under 3×3 m.

Introduction

Sole cropping is main agricultural practice worldwide. However, intercropping in a same unit of land is also in use (9). The main aim of these traditional cropping practices is to sustain food production through diversification of agriculture and income generation (10). In recent decades, these traditional cropping systems have become more effective because of their potential to generate higher yield and neutralize the process of resource degradation (8). For better utilization of natural resources, agroforestry is one of the important strategy (18), and the agroforestry practices have become more effective through regulating ecosystem services such as environmental amelioration, soil moisture and biodiversity

conservation (1, 19). Several researchers have widely demonstrated that agroforestry practices have a greater potential for carbon sequestration and also mitigate the emissions of other greenhouse gases in present era of changing climate (14); Rosenstock et al., 2014). Agroforestry is also expected to assist farmers to enhance their farm productivity through getting additional farm products such as fuelwood, fodder, timber, fruits, etc. in the face of climate change (27, 25). In agricultural lands, planting of trees improves the ecosystem services, enhances soilfertility through addition and decomposition of leaf litter on sustainable basis (28). For such scenario, agroforestry is considered as a natural resource conserving system (24).

Intercropping with high density short rotation tree species is the best option to meet increasing food and industrial raw material requirement through sustainable utilization of natural resources (23). There is a growing interest among farming communities to integrate fast growing multipurpose trees in agroforestry systems to obtain early and good economic returns. Among various fast growing tree species, *Populus deltoides* Bartr. ex Marsh. is one such promising species recognized as an important tree under agroforestry system (11). In various states like Haryana, Punjab, Uttar Pradesh, Himachal Pradesh and Arunachal Pradesh, *P. deltoides* has become the most popular tree species for plantation under agroforestry by farmers because of its rapid growth, less competition with associated crops, pruning tolerant nature and good economic returns in short rotation i.e. 5-7 years.

Because of deciduous nature, low shading problem and sufficient availability of light intensity, poplar based agroforestry is highly suitable for winter crop i.e. wheat among farmers of Northern India. By the time poplar develops their foliage, the under storey wheat crops have virtually completed vegetative growth and enters into reproductive phase. Although there is yield reduction (10-46%) of wheat from 1-6 year of poplar plantation but this yield loss is often compensated by the sale of poplar wood at the end of rotation (7). With intensive management of poplar based agroforestry models, farmers may get better returns than from other crop rotations. It has not only benefited farmers but also helped the wood based industries. In northern India, farmers are cultivating different wheat varieties with poplar however, the information on their cumulative and interactive effects is lacking. The main objective of this study was to investigate the performance of different wheat cultivars under poplar based agroforestry as well as sole crop.

Materials and Methods

A field experiment was carried out during rabi season of 2019-20 in the research farm of CCS Haryana Agriculture University Hisar, Haryana. Geographically, the research farm is situated at 29° 09' N and 75° 43' E at an elevation of 215.2 m above mean sea level in the arid region of North-Western India. During 2018-19, rainfall at experimental site was below normal. A total of 333.4 mm of rainfall was recorded during July-April against long term mean rainfall of 392.3 mm during this period. Due to frequent western disturbances during winter season, a few amount of rain fall was received. The summer months are very hot with maximum temperature ranging from 39.6 to 40.6 °C in May and June whereas, December and January are the coldest months. Poplar was planted at six different spacing geometry (3×3, 4×3, 5×3, 6×3, 7×3 and 8×3 m) during 30th January to 2nd February, 2017. The mean height, basal diameter and diameter at breast height (DBH) of poplar saplings at the time of transplantation were 5.46 m, 3.51 cm and 2.83 cm, respectively. The experiment was laid out in factorial randomized block design with three replications. The sowing of wheat varieties (WH-1105, HD-2967 and WH-711) was done during 1st fortnight of November, 2019 under above mentioned six different spacing of poplar keeping a row to row distance of 22.5 cm with a seed rate of 100 kg ha⁻¹. In nearby field, all three wheat varieties were sown as control (without tree). The recommended dose of fertilizer (N: 150 kg ha⁻¹, P₂O₅: 60 kg ha⁻¹ and K₂O: 60 kg ha⁻¹) was applied to the crop. The whole amount of P and K and half N was applied at the time of sowing. The remaining N through urea was top dressed at crown root initiation stage. Data of wheat crop was recorded from different spacings of poplar as well as from control. The plant height (cm) of wheat varieties was observed at different stages of

crop growth. Yield attributing parameters like total tillers (m⁻²), number of ear heads (m⁻²), number of grains/ear head and test weight of 1000 seeds (g) were determined at maturity. The net plots were harvested to obtain grain and straw yield. The above parameters were also recorded in control field and data were statistically analyzed.

Results and Discussion

Growth of Poplar Under Different Spacings

The height of poplar ranged from 11.6 (8×3 m) to 15.6 m (5×3 m spacing). Different spacings had significant effect on DBH of the plant. The highest DBH (16.3 cm) was observed in 8×3 m, closely followed by 7×3 and 6×3 m and lowest (11.2 cm) in 3×3 m spacing (Table 1). The highest DBH under 8×3 m spacing may be attributed to availability of more space to each tree in all the four directions. These results are also in close conformity with the findings made by (13). Similar trends in growth of poplar under different spacings in irrigated eco-system with slight variable values have been reported by (2).

Table 1: Growth Parameters of 3 Year Old Poplar Plantation Under Different Spacings

Spacing (m)	2019-2020	
	Height (m)	dbh (cm)
3 × 3	12.6	11.2
4 × 3	14.6	12.3
5 × 3	15.6	13.3
6 × 3	13.6	14.1
7 × 3	13.2	15.2
8 × 3	11.6	16.3
C.D. at 5%	0.75	0.30

Yield Attributing Parameters of Wheat

The yield attributing parameters of wheat varieties were significantly higher in sole crop than under poplar plantation. The wheat variety HD-2967 showed more number of tillers and ear heads than WH-711 and WH-1105 in different spacings of poplar;

however, differences were non-significant. Under closer spacing (3×3 m), all wheat varieties showed significantly lesser number of tillers than other spacings under study. There were non-significant variations in number of tillers in 4×3 and 5×3 m and between 7×3 and 8×3 m spacing. Almost similar pattern was observed in ear heads (m⁻²) of wheat varieties under different spacings of poplar. These findings agree with the observations made by (5). According to them, the physiological metabolism of wheat, ecological conditions and crop growing practices affect the number of tillers of wheat crop which ultimately reduce the yield of wheat under agroforestry. However, in control, tillers and ear heads were significantly higher than under poplar plantation. Variety WH-1105 exhibited higher number of tillers and ear heads (349.4 and 341.8), closely followed by HD-2967 (344.1 and 337.5) in control treatment. These results are in broad agreement with the findings of (6). They reported that the growth attributes like total tillers and effective tillers of different wheat varieties of Punjab (PBW-502, PBW-343, WH-542, PDW-274, PBW-509 and PBW- 373) were also affected significantly under 5×4 m spacing of poplar. They further revealed a declining trend in the number of tillers with increase in age of poplar plantation. (20) also reported significant variation in growth characters of different wheat varieties under poplar based agroforestry system. (12) reported comparatively higher number of tillers under three-years poplar plantation than four-years old plantation. According to (17), amount of poplar leaf litter increases with increase in the age which may hinders the seed germination and thus, number of tillers per unit area.

Different spacings of poplar plantation showed significant effect on formation of grains/ear head (Table 3). The number of grains/ear head was affected both by spacings

and varieties. Among different spacings, variety HD-2967 exhibited significantly higher number of grains/ear head than WH 1105; however, these were statistically at par with variety WH-711 under different spacings of poplar and in open. Among different wheat varieties, minimum number of grains/ear head was recorded in variety WH-1105 (35.5) under 3×3 m, closely followed by 4×3 m spacing of the same variety. The test weight of wheat crop also exhibited similar trend as that of number of grains/ear head with respect to different wheat varieties as well as different spacings of poplar and control. It might be due to the effect of tree-crop competition, which extended as a result of increase in canopy with age of trees. In other research number of grains (m-2) and test weight of the grains may be related to decreasing the grain yield of wheat where the effects of shade are deliberated (16). They observed that number of grains in wheat crop reduced by 36% when intercropped with *Paulownia elongata* based agroforestry. Similar findings were also made by (27) who noted that grain yield of wheat was decreased by 35.6% when wheat intercropped with summer maize under agroforestry.

Table 2: Effect of Different Poplar Spacings on Yield Parameters of Various Wheat Varieties

Spacing (m)	Tillers/m ²				Ear heads/m ²			
	Variety			Mean	Variety			Mean
	WH-1105	HD-2967	WH-711		WH-1105	HD-2967	WH-711	
3 × 3	249.3	253.6	251.9	251.6	240.7	246.5	243.2	243.5
4 × 3	257.7	263.0	260.6	260.4	247.9	255.0	250.1	251.0
5 × 3	266.2	272.8	268.4	269.1	256.1	263.4	258.6	259.4
6 × 3	277.5	283.3	281.6	280.8	269.3	274.2	271.4	271.6
7 × 3	287.2	289.9	286.0	287.7	277.1	282.9	280.2	280.1
8 × 3	301.8	308.9	305.4	305.4	293.5	301.2	297.7	297.5
Control	349.4	344.1	339.2	344.2	341.8	337.5	331.2	336.8
Mean	284.2	287.9	284.7		275.2	280.1	276.1	
C.D. at 5%	Variety: 9.15				Variety: 7.88			
	Spacing: 10.89				Spacing: 9.54			
	Variety × Spacing: NS				Variety × Spacing: NS			

Table 3: Effect of Different Poplar Spacings on Yield Parameters of Various Wheat Varieties

Spacing (m)	Grains/ear head				Test weight (g)			
	Variety			Mean	Variety			Mean
	WH-1105	HD-2967	WH-711		WH-1105	HD-2967	WH-711	
3 × 3	35.5	37.4	36.6	36.5	37.7	40.5	39.1	39.1
4 × 3	36.8	39.6	38.1	38.2	38.6	41.8	40.8	40.4
5 × 3	38.3	40.9	39.6	39.6	40.5	43.4	42.6	42.2
6 × 3	39.2	42.1	40.6	40.6	42.1	44.9	43.5	43.5
7 × 3	39.5	42.3	40.9	40.9	43.0	45.2	44.1	44.1
8 × 3	40.9	44.1	42.7	42.6	44.5	47.0	45.5	45.7
Control	50.2	47.1	46.1	47.8	49.3	47.2	46.3	47.6
Mean	40.1	41.9	40.7		42.2	44.3	43.1	
C.D. at 5%	Variety: 1.36				Variety: 1.50			
	Spacing: 2.13				Spacing: 2.17			
	Variety × Spacing: NS				Variety × Spacing: NS			

Grain and Straw Yield

There was significant reduction in the yield of wheat as intercrop in poplar as compared to sole wheat (Table 4). The grain yield of wheat was significantly influenced both by variety and spacing. The maximum grain yield was recorded in variety HD-2967, followed by WH-711 in 8×3 m spacing. The grain yield of wheat declined significantly with the decrease in spacing. On an average, the highest per cent reduction in grain and straw yield over control was recorded in WH-1105 (27.2 and 29.7%), followed by WH-711 (19.7 and 28.6%) and HD-2967 (14.7 and 24.1%) under 3×3 m spacing (Figure 3). The overall reduction in grain and straw yield was more in 3×3 m spacing due to more vigorous growth of poplar tree and obviously more competition for moisture, nutrients and solar radiation between the annual crops and poplar plants. These results are supported by Sirohi et al. (2016) who reported maximum reduction in grain yield of wheat variety WH-1105 (59.2%), followed by HD-943 (48.7%), WH-542 (44.6%), DPW-621-50 (42.8%) and HD- 2967 (27.9%) under different spacings of poplar plantations. (17) also reported that the grain yield of wheat variety WH- 896 was significantly higher than all other varieties of wheat under poplar based agroforestry system. Lesser grain yield under poplar plantation may be due to the increase in competition for different resources (moisture, nutrients etc.) and microclimatic changes (light, temperature, humidity etc.). Wheat yield reduction under poplar

plantations had also been recorded earlier by (4). In accordance with our results, (15) accounted that number of ears (m⁻²) in close spacing of poplar was found lower which affected yield of winter wheat and winter barley. According to (28), root competition and decreased light intensity leads to decrease in yield and biomass of wheat crop under agroforestry. A less light intensity under poplar based agroforestry and its adverse effect on yield of flowering crops has also been recorded by (21). (4) reported annual decline of 23, 35, 46 and 47% in light under agroforestry in comparison to open field (without tree), exhibiting that light was a limiting factor. In present study, the rate of decrease in straw yield was comparatively lower than grain yield under different spacings of poplar. These findings are in conformity with the reports of (3). The straw: grain ratio was estimated to be 1.406 under control, whereas, the values varied from 1.340 to 1.419 under different spacings of poplar which indicated at par values with control. The winter cereals are normally compatible with deciduous trees. The crop grows strongly during the initial period (November to mid March), when shading is not a problem. By the time, poplar have developed their foliage, the wheat crop has virtually entered into reproductive phase/completed its vegetative growth and the reproductive phase is affected by the shade and even the ripening of the crop is delayed by a fortnight. That's why the effect on the straw yield is comparatively lesser than the grain yield.

Table 4: Effect of Different Poplar Spacings on Yield of Various Wheat Varieties

Spacing (m)	Grain yield (t/ha)				Straw yield (t/ha)			
	Variety			Mean	Variety			Mean
	WH-1105	HD-2967	WH-711		WH-1105	HD-2967	WH-711	
3 × 3	3.34	3.70	3.38	3.47	3.93	4.43	4.11	4.16
4 × 3	3.42	3.80	3.45	3.56	4.02	4.54	4.21	4.26
5 × 3	3.50	3.92	3.56	3.66	4.13	4.66	4.31	4.37
6 × 3	3.61	4.02	3.65	3.76	4.23	4.76	4.49	4.49
7 × 3	3.68	4.10	3.72	3.83	4.36	4.82	4.56	4.58
8 × 3	4.18	4.68	4.25	4.37	4.64	5.04	4.77	4.82
Control	4.59	4.34	4.21	4.38	5.59	5.84	5.76	5.73
Mean	3.76	4.08	3.75		4.42	4.87	4.60	
C.D. at 5%	Variety: 0.12 Spacing: 0.26 Variety × Spacing: NS				Variety: 0.15 Spacing: 0.29 Variety × Spacing: NS			

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GENETIC VARIABILITY STUDIES IN CHERRY TOMATO FOR QUALITY TRAITS IN PROTECTED CONDITIONS

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Abstract

The present study was undertaken to gain information on the nature and magnitude of genetic variability, heritability and genetic advance existing for various quality traits in cherry tomato. Ten diverse lines of cherry tomato were crossed in diallel fashion (excluding reciprocals) and evaluated for genetic variability studies in protected conditions. The experimental findings revealed that the phenotypic variation and the genotypic variation was equal in magnitude for all the traits indicating the less influence of environment on all these traits. High PCV, GCV and genetic advance as percent mean was observed for dry matter content (%), titratable acidity (%) and lycopene content (mg/100g⁻¹), indicating the additive genetic effect. Phenotypic selection for their improvement could be achieved by simple selection.

Key words: Genetic variability, Heritability, Genetic advance, PCV, GCV, Cherry tomato.

Introduction

Cherry tomato, one of the most promising vegetable crop, is grown throughout the world due to its commercial and dietary value, widespread adaptability, possibility of growing under different cultivation conditions, relatively short life cycle, good productivity, seed production ability and resistance to some pests and diseases. It is typically a day neutral plant, that often requires long growing periods to fetch more harvests and is one of the most promising crop under protected structures or shade net

conditions (15) and reasonably tolerant to heat and drought. It is native to the Andean region encompassing Ecuador and Peru of South America and thereafter it spread around the world following the Spanish colonization of the Americas (10, 14, 4). It is also highly rich in vitamins like vitamin A, vitamin B9, vitamin C (>57 mg 100g⁻¹) (1) and other minerals like phosphorus, calcium, potassium, manganese, sodium, magnesium and iron (9). It is also considered as a 'Protective Food' because of its special nutraceutical value and high level of

antioxidants like α -carotene, vitamin C, carotenoids, polyphenols, phenolics, ascorbate, free amino acids and flavonoids (7, 6).

In order to make selection and crop improvement programmes effective, it is essential to study and partition the total variability existing in a germplasm into genetic, phenotypic and environmental components. The presence of genetic variability is an essential pre-requisite of genetic improvement in a crop. This enables the breeder to select a suitable breeding programme. So, variability is a key factor, which determines the amount of progress expected from selection. The potential for improvement is directly proportional to the magnitude of genetic variability present in the germplasm of the crop. Greater the genetic variability present in a crop, wider would be the scope for its improvement and vice-versa. Phenotypic and genotypic coefficients of variation are useful in detecting amounts of genetic variability present in the germplasm. On the other hand, heritability and genetic advance helps in determining the influence of environment in the expression of characters and the extent to which the improvement is possible after selection. Heritable variation can be effectively studied in conjunction with genetic advance. High heritability alone is not enough to make selection effective in segregating generation and needs to be accompanied by a substantial amount of genetic advance (5). Hence, an insight into the magnitude of variability present in the available accessions of cherry tomato is of utmost importance to a plant breeder for starting a judicious breeding programme.

Keeping this in consideration, efforts were made to gain information on the nature and magnitude of genetic variability existing for various quality traits in cherry tomato.

Materials and Methods

The genetic variability studies in cherry tomato were carried out at Vegetable Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar, India during Kharif season, 2020 in open field conditions. Fifty-seven treatments comprising of 45 F1's, 10 parents and 2 checks were evaluated for various quality traits in Augmented Block Design. The seeds of all accessions and their crosses were first sown in nursery and then transplanted to the hi-tech polyhouse at a spacing of 60 x 60 cm between rows and plants respectively. Recommended package of practices were followed to raise a healthy crop. The observations were recorded on 9 quality traits viz., dry matter content, total soluble solids, titratable acidity, ascorbic acid content, lycopene content, total sugars, reducing sugar, non-reducing sugar and juice to pulp ratio by selecting fresh red-ripe fruits from five random plants and the average was worked out.

Results and Discussion

Analysis of variance in respect of 57 treatments for sixteen diverse traits, revealed the significant mean squares for all the traits under study, indicating the presence of sufficient amount of genetic variability among the lines, which can be exploited through selection (Table 1.0).

Genetic Variability

The phenotypic variance and the genotypic variance ranged from 0.004 for titratable acidity (%) to 53.19 for ascorbic acid content ($\text{mg}100\text{g}^{-1}$). The phenotypic coefficient of variation (PCV) and the genotypic coefficient of variation (GCV) ranged from 16.32 for juice to pulp ratio to 45.24 for dry matter content (%) (Table 2.0).

The study thus revealed that the phenotypic variation and the genotypic variation was equal in magnitude for all the traits indicating the less influence of environment on all these traits. The phenotypic coefficient of variation (PCV) and the genotypic coefficient of variation (GCV) were found higher for dry matter content (%), titratable acidity (%) and lycopene content (mg100g^{-1}), which indicated the prevalence of greater phenotypic and genotypic variability among the accessions.

Heritability and Genetic Advance

The estimates of h^2 (broad sense heritability) were found high for all the traits of interest i.e., 100% (Table 2.0). Such high values of heritability indicates that it may be due to environment influence and the selection based on phenotypic performance would be reliable whereas, in the traits with low heritability, influence of environmental factors is strong for their expression and the selection of these characters based on their genotype may be postponed to the later generations.

High genetic advance was observed for ascorbic acid content (mg100g^{-1}) and dry matter content (%). This indicates that

these traits maybe controlled by additive gene action. High heritability with low genetic advance was recorded for titratable acidity (%), juice to pulp ratio and non-reducing sugar (%), which implies that these traits are controlled by non-additive gene action (Table 2.0).

Similar, findings have been reported by (3, 12, 2, 11, 8, 16).

Conclusion

From the study, it is concluded that the information generated from this study can be exploited for further breeding programmes in cherry tomato. High heritability coupled with high genetic advance as percent mean has been recorded for dry matter content (%), titratable acidity (%) and lycopene content (mg100g^{-1}). Hence, these traits are largely governed by additive gene action and there is further scope for effective crop improvement through selection.

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Table 1.0: Analysis of variance for quality traits in Cherry tomato.

Source of Variation	d.f	Dry matter content (%)	Total Soluble Solids (OBrix)	Titratable acidity (%)	Ascorbic acid content (mg100g^{-1})	Lycopene content (mg100g^{-1})	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)	Juice to pulp ratio
Replication	2	0.05**	2.28**	0.05**	112.51**	0.01**	0.01**	0.01**	0.01**	0.05**
Treatment	56	27.98**	11.82**	0.01**	159.56**	12.43**	3.87**	2.98**	0.14**	0.27**
Error	112	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**** Significant at 1 per cent level.**

Table 2.0: Estimates of range, mean, components of variance, heritability and genetic advance for quality traits in Cherry tomato.

Trait	Range		Mean	PV (2p)	GV (2g)	PCV (%)	GCV (%)	h ²	GA	GAM (%)
	Min.	Max.								
Dry matter content (%)	1.94	15.38	6.75	9.33	9.33	45.24	45.24	1.00	6.29	93.19
Total Soluble Solids (0Brix)	4.90	10.80	8.33	3.94	3.94	23.82	23.82	1.00	4.09	49.07
Titrateable acidity (%)	0.08	0.40	0.19	0.004	0.004	32.46	32.46	1.00	0.13	66.87
Ascorbic acid content (mg100g ⁻¹)	28.00	63.00	41.27	53.19	53.19	17.67	17.67	1.00	15.02	36.40
Lycopene content (mg100g ⁻¹)	2.86	10.72	6.30	4.14	4.14	32.33	32.33	1.00	4.19	66.60
Total sugars (%)	1.05	5.74	5.22	1.29	1.29	21.76	21.76	1.00	2.34	44.83
Reducing sugar (%)	0.75	5.68	4.32	0.99	0.99	23.04	23.04	1.00	2.05	47.47
Non-reducing sugar (%)	0.03	1.00	0.90	0.05	0.05	23.77	23.77	1.00	0.44	48.96
Juice to pulp ratio	1.25	2.64	1.82	0.09	0.09	16.32	16.32	1.00	0.61	33.61

PV = Phenotypic variance, GV = Genotypic variance PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, h²= heritability (broad sense), GA=Genetic advance, GAM= Genetic

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GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN BOTTLE GOURD (*LAGENARIA SICERARIA* (MOL.) STANDL)

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Abstract

Twenty genotypes of bottle gourd were evaluated for genetic variability, heritability, and genetic advance in bottle gourd at Horticulture Research Centre, SVP University of Agriculture and Technology, Meerut (U.P.) during the year 2019- 2020. The genotype exhibited significant differences for all the traits under study. A wide range of variability along with high estimates of the phenotypic and genotypic coefficient of variation (PCV and GCV) was observed for vine length, number of leaf, no of primary branches, days to first flower initiation, days to 50% flowering, days to first fruit set, number of fruit per plant, fruit length, fruit girth, average fruit weight, days to first fruit harvest, duration of the crop, fruit yield (q/ha) indicating considerable variability among the genotypes. The highest GCV (21.19) and PCV (21.34) were observed for fruit length while high heritability with genetic advance was observed for day to 1st flower initiation, day to 1st fruit set, vine length (cm), number of primary branch, fruit length cm, fruit girth cm, average fruit weight (gm), day to 1st fruit harvest, number of fruit per plant and yield q/hac. The results indicated that these characters had additive gene effect and therefore, these are more reliable for effective selection for their further improvement.

Keywords: Bottle gourd, genetic variability, heritability, genetic advance.

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is also known as calabash gourd or white flowered gourd plant belongs to the family Cucurbitaceae which involves 120 genera and 825 species in the world, out of the 36 genera and 100 species are accessible in India. Bottle gourd ($2n = 2x = 22$) locally known in Hindi as Lauki, It is native to Africa (Whitaker, 1971). It is a highly cross pollinated crop due to its monoecious and Andromonecious nature (5). The

Cucurbitaceous family is economically most significant family, supplying edible and nutritious fruits to humanity (4). Plants of this family are characterized by great genetic variability in plants structure, fruit shape, fruit length and texture of fruit, resulting in variability and wide range of diversity. The genetic parameters such as heritability, genetic advance, genotypic and phenotypic coefficients of variability provide an effective tool in the hands of a breeder to select a genotype having the most desirable

traits for yield. Keeping in view of the above facts, the present investigation was carried out to investigate the genetic variability, heritability and genetic advance parameters in bottle gourd germplasm.

Materials and Methods

The experimental material consisted for twenty genotypes were laid out in Randomized Complete Block Design (RBD) with three replications at Horticulture Research Center (HRC), Sardar Vallabhbhai Patel university of Agriculture and Technology Meerut during the kharif of 2019-2020. Each genotype was represented by a single row plot of 3 m length with 3 plants sown at a distance of 1 m between rows and 1 m between plants. The genotype collections of Bottle gourd augmented from the Indian Agriculture Research Institute (IARI) New Delhi. Various observations were recorded from three randomly selected plants for the characters viz., vine length, number of leaf, no of primary branches, days to first flower initiation, days to 50% flowering, days to first fruit set, number of fruit per plant, fruit length, fruit girth, average fruit weight, days to first fruit harvest, duration of the crop, fruit yield (q/ha). Analysis of variance measured by described method (23) for each of the characters separately. Phenotypic and genotypic components of variance were estimated as per the formula suggested by (19). The broad sense heritability was estimated by following the procedure suggested by Weber and Moorthy. Estimates of phenotypic and genotypic coefficients of variation were calculated as per the standard formulae (6). Genetic advance for each character was predicted by the formula given by (10).

Results and Discussion

The mean values of twenty genotypes for thirteen characters had been presented in (Table-1). The wide range of variation in mean performance of genotypes were recorded for day to first flower initiation (44.60 - 61.85), day to 50% flowering (55.15-74.82), day to first fruit set (50.15-70.70), vine length (336.67-476.67), number of leaf (67.00-86.50), number of primary branch (5.66-7.44), fruit length (14.63-42.03), fruit girth (19.63-31.23), average fruit weight (921.52-1238.67), day to first fruit harvest (60.14-84.56), number of fruit per plant (16.44-27.22), duration of crop (101.55-131.00), yield q/ha (154.33-301.67). The comparison of mean performance of twenty genotypes exhibited considerable morphological variability among the genotypes. The yield performance of genotype viz: Narendra Jyothi (301.67), Narendra Rashmi (294.67), Pusa Sandesh (292), Vallabh Saral (250), Pusa Samridhi (277), Arka Bahar (249) gave significantly higher yield q/ha over the other genotypes. The variation in different characters among the genotypes attributed to be an important varietal character that depends upon the genetic constitution of individual plant. Similar results in different morphological traits were also reported by (17, 18, 13) 2015a, (27, 21) when worked on different horticultural crops

Combined analysis of variance for thirteen qualitative and quantitative characters indicated that the magnitude of mean sum of square was found maximum for fruit yield q/ha followed by, average fruit weight (g) and least value showed by number of primary branch (Table 2). The extent of variability in respect of range, mean, phenotypic and genotypic coefficients of variation, heritability and genetic advance is given in Table 3. The magnitudes of PCV were relatively higher than of GCV for all the characters showing the

environmental factors influence the expression. The highest phenotypic coefficient of variation (PCV)(> 20%) and genotypic coefficient of variation (GCV) (> 20%) was recorded for fruit length (cm) (PCV=21.34%, GCV= 21.19). High magnitude of PCV and GCV for above characters suggested greater phenotypic and genotypic variability among the populations and indicated that these characters can be improved through phenotypic selection. The similar high PCV

and GCV values were observed by (18, 14, 30, 1, 28, 2) Gupta et al., 2020 . The moderate PCV and GCV estimates (>10 to <20) was recorded for number of primary branch (PCV=12.80%, GCV= 12.54), fruit girth (cm) (PCV=14.25%, GCV= 14.06), number of fruit per plant (PCV= 11.50%, GCV= 11.18), yield q/hac (PCV= 13.94, GCV= 13.70%) indicating the existence of comparatively high variability, which could be exploited for improvement through selection in an advanced generation.

Table 1: Mean Performance of Twenty Genotypes for Thirteen Characters in Bottle Gourd

S.N.	Genotypes	Day to 1st flower initiation	Day to 50% flower	Day to 1st fruit set	Vine Length (cm)	Number of leaf	Number of primary branch	Fruit Length cm	Fruit girth cm	Average fruit weight (g)	Day to 1st fruit harvest	Number of fruit per plant	Duration of crop	Yield q/hac
	Lines													
1	Narendra Jyothi	45.22	59.18	52.22	428.33	84.33	6.44	35.00	23.53	926.50	65.33	27.22	123.22	301.67
2	Narendra Rashmi	47.88	60.00	56.84	423.33	67.00	7.07	34.23	21.30	1061.00	70.99	26.55	125.33	294.67
3	Pusa Sandesh	52.15	65.22	60.00	403.50	78.83	6.33	14.63	31.23	967.50	73.61	26.33	127.22	292.00
4	Vallabhsaral	55.74	68.89	63.85	411.52	84.33	6.44	24.43	21.63	988.33	77.70	22.55	129.76	250.00
5	Pusa Santusti	56.03	69.03	64.18	426.67	81.50	6.55	18.33	22.87	975.52	77.51	21.28	128.19	236.00
6	IC-321412	59.22	72.33	67.92	393.33	77.83	6.11	30.88	22.57	1042.55	81.40	19.04	131.00	211.00
7	IC-338119	52.33	64.48	60.18	380.00	83.33	6.33	32.67	23.97	921.52	84.29	21.34	128.18	236.67
8	IC-592210	51.15	63.44	59.51	363.60	75.52	6.44	35.87	20.53	1092.52	82.84	20.78	129.55	230.33
9	IC-321460	61.85	74.82	70.70	416.52	71.00	6.66	34.13	23.50	1008.50	84.07	17.43	123.92	203.00
10	IC-398510	45.22	55.15	50.15	453.33	70.00	6.33	33.00	19.73	988.67	84.56	16.44	124.29	182.33
11	IC-321747	53.04	55.56	61.16	438.67	86.50	6.11	32.20	22.30	1238.67	84.14	19.66	128.07	218.00
12	NDBG-132	44.60	62.37	50.51	386.66	75.15	6.44	42.03	23.30	1053.00	62.66	26.66	123.55	195.67
13	Pant louki-1	47.55	61.23	55.22	443.33	70.00	7.33	27.80	23.83	1017.67	70.73	23.44	118.00	160.00
14	Narendra Dharidar	47.52	61.66	56.58	390.00	83.67	6.89	36.83	20.20	1220.67	69.94	25.55	124.55	154.33
15	pusa Samridhi	46.11	59.88	56.04	456.67	80.18	5.66	24.07	21.87	957.33	69.00	25.00	117.33	277.00
16	Punjab long	47.44	61.36	55.90	476.67	74.67	7.44	30.83	25.07	982.00	70.66	27.00	125.77	239.33

	Tester													
1	Kashi Ganga	47.17	60.27	55.00	336.67	77.67	6.89	28.44	20.50	1006.67	60.14	24.22	125.00	218.50
2	Arka Bahar	53.26	61.25	61.15	350.00	74.73	7.08	30.25	20.13	926.67	66.69	21.50	121.00	249.00
3	Narendra Madhuri	50.66	63.92	58.53	373.52	75.25	7.22	16.00	22.43	955.33	64.85	22.23	122.00	224.50
4	Pusa Naveen	50.53	60.94	60.03	370.11	81.00	6.55	33.52	19.63	1002.50	62.52	21.52	101.55	245.50
	Mean	50.73	63.05	58.78	406.12	77.63	6.62	29.76	22.51	1016.66	73.18	22.79	123.87	230.98
	Min	44.60	55.15	50.15	336.67	67.00	5.66	14.63	19.63	921.52	60.14	16.44	101.55	154.33
	Max	61.85	74.82	70.70	476.67	86.50	7.44	42.03	31.23	1238.67	84.56	27.22	131.00	301.67
	SE(d) $\pm$	0.94	1.29	0.96	6.64	1.21	0.11	0.63	0.33	22.07	1.60	0.54	1.79	5.19
	C.D. at 5%	1.91	2.62	1.95	13.48	2.46	0.22	1.28	0.68	44.86	3.24	1.11	3.63	10.54
	C.V. (%)	2.27	2.51	2.00	2.00	1.91	2.03	2.60	1.81	2.66	2.67	2.93	1.77	2.75

Table 2: Analysis of Variance for the Characters Under Study in Bottle Gourd

Genotypes	d.f.	Day to 1st flower Initiation	Day to 50% flower	Day to 1st fruit set	Vine Length (cm)	Number of leaf	Number of primary branch	Fruit Length cm	Fruit girth cm	Average fruit weight (g)	Day to 1st fruit harvest	Number of fruit per plant	Duration of crop	Yield q/hac
Rep.	2	0.08	0.35	0.09	8.24	0.82	0.01	0.15	0.31	668.63	0.09	0.14	2.88	37.37
Treat.	19	69.02**	75.63**	84.42**	4292.72**	91.35**	0.62**	151.79*	20.04**	22174.73**	206.01*	31.41**	123.06**	5051.74**
Error	38	1.33	2.49	1.38	66.04	2.20	0.02	0.60	0.17	730.89	3.82	0.44	4.79	40.34
Total	59	23.09	25.97	28.08	1425.21	30.86	0.21	49.27	6.57	7634.43	68.81	10.41	42.81	1654.08

Table 3: Genetic Variability, Heritability and Genetic Advance in Percent Over Mean for Different Characters Under Study in Bottle Gourd

Characters	Mean	Min	Max	variability (g)	variability (p)	Heritability (%)	GA	GA% mean	GA 1%	GA mean 1%	GCV (%)	PCV (%)
Day to 1st flower Initiation	50.89	43.66	61.85	16.88	18.08	93.33	8.18	16.07	10.48	20.59	8.07	8.36
Day to 50% flowering	64.24	55.15	74.82	16.47	18.81	87.58	7.82	12.18	10.03	15.61	6.32	6.75
Day to 1st fruit set	58.37	46.22	70.70	20.28	22.36	90.70	8.84	15.14	11.32	19.40	7.72	8.10
Vine Length (cm)	440.40	336.67	503.22	1006.69	1103.54	91.22	62.43	14.18	80.00	18.17	7.20	7.54
Number of leaf	81.80	67.00	94.52	31.57	35.37	89.26	10.94	13.37	14.01	17.13	6.87	7.27
Number of primary branch	7.04	5.12	9.66	0.78	0.81	96.02	1.78	25.32	2.28	32.45	12.54	12.80
Fruit Length cm	31.19	14.63	42.52	43.68	44.27	98.65	13.52	43.36	17.33	55.57	21.19	21.34
Fruit girth cm	22.91	19.21	36.55	10.38	10.65	97.46	6.55	28.60	8.40	36.65	14.06	14.25
Average fruit weight (gm)	1061.18	921.52	1320.50	7462.33	8168.74	91.35	170.08	16.03	217.97	20.54	8.14	8.52
Day to 1st fruit harvest	71.24	59.22	84.56	30.72	33.93	90.53	10.86	15.25	13.92	19.54	7.78	8.18
Number of fruit per plant	25.16	16.44	30.00	7.91	8.37	94.57	5.64	22.40	7.22	28.71	11.18	11.50
Duration of crop	123.85	101.55	131.00	12.02	21.12	56.91	5.39	4.35	6.91	5.58	2.80	3.71
Yield q/hac	273.64	154.33	333.03	1405.44	1454.76	96.61	75.91	27.74	97.28	35.55	13.70	13.94

These results coincide similar with results obtained by earlier Mandal et al., (2015) and Damor et al., (2016). The lowest (<10) estimate of PCV and GCV were Observed for day to first flower initiation (PCV= 8.36%, GCV= 8.07%), day to 50% flowering (PCV= 6.75%, GCV=6.32%), day to first fruit set (PCV= 8.10%, GCV= 7.72%), vine length (cm) (PCV= 7.54%, GCV= 7.20%), number of leaf (PCV= 7.27%, GCV= 6.87%), average fruit weight (PCV= 8.52%, GCV= 8.14), day to First fruit harvest (PCV= 8.18%, GCV= 7.18) and duration of crop (PCV= 3.71%, GCV= 2.80%). The GCV was found to be less than PCV for studied traits indicated that these characters were having interaction with the environment. Similar results were also reported earlier in bottle gourd by (22, 26).

Heritability measures how important genetics is to a trait. A high heritability, close to 1, indicates that genetics explain a lot of the variation in a trait between different germplasm; a low heritability, near zero, indicates that most of the variation is not genetic. In addition broad-sense heritability, defined as $H^2 = VG/VP$, captures the proportion of phenotypic variation due to genetic values that may include effects due to dominance and epistasis.

On the other hand, narrow-sense heritability, $h^2 = VA/VP$, captures only that proportion of genetic variation that is due to additive genetic values (VA). The highest heritability were observed for fruit length (98.65cm) followed by fruit girth (97.46), yield q/ ha (96.61), number of primary branch (96.02), number of fruit per plant (94.57), day to first flower initiation (93.33), average fruit weight (91.35), vine length (91.22), day to first fruit set (90.70) and day to first fruit harvest (90.53). The moderate heritability was found in case of number of leaf (89.26), day to 50% flowering (87.58) and duration of crop (56.91).

High heritability indicated that the character is least influenced by the environmental effect. The selection for improvement of such characteristics may not be useful because broad-sense heritability is based on total genetic variance. The present results are in line with the finding of Yadav and Kumar (2011), (26, 24).

Genetic advance as percentage of mean was observed high for all character under the study viz., fruit length (55.57%), fruit girth (36.65%), yield q/ha (35.55%), number of primary branch (32.45), number of fruit per plant (28.71), day to first flower initiation (20.59%), average fruit weight (20.54), day to first fruit harvest (19.54), day to first fruit set (19.40%), vine length (18.17), number of leaf (17.13), day to 50% flowering (15.61), duration of crop (5.58) This indicated that, genetic advance is high it shows that character is governed by additive genes and selection will be rewarding for improvement such traits. Similar finding reported by (32, 26, 29, 20, 24) and (14, 12).

Conclusion

Significant differences among the genotypes for all the characters were observed in study. Based on mean performance of yield q/ha genotypes, Narendra Jyothi, Narendra Rashmi, Pusa Sandesh, Vallabh saral, Pusa Samridhi, Arka Bahar were identified as most promising genotypes for yield q/ha major components traits. Fruit length, fruit girth, yield q/ha, number of primary branch, number of fruit per plant recorded high GCV and PCV coefficient of variation respectively, indicating that the genotypes can be used for further breeding programme. High heritability with high genetic advance was observed for fruit length, number of primary branch, fruit girth, yield q/ha content indicating the preponderance of additive gene action.

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ENGINEERING PROPERTIES OF CHEWABLE SIZE MORINGA PODS

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Abstract

Moringa (pod) is a very popular vegetable in South Indian cuisine and valued for its distinct flavour and its nutritional values. It is a magic vegetable, can rebuild weak bones, enrich anemic blood and enable a malnourished. The physical properties of biological materials include density, porosity, coefficient of friction and angle of repose. The average weight of moringa pod of PKM-1 variety was found to be 70.3 g. Its average width and thickness were found to be 2.17 and 1.83 cm respectively. As the moringa pod is too long to use as such, it was cut into two small sizes of 2.5 (one inch) and 5.0 cm (two inches) in length (ready to cook size). Bulk density, true density and porosity of fresh ready to cook size moringa pods were 400.64, 358.68 kg per m³, 1047.31, 977.68 kg per m³ and 61.75, 63.38 per cent, respectively at 753.05 per cent moisture content (db). The 2.5 and 5.0 cm length fresh moringa pods recorded a value of 0.543, 0.561, 0.582, 0.660 and 0.551, 0.573, 0.591, 0.682 as coefficient of friction on stainless steel, aluminium, galvanized iron and mild steel surfaces, respectively. The angle of repose of 2.5 and 5.0 cm length moringa pods was recorded as 28.57 and 32.85 , respectively. The thermal properties of fresh moringa pods such as specific heat, thermal conductivity and thermal diffusivity were found to be 3.461 kJ kg⁻¹ K⁻¹, 0.139 W m⁻¹ K⁻¹ and 1.056×10⁻⁴ m²s⁻¹, respectively, at 753.05 per cent moisture content (db).

Key words : Moringa (pod), Porosity, Frictional properties.

Introduction

Moringa (pod) is a very popular vegetable in South Indian cuisine and valued for its distinct flavour and its nutritional values and significant quantities of vitamin C, calcium, iron, protein, potassium, magnesium, selenium, zinc and a good balance of all the essential amino acids. It is a magic vegetable, can rebuild weak bones, enrich anemic blood and enable a malnourished, mother to nurse her starving baby. Doctors use it to treat diabetes in West Africa and high blood pressure in India, (Anon, 1995).

Materials and Methods

Fresh moringa pods (Annual Moringa type cv PKM-1) handpicked from Western block farm of Horticultural College and Research Institute, TNAU, Periyakulam, Tamil Nadu were used for the study. Important engineering properties of moringa pods were determined by the procedures prescribed by (6). Fresh moringa pods were washed in running tap water to remove adhering extraneous matter, shade dried to remove surface water As the moringa pod is too long to use as such, it was cut into two small sizes of 2.5 (one inch) and 5.0 cm (two inches) in length

(ready to cook size) and then used to conduct different experiments. Important physical properties viz., bulk density, true density and porosity were determined along with whole weight, skin weight and pulp weight from known weight of fresh moringa pods. The methods followed to determine these properties are detailed below.

Whole Weight Versus Skin Weight of Moringa Pods

Fresh moringa pods having 751.42 ± 5.00 per cent (db) moisture content, in the mass range of 70 to 110 g were selected from the bulk. The mass of the individual moringa pods was recorded. The skin was separated from moringa pods manually by scraping the inner soft portion and solid fibre portion gently using a sharp stainless steel knife. The mass of the skin, edible pulp and seed were weighed and recorded for individual moringa pods. Graph was plotted between whole weight of the moringa pods versus skin weight and pulp weight of moringa pods versus skin weight.

Shape

The shape of moringa pods may be expressed in terms of cylindricity. Cylindricity measures the cylindrical nature of the given solid. The cylindricity (5) of moringa pods were calculated by tracing the magnified shadow graphs of fifty moringa pods in two mutually perpendicular positions for cylindricity on graph sheet, with the help of an overhead projector. The projected area, length and diameter of the largest inscribing and the smallest circumscribing cylinders of the projected view were measured. The shape of the product was also defined by descriptive terms for fruits and vegetables (Mohsenin, 1986).

Bulk Density

Bulk density was calculated as the ratio between mass and bulk volume of chewable size moringa pods. As the size of chewable size moringa pods was larger than grains, the

following method was adopted to determine the bulk density as per the standard method followed by (3). Each time, test was replicated thrice and the average value was taken as average bulk density at that moisture content.

True Density

True density of chewable size fresh moringa pods was determined by platform scale method (6). The true density was calculated by as per standard method followed as per (6).

Porosity

Porosity of chewable size moringa pods was computed using the formula given below and expressed in per cent as reported by (5).

Frictional Properties

Frictional properties of chewable size moringa pods on selected surfaces were studied to understand the ease with which the chewable size moringa pods move over selected surfaces (2). This is necessary to identify the materials suitable for making processing equipments or surfaces. The methods adopted for estimating these properties are described below.

Angle of Repose

Angle of repose is the angle made by the material with the horizontal surface when piled from a known height. One bag of known weight of chewable size moringa pods was piled over a horizontal surface by free falling from a height of 50 cm. The radius of the pile was calculated from the circumference of the pile formed and the slant height of the pile was determined by measuring actual slope of the pile at different places and average value was taken as the slope of the pile. The angle of repose was calculated by using the formula

$$\cos^{-1} \frac{r}{l} \quad \dots (2.1)$$

where, θ - angle of repose, degrees

r - radius of the pile, cm

l - slant height of the pile, cm

The experiment was conducted thrice and the average value was taken as the average angle of repose of chewable size moringa pods.

Co-efficient of Friction

The experimental apparatus used in the friction studies consisted of a frictionless pulley fitted on a frame, a bottomless cylindrical container (94 mm diameter and 98 mm height), a loading pan and test surfaces. The bottomless container was placed first on the test surface and filled with known weight of chewable size moringa pods and weights were added over the loading pan until the container began to slide. The mass of chewable size moringa pods and added weights represent the normal force and frictional force, respectively. The co-efficient of static friction was calculated as the ratio of frictional force to the normal force as,

$$\frac{F}{N} \quad \dots (2.2)$$

where, μ - co-efficient of friction, fraction, dimensionless unit

F - frictional force, kg

N - normal force, kg

The experiment was performed using test surfaces like galvanised iron, mild steel, aluminium and stainless steel. Experiments were replicated three times by emptying and refilling the container with new samples every time and the average value was determined and recorded as the average static coefficient of friction.

Results and Discussion

Investigations were made on some important engineering properties and the results are presented and discussed below.

Physical Properties

The physical properties namely size, shape, bulk density, true density, porosity, etc., of chewable size moringa pods were determined and the results are presented and discussed below.

Size

Size, generally refers to the characteristic of an object, which determines space requirement within the limit and is described in terms of length, width and thickness. Chewable size moringa pods of 2.5 and 5.0 cm length were prepared from lengthy pods after discarding stalk and apex ends. The average width and thickness of 5.0 and 2.5 cm length fresh chewable size moringa pods were measured at three mutually perpendicular directions at natural rest position and the values are presented. The average width and thickness of moringa pods variety PKM-1 were 2.17 and 1.83 cm, respectively. That is, the average width of fresh moringa pod was 15.67 % higher than average thickness of moringa pods.

Shape

The shape of chewable size (2.5 and 5.0 cm) moringa pods in terms of cylindricity was measured at an average moisture content of 753.05 per cent (db) moringa pods and presented in Table 1. From table, it was found that the mean value of cylindricity of fresh 5.0 cm and 2.5 cm length moringa pods were found to be 0.729. The shape of the fresh moringa pods can be considered as cylinder for all practical purposes.

Table 1. Physical properties of moringa pods

Nature of moringa pods	Length of moringa pods, cm	Cylindricity (decimal)	Bulk density, kg m ⁻³	True density, kg m ⁻³	Porosity, per cent
Fresh (moisture content, 751.42±5.00 per cent, db)	5.0	0.729	358.68	977.68	63.38
	2.5	0.729	400.64	1047.31	61.75

(5) reported the shape of the red chillies. The mean value of cylindricity was 0.689 and reported the shape of chilli as cylinder. In the present study also the cylindricity value of fresh 2.5 and 5.0 cm length chewable size moringa pods and dried were found to be 0.729 which is similar to the values reported for red chillies. This confirms correctness of classification of moringa pods as cylinder in the present study.

Composition of Moringa Pods

The composition of moringa pod was calculated and found that the average weight of fresh whole moringa pod was 70.3 g. The weight of skin, pulp and seed were found to be 16.20, 44.11, and 9.99 g, respectively. The ratio of seed to whole pod, pulp to whole pod and skin to whole pod were calculated and found to be 0.1421, 0.6275 and 0.2303. Among the three ratios mentioned above, the ratio of seed to whole pod ratio recorded minimum value. The seed weight was very less when compared to weight of whole pod. It was also recorded that the pulp to whole pod ratio was maximum and recorded a value of 0.6275. It was also calculated and found that skin to pulp ratio to be 0.3671. From this, it is clear that in fresh moringa pods, the pulp is having more weight as compared to skin and seed.

Bulk Density

Bulk density of fresh moringa pods (2.5 and 5.0 cm length) were determined and presented in Table 1.

The fresh moringa pods of 5.0 cm length recorded a bulk density value of 358.68 kg/ m³ and 2.5 cm length pods at the same moisture

content recorded a value of 400.64 kg/ m³. From this, it is seen that a reduction in size of moringa pods from 5.0 to 2.5 cm, i.e., 50 per cent reduction in size, increased the bulk density value by 41.96 kg per m³ or 11.70 per cent increase in bulk density at 753.05 per cent moisture content (db) due to length of pods.

True Density

The values of true density of chewable size (2.5 and 5.0 cm) moringa pods at fresh were recorded and presented in Table 1. From the same table, it is also seen that the true density of 2.5 and 5.0 cm length chewable size moringa pods are 1047.31 and 977.68 kg/m³, respectively. That is, 7.10 per cent reduction in 5.0 cm length chewable size moringa pods in true density, which clearly indicates that reduction in true density is less in 5.0 cm length chewable size moringa pods.

The increase of true density in 2.5 cm length chewable size moringa pods as compared to 5.0 cm length chewable size moringa pods. Similar results were reported in ginger (4), turmeric rhizomes (7). This confirms the findings of change in true density, in the present study.

Porosity

The porosity of chewable size (2.5 and 5.0 cm) moringa pods is shown in Table 1. Porosity of chewable size (5.0 cm) moringa pods was 63.38 per cent. From the results, it is seen that 2.5 cm length moringa pods for 2.57 per cent decrease in porosity when compared to 5.0 cm moringa pods.

Increase in porosity due to length of moringa pods was observed for ginger (4), turmeric rhizomes (7). The result of change in porosity recorded in the present study is confirmed by the above mentioned published literatures.

Among the three important physical properties studied namely, bulk density, true density and porosity, the highest percentage

change were observed in bulk density, true density and the least change was observed in porosity.

Frictional Properties

The frictional properties such as angle of repose and coefficient of friction of chewable size (2.5 and 5.0 cm length) moringa pods on selected surfaces are recorded, presented and discussed below.

Angle of Repose

The angle of repose of chewable size (2.5 and 5.0 cm) moringa pods was determined at different length. It is seen that angle of repose of 5.0 and 2.5 cm length chewable size moringa pods were 32.85° and 28.57° at same moisture content of pods of 753.05 per cent (db). It is further observed that 2.5 cm length moringa pods for 13.02 per cent decrease in angle of repose when compared to 5.0 cm moringa pods. The wet or fresh pods having high moisture content exhibits high cohesive force, internal friction between pods. This resulted in more height of piling and hence more angle of repose. Similar angle of repose was reported in ginger (4), turmeric rhizomes (7). This confirmed the findings of the present study.

Co-efficient of Friction

From the table, it is seen that, fresh, 5.0 and 2.5 cm length moringa pods recorded 0.551, 0.573, 0.591, 0.682 and 0.543, 0.561, 0.582, 0.660 as coefficient of friction on stainless steel, aluminium, galvanized iron and mild steel surfaces, respectively. Among the different surfaces studied, stainless steel recorded the minimum coefficient of friction and mild steel recorded the maximum coefficient of friction for both 5.0 and 2.5 cm length moringa pods. Similar results was reported by (4). This confirmed the findings of the present study.

Conclusion

The physical dimensions of chewable size moringa pods (PKM 1, variety) the average width and thickness of moringa pods variety PKM-1 were 2.17 and 1.83 cm, respectively at a moisture content value of 753.05 per cent (db). The mean value of cylindricity of fresh 5.0 and 2.5 cm length chewable size moringa pods were found to be 0.729. The fresh moringa pods of 5.0 and 2.5 cm length recorded a bulk density values of 358.68 kg/ m³ and 400.64 kg/ m³ respectively. The true density is 1047.31 and 977.68 kg/m³. Porosity of chewable size (5.0 cm) moringa pods decreased from 69.34 to 63.38 per cent which is compared to chewable size (2.5 cm) moringa pods. Fresh, 5.0 and 2.5 cm length moringa pods recorded 0.551, 0.573, 0.591, 0.682 and 0.543, 0.561, 0.582, 0.660 as coefficient of friction on stainless steel, aluminium, galvanized iron and mild steel surfaces, respectively. The angle of repose of 5.0 and 2.5cm length chewable size moringa pods was 32.85 and 28.57 respectively, at same moisture content of pods.

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EFFECT OF WATER STRESS ON TUBER QUALITY (DUMBELL, POINTED, CRACKS AND TOTAL DEFORMED TUBERS) IN POTATO (*SOLANUM TUBEROSUM* L.)

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Abstract

The potato (*Solanum tuberosum* L.) is the main vegetable crop in India, belonging to the family Solanaceae. Potato is considered to be very drought sensitive and drought stress even occurs under irrigated potato production. Hence, yields are frequently constrained by drought in most of the environments. Short stress period during the tuber bulking period often lead to malformation such as Knobby, dumbbell shaped or pointed end tubers (1). Water stress affects the development and the growth of shoots, roots and tubers. In order to minimize the yield losses due to water stress, it is desirable to use drought tolerant varieties, adopt improved agro technology which requires less water, identify the critical growth stages sensitive to water stress in potato cultivars so that drought can be avoided on these crucial stages of growth and development.

Key words : Water stress, Potato (*Solanum tuberosum* L.), Knobby, dumbbell shaped or pointed end tubers, cracks and total deformed tubers.

Introduction

Short stress period during the tuber bulking period often lead to malformation such as Knobby, dumbbell shaped or pointed end tubers (1, 2). Moisture stress during the early tuber development stage can cause tubers to be pointed on the stem or basal end. These tubers generally develop into translucent or jelly end potatoes. Period of stress later in the development stage can cause dumbbell shaped tubers or tuber pointed on the apical end. Knobby tubers are generally considered to be caused by a high

top/tuber ratio (3). Another tuber malformation, growth cracks is also the result of fluctuating, moisture supply. (5) found more tuber malformation in long shaped varieties such as Russet Burbank than in more spherical varieties like Kennebec. Almost similar results were obtained by (4).

(6) distinguished two forms of tuber cracking i.e. the form of growth cracking typical of Guardian cultivar which produced cracks that are 15-25 mm deep and have straight smooth edges whereas another form exhibited

by Record cultivar produces cracks that are usually 2-5 mm deep. The latter have jagged and sharp edges and they progress erratically across the surface of the tuber and do not usually extend for more than one third of the perimeter of the tuber. (5) found that plants stressed for a period of only two days, after which rewatering took place had more malformed tubers than plants grown under continuous water stress. (7) concluded from compression studies on potato tubers that cracking occurred when the potential energy within a tuber exceeded a critical value. (8) suggested that growth cracking was associated with mid season water stress followed by a resumption of water supply but (9) showed that such a sequence of soil moisture conditions did not reliably induce the disorder.

Materials and Methods

Forty eight plots were used in a split plot design for accomodating 4 treatments (as main plots) each having 4 varieties (as sub-plots) in 3 replications. A plot of 7.2 m² (3 x 2.4 m) size was used for each treatment in every replication during main crop in rabi season of the year I and II.

Field trials were conducted in split plots with three replicates employing the 4 varieties (i.e Kufri Chipsona-1, Kufri Pukhraj, Kufri lauvkar and Desiree) having following treatments:

T₁ : Control (well watered plants)

T₂ : Water stress at- tuber initiation stage

T₃ : Water stress at - tuber enlargement stage

T₄ : Water stress at - tuber maturation stage

T₁ control (well watered) plots were irrigated at 6 DAP (days after planting), 27 DAP, 42 DAP, 63 DAP and 80 DAP during the year 2005-06 and at 8 DAP, 25 DAP, 44 DAP, 67 DAP and 83 DAP during the year 2006-07. The water stress was imposed by withholding water in T₂, T₃ and T₄ treatments at different growth stages according to Table 1. The

growth stage was identified and confirmed by uprooting the plants and by examining the stage of tuber development. Experimental plots were dehaulmed at 90 DAP and harvesting was done 10-15 days after of dehaulming so that tuber skin is matured.

The sorting of potatoes was done on the basis of defects in their shape (Pointed, Dumbell shaped, Cracks) and size (i.e. Marketable tubers >30 g and Non marketable tubers <30 g). The potato grading was done manually and yields were weighed on 30 kg electronic, portable balance (Avery, A 611W digital scale).

Data recorded during the course of study were subjected to statistical analysis by applying the technique of analysis of variance (ANOVA) prescribed for the split plot design (10) to the significance of the overall difference among treatments by the "F" test. The critical difference at 5% level of probability was worked out to compare treatment means where "F" test was significant.

Results and Discussion

Data on tuber defects as influenced by water stress at different growth stages is presented in Table 1.

Influence of Water Stress Treatments

Mean values of treatments in table 1 showed that tuber deformity (dumbbell, pointed, cracks etc.) increased due to water stress. Maximum number of total deformed tubers (35 and 38 th/ha during I and II year respectively) was observed when water stress was imposed at tuber enlargement stage(T₃) whereas minimum number of deformed tubers (13 and 14 th/ha during 2005-06 and 2006-07 respectively) was observed when water stress was imposed at tuber maturation stage (T₄).

Maximum percent increase in total tuber deformity (150% and 137% in respective years) was found due to water stress at tuber enlargement stage (T₃) while increase in deformity was not observed when water stress was imposed at tuber maturation stage (T₄).

Table 19. Effect of water stress on tuber quality (dumbel, pointed, cracks and total deformed tubers) of potato cultivars (000/ hec.)

Treatment*	Ist Year				II Year			
	Dumbel	Pointed	Cracks	Total	Dumbel	Pointed	Cracks	Total
Kufri Chipsona-1								
T ₁	7	6	4	17	7	6	4	17
T ₂	12(+71%)*	11(+83%)	10(+150%)	33(+94%)	14(+100%)	12(+100%)	11(+175%)	37(+117%)
T ₃	20(+185%)	14(+133%)	16(+300%)	50(+294%)	19(+171%)	13(+116%)	16(+300%)	48(+182%)
T ₄	5(-28%)	7(+16%)	4 (00%)	16 (-5%)	7 (00%)	7(+16%)	4(00%)	18(+6%)
Mean								
Kufri Pukhraj								
T ₁	8	5	4	17	11	5	4	20
T ₂	10 (+25%)	12(+140%)	9 (+125%)	31 (+82%)	13 (+18%)	14(+180%)	10(+150%)	37(+85%)
T ₃	14 (+75%)	16(+220%)	11(+175%)	41(+141%)	14(+27%)	16(+220%)	12(+200%)	42(+110%)
T ₄	8 (00%)	5 (00%)	4 (00%)	17 (00%)	9 (-18%)	6(+20%)	4(00%)	19(+5%)
Mean								
Kufri Lauvkar								
T ₁	4	3	3	10	4	4	3	11
T ₂	7 (+75%)	10(+233%)	6 (+100%)	23(+130%)	8(+100%)	10(+150%)	7(+133%)	25(+127%)
T ₃	8 (+100%)	9 (+200%)	8 (+166%)	25(+150%)	10(+150%)	10(+150%)	8(+166%)	28(+154%)
T ₄	3 (-25%)	3 (00%)	3 (0%)	9 (-10%)	3 (-25%)	3(-25%)	3(00%)	9 (-18%)
Mean								
Desiree								
T ₁	4	5	3	12	4	5	4	13
T ₂	6 (+50%)	12(+140%)	6 (+100%)	24(+100%)	8(+100%)	12(+140%)	6(+50%)	26(+100%)
T ₃	10(+150%)	10(+100%)	4 (+33%)	24(+100%)	14(+250%)	12(+140%)	5(+25%)	31(+138%)
T ₄	4 (+00%)	5 (00%)	3 (00%)	12 (00%)	3 (-25%)	5(+50%)	4(00%)	12(+7%)
Mean								
Mean Values of Treatments								
T ₁	6	5	3	14	7	5	4	16
T ₂	9 (+50%)	11(+120%)	8 (+166%)	28(+100%)	11(+57%)	12(+140%)	8(+100%)	32(+100%)
T ₃	13(+116%)	12(+140%)	10(+233%)	35(+150%)	14(+100%)	13(+160%)	10(+150%)	38(+137%)
T ₄	5 (-16%)	5 (00%)	3 (00%)	3 (-7%)	5 (-40%)	5(00%)	4(00%)	14(-12%)
CD at 5%								
Cultivar(C)	1.31	0.98	0.62	1.72	0.55	0.53	0.32	0.85
Treatment (T)	1.31	0.98	0.62	1.72	0.55	0.53	0.32	0.85
C × T	2.62	1.97	1.24	3.44	1.11	1.06	0.66	1.70

*Treatments: T₁ = Control (well watered), T₂ = water stress at tuber initiation, T₃ = water stress at tuber enlargement and T₄ = water stress at tuber maturation stage.

**Figures in parenthesis are percent (%) change due to water stress treatment T₂, T₃ and T₄ as compared with respective control

Varietal Behaviour

Data in table 1 showed that cultivar Kufri Chipsona-1 recorded maximum number of deformed tubers (50 and 48 th/ha during I and II year respectively) whereas cultivar Kufri Lauvkar recorded minimum number of deformed tubers (25 and 28 th/ha during I and II year respectively) under water stress conditions at tuber enlargement stage (T₃) in comparison with well irrigated control.

Maximum percent increase in total deformed tuber (294% and 182% in respective years) was observed in cultivar Kufri Chipsona-1 whereas minimum percent increase (100% and 138% in respective years) was observed in cultivar Desiree when water stress was imposed at tuber enlargement stage (T₃) in comparison with respective control.

Similar trend in respect of cultivar was found when water stress was imposed at tuber initiation stage (T_2) and tuber and tuber maturation stage (T_4). The reduction in marketable tuber yield was found not only due to smaller tuber size formation but also because water stress increased the formation of deformed tubers like knobby, dumbbell shaped and cracked tubers (Table1). Similar results were also reported by (8) and (11). Once tubers have been initiated, their subsequent growth may also be affected by drought (8). Knobby or dumbbell shaped tubers and cracked tubers are the result of short periods of water deficit (2). During a period of stress, longitudinal growth slows or may even stop. When favourable conditions return, tuber growth resumes "stop and go" growth. Therefore, dumbbell appearance is due to irregular longitudinal growth, often because of a constriction. Pointy stem-end or bottleneck growth disruption occurred during early bulking and the constriction is at the stem end. dumbbell and elongated growth disruption occurred at mid-bulking. Dumbbells have a constriction in the middle. Kidney-shaped tubers tend to have a slighter mid-section constriction and tend to curve, giving the kidney-shape appearance (11). Knobbiness also sometimes referred to a secondary growth is due to stimulated growth of lateral buds in one or more eyes. Maximum total tuber deformity (150%) was found when water stress was imposed at tuber enlargement stage. The size and shape of knobs depends on the growth stage of the tuber under stress (12). Large growth cracks are due to desynchronized growth between inner and outer tuber tissue. The sudden and rapid growth of internal tuber tissue or growth cracking is primarily due to an uneven

availability of soil moisture and rapid, uneven uptake of water. Sometimes this is referred to as bursting. Longitudinal fissures develop when the core tissue inside the tuber grows faster than the outer tissues, the periderm. In other words, the internal pressure of the tuber is greater than the tensile strength of the skin or surface tissue. The resulting fissure or crack can extend the entire length of the tuber and may be shallow or a half inch deep (6). Such deformities, however, are not only due to water stress but also because of other stress factors, such as heat (13).

Conclusion

The reduction in marketable tuber yield was found not only due to smaller tuber size formation but also because water stress increased the formation of deformed tubers like knobby, dumbbell shaped and cracked tubers.

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Dr. Bijendra Singh,
President, Hi-Tech Horticultural Society
B-94, European Estates, Kankerkhara, By-pass, Meerut-250 001, U.P. INDIA

Dear Sir,

Please enrol me as a Life/Annual Member of I am enclosing herewith my Biodata and a draft of Rs. (in words.....), having draft No..... Dated or Online transaction ID Dated Bank Name for Life/Annual Subscription & if enrolled, agree to abide by its rules and regulations.

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The life membership fee may be paid either in lumpsum or in two equal instalments within one year of enrolment. Membership fee must be paid through M.O./Bank Draft / Multicity Cheque in favour of the **HI-TECH HORTICULTURAL SOCIETY** and payable at SBI S.V.P.U.A.&T. Modipuram, Meerut (Branch Code: 10653) Direct online transfer in Account No.: 33901961944, IFSC Code: SBIN0010653. Correspondence regarding membership subscription and any other matter on the journal should be addressed to **President, HI-TECH HORTICULTURAL SOCIETY**, B-94, European Estates, Kankerkhara, By-pass, Meerut-250 001, U.P. INDIA or email to : annalsofhorticulture@gmail.com, drbijendrasingh66@gmail.com

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