# First evaluation of taro (Colocasia esculenta) genotypes against leaf blight (Phytophthora colocasiae) in Ghana.



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ISSN: 2250-2823

# HortFlora Research Spectrum

An International Peer Reviewed JOURNAL

Volume 3 (4) December 2014

Journal's International Impact

Index Copernicus Value (ICV): 27.39 (Poland); Global Impact Factor (GIF): 0.364



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*Subscription rates for 2015 have been revised as :

Rs. 3000/-(US$300) for Life Membership; Rs. 1000/- (US$ 160) for Annual Membership

Rs. 700/- (US$70) per article printing fee.

ISSN: 2250-2823

# HortFlora Research Spectrum

Volume 3(4) : December 2014

An International Peer Reviewed JOURNAL

International Impact
Index Copernicus Value (ICV) : 27.39 : Global Impact Factor (GIF) : 0.364

*Indexed / Abstracted in :*

- Index Copernicus International, Poland
- Indian Science Abstracts
- CAB Abstracts
- CABI Full text
- CiteFactor
- OAJI.net
- InfoBase Index
- Google Scholar
- Research Bib
- ICRISAT InfoSAT
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www.hortflorajournal.com

Date of Publication : 25-12-2014

ICV: 27.39; GIF: 0.364

***HORTFLORA RESEARCH SPECTRUM*** **ISSN : 2250-2823**

**Volume 3, Issue 4 : December 2014**

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www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 301-309 (December 2014) ISSN : 2250-2823

# AN OVERVIEW ON EXPLOITATION OF MALE STERILITY FOR DEVELOPMENT OF HYBRIDS AND SEED PRODUCTION IN HOT PEPPER

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**ABSTRACT :** Male-sterility in chili was documented for the first time in the 1950's. Since then, considerable knowledge has been accumulated on the nature of the trait, the means of its identification, induction, inheritance of both genetic and cytoplasmic genetic male-sterility, maintenance of inbreds, and their potential for breeding hybrid cultivars. Heterosis for various economic traits like; maturity, fruit weight, size, number and total yield have been utilized. Today, several internationally known seed companies and research institute use the genetic mechanism [msms] on a large scale for producing hybrids of sweet pepper, whereas the cytoplasmic genetic sterility [(S) Rf rf] is used mainly for breeding pungent hybrids. The possibilities of exploitation of male sterility for crop improvement as well as production of $F_1$ hybrids have been reviewed and discussed in the present paper. Biochemical as well as biotechnological aspects of this phenomenon has also been vividly reviewed.

**Keywords:** *Hot pepper, male sterility, hybridization, heterosis, hybrid seed production.*

Chilli (*Capsicum annuum* L.) is an essentially old world genus native to tropical America (Thompson and Kelly, 76). The fruit, consumed either as green or red powdered form is a culinary item in all parts of globe. The fruits are quite rich in nutrients, phytochemicals and antioxidants. The global acreage for both chilies and bell pepper was 1.7 million hectares with a production of 26.06 million tones, whereas the dry chilies and pepper occupy an area of 1.56 million hectares and production of 2.35 million tonnes. India tops the list of chilies and dry pepper production, while China tops the list for green chilies and green pepper production. In last few years per capita consumption of all peppers has increased. The consumption of bell peppers grew from 9.2 pounds to 9.8 pounds, while chilli pepper consumption grew from 6.1 pounds to 6.6 pounds (Anon., 2). But, most of the area is covered by open pollinated varieties, which mainly account for lower production and productivity. Exploitation of heterosis through hybrid development is essential to augment production and ensure stability of yield. Deshpande (16) was pioneer in reporting heterosis in chilies from India. Heterosis for various economic traits like maturity, fruit weight, size, number and total yield have been reported by many other authors (Shankarnag *et al.,* 66; Satish and Lad, 64; Patel *et al.*, 54). Reddy *et al.* (60) reported 88.27% better parent heterosis and 60.51% economic heterosis for fruit yield per plant in the hybrid SKAU-SC-1003 × Arka Lohit. Male sterility is a handy tool for the exploitation of heterosis in many crops, including chili. The high labour cost, tedious process of manual emasculation and sensitivity of flowers to physical injury limits the commercial exploitation of heterosis. Breuits and Pochard (5) developed the first hybrid Lamuyo by using male sterile line *ms*-509. Singh and Kaur (73) recommended use of male sterility for production of $F_1$ hybrids. Hundal and Khurana (29) reported 235.71% and 138.0% standard heterosis for green fruit yield and red ripe fruit yield, respectively using male sterility system. Heterosis for yield and different yield related traits utilizing male sterility system has also been reported by Meshram and Ghongade (47), Shankarnag and Madalageri (65) and Patel *et al.* (54).

## FLORAL BIOLOGY OF CHILIES

Chilli is a hermaphrodite plant. The flowers are borne solitary or in clusters in the axil of the leaves. Sepals and petals are usually five in number, stamens varies from five to 14, stigma is club shaped, ovary superior and consists of 2 to 4 or more locules. The anther dehiscence and stigma receptivity are influenced by weather conditions. The flowers have been reported to open by 5.00-6.00 hr and anther dehiscence occurs between 8.00-11.00 hr. The pollen fertility and stigma receptivity is highest on the day of anthesis, therefore self pollination is favoured. However, differential position of stigma (e.g. heterostyly with longer stigma), prevailing protogyny (reported in some lines) and preference of honeybees and other pollinating insects determine the extent of cross pollination. Most cultivated peppers are

*Received:09-07-2014; Revised:08-10-2014; Accepted:26-10-2014*

autogamous and cross pollination as high as 68% has been reported (Greenleaf, 22). In open field, out-crossing commonly ranges from 7% to 90%, which shows that *Capsicum* should be considered facultative cross-pollinating species (Franceschetti, 20).

## MALE STERILITY SYSTEM IN CHILLI AND ITS EXPLOITATION IN HYBRID DEVELOPMENT

The flowers are small in structure, therefore, hand emasculation and pollination is a time taking process. Unlike tomato, the stamens are neither epipetalous, nor are the flowers bigger and stout as in brinjal. Besides, manual emasculation significantly increases the cost of hybrid seed production. To mitigate this problem, both genetic as well as cytoplasmic systems have been exploited for use in hybrid seed production. Male sterility is characterized by the absence of functional pollen in the hermaphrodite flower, which is used as an aid in the hybridization programme of chilies. In India, Punjab farmers are producing chilli hybrid seeds, using nuclear male sterile lines and natural cross pollination (Dash *et al.*, 11; Kumar and Singh, 39). CGMS system in chilies had also been reported from IIHR, Bangalore (Madhavi, 45). Male sterility system in chilies is governed by nuclear genes alone (genetic male sterility) or a combination of cytoplasmic and nuclear gene (cytoplasmic-genetic male sterility). Male sterility was first documented by Martin and Crawford (46) in *Capsicum* pubescence. A few years later, Peterson (57) isolated a male sterile line from a non-pungent collection of India (USDA PI 164835). The trait was reported to be controlled by a sterile cytoplasm with a recessive *ms* genes, while dominant *ms i.e., Ms* allele restores the pollen fertility in the hybrid. In many test crosses, a dihybrid ratio of 3 fertile: 1 sterile was observed and suggested presence of another restorer locus *ms-2*. Nevertheless, all other reports so far have concluded restoration to be monogenic dominant. Ms-509 line (Pochard, 58) was renamed *ms*-10 by Daskalov and Poulos (15), later brought to India and introgressed into Indian chilli lines and developed *ms*-12, *ms*-13 and *ms*-14 (Singh and Kaur, 73) lines. Later *Ms*-12 became a successful parental line and two chilli hybrids *viz.,* CH-1and CH-3 gained a lot of popularity in North India. Shifriiss and Pilowsky (72) reported a digenic male sterility in *C. annuum*, controlled by two loci viz., *Ms1 and Ms2*, the recessive forms of which were responsible for expression of male sterility. Yazawa *et al.* (80) developed a new line of capsicum by transferring Peterson's male sterile line into a Japanese accession and reported it to be stable under fluctuating temperatures. They also transferred this cytoplasm into the background of a Japanese variety Murasaki to obtain a non-pungent male sterile line. Kumar *et al.* (36) were successful in transferring genetic male sterility from *ms-12* to sweet peeper and obtaining non-pungent bell shape fruits by back crossing method.

## MALE STERILITY THROUGH MUTATION: SPONTANEOUS AND INDUCED

Every open pollinated cultivar would be a potential candidate in which male sterile mutants could be found, particularly the exceptionally tall, poor bearing plants revealed sterility (Shifriiss, 67). While many times mutants appear in open pollinated populations of established varieties, it is observed mostly in segregating generations of intra and interspecific crosses. Peterson's male sterility system was a spontaneous one. Roussenova-Kondareva (61) obtained spontaneous mutants from the $F_4$ generation of two crosses viz., *C. pendulum* var. *bicoloratum* × *C. annuum* and *C. pendulum* var. *longisilicum* × *C. annuum*. The flowers were stamenless or sometimes with only rudimentary stamens. Dikii and Analkecko (18) succeeded in improving the morphological and biological characters by backcrossing with different varieties, but could not identify restorer lines for this. Shifriiss (67) suggested screening old cultivars for spontaneous male sterile mutants they might contain more of recessive mutants in comparison to lines, which were developed after strict selection for uniformity. Shifriiss (68) identified twenty four unfruitful plants in a population of ten thousand plants and one plant was found to produce small and shrunken anthers, which was unable to produce pollen grains.

Several mutagens have been tried to create male sterile mutants in *Capsicum*. Daskalov (12) obtained 6 male sterile mutants after seed irradiation with $\gamma$ or X-rays. Genetic studies revealed that five of the mutants were non-allelic monogenic mutants (*ms*-3, 4, 6, 7 and 8), whereas one of the mutants was found dominant (designated *Dms*). Pochard (58) induced male sterility through application of X-rays or EMS (ethyl methyl sulphonate) on monoploid material and obtained three different mutants viz., *ms*-9, *ms*-509 and *ms*-705. Thakur *et al.* (75) irradiated California Wonder seeds with different doses of X-rays; male sterile mutants were detected at 5 & 10 kR dose levels. Yu (82) found that a material isolated spontaneously (*msk* allele) was allelic to Pochard's material. Shifriiss and Frankel (70) isolated a sterile cytoplasm while studying intraspecific crosses, which was subsequently found identical to Peterson's male sterile. Many of the male sterility genes induced through mutagenesis were later reported to be identical among themselves or themselves or to some already existing system. An interspecific hybrid between *C. frutescens* and *C. annuum* following back crosses with sterility maintainer lines produced male sterile progenies (Csillary, 9). The cytoplasm of *C. frutescens* was found identical to Peterson's type in its sterility expression and response to the Peterson's maintainer and restorer lines. Cytoplasmic male sterile plants were isolated from segregating population of an interspecific cross involving *C. chinensis*, *C. baccatum* and *C. annuum* at Katrain centre of Indian Agricultural Research Institute (Anon., 3).

## INDUCTION OF MALE STERILITY BY INTERSPECIFIC HYBRIDIZATION

The chromosomal or plasmon-genome incompatibility of interspecific hybrids may result in different degree of sterility. Shifriiss and Frankel (70) obtained male sterile forms after hybridization between *C. chinense* and *C. annuum,* followed by two backcrosses with *C. annuum*. The fertility restorer was identified in *C. chinense*. Dikii *et al.* (19) reported sterile plants as a result of hybridization between *C. peruvianum* and *C. annuum*. The fertility of progeny resulting from crosses between different species range between complete sterility (*C. chacoense* × *C. annuum*) to normal fertile hybrids (*C. annuum* × *C. baccatum*) (Kumar *et al.*, 35). Pollen sterility was also seen in three way hybrids (*C. annuum* × *C. chinense*) × *C. baccatum* (Yoon and Park, 81). The cross between *C. baccatum* and *C. annuum* were frequently found unsuccessful; in the few successful cases the $F_1$ hybrid was completely sterile or selfing was possible scarcely. In an attempt to obtain male sterility Andrasfilvy and Csillary (1) backcrossed the $F_1$ progeny to *C. annuum* repeatedly, which resulted in an antherless progeny frequently combined with reduced female fertility. Cytoplasmic male sterile plants were isolated from segregating population of an interspecific cross involving *C. chinensis*, *C. baccatum* and *C. annuum* (Anon. 3).

## INDUCTION OF STERILITY USING PLANT GROWTH REGULATORS

Use of androecides had been suggested by many workers; 2-3 dichloroisobutyrate (Hirose, 26), maleic hydrazide @ 0.4-0.5% (Chauhan and Singh, 7), 2-2 dichloropropionate or dalapon (Hirose, 27; Chauhan, 6; Salgare, 63) to be used as inducers of complete sterility, whereas 2, 4-D was found to cause incomplete (up to 83%) male sterility. Kohli *et al.* (32) found spraying of $GA_3$ @ 1000 mg/l at 10 days interval from the onset of flowering for 3 times caused complete male sterility which lasted throughout the crop season. However, there are no reports of commercial hybrid seed production using this technology.

## EFFECT OF ENVIRONMENT

Peterson (57) observed that instability in the male sterility could be attributed to interaction between temperature and sterility modifier genes. Later, it was reported that when the temperature drops (e.g. 25°C in day and 17°C in night) pollen fertility is restored (Kubisova and Haslbachova, 33; Ledo *et al.,* 42; Shifriiss and Guri, 71). The variation among cytoplasmic male sterile lines in the expression of sterility is possibly a result of differences in number and nature of sterility modifier genes. Yu (82) demonstrated that development of 'B'-lines with potential resistance to seasonal fluctuation was possible. Moreover, Shifriiss (67) suggested a system to take advantage of sensitivity of lines viz.; male sterile, maintainers and restorers to seasonal fluctuations for hybridization during summers when the temperatures are high (mean diurnal temperature 30°C). Multiplication of seeds of parental lines ('A'-line) during the cool season (diurnal mean temperature 17°C), when sterility remained stable in (S) *rf rf* could possible. Bashir (4) also recorded that male sterility was accentuated by higher temperatures. Hirose (24, 25) reported that high temperature a fortnight before anthesis causes pollen abortion and deterioration of pollination efficiency.

## IDENTIFICATION OF MALE STERILE AND RESTORER LINE USING MOLECULAR MARKERS

Identification of restorer line and maintainer line is a tedious task, which requires screening of large number of genotypes. The fertility restoration in chili pepper is controlled by a major nuclear gene (Rf), along with several modifiers and some environmental factors. Kim *et al.* (31) identified molecular markers closely linked to fertility restorer locus (Rf) in chili pepper using bulk segregant analysis. The AFRF8 marker was successfully converted to CAPS marker for fast and reliable detection of restorer lines during $F_1$ hybrid seed production and breeding programmes in pepper. The distribution of RAPD markers linked with fertility restoration in chili was reported by Kumar *et al.* (37) and they found that Rf gene associated with two markers ($OPW19_{800}$ and $OPP131_{400}$) were not frequently distributed in the restorer inbred lines. Lee *et al.* (44) carried out bulk segregation analysis using 768 AFLP primer combinations and based on the sequence of the internal and flanking regions of the AFLP fragment closely linked to partial fertility restoration locus, the AFLP marker E-AGC/M-$GCA_{122}$ was converted to CAPS marker, PR-CAPS. They further reported that this PR-CAPS marker could be useful in selecting fully fertile lines (Pr/Pr) and eliminating partially fertile (pr/pr) and heterozygous lines (Pr/pr) in segregant population during development of new inbred restorer lines. Mitochondrial DNA differences of CMS pepper line 21A and its maintainer line 21B were reported by Wang *et al.* (77). They utilized 100 random primers to differentiate mitochondrial DNA and found that specific RAPD marker CMSAG3 $_{430}$ was related to CMS gene.

## MAINTENANCE AND RESTORATION

Yu (82) used Peterson's male sterile plants, which after crossing with fertile plants, were subjected to selfing and rigorous selection. Selection was eventually found effective and stable and efficient maintainers as well as restorers were isolated from this material. Yu (82) also found that hot pubescent pepper lines contained no maintainer lines and suggested a linkage between pubescence and fertility restorer genes. Among the sweet pepper lines, he was able to identify only one restorer viz., DiQuneo.

Male sterility (anther less flowers) was observed in a cross of *C. baccatum* × *C. annuum*, which was subsequently back crossed to *C. annuum* (Saccardo and SriRamulu, 62; Andrasfilvy and Csillary, 1; Csillary, 9) and gradual feminization was observed with advancement of backcrossing, thereby suggesting a polygenic plasmon-genome interaction and recessive fertility restoration. This condition was not conducive for male fertile hybrids. The *ms* genes interacting with sterile cytoplasm (*S*) and corresponding fertile cytoplasm (*N*) were initially designated as *ms* genes (Peterson, 57; Martin and Crawford, 46; Shifriiss and Frankel, 69). Instead, such genes should be ideally classified as *rf* genes. Only the genes operating independent of cytoplasmic interaction should be designated as *ms* genes.

Shifriiss and Frankel (70) indicated that hot pepper varieties contained only fertility restorer genes and bell type and other sweet varieties contained either maintainer or both maintainer and restorer genes. They also identified a new source of sterile cytoplasm collected from India, which behaved similar to Peterson's *S*-type.

Meshram and Mukewar (49) and Gill and Gill (21) found that manual pollination brings much better effects and obtained 68-100 seeds through manual pollination as compared to 10-12 seeds when pollination was carried out by insects. Nowaczyk and Nowaczyk (52) observed distinct differences based on location of plants in a protection structure. The seed setting was found to be better in the plants situated in the central part of the polyhouse (75.3% setting) as compared to plants near the walls (52.6% setting). There was more stable temperature in the central part of the polyhouse. They found microclimatic conditions in the close neighbourhood of the tent wall less conducive for hybrid seed setting.

## CYTOLOGICAL ASPECTS OF MALE STERILITY

Microscopic observations and electron microscopy revealed that after the tetrad stage of meiosis of CMS plants, where both the outer and inner layers of tapetum degenerated and the microspores aborted. Horner and Rogers, 28). Kumar *et al.* (41) by crossed a set of eight maintainer and restorer inbreds on four CMS lines possessing two independently isolated and commercially utilized S-cytoplasms (Peterson's and Reddy's). Based on fertility restoration/maintenance reaction of 32 resulted F1s and on the presence of two SCARs (atp6607 and coxII708) in both the S-cytoplasms, concluded that although two S-cytoplasms were isolated and commercially utilized independently,

## LINKAGE WITH MARKER TRAITS

Generally the genetic male sterile mutants are similar in function and in certain cases they have been found to be linked with marker traits, which may be helpful in the identification of male sterile individuals at early stages (Meshram and Narkhede, 48; Murty and Lakshmi, 50; Pathak *et al.*, 56). Gulyas *et al.* (23) attempted to estimate the physical distance between restorer marker and the *rf* gene based on a closely linked molecular marker identified by Yanagawa *et al.* (79). Based on the pollen analysis and the use of *rf* marker in $F_2$ generation, the physical distance between the restorer gene and the marker gene was found to be 20 cM while it was 5.3 cM and 4.8 cM in $F_3$ and $F_4$ generations, respectively. Through, the environment did not alter the expression of a molecular marker (Tanksley, 74). Therefore, the sterility expression was considerably influenced by environmental factors a more precise estimate of the physical distance between the restorer and marker genes could be possible by eliminating the environmental effects. Pakozdi *et al.* (53) identified a molecular marker for the restorer of CMS system and the genetic distance was 20 cM. A CAPS marker linked to a genic male-sterile gene in the colored sweet pepper, 'Paprika' (*Capsicum* *annuum* L.) was identified by Lee *et al.* (43). Woong *et al.* (78) were also able to develop new molecular markers for the identification of male sterile cytoplasm in peppers (*Capsicum annuum* L.).

## POLLINATION REQUIREMENT

Capsicum is generally considered a self-pollinated genus, but a high level of cross-pollination has also been reported. Cochran (8) observed that cross pollination takes place more frequently than it is generally believed. Although honeybees are considered the most common pollinators for capsicum, ants and bumble bees have also been observed to effect cross pollination in this crop. Moreover, the expenditure incurred on labour deployed in emasculation and hand pollination was found to be as high as 78 % of the total expenditure on labour employed in hybrid seed production (Kumar and Thakur, 34). Availability of male sterility has ruled out the necessity of selfing and done away with the need of manual emasculation. Several attempts had been reported to make hybrid seed production more economical by modifying the mode of manual pollination (Kumar *et al.*, 40), use of honeybees to transfer pollen from male to male sterile female parent proved an effective method of pollination for hybrid seed production on commercial scale. Several workers had explored the possibility of use of natural cross pollination for hybrid seed production and the commercial exploitation of male sterility system largely depends on natural cross pollination of the male sterile lines. Murty and Murty (51) have recorded as high as 68% natural cross pollination in chilies. Patel *et al.* (55) observed considerable amount of natural cross pollination in male sterile plants surrounded with fertile plants. Kumar *et al.* (38) reported that considerable amount of natural cross pollination takes place on male sterile plants of chilli. They further suggested that during CMS (CCA-4261) based chilli hybrid seed production, expenditure on manual pollination could be saved, without compromising the yield of hybrid seeds. Farmers in Punjab state of India produce chili hybrid on a large scale by using female: male ratio of 2:1 and honeybee for natural cross pollination.

Both manual and open pollinated methods are being practiced for pollen transfer for large scale hybridization. Capsicum flowers produce both pollen and nectar; hence, are attractive to honeybees. Kubiasova and Hslbachova (33) observed that honeybees visit both male sterile and male fertile plants and changed lines frequently. Rabinowitch *et al.*. (59) reported that pepper genotypes varied in frequency of honeybee visits and there was significant correlation between sugar quantity and honeybee visit per flower. Increasing number of visits increased the number of seeds in the pepper fruits. Considerable variation in nectar characteristics could be exploited for facilitating bee pollination in commercial hybrid seed production. Some workers have suggested possibility of capsicum hybrids seed production under protected cultivation. Jarlan *et al.* (30) assessed the possibilities of using syrphid fly (*Eristalis tenax* L.) as a pollinator of sweet pepper under glass house conditions. Higher seed set was observed in insect pollinated flowers as compared to fruits from unvisited flowers and the duration of visits also increased the seed set significantly.

## CONCLUSION

It took a long time from discovery of male sterility system to its utilization for hybrid seed production. The male sterile mutants have been commercially used in hybrid seed production of hot pepper despite the need to identify and rogue out the sterile plants from the female line. Because of the lack of tightly linked marker systems, this process is carried out after flowering which is the biggest drawback in the use of genetic male sterility. Csillary (10) proposed accumulation of several male sterility genes to produce a line that segregates into a large proportion of male sterile plants containing two sterility genes viz., *ms*-3 and *ms*-8. Shifriss and Pilowsky (72) proposed that the $F_2$ derived from two near isogenic lines (NILs) differing for male sterility genes (*ms*-1*ms*-1*Ms*-2*Ms*-2 × *Ms*-1 *Ms*-1 *ms*-2 *ms*-2) should segregate either in 3:1 or 9:7 (fertile: sterile) ratio. However, they did not clearly indicate as to how crossing would be effected between these two male sterile lines. Daskalov and Mihailov (13, 14) proposed a technique for hybrid seed production based on male sterility (genetic or cytoplasmic), combined with a lethal gene whose action may be inhibited by a specific chemical. The aim of using such gene was elimination of the selfed plants. The cytoplasmic male sterility system is free from this disadvantage and it supplies a population comprised completely of male sterile plants.

A cytoplasmic male sterility (CMS) system in pepper is characterized by a known restorer gene required to overcome the sterility in the $F_1$ progeny and ensure fruit setting in the commercial crop. The CMS is better known as CGMS (cytoplasmic genetic male sterility) system and consists of three lines, namely; male sterile (female) ‘A’-line, male fertile ‘B’-line and fertility restorer ‘R’-line. This is the predominant method of pollination control for hybrid seed production in hot pepper. There are two major limitations in use of CGMS system in hybrid seed production of sweet pepper.

Firstly, restorer genes are very rare among sweet pepper lines. Moreover, transfer of male sterility system from hot pepper to sweet pepper requires crossing with hot pepper which results in inadvertent movement of genes for pungency into sweet pepper which is not eliminated even after several backcrosses. Otherwise no agronomic differences were found in hot pepper when $F_1$ hybrids containing sterile cytoplasm were compared with their isogenic $F_1$ hybrids containing fertile cytoplasm. To harvest higher yield of hybrid seed, sweet pepper lines can be used for producing hybrid seed of hot pepper hybrids.

The chili hybrids, CH-1 and CH-3 released by Punjab Agricultural University, Ludhiana, India based on GMS system are very popular in North India. Dhungel *et al.* (17) recorded maximum hybrid seed yield of chilies by planting in a ratio of 2:1 (female: male) followed by spray of 1% aqueous solution of urea at 30 and 40 days after transplanting. Similarly, two hot pepper hybrids viz., Arka Harita and Arka Shweta based on CGMS system, released by Indian Horticultural Research Institute, Bangalore are gaining popularity in South India and among several hybrids of private seed companies.

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**Citation :** Kumar P.R., Lal S.K., Yadav S.K., Saran P.L. and Solanki I.S. (2014). An overview on exploitation of male sterility for development of hybrids and seed production in hot pepper. *HortFlora Res. Spectrum,* **3**(4) : 301-309.

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 310-314 (December 2014) ISSN : 2250-2823

# INTERCROPPING FOR EFFICIENT RESOURCE UTILIZATION IN INDIAN AGRICULTURE: A REVIEW

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**ABSTRACT :** In India, agriculture is driven by small and marginal farmers mostly and hence effective land utilization is an only way to get more harvest and simultaneously targeting important upcoming environmental problems, including reduced soil fertility and reduced biodiversity. Intercropping of two or more crops is an age old practice in India especially under rainfed conditions. The most common advantage of intercropping is to produce a greater yield on a given piece of land by achieving more efficient use of the available growth resources that would otherwise not be utilized by each single crop grown alone. Cereals, oilseeds, legumes, cash crops like sugarcane and horticultural crops; all can be efficiently used in intercropping for taking advantage of ecological balance, more utilization of resources, increasing the quantity and quality of harvest and reducing damage by pests, diseases and weeds simultaneously.

**Keywords :** *Intereropping, resource utilization, ecology.*

All over the world, farmers work hard but do not make money, especially small farmers because there is very little left after they pay for all inputs. Human race depends more on farm products for their existence than anything else since food and clothing – the prime necessaries are products of farming. Even for industrial prosperity, farming forms the basic raw material. To sustain and satisfy as many as their needs, the farmers include crop production, livestock, poultry, fisheries, beekeeping etc. at their farms. Presently, the farming objective is the sustainable economic yields for the present generations without dislocating the natural resource base for the future generations. In India, due to prevailing socio-economic situations (such as; dependency of large population on agriculture, small land-holding size, very high population pressure on land resource etc.), improving household food security has been an issue of supreme importance specially considering many million farmers of India, constituted by 56.15 million marginal (<1.0 hectare), 17.92 million small (1.0-2.0 hectare) and 13.25 million semi-medium (2.0-4.0 hectare) farm holdings, making together 90 per cent of 97.15 million operational holdings. An important consequence of this has been that crop production in India remained to be considered, by and large, a subsistence rather than commercial activity (Das, 4).

In terms of ecology and environment, monocropping has been caused a series of serious problems. Human by excessive use of resources such as water, soil, forests, pastures and natural resources not only put them at risk of extinction, but also with the creation of pollution caused by industrial activities, chemical fertilizers and pesticides, threatens the earth. If farming activities be conducted based on ecological principles, in addition to preventing the destruction of natural ecosystems, the result is stable condition. Also agricultural systems must provide needs of people today and future generations; therefore it seems that is essential achieving to sustainable agriculture. One of the key strategies in sustainable agriculture is restoration diversity to agricultural ecosystems, and its effective management.

The major challenge, which lies ahead, is to develop technologies that enhance quality and productivity of crops under reducing land, declining natural resources, increasing biotic and abiotic stresses and ever increasing population. As stated above agriculture in India is driven by small and marginal farmers mostly and hence effective land utilization through intensive cropping pays high dividend and simultaneously targeting important environmental problems, including reduced soil fertility and reduced biodiversity. Intercropping can be a more-efficient means of exploiting the resources required for plant growth (Gangwar, 6).

Traditional agriculture, as practiced through the centuries all around the country has always included different forms of intercropping. In fact, many crops have been grown in association with one another for

*Received : 30-10-2014* *Accepted : 26-11-2014*

hundred years. Intercropping of two or more crops is an old practice in India also, especially under rainfed conditions. The total percentage of cropped land actually devoted to intercropping in India is about 17 percent. Farmers use intercropping to the mutual advantage of both main and secondary crops in a multiple-crop-production system (Coolman and Hoyt, 3). Integration of trees with crops adds a significant element of biological diversity and favourable micro climate to crop growing systems and also promotes sustanable, protective and production land/resource use (Singh *et. al.,* 13). This system helps to improve utilization of natural resources, i.e. sunlight, land and water, and to combine cultural practices, often resulting increased productivity per unit area and time. Improved and vibrant new agro-technologies adoption is the only way to minimizing the outbreak of diseases and insect pests as well as improving productivity of agri-horticultural crops (Singh *et al.,* 15).

The term intercropping is used when two or more crops are grown simultaneously on the same plot of land. Such crops may be mixed planted, that is, the plants of different crops are intermingled; or they may be sole (pure stand) planted in alternating rows, that is, the plants of each crop are grown inseparate rows or strips (wide rows). When one crop is interplanted with a second crop as the first crop approaches maturity, the practice is termed “relay cropping.” All of these cropping practices come under the general heading of multiple cropping. Intercropping is a ways to increase diversity in an agricultural ecosystem. Intercropping as an example of sustainable agricultural systems following objectives such as: ecological balance, more utilization of resources, increasing the quantity and quality and reduce yield damage to pests, diseases and weeds.

Plant interactions are both competitive and cooperative. Farmers use intercropping to the mutual advantage of both main and secondary crops in a multiple-crop-production system. Multiple farming exists in many forms depending on external and internal factors. External factors are weather patterns, market prices, political stability, technological developments, etc. Internal factors relate to local soil characteristics, composition of the family and farmers’ ingenuity. Farmers can decide to opt for mixed enterprises when they want to save resources by interchanging them on the farm - because these permit wider crop rotations and thus reduce dependence on chemicals, because they consider mixed systems closer to nature, or because they allow diversification for better risk management.

The most common advantage of intercropping is to produce a greater yield on a given piece of land by achieving more efficient use of the available growth resources that would otherwise not be utilized by each single crop grown alone. One important reason for intercropping is the improvement and maintenance of fertility. An example of this is when a cereal crop or tuber crop is intercropped with legumes (beans, peas, ground nuts. After the intercrop is harvested, decaying roots and fallen leaves provide nitrogen and other nutrients for the next crop, legumes also fix nitrogen. The crop residues of the legumes can also be used as fodder, by cutting and carrying them to the animals, or by letting the animals graze the residues in the field. The nutrients in the crop residues can then be recycled when manure is used to fertilize crops. Legumes in an intercrop system also provide humus in the soil, due to decaying crop remains resulting in improved soil structure, reducing the need for soil tillage. Water losses, soil erosion and leaching of nutrients are also reduced in intercropping systems due to the improved structure and better soil cover. In intercropping, nitrogen fixation by the legume is not sufficient to maintain soil fertility. If chemical fertilizers are applied, it is not necessary to use nitrogen fertilizer on the cereal crop. Fertilizers are more efficiently used in an intercropping system, due to the increased amount of humus and the different rooting systems of the crops as well as differences in the amount of nutrients taken up. Intercropping practices are also helpful in conservation of the soil resource, improvement of soil health and protection of the environment by minimizing nitrate leaching, besides improving nutrient and water-use efficiencies (Gangwar and Prasad, 7).

Intercropping requires only 60-80 percent of the land to equal the production of monocropping systems. Traditional farmers in many parts of the world-have practiced intercropping in various forms for many centuries. This form of multiple cropping, which generally involves the growing of rain-fed crops in mixtures, uses available resources and permits farmers to maintain low but often adequate and relatively steady production. Intercropping can take any of three forms–strip planting, row planting, or mixed planting. The form chosen should be based on crops grown and such factors as ease of planting, weeding, and harvesting. Yield also may be affected. Intercropping is particularly suited to those situations where laboris abundant and land is not. If it is to be successful economically, the sum of the competition of the interplanted species should be less than when the species are grown alone. Crops of different maturities have varying peak requirements for water, fertilizer, light, and space. Thus, there may be less competition between different crops than there is in a sole planting of identical plants (Gangwar, 6; Mousavi and Eskandari, 9).

Disease and insect infestation of intercropped plants tends to be less. For example, virus diseases may spread more easily through adjacent plants than to those separated by unlike, and frequently non-susceptible, neighbouring plants. Insects that spread disease are also thwarted or at least slowed. Insects tend to be less attracted to plants that are intermingled with other species than to those in solid stands of the same species. Good agronomic practices (GAP) are in general non-monetary effective tools minimizing diseases and pests infestations in any crop (Singh and Umrao, 12).

The development of herbicide-resistant biotypes, environmental sustainability and public health risk are cause of concern of herbicide-dominated systems. Use of herbicides in any crop mixture is a risky endeavour and certainly not eco-friendly approach. Therefore, of late, scientists as well as farmers are seeking a broader perspective to weed management than relying primarily on herbicides. Cultural tactics, sometimes referred to as the 'many little hammers' approach, are alternative weed management options that can effectively substitute for herbicides and reduce herbicide inputs and cost. Biological and cultural weed controls are important components of integrated weed management. Diversification of cropping systems, for instance by increasing the number of crop species grown, has been proposed as a solution to some problems of modern agriculture (Sharma and Banik, 11).

Some common combinations are maize-bean, maize-soybean, maize-rice, maize-sorghum, sorghum-millet, sweet potato (*Ipomoea batatas* Lam.) in sugarcane and cotton with peanuts. The net result of such combinations can vary widely from productive to unproductive compared to sole planting of the same crops. Factors such as fertilization schedule, seeding rate and spacing, selection of variety and type of plant, e.g., dwarf versus normal (maize), bush versus pole (bean), as well as many other cultural factors can markedly influence results.

In nutshell, the overall advantages of intercropping include the following:

1. provides increased protection against erosion;
2. insures against crop failure;
3. spreads labour and harvesting more evenly during the growing season and helps minimize storage problems;
4. helps allocate space for crops required in small quantities, and facilitates production of many commodities in a limited area;
5. results in efficient use of resources by plants of different heights, rooting systems, and nutrient requirements;
6. where legumes are grown with grasses (or other non-legumes), grasses may benefit from the nitrogen fixed by the legume companion crop; and
7. inhibits the spread of diseases and pests since not all crops involved are susceptible to the same extent to the same problems.

Drawbacks, on the other hand, are:

1. mechanized planting and harvesting are difficult;
2. it is more difficult to apply needed fertilizers and other chemicals as in sole cropping; and
3. experimentation with intercropping is more complex and difficult to manage than with sole cropping.
4. Allelopathic effects if any (Allelopathy is defined as "any direct or indirect harmful effect that one plant has on another through the production of chemical compounds that escape into the environment."The harmful compound may take varied forms such as volatile chemicals produced by roots, or leached from leaves. Dead or decaying plant tissues may also be a source of allelopathic substances. The nitrogen released from legumes is not considered as a form of allelopathy. By due emplasis, allelopathy could play a major role in enhancing the production and productivity in ago forestry systems by having their better understanding about interopping following tree-crop combination (Singh *et al.,* 14).

To take advantage of the slow initial growth and lack of lateral spread across the vacant space between rows of sugarcane, and of good amount of moisture available in ridges between sugarcane planted furrows, a number of crops have been tested by planting simultaneously with sugarcane in different parts of India. Aiyer (1) recommended vegetable crops for intercropping with sugarcane, while Arakeri *et al.* (2) found lucerne (*Medicago sativa*), a good crop for this purpose. Gill (8), in his exhaustive countrywide review of intercropping in sugarcane, concluded that although on numerous occasions, the number of tillers and of millable canes and the yield of sugarcane were reduced, juice quality was unaffected by companion crops.

Pulses leguminous vegetables and oilseeds are popular for their suitability in different cropping systems. Since pulses due to economic considerations on their own cannot replace other profitable cereals, oilseeds or commercial crops, the area under the crop could be increased only by including pulses under various cropping systems along with the regular crops by exploiting their intrinsic potential of growing along with other crops without competitive interferences. In this, pulses like French bean hold promise. Being wider spaced, maize crop provides an opportunity for introducing a short duration pulse crop like French bean as an intercrop in additive series. Recent advances in the development of large number of varieties of pulse and oilseed crops, varying largely for maturity duration, have made it possible to include them in irrigated crop sequences. The popular cropping systems are pigeon pea-wheat in Madhya Pradesh and groundnutwheat in Gujarat, Maharashtra and Madhya Pradesh and groundnut-sorghum in Andhra Pradesh and Karnataka. Legumes are most suited inter-crop in cassava. Intercropping of blackgram in Tamil Nadu, greengram or blackgram in Andhra Pradesh and French bean in Assam are suitable and profitable. (Ganajaxi *et al.,* 5; Sharma and Banik, 11)

Regarding short-term and early bearing fruit crops as intercrops, due consideration is essential in the selection of a particular fruit. This is essential because the roots of such trees may start competing with the roots of main fruit trees for nutrients and moisture. The filler trees, unless removed at appropriate time when primary fruit trees start giving economic crop, may create problems of low orchard efficiency. Keeping this point in mind, it is apparent that wherever pineapple and strawberry can be grown, these may serve as an ideal intercrop. Wherever frost hazard is less, an intercrop of papaya can be taken profitably in a mango orchard. Phalsa and guava could also be included in the early stages of growth of the trees, provided these are maintained properly by adequate pruning and removal at proper time. (Ouma and Jeruto, 10) The partial shade loving crops like pineapple, ginger, turmeric, etc. can be grown in fully grown orchards. In addition to field crops, some short duration, less exhaustive and dwarf type inter-fillers like papaya, moringa, curry leaf, etc. can also be grown till these do not interfere with the main mango crop. Inter-cropping can be taken up till the mango trees attain suitable height and develop canopy (at 5-6 years of age).

Most of the vegetables, being short duration crops, fit very well in the intensive cropping system and are capable of giving very high yields and very high economic returns to the growers besides providing better health standards to the people. They either vacate the field early or start yielding in a short time. Small and marginal farmers can even grow vegetables all the year round. In north India, it is possible to grow each of radish, turnip, carrot, cauliflower and potato being short duration in *rabi* season. Vegetables like tomato, brinjal, okra, beans and cucurbits, though being yielding early, carry on for a longer period. Inter-cropping of vegetables in field crops like sugarcane, maize, cabbage and mustard has proved useful. Intercropping of spinach, onion and radish with tomato, cauliflower and cabbage has been found more profitable.

All crops harvested remove nutrients from the soil. Make sure these nutrients are replenished. All legumes have the ability to fix nitrogen from the atmosphere, but some are better than others. Yam production has great potential as an intercrop besides as a monocrop under annual or perennial systems. It can be cultivated as an intercrop in home gardens, an annual monocrop in shifting cultivation or an annual intercrop in sedentary system with semi-perennials, perennials or as an intercrop in large plantations.

After considering various aspects of intercropping and its potential applications in different crop groups, finally it can be concluded that intercropping is a ways to increase diversity in an agricultural ecosystem. Ecological balance, more utilization of resources, increases the quantity and quality of products and reduction damage by pests, diseases and weeds will increases with use of intercropping systems. Mixed farming has both its advantages and disadvantages. For example, farmers in mixed systems have to divide their attention and resources over several activities, thus leading to reduced economies of scale. Advantages include the possibility of reducing risk, spreading labour and re-utilizing resources. The importance of these advantages and disadvantages also differs according to the socio-cultural preferences of the farmers and to the biophysical conditions as determined by rainfall, radiation, soil type and disease pressure. The research results during the last two decades have clearly established that these adverse impacts of green revolution technologies may be mitigated through an appropriate choice of alternative crops and cropping systems, which are efficient user of resource base (land, water, light and energy), economically more remunerative and environmentfriendly. (Das, 4; Gangwar, 6). An adoption of well-designed situation-specific alternative cropping systems along with appropriate method of cultivation could minimize the occurrence or intensity of diseases and insect pests, including weeds, considerably. These are also helpful in conservation of the soil resource, improvement of soil health and protection of the environment by minimizing nitrate leaching, besides improving nutrient and water-use efficiencies.

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**Citation :** Kashyap P.S., Verma A. and Siebert S. (2014). Intercropping for efficient resource utilization in Indian agriculture-a review. *HortFlora Res. Spectrum,* **3**(4) : 310-314

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*HortFlora Research Spectrum*, 3(4): 315-322 (December 2014) ISSN : 2250-2823

# DEVELOPMENT OF READY-TO-FRY FROZEN POTATO SNACK AND ITS QUALITY EVALUATION DURING STORAGE

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**ABSTRACT :** A simple technique for the preparation of ready-to-eat frozen potato snack was developed which do not require any costly machinery. Snacks were prepared using standardized formulation with 100 g mashed potato and 30 g boiled mashed peas. The prepared snacks were par-fried, packed in LDPE and stored under frozen (-20±2°C) storage for three months to study the shelf life and quality attributes of the product. All the nutritional parameters remained unaffected during storage upto three months within the cultivars studied Snacks prepared from 'K.Pukhraj' showed the highest total antioxidant activity. Snacks prepared from 'K.Chipsona-1' had lower oil uptake than from 'K.Pukhraj'. Rancidity parameters in terms of free fatty acids and peroxide value remained unaffected during the entire frozen storage period. The developed product from all the three cultivars were found to be highly acceptable for up to 3 months of storage without any change in sensory quality

***Keywords:*** *Potato, frozen storage, deep fat frying, total phenolics, antioxidants.*

The demand for ready to eat convenient food items is increasing continuously in the present day liberalized economy mainly due to improved living standards, urbanization growth, preference of new generation for fast foods, rise in per capita income and increase in the number of working women preferring ready cooked food (Bhat and Pathak, 5). Snack foods have emerged as one of the main entries in the food market that can be adapted to consumer needs. However, maintenance of quality of this product is of key importance to the continued development of this sector. Quality and safety of frozen snack foods are the aspects affecting the overall consumer acceptability in terms of flavour, aroma, colour and appearance besides nutritional quality (Torres and Canet, 32). Generally frozen ready-to-eat snack food is consumed with no or little further processing except reheating. These frozen vegetable snacks can directly be fried in oil without thawing after frozen storage (Creed, 7).

Formulations of various non-vegetable kebabs are reported in literature (Bhat and Pathak, 5, Pandey *et al;* 20; Zeb and Ali, 33). However, there is no report available for the preparation of ready to fry frozen vegetable kebabs.

Potato is a nutritious vegetable containing significant amount of carbohydrates, superior quality protein, dietary fibre and some minerals. Potato also contains biologically active components including phenolic acids and ascorbic acid which are commonly described as antioxidants (Gumul *et al.,*10). Increased potato production has led to several post-harvest problems especially their storage (Marwaha and Sandhu, 19). Potato is a highly versatile and inexpensive raw material that can be incorporated either in fresh or dried form in various value added products such as bakery products and fabricated snacks (Singh *et al.,* 27). There is a need to find more diversified uses of potato and to develop new processed products in order to maximize its utilization and to cater the fast changing taste of the new generation as well as different sections of the society (Marwaha and Sandhu, 19). Keeping the above factors in view, a simple technique for the preparation of ready-to-fry frozen potato snack with vegetable stuffing was developed which does not require any costly machinery. The prepared snack was evaluated for storage stability in terms of rancidity parameters such as free fatty acids and peroxide value and phytochemical parameters such as total phenolic content and total antioxidant activity. Changes in organoleptic characteristics was also examined during storage.

## MATERIALS AND METHODS

Three potato cultivars including two processing varieties Kufri Chipsona-1 and Kufri Chandramukhi, and one commonly cultivated variety 'Kufri Pukhraj' having low dry matter content and high reducing sugars were evaluated for the preparation of frozen potato snack. Healthy, fully cured tubers of the above cultivars were procured from Department of Vegetable Crops of the University. The tubers were washed under

*Received : 04-09-2014* *Accepted : 02-10-2014*

running tap water, surface dried and used for analysis of fresh tubers and preparation of frozen snack.

## Preparation of raw material

**Potatoes:** Fresh potato tubers of all the three cultivars were peeled and cut into thick slices (10 mm) using a rotary hand slicer. The slices were cooked in a pressure cooker for 10-15 minutes. The boiled potato slices were cooled and mashed.

**Peas :** Fresh peas were depodded and blanched in hot water at 90±2°C for 3 minutes to inactivate polyphenol oxidase enzyme and to soften and enhance green color of the peas. Immediately after cooking, the peas were cooled under running tap water. The cooled peas were grinded in an electric grinder. The mashed material was then sauted in soybean oil in 1:10 ratio (w/v) to remove maximum moisture. The sauted cooled mashed peas were then used for product preparation.

## Preparation of frozen potato snack

**Formulation :** Various proportions of raw ingredients were tried for the preparation of frozen potato snack. Proportion of ingredients which was liked best sensorily was selected for the development of final product. Based on the preliminary trials, following recipe (Table 1) was selected for the preparation of final product.

**Table 1: Standardized recipe for frozen potato snacks of formulation of product.**

| Ingredients | Quantity (g) |
|---|---|
| Fresh potato mash | 100 |
| Boiled mashed peas | 30 |
| Ginger paste | 3 |
| Garlic paste | 3 |
| Cumin | 0.8 |
| Green chilli powder | 1.5 |
| Garam masala | 0.4 |
| Salt | 1.2 |
| Corn flour | 3.0 |

## Processing methods

Frozen potato vegetable snack was prepared using the standardized formulation (Table 1). Freshly boiled potato mash was blended with mashed peas, ginger, garlic and various spices and kneaded into a soft dough. Balls of 25 g from the prepared dough were made and flattened with hand. To get crispy texture in the final fried snack, balls were given an outer coating of bread crumbs. The prepared snacks were par-fried in a laboratory scale deep fat fryer maintained at 175±5°C for 40 sec. After frying, the snacks were drained and gently wiped with adsorbent paper to remove surface oil. After cooling the snacks were packed and sealed in polythene pouches of 200 gauge. Various steps in the preparation of vegetable snack are outlined in Fig. 1. The pre-cooled snacks were stored in

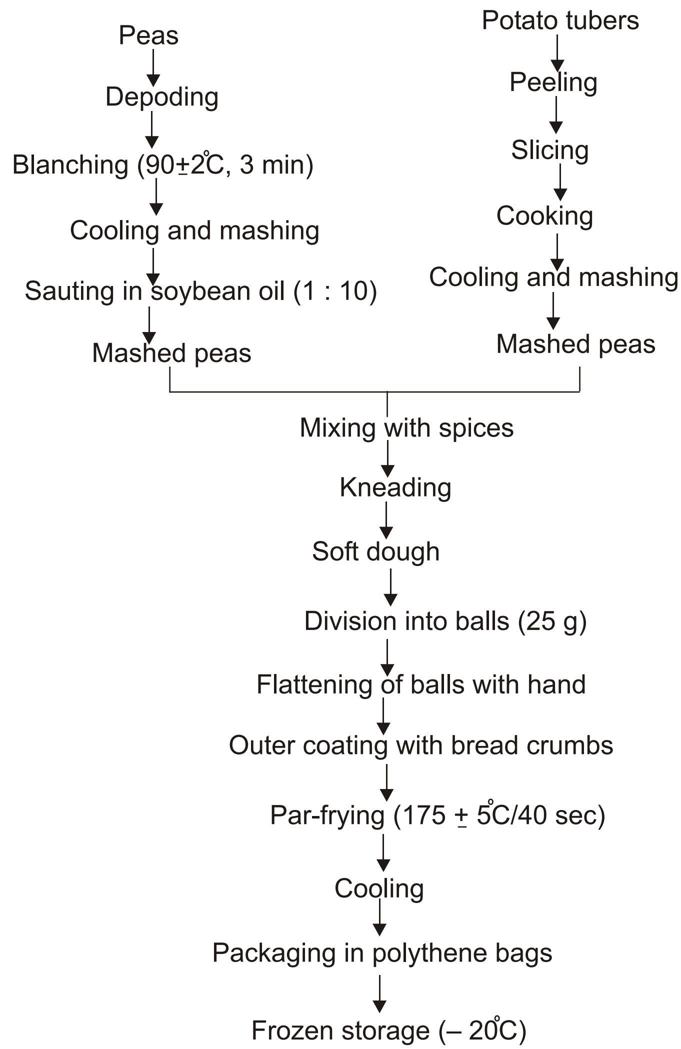


Fig. 1 : Flow chart for the preparation of frozen potato vegetable snack.

a deep freezer at -20°C until final frying.

## Frying of snacks

Snacks were deep fat fried from the frozen state immediately after freezing and at an interval of 1 month up to the end of storage period.

## Quality Analysis of Raw Material and Prepared Products

**Proximate composition :** The raw materials and prepared snacks were analyzed for proximate components, *viz*; moisture, protein, fat, ash by using standard methods (AOAC, 2). All the analyses were carried out in triplicate.

**Storage studies** : Bioactive components including total phenolic content and total antioxidant activity and rancidity parameters including free fatty acids and peroxide value of the snack during storage at -20°C were analyzed.

**Total phenolic content :** Total phenols were estimated by the Folin-Ciocalteu's colorimetric method (Singleton and Rossi, 26). Total antioxidant activity of the raw tubers was estimated by DPPH (1, 1- diphenyl-2-picrylhydrazyl) as described by Shimada *et al.* (25) with some modifications. Methanolic extract of 5g sample was taken for antioxidant activity and calculated according to the following formula. BHT was taken as a standard at a fixed concentration of 5 mg/ml.

Radical scavenging activity (%)

$$= \frac{\text{Absorbance of control (0 minute)} - \text{Absorbance of sample (30 minute)}}{\text{Absorbance of control (0 minute)}} \times 100$$

During storage, the quality of prepared product was monitored by studying the changes in free fatty acids and peroxide value as per AOAC (2).

**Sensory evaluation :** The sensory evaluation of the product was carried for attributes namely appearance, flavor, texture and the overall acceptability by a panel of semi-trained members composed of scientists and research scholars of department based on a 9-point Hedonic scale, wherein 9 denoted "extremely liked" and 1 donated "disliked extremely" (Larmond, 17). Coded samples for sensory evaluation were prepared and served warm to panelists. Water was provided for oral rinsing between the samples.

**Statistical analysis :** All the measurements in this study were made in three replications. Statistical analysis was performed by analysis of variance (ANOVA) to calculate critical difference of the data to statistically predict the significance. Significance was established at $p < 0.05$ level.

## RESULTS AND DISCUSSION

**Proximate composition of raw materials :**

Comparison of physicochemical parameters (Table 2) indicated varietal difference in moisture contents among different potato cultivars. 'Kufri Pukhraj' had a higher (84.69%) percentage of moisture content which is indicative of its lower dry matter content compared to 'Kufri Chipsona-1' and 'Kufri Chandramukhi' which contained a lower percentage of moisture. Protein and ash content was in the range of 3.90-5.42% and 0.98-2.18%, respectively and showed significant ($p < 0.05$) differences between the cultivars (Table 2). These differences might be related to the genetic variation and botanical origin among the different cultivars (Singh *et al.,* 28). Data for protein and ash content is in line with those reported by Sandhu and Parhawk (24) and Abbas et al. (1) for different potato cultivars.

Spice mix used in the preparation of frozen snack contained 3.10 per cent moisture, 0.10 per cent protein and 3.81 per cent ash, respectively (Table 2). Other ingredients used such as fresh peas, ginger and garlic had 75.42-80.12% moisture, 0.11-0.14% protein and 0.81-0.90% ash, respectively (Table 2).

Potatoes are considered significant source of antioxidants including total phenolics (Ezekiel *et al.,* 9). In the present study, total phenolics among different cultivars were found to be significantly ($p < 0.05$) higher in 'Kufri Pukhraj' (64.30 mg GAE/100g), followed by Kufri Chandramukhi (53.80 mg GAE/100g) and Kufri Chipsona-1 (40.20 mg GAE/100g) (Table 2). Findings with slight variations were reported earlier by Singh *et al* (28). Significant difference among cultivars may be attributed to genotypes and harvest location which influence the accumulation of phenolic compounds by synthesizing different quantities and/or types of phenolics (Hesam *et al.,* 11).

Antioxidant activity as measured by DPPH radical scavenging method was found to be in the range of 38.10-63.50% among various cultivars (Table 2). Maximum activity was observed in cultivar 'Kufri Pukhraj' (63.50%) and minimum in Kufri Chipsona-1 (38.10%). The high antioxidant activity in 'Kufri Pukhraj' might be due to presence of higher total phenolics in the cultivar. The relationship between the total phenolic content and antioxidant acidity of raw potato tubers is well established (Kaur and Kapoor, 14; Reyes *et al.,* 22, Ah-Hen *et al.,* 3).

Spice mix used in the preparation of frozen snack contained high levels of total phenolics (644.8 mg GAE/100g) and total antioxidant activity (85.43%) (Table 2). The present findings are in line with those reported by Shah *et al.* (23). Fresh peas, ginger and garlic had 37.80, 221.3 and 145.10 mg GAE/100g total phenolics and 57.0, 71.80 and 62.10 per cent total antioxidant activity (Table 2). Kaur and Kapoor (14) also reported similar observations during evaluation of antioxidant activity and total phenolic content of some Asian vegetables. The authors established a positive correlation between total phenolic content and antioxidant activity of vegetables.

**Table 2 : Proximate composition of raw materials.**

| Raw material | Moisture (%) | Protein (%) | Ash (%) | Total phenolic content (mg GAE/100g) | Antioxidant activity (%) |
|---|---|---|---|---|---|
| Kufri Chipsona-1' tubers | 75.69±0.90 | 5.42±0.25 | 0.98±0.29 | 40.20±0.29 | 38.10±0.25 |
| Kufri Chandramukhi tubers | 75.70±0.80 | 4.50±0.28 | 2.18±0.05 | 53.80±0.38 | 53.20±0.50 |
| Kufri Pukhraj tubers | 84.69±0.50 | 3.90±0.24 | 1.93±0.11 | 64.30±0.20 | 63.50±0.30 |
| Peas | 80.12±0.42 | 0.14±0.10 | 0.88±0.10 | 37.80±0.33 | 57.0±0.50 |
| Ginger | 80.14±0.40 | 0.12±0.10 | 0.81±0.12 | 221.3±1.40 | 71.80±0.61 |
| Garlic | 75.42±0.31 | 0.11±0.09 | 0.90±0.12 | 145.10±1.20 | 62.10±0.35 |
| Spice mix | 3.10±0.11 | 0.10±0.01 | 3.81±0.28 | 644.8±1.20 | 85.43±0.55 |
| CD (P = 0.05) | 0.87 | 0.25 | 0.17 | 0.28 | 0.78 |

Values are mean ±SD, n = 3

**Table 3: Proximate composition of prepared frozen snacks from different cultivars**

| Cultivar | Moisture (%) | Protein (%) | Fat (%) | Ash (%) |
|---|---|---|---|---|
| Kufri Chipsona-1 | 53.89±0.39 | 4.80±0.20 | 6.10±0.10 | 2.89±0.08 |
| Kufri Chandramukhi | 53.80±0.31 | 4.82±0.18 | 6.53±0.12 | 2.80±0.10 |
| Kufri Pukhraj | 53.85±0.25 | 4.46±0.11 | 8.18±0.14 | 2.93±0.11 |
| CD ( P=0.05) | NS | NS | 0.19 | NS |

Values are mean ±SD, n = 3; NS – Non Significant

**Table 4: Organoleptic quality of fresh and stored frozen potato snack.**

| Cultivar | Storage (months) | Appearance | Flavour | Texture | Overall acceptability |
|---|---|---|---|---|---|
| Kufri Chipsona-1 | 0 | 8.66±0.03 | 8.30±0.04 | 8.35±0.02 | 8.44±0.04 |
| | 1 | 8.60±0.05 | 8.28±0.01 | 8.32±0.01 | 8.40±0.03 |
| | 2 | 8.68±0.06 | 8.30±0.02 | 8.31±0.02 | 8.43±0.03 |
| | 3 | 8.65±0.02 | 8.31±0.03 | 8.31±0.04 | 8.42±0.01 |
| Kufri Chandramukhi | 0 | 8.60±0.05 | 8.31±0.03 | 8.30±0.01 | 8.40±0.02 |
| | 1 | 8.61±0.03 | 8.29±0.06 | 8.33±0.02 | 8.41±0.08 |
| | 2 | 8.59±0.04 | 8.28±0.02 | 8.28±0.03 | 8.38±0.01 |
| | 3 | 8.58±0.04 | 8.28±0.04 | 8.28±0.03 | 8.38±0.02 |
| Kufri Pukhraj | 0 | 8.63±0.01 | 8.35±0.01 | 8.33±0.04 | 8.44±0.04 |
| | 1 | 8.60±0.05 | 8.31±0.02 | 8.31±0.08 | 8.40±0.03 |
| | 2 | 8.61±0.05 | 8.34±0.01 | 8.30±0.07 | 8.41±0.01 |
| | 3 | 8.60±0.04 | 8.30±0.01 | 8.29±0.07 | 8.40±0.01 |
| **CD (P=0.05)** | | | | | |
| Cultivar (C) | | 0.02 | 0.02 | 0.02 | 0.02 |
| Storage period (S) | | NS | NS | NS | NS |
| C x S | | NS | NS | NS | NS |

## Proximate composition of the prepared frozen snack

The moisture content variation in snack samples prepared from different potato cultivars was not significant ($p < 0.05$) (Table 3). Slight differences were observed in the protein and ash content of prepared snacks which ranged 4.46-4.82 and 2.80-2.89 per cent, respectively. These differences might be due to their compositional differences. Fat content of snack samples varied between 6.10-8.18% (Table 3). The fat content of prepared snacks was found to be positively correlated with the dry matter of tubers. Cultivars, which had higher tuber dry matter content, produced snacks with low oil uptake in comparison to cultivars with low tuber dry matter content (Fig. 2). Among the cultivars studied, 'Kufri Pukhraj' with lowest tuber dry

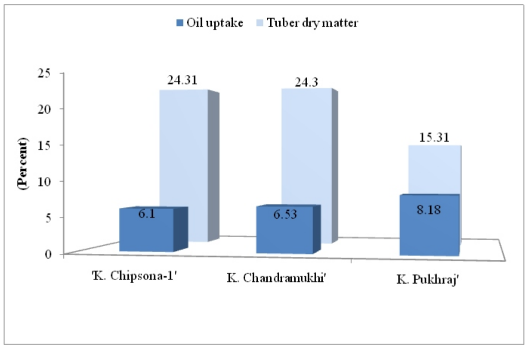


Fig. 2 : Tuber dry matter content and oil uptake of frozen potato snack prepared from different cultivars.

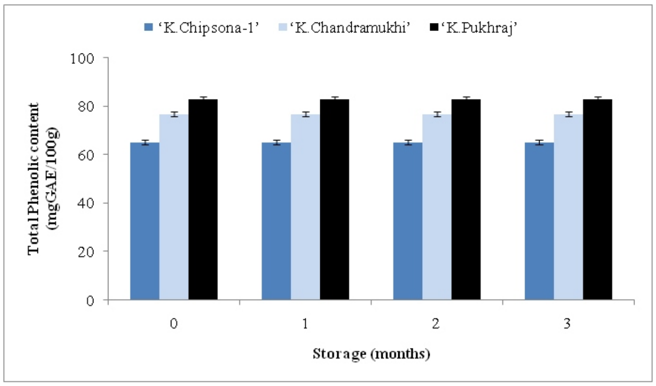


Fig. 3A : Effect of storage on total phenolic content of frozen potato snack prepared from different cultivars. Values are means ± SD, n=3. Error bars represents SD of the means.

matter content (15.31%) displayed maximum uptake of oil in the developed product while 'Kufri Chipsona-1' with highest dry matter content (24.31%) produced snacks with minimum oil uptake. A positive correlation of tuber dry matter with oil uptake is also reported earlier (Marwaha and Sandhu, 19; Kaur *et al.,* 15; Kaur *et al.,* 16).

## Storage studies

**Bioactive (phytochemical) composition :** Phenolic compounds are secondary plant metabolites present in fruits and vegetables. Phenolic acids and flavonoids are the two major classes of phenolic compounds which are known to possess antioxidant activity. In the present study, total phenolic content in the fresh frozen potato snack ranged 65.20-82.83% (Fig. 3A). Between the cultivars studied, 'Kufri Pukhraj' snack had the highest phenolic content (82.83 mg GAE/100g), followed by 'Kufri Chandramukhi' (76.84 mg GAE/100g) and 'Kufri Chipsona-1' (65.20 mg GAE/100g). This might be due to higher level of total phenolics in the raw tubers of cultivar 'Kufri Pukhraj' which might have contributed to the overall total phenolic content in the prepared product.

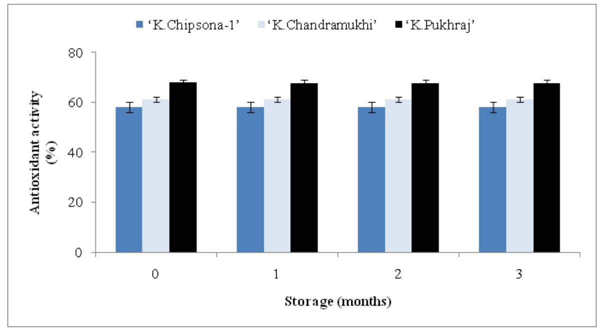


Fig. 3B : Effect of storage on total antioxidant acticvity of frozen potato snack prepared from different cultivars. Values are mean ± SD. m = 3. Error bars represents SD of the means.

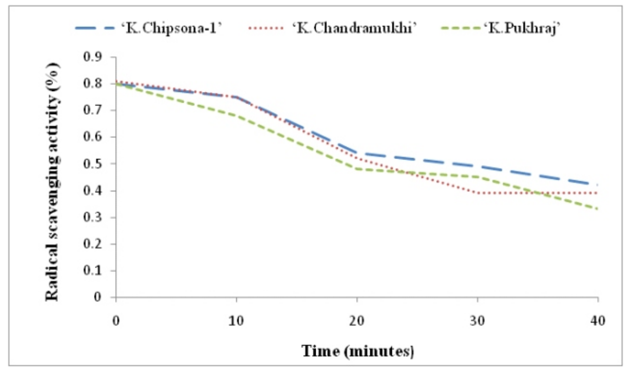


Fig. 3C : Radical scavenging activities of frozen potato snacks prepared from different cultivars.

As explained by Bof *et al,* (6), bioactive compounds including phenolics are susceptible to oxidation reactions during the processing and storage of food because some of these compounds are unstable under thermal processing and cold storage (Ibrahim *et al*., 12). In the present study, storage temperature of -20°C did not affect the total phenolic content of the snacks significantly, indicating that the temperature of -20°C had a protective effect on total phenolic content.

Total antioxidant activities of fresh and stored frozen snack as determined by DPPH radical scavenging method is presented in Fig. 3B. DPPH radical has an intense violet color but turns colorless as unpaired electrons are sequestered by antioxidants (Suna *et al.,* 31). Radical scavenging activities of methanolic extracts of fresh frozen snack samples was in the range of 58.14-67.89% (Fig. 3B) with maximum antioxidant activity in snack prepared from 'Kufri Pukhraj' (67.89%), followed by 'Kufri Chandramukhi' (61.18%) and minimum in 'Kufri Chipsona-1' snack (58.14%). It can be observed from Fig. 3C that radical scavenging activity in fresh frozen kebab samples decreased continuously with increase in retention time

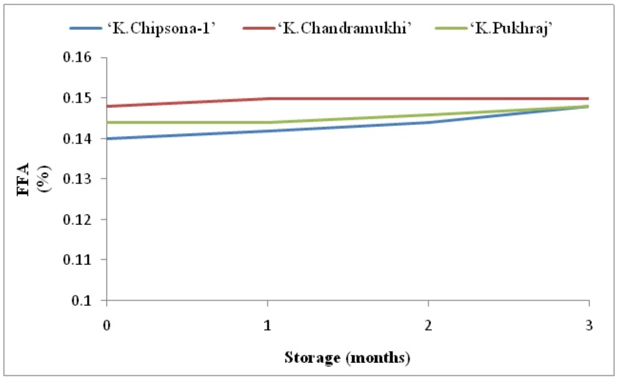


Fig. 4A : Effect of storage on FFA of frozen potato snack prepared from different cultivars. Values are mean ± SD, n = 3.

and maximum activity was shown at 30 minutes and became stable thereafter. The higher antioxidant activity in snack prepared from 'Kufri Pukhraj' might be due to higher total phenolic content in the raw tubers of 'Kufri Pukhraj' which might have contributed towards it high antioxidant activity. These results are in agreement with previous reports (Reyes *et al.,* 22) which suggested that phenolic compounds were the major contributor to total antioxidant capacity in potato.

Many research groups have documented the influence of different processing methods and storage conditions on retention of these phytochemicals in fresh fruits and vegetables (Srzednicki and Craske, 30; Patthamakanokporn *et al.,* 21). But very limited studies

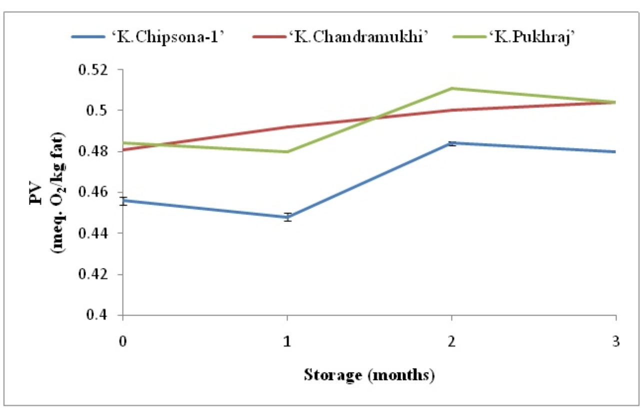


Fig. 4B : Effect of storage on PV of frozen potato snack prepared from different cultivars. Values are mean ± SD,

are available on the effect of storage on these bioactive components in frozen snack foods. In the present study, slight but non significant ($p < 0.05$) change in antioxidant activity was observed in the frozen potato snack during storage at -20°C for 3 months.

## Changes in free fatty acids (FFA) and peroxide value (PV)

FFA are the products of enzymatic or microbial degradation of lipids (Kashyap *et al.,* 13). Determination of FFA gives information about stability of fat during storage. Fig. 4A and 4B represents the change in FFA and PV of the prepared snacks during the frozen storage. There was no significant ($p < 0.05$) varietal difference in the levels of FFA in fresh frozen snacks. The mean FFA content and PV of snack samples increased at the end of 3 months of frozen storage but the increase was found to be non-significant ($p < 0.05$) (Fig. 4A; 4B). The change in FFA content and PV during the entire frozen period from the initial values was very less i.e. 2.7 and 4.8%, respectively, which might be due to low temperature (-20°C) of the storage at which rate of chemical reactions ceases down.

Maity *et al.* (18) observed a restricted rise in FFA content and PV of frozen vegetable snack with the progression of storage period. On contrary, Berry (4) and Kashyap *et al.* (13) reported a significant increase in FFA content in ground beef and chicken patties, respectively after a frozen storage of 18 months.

**Organoleptic evaluation :** Table 4 represents the effect of storage on organoleptic attributes of frozen potato vegetable snack. The scores for appearance, flavor, texture and overall acceptability were found to be almost the same, indicating a non-significant ($p < 0.05$) effect of storage on sensory quality of prepared snack, regardless of the cultivars. Smith *et al.* (29). reported appearance and sensory scores unaffected on storage at -18°C up to 12 months in case of beef patties. Devalakshmi *et al.* (8) studied the sensory quality of chicken meat chips stored under refrigerated (7±1°C) temperature and the authors found the sensory scores within the acceptable limits upto 2 months of storage.

In the present study, the developed products retained the desirable brown color, flavor and crispy texture during storage for up to 3 months at -20°C.

## CONCLUSION

A simple process for preparation of frozen potato snack was standardized. Total phenolic content and antioxidant properties in the prepared snack did not change significantly for a period of 3 months of frozen storage. The developed snack maintained the sensory attributes throughout the storage period. These products could be successfully prepared from underutilized low dry matter and high sugar verities which are considered unfit for processing. Moreover, the developed ready-to-fry frozen vegetable snack can provide convenience to the consumers by restricting the kitchen drudgery and time involved in the preparation of the snack.

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**Citation :** Kaur S. and Aggarwal P. (2014). Development of ready-to-fly frozen-potato snack and its quality evaluation during storage. *HortFlora Res. Spectrum,* **3**(4) : 315-322

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 323-328 (December 2014) ISSN : 2250-2823

# EFFECT OF PLANTING DISTANCE ON GROWTH AND FROND PRODUCTION IN BOSTON FERN [*Nephrolepis exaltata* (L.) Schott]

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**ABSTRACT :** Studies were conducted to optimize planting distance for frond production in Boston fern [*Nephrolepis exaltata* (L.) *Schott*]. The suckers were planted at a spacing of 30 x 30 cm, 30 x 45 cm, 45 x 45 cm, 45 x 60 cm and 60 x 60 cm, in the month of March, 2012 under net house conditions which provided 50 per cent shading. Planting density had significant effect on plant spread, frond length, mean lamina length and leaf area. Increase in planting density (30 x 30 cm) led to increase in frond production per unit area but with regard to the production per plant, it was at par in all the spacings where row to row distance was 45 cm i.e. 45 x 30 cm, 45 x 45 cm and 45 x 60 cm. Number of fronds per plant increased as the plants were widely spaced, highest being recorded at 60 x 60 cm. The fronds produced from wider spaced plants were of superior quality in terms of length and strength of the stem. Quality parameters, *viz.* length of longest frond as well as fresh and dry weights of fronds was observed to be higher with closer spacing. Frond production per plot and yield per hectare exhibited significant increase with decreasing plant spacing. Planting density did not affect longevity of the fronds. Considering the yield of fronds per hectare, cost of production and net return, 30 x 45 cm spacing is recommended for the cultivation of Boston fern.

***Keywords :*** *Nephrolepis exaltata, planting distance, frond production.*

Cut greens are an important component of floricultural industry, largely used as fillers in bouquet making and in flower arrangements. Cut foliage is either used alone in large quantities as a source of decoration or in association with flowers and other accessories for value addition. In general, the foliage that is deep green with long lasting evergreen properties is commonly used by the floral industry as accents in floral arrangements (Schlosser and Blatner, 21). There has been a tremendous increase in the volume and usage of cut foliage in the ornamental industry. The trade of foliage indicates that India has emerged as the top most supplier among the developing countries and has been successful in developing a sustainable market in the EU (Ladha and Gunjal, 13).

Leaves of several ferns are used as cut foliage. Commercially important species are *Rumohra adiantiformis* (leather leaf fern), giant holly fern (*Polystichum munitum*) and *Nephrolepis exaltata* L. Schott (flat fern) commonly called as Boston fern (Carow, 5). Besides, ferns are an attractive addition to the landscape of any home, office or garden because of their graceful foliage, growth habit and ability to grow in low light (Pacifici *et al.,* 18). The foliage of fern is highly valued in the international florist greenery market because of its long post harvest life, low cost, year-round availability and versatile design qualities in form, texture and color (D'Souza *et al.,* 7; Muthukumar and Prabha, 17).

Amongst various ferns used by the florists, cut foliage of *Nephrolepis species* remains in great use for the floral decorations that are characterized by their attractive form, colour, freshness and long shelf life in flower arrangements. Different varieties of this species can be grown in Punjab but due to fluctuating environment, plant growth and production of cut foliage has been observed to be erratic. Proper planting distance is an important practice for providing good open position for sunlight, availability of moisture and nutrients vital for successful crop production and quality (Khajal and Edrisi, 11). Planting density plays an important role in achieving high productivity per unit area. Total and early marketable yield increased linearly as plant density increased (Khajal *et al.,* 12). Since there is hardly any data available in India regarding the production technology of ferns and their vase life, studies were planned to work out an optimum planting distance for the production of quality fronds in Boston fern (*Nephrolepis exaltata*) under 50% shade and its effect on the post harvest performance of the fronds under sub-tropical climatic conditions of Punjab.

## MATERIALS AND METHODS

.The experiment was conducted at the research farm of the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana,

*Received:30-07-2014; Revised:22-09-2014;Accepted:18-10-2014*

India during the two successive years of 2012-13 and 2013-14. Chemical and physical characteristic of the soil at the experimental site showed that the farm soil was loamy sand in texture with pH of 8.30. The available organic carbon, phosphorus and potassium was 0.69kg/ha, 18.4 kg/ha and 237 kg/ha, respectively. The experiment was laid out in a Randomized Complete Block Design with five replications and five planting densities i.e. 30 x 30 cm, 30 x 45 cm, 45 x 45 cm, 45 x 60 cm and 60 x 60 cm. The nutrient content of farmyard manure used in the experiment in the 2012-13 experiment was 0.43% N, 0.18% $P_2O_5$ and 0.42% $K_2O$, whereas in the 2013-14 was 0.48% N, 0.21% $P_2O_5$ and 0.40% $K_2O$, respectively. The plants of Boston fern (*Nephrolepis exaltata* L. Schott) were planted in the plots measuring 3.60 x 1.80 m in the first fortnight of March under 50% shade. The basal dose of farmyard manure at 25 tones per ha per treatment was added and well mixed in the soil a week prior to the planting. The beds were watered and left for one week before the planting to enable carbon dioxide to escape to prevent burning and scorching of the tender plants. Nitrogen at 250 Kg per ha was applied in four equal split doses, i.e., one-fourth at the time of planting and remaining at quarterly intervals *i.e.* in March, June, September and December. The crop was irrigated depending on the moisture status of the soil and requirement of plants. Fronds were cut 1 cm above the ground level. Growth and yield parameters (plant height, spread, average length of fronds, length of longest frond, mean lamina length, leaf area index, number of fronds per plant and chlorophyll content) were recorded in the months of March, June, September and December. A set of 10 fronds per treatment was used to record fresh and dry weight of fronds. The leaves from each treatment were dried at 60°C to constant weight, ground, powdered and analyzed for nitrogen, phosphorous and potassium contents. Nitrogen was analyzed by Kjeldahl's method using semi auto analyzer nitrogen estimation system (M/S Pelican Equipment, Chennai). For estimating P and K, 0.50 g of samples was wet digested using concentrated nitric acid and perchloric acid (4:1 v/v). Phosphorous content of samples was determined by vanadate-molybdate colorimetric method (Analyst 200, Perkin Elmer, Shelton, CT, USA). Leaf potash was determined by the Flame Photometer method (AOAC, 1). All the nutrient contents were expressed on dry matter basis. The total leaf area of the fronds was recorded using CI- 203 portable leaf area meter. The chlorophyll content of the leaf was determined in form of SPAD values with a portable chlorophyll meter (supplied by M/S Minolta SPAD 502 type) from the basal three leaves. Postharvest studies were carried out on cut fronds harvested during the months of March, June, September and December. Foliage were harvested at the commercial stage. Immediately after harvest, cut foliage was transferred to the postharvest evaluation laboratory with a temperature of 20±2°C, 60±5% RH and 12 h light of 10 $\mu$mol $m^{-2}$ $s^{-1}$ PAR. Observations were recorded for vase life (till the fronds began to show the first sign of yellowing) and water uptake in ml at the end of vase life. Three randomly selected plants were used in each replication and treatment for observations. The results presented a mean of four quarters (March, June, September and December) for both the years (2012-13 and 2013-14). The data were statistically analyzed with the procedure described by Cheema and Singh (6) in statistical package CPCS-1 for significant differences between treatments.

## RESULTS AND DISCUSSION

### Effect of spacing on growth parameters

The results presented in Table 1 show that the mean plant height increased with increase in planting density and maximum plant height was attained at 30 x 30 cm during the two years. The variations in plant height were statistically non-significant. The height was the minimum at wider spacing of 60 x 60 cm during both the two years, respectively. The increased plant height under maximum planting density could be ascribed to intra plant competition for light, moisture, space, nutrients and aeration. Similar observation had also been reported in gaillardia (Hugar, 8), chrysanthemum (Karavadia and Dhaduk, 9) and tuberose (Mane *et al.,* 14). Modawei (16) also reported that increasing of plant spacing decreased plant height of different flowering annuals. Closer spacing enhanced the plant height significantly whereas wider spacing increased the other growth parameters including chlorophyll content in leaves (Ahirwar *et al.,*2).

Plant spread differed significantly under different spacing levels (Table 1). It increased with increase in planting distance and maximum plant spread was recorded in plants of the widest spacing (60x60 cm) during both the years, respectively and was significantly at par with 45 x 45 cm and 45 x 60 cm spacing. The lowest plant spread was recorded from the closest spacing of 30 x 30 cm during both the years, respectively. The beneficial effect of wider spacing on plant spread, leaf length and number of leaves has also been reported by Karavadia and Dhaduk (9) in

**Table 1 : Effect of planting distance on growth parameters under 50% shade level in Boston fern {*Nephrolepis exaltata* (L.) Schott}.**

| Planting distance | Plant height (cm) | | Plant spread (cm) | | Growth index | | Average frond length (cm) | |
|---|---|---|---|---|---|---|---|---|
| | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| 30 x 30 | 36.40 | 40.13 | 29.33 | 30.27 | 32.86 | 35.22 | 35.80 | 38.87 |
| 30 x 45 | 35.70 | 39.87 | 30.91 | 32.23 | 33.31 | 36.05 | 36.79 | 39.07 |
| 45 x 45 | 35.63 | 39.33 | 31.65 | 35.33 | 33.64 | 37.33 | 35.11 | 39.47 |
| 45 x 60 | 34.22 | 38.71 | 32.18 | 36.97 | 33.19 | 38.22 | 29.72 | 40.00 |
| 60 x 60 | 34.00 | 36.40 | 32.92 | 37.07 | 33.46 | 36.73 | 32.55 | 36.40 |
| Mean | 35.11 | 38.69 | 31.40 | 34.17 | 32.89 | 36.33 | 33.99 | 38.76 |
| CD(P=0.05) | NS | 2.60 | NS | 3.75 | NS | 2.30 | 4.86 | NS |

**Table 2: Effect of planting distance on growth and yield parameters under 50% shade level in Boston fern {*Nephrolepis exaltata* (L.) Schott}.**

| Planting distance | Length of longest frond (cm) | | Mean lamina length (cm) | | Leaf area ($cm^2$) | | Number of fronds | |
|---|---|---|---|---|---|---|---|---|
| | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| 30 x 30 | 39.40 | 40.73 | 32.27 | 34.31 | 203.39 | 199.67 | 58.00 | 54.20 |
| 30 x 45 | 38.18 | 40.20 | 33.64 | 34.80 | 295.66 | 258.05 | 68.27 | 60.47 |
| 45 x 45 | 36.58 | 43.40 | 32.32 | 35.30 | 270.03 | 246.77 | 70.47 | 61.67 |
| 45 x 60 | 33.40 | 42.73 | 27.40 | 35.33 | 199.67 | 207.89 | 69.53 | 63.87 |
| 60 x 60 | 35.70 | 36.53 | 28.76 | 30.70 | 217.85 | 202.04 | 73.27 | 68.33 |
| Mean | 36.65 | 40.72 | 30.88 | 34.09 | 237.32 | 222.88 | 67.91 | 61.71 |
| CD(P=0.05) | 4.01 | 4.62 | 4.26 | NS | 54.81 | 21.62 | NS | NS |

chrysanthemum, Khalaj *et al* (12) in tuberose and Ram *et al.* (19) in gladiolus.

Similar trend was observed with regard to the growth index. The growth index continues to increase with increasing planting distance. The maximum growth index was observed at 45 x 45 cm spacing in both the years, respectively. The average frond length also differed significantly with the planting distance and was the maximum at the spacing of 30 x 45 cm in 2012-13 and at 45 x 60 cm in 2013-14 (Table 1). The plant spacing was found to significantly influence length of the longest fronds. Length of the longest fronds was the maximum at 30 x 30 cm in 2012-13, whereas in 2013-14 the maximum length was observed at 45 x 45 cm (Table 2). Similar trends were observed for mean lamina length.

Leaf area also differed significantly at different spacing levels (Table 2). The maximum leaf area was observed at a spacing of 30 x 45 cm during both the years. Leaf area was the minimum in closer planting of 30 x 30 cm during both the years, respectively and could be ascribed to lesser penetration of light and increased competition among the plants for nutrients and water. Similar results were obtained by Akparobi (3) in *Amaranthus cruentus.*

Planting distance had no significant effect on the number of leaves produced (Table 2). However, the average number of leaves produced per plant increased with increasing planting distance. The wider spacing produced more leaves per plant relative to plants of the closer spacing throughout the study period. The frond production per plant was the maximum at 60 x 60 cm during both the years but was statistically at par under all the other planting densities. The minimum number of leaves per plant was recorded from 30 x 30 cm plant spacing. Considering the planting density per unit area, it was observed that closer plantation of 30 x 30 cm exhibited the maximum frond production per unit area and was hence, inversely related to the plant spacing. The higher yield of fronds in closer spacing was mainly contributed by

**Table 3 : Effect of planting distance on fresh/dry weight, chlorophyll content and vase life of fronds under 50% shade level in Boston fern {*Nephrolepis exaltata* (L.) Schott}.**

| Planting distance | Fresh weight of fronds (g) | | Dry weight of fronds (g) | | Chlorophyll content | | Vase life (days) | |
|---|---|---|---|---|---|---|---|---|
| | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| 30 x 30 | 13.90 | 16.52 | 4.14 | 5.44 | 28.76 | 40.22 | 15.92 | 18.08 |
| 30 x 45 | 15.06 | 17.00 | 4.73 | 5.57 | 29.18 | 41.38 | 16.73 | 19.12 |
| 45 x 45 | 13.94 | 16.16 | 4.13 | 5.67 | 29.04 | 43.07 | 14.65 | 20.16 |
| 45 x 60 | 13.23 | 14.38 | 4.04 | 5.48 | 28.91 | 39.21 | 13.96 | 18.80 |
| 60 x 60 | 11.38 | 13.00 | 3.18 | 3.71 | 27.39 | 28.21 | 13.83 | 15.43 |
| Mean | 13.50 | 15.41 | 4.04 | 5.17 | 28.66 | 38.42 | 15.02 | 18.32 |
| CD (P=0.05) | NS | NS | NS | NS | NS | 7.65 | NS | NS |

**Table 4 : Effect of planting distance on total N, P and K uptake of fronds under 50% shade level in Boston fern {*Nephrolepis exaltata* (L.) Schott}.**

| Planting distance | Water absorbed (ml) | | Available N (%) | | Available P (%) | | Available K (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| 30 x 30 | 12.28 | 8.80 | 1.47 | 1.61 | 0.14 | 0.13 | 1.23 | 1.48 |
| 30 x 45 | 13.20 | 11.53 | 1.50 | 1.63 | 0.14 | 0.13 | 1.19 | 1.53 |
| 45 x 45 | 13.20 | 11.2 | 1.56 | 1.68 | 0.16 | 0.15 | 1.11 | 1.39 |
| 45 x 60 | 12.20 | 9.20 | 1.66 | 1.74 | 0.13 | 0.14 | 1.50 | 1.35 |
| 60 x 60 | 11.00 | 8.13 | 1.53 | 1.73 | 0.13 | 0.16 | 1.12 | 1.47 |
| Mean | 12.38 | 9.77 | 1.54 | 1.68 | 0.14 | 0.14 | 1.23 | 1.44 |
| CD (P=0.05) | NS | NS | 0.11 | NS | NS | NS | NS | NS |

the higher plant population per unit area. However, decrease in inter or intra plant competition under wider spacing resulted in an increased number of fronds per plant. Marino *et al.* (15) also observed that the higher planting density in *Asparagus plumosus* and *Asparagus densiflorus* increased the number of stems.

Similarly Al-Kiyyam *et al.* (4) reported that the higher plant densities resulted in significant increase in fresh weight of branches, number of leaves and fresh weight of leaves produced per unit area in marjoram, a perennial herb.

The fresh weight of the fronds did not vary significantly in different planting densities and ranged from 11.00 to 15.06 g in 2012-13 and 13.00 to 17.00 g in 2013-14 (Table 3). The maximum fresh weight of fronds was recorded in the closer spacing of 30 x 45 cm during both the years. Marino *et al.* (15) observed that the higher planting density in *Asparagus plumosus* and *Asparagus densiflorus* increased total fresh weight in both the species. Similar trend was observed for dry weight of the fronds.

There was no significant effect of plant distance on chlorophyll content of leaves in 2012-13, whereas, the content was significantly higher at closer planting of Boston fern during 2013-14 (Table 3). The SPAD value indicating chlorophyll content was observed to be maximum at a spacing of 30 x 45 cm in 2012-13 and at 45 x 45 cm in 2013-14. The higher chlorophyll content found in the fronds of *Asparagus* planted at closer planting was suggested to be due to mutual shading (Marino, *et al.,* 15). Higher chlorophyll content in carnation planted at closer spacing (Karthikeyan and Jawahar, 10) also supports to the present findings. The effect of shading on chlorophyll content is, however, reported to vary in different species as observed in several woody cut foliage crops (Stamps, 22).

## Vase life

Cut fronds did not show significant differences in vase life with respect to the planting distance. Longevity of the fronds ranged from 13.83 days to 16.73 days in 2012-13 and 15.43 days to 20.16 days in 2013-14 (Table 3). Marino *et al.* (15) observed that cut

*Asparagus* foliage did not show any significant differences in vase life regardless of planting density. However, closer planting density has been reported to decrease vase life of different flowering annuals (Ahirwar *et al.*, 2; Modawei, 16). In contrast, vase life of tuberose (Mane *et al.,* 14) and gladiolus (Sanjib *et al.,* 20) is reported to increase with an increase of plant spacing.

Planting distance did not significantly affect water absorption by the fronds (Table 4). Similar observations were recorded by Marino *et al.* (16), who reported that water uptake did not differ between cut foliage of *Asparagus* harvested from the two planting densities.

## Available NPK

Planting distance had no significant effect on the available of P and K (Table 4). However, the availability of N was higher at wider spacing.

## CONCLUSION

The studies revealed that in *Nephrolepis exaltata* L. Schott frond production per plant was higher at wider planting but total production per unit area was maximum with close planting. Higher chlorophyll content was found in the fronds at close planting. Vase life of the fronds of *N. exaltata* ranged between 13 and 20 days. Therefore, from the above results, 30 x 45 cm spacing was found to be the best for quality production of Boston fern under the sub-tropical conditions of Punjab.

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**Citation :** Singh P. and Dubey R.K. (2014). Effect of planting distance on growth and frond production in Bostan fern {*Nephrolepis exaltata* (L.) Schott}. *HortFlora Res. Spectrum,* **3**(4) : 323-328

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 329-333 (December 2014) ISSN : 2250-2823

# IMPACT OF SEASONAL VARIATION FLUX ON GROWTH, LEAF PHENOLOGY AND FRUIT DEVELOPMENT IN NAGPUR MANDARIN OF JHALAWAR DISTRICT

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**ABSTRACT :** It may be inferred that during early bearing phase of Nagpur mandarin, the major contribution of vegetative growth was from spring and rainy season flushes. In the early bearing phase of Nagpur mandarin, the extent of seasonal vegetative growth was maximum in spring flush (45.03%) followed by rainy season flush (42.02%), however, the winter fall flush comprised only scanty flush of the annual vegetative growth to the tune of 10.75% only. Likewise, spring flush leaves exhibited the minimal values of leaf sclerophylly i.e. leaf fresh weight and dry weight, density of foliar tissue and leaf succulence with respect to rainy and winter season flushes inferring that growth during spring season is utilized as a sink for developing fruits. About 72 per cent of the fruit radius was found contributed by peel thickness in I phase of fruit growth. During phase II, fruit growth was found dependent upon increase in pulp tissue thickness contributing about 81 per cent of the total fruit weight. Finally, during III phase of maturity and ripening there was comparatively decreased rate of increase in fruit weight and size and little bit increased rate of dry weight, rind thickness and reduction in moisture percentage.

***Keywords***: *Nagpur mandarin, seasonal growth, leaf sclerophylly, fruit growth,*

Citrus fruits occupy second position amongst cultivated fruits of India. Being rich source of vitamin C, they are economically important fruit crops of the world which are grown in developed and developing countries for fruits. Amongst citrus fruits; Nagpur mandarin occupies significant position within mandarin group. In Rajasthan state, this variety holds dominion position in Jhalawar district. It is the main cash crop of farmers of the district. In India, citrus fruits are being grown over 9.87 lakh ha area with a total production of 96.38 lakh tonnes having the productivity level of 9.67 tonnes $ha^{-1}$. Mature citrus trees throughout Central India tend to produce growth flushes at about the same time annually. Three distinct growth flushes appear on the plant coinciding spring (February- March), rainy season (July-August) and winter fall (October-November). Stages of vegetative growth flushes and ontogeny of fruit development are important in view point of adoption of measures of plant protection, irrigation and fertilizer scheduling. There is very scanty literature available on the estimation of foliage growth with respect to season or quantity. Simanton (11) estimated that amount of new tender growth on spring flush comprised 59 per cent of annual growth; however, fall growth was found minor and erratic. The magnitude of differences in different growth flushes are mostly attributed to temperature and soil moisture effect immediately preceding or during the flush period and crop load. In bearing plants with full crop load, the rainy season flush is either minor or less due to sink pressure by vegetative and fruit development. Goldschmidt (5) reported that the annual changes in carbohydrate levels represent a combination of developmental and seasonal trends with the demand exerted by developing vegetative and reproductive sink organs.In fully expanded leaves starch and soluble sugar levels decline and stay low during summer and autumn, because of the heavy demand of developing fruits on the tree. Hence, the gratis utility of adequate foliage to yield and quality of crop is well recognized. Iglesias (7) stated that regulation of fruit growth and development in citrus is an intricate phenomenon which depends upon many internal and external factors that may operate both sequentially and simultaneously. Davies and Albrigo (3) reported that cell enlargement phase in citrus phase persists for 3 to 4 months depending upon cultivar and environmental conditions. Such variations hold importance in view of their implication in commercial trait of the plant. Accordingly, the elements and mechanisms whereby endogenous and environmental stimuli affect fruit growth are being interpreted and this knowledge may help to provide tools that allow optimizing production and fruit with enhanced nutritional value under changing climate scenario. Physical and frictional propterties of fruits as well as

*Received : 01-11-2014* *Accepted : 05-12-2014*

oranges are also important for designing the post harvest handling and processing machineries (Sayyad *et al.* 10). Keeping in view the above facts, the present study was undertaken. The study intends to explore the data quantitatively on the new foliar growth arising during varying seasonal flushes and fruit development pattern of Nagpur mandarin, which will cater to obtaining required resource input for harnessing maximum output at critical growth stages.

## MATERIALS AND METHODS

### Plant material and growth conditions

The experiment was conducted during the years 2011 and 2012 at the experimental orchard of Fruit Instructional Farm of the Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, India, located at $23^0 4'$ to $24^0 52'$ N-Latitude and $75^0 29'$ to $76^0 56'$ E-Longitude in South Eastern Rajasthan. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. About 84.22 per cent population of the district is rural whose main occupation is agriculture. Average rainfall in the region is 954.7 mm. Maximum temperature range in the summer is $43^0$ - $48^0$ C and minimum $1^0$ - $2.6^0$ C during winter. Rainfall mostly takes place through South-Western *monsoon*. Agriculture and forest lands occupy 73.5 per cent area, respectively in the district. The district has attained premier position in cultivation of Nagpur mandarin orange.

### Experimental conditions

The soil of the experimental orchard was low in organic carbon (0.30%), medium in available nitrogen (258.66 kg/ha) and phosphorous (20.83 kg/ha) and high in potash content (286 kg/ha). The experiment was conducted on six years old Nagpur mandarin plants budded on *Citrus jambhirii* rootstock and planted at 6m spacing with uniform cultural practices.

### Growth assessment

The active vegetative growth cycle appeared trifurcated into three flushes i.e. spring flush (February-March), rainy season flush (July-August) and winter fall (October-November). The quantitative magnitude of flush growth and trunk diameter was estimated for these three different flushes during 2011. The flush growth from the respective seasons was quantified after growth cessation from the trees and their fresh weight was measured by electronic weighing balance. The trunk diameter was measured 5 cm above the bud union during mid of January, April and September in the next year and trunk growth rate/season was estimated by working out the differences for the spring, rainy and winter fall seasons, respectively.

### Physiological parameters of leaf

Twenty physiological mature leaves, three months old per replication were collected from each tree from each season flush and leaf parameters like: leaf area (LA) by Laser Leaf Area Meter (Spectra), leaf fresh weight (FW) and dry weight (DW) per leaf using electronic balance were estimated during the year 2012. The leaves were brought to the laboratory in polythene bags. The leaves were then weighed immediately after harvest to estimate their fresh weight. Then these leaves were oven dried at $72^oC$ for 48 hours and their dry weight was measured. Leaf physiological parameters {Specific leaf area (SLA = LA/DW: in $cm^2 g^{-1}$, specific leaf weight (SLW= DW/FW x 1000: in $gkg^{-1}$ and succulency {S= (FW-DW)/LA: in mg $H_2O$ $cm^{-2}$}. were measured according to the formulae as suggested by Ennajeh *et al*. (4). The experiment was carried out in randomized block design using four replications taking single plant as unit replication.

### Fruit development and other parameters

Fruit growth was estimated in terms of incremental fruit diameter, peel and pulp thickness, fresh weight of fruit, dry weight of fruit and moisture content. These attributes were measured from end of April onwards at monthly intervals up to the month of December during the years 2011 and 2012 and the average of these two years data was used for statistical analysis. Fruit diameter was estimated by tagging fruits on four plants i.e four fruits on each plant comprising all four directions of the tree and the same fruits were used every month for measuring diameter by Vernier Calipers. Twelve fruits were harvested on each date of observation and weighed with electronic balance. These fruits were subsequently cut into two halves and peel thickness and fruit peel were measured in horizontal region with Vernier Calipers. Afterwards, fruits were cut into little pieces and oven dried at $52^0C$ till their constant weight was achieved. Moisture content percentage of fruits was worked out by subtracting the dried weight from fresh weight on fresh weight basis. Two years data of fruit growth was collected and averaged.

### Data analysis

Healthy and uniform plants of Nagpur mandarin were selected on the basis of trunk diameter and canopy volume from the experimental block. For growth assessment and leaf physiological parameters, the treatments were replicated four times by taking single plant as unit replication. Data were analyzed statistically in a Completely Randomized Design and differences between treatments were considered statistically at $P < 0.05$. All statistical analyses were performed using the Windostat software package (India).

## RESULTS AND DISCUSSION

The magnitude of vegetative flush variation amongst different flushes varied significantly in the early bearing phase (Table 1). The magnitude of variation of spring flush was found to be statistically significant and higher (4.55 kg plant$^{-1}$) over rainy season (4.20 kg plant$^{-1}$) and winter fall flush (1.02 kg plant$^{-1}$). The comparative contribution of growth on fresh weight basis was estimated again higher in spring flush (46.57%) followed by rainy season flush (42.98%) and winter fall flush (10.44%) of the total annual growth. Variation in trunk growth rate was found significantly influenced during the different seasons. The maximum growth rate in trunk was found during the spring season (0.57cm) closely followed by rainy season (0.53 cm) and statistically lowered trunk growth rate was observed in winter fall season (0.38 cm).

**Table 1 : Seasonal changes in the vegetative growth of Nagpur Mandarin**

| Seasons | Fresh weight of growths/ plant | Growth on fresh weight basis (%) | Trunk growth rate (% increase in trunk diameter cm/season) |
|---|---|---|---|
| Spring season | 4.55 | 46.57 | 0.57 |
| Rainy season | 4.20 | 42.98 | 0.53 |
| Winter fall | 1.02 | 10.44 | 0.38 |
| CD (P = 0.05) | 0.37 | 4.31 | 0.07 |

The cyclic growth is a characteristic feature of woody plants and also that spring flush comprise 59 per cent of annual growth and fall growth was usually minor and erratic. The results of present findings are in conformity to those as reported by Simanton (11). Spring flushes comes up more intensely after dormant period exposure to low temperatures under Northern hemispheres due to resumption of active root growth in the rhizosphere.

There were significant variations in leaf physiological parameters amongst different flushes (Table2.). Rainy season leaves exhibited the maximum leaf area (19.64 cm$^2$ leaf$^{-1}$), leaf fresh weight (0.46g) and leaf dry weight (0.18g) which was significantly higher over spring and winter fall flushes. The minimum leaf fresh weight (0.35g), leaf dry weight (0.13g), specific leaf weight (0.007 g/cm$^2$), density of foliar tissue (371.42 g kg$^{-1}$) and succulency (0.013 mg $H_2O$ cm$^{-2}$) was observed from spring flush leaves. Winter fall flush had significantly higher leaf dry weight (0.19g), specific leaf weight (0.013 g cm$^{-2}$) and density of foliar tissue (463.41 g kg$^{-1}$), however, succulency was at par with rainy season flush. The higher values of leaf area, leaf fresh weight and leaf dry weight obtained under rainy season might be due to better availability of soil moisture, high relative humidity, low transpiration losses and better mobilization of nutrients. However, minimum values of leaf fresh weight, dry weight, specific leaf weight, density of foliar tissue and succulency obtained under spring flush might be attributed to prevailing higher temperatures at the time of leaf sampling thus favouring rapid transpirational losses owing to the lower values of leaf attributes during spring season. The lower fresh weight, dry weight of leaf during spring season may be explained in the light of the fact that in fully expanded leaves starch and soluble sugar levels decline and stay low during summer and spring, because of the heavy demand of developing fruit and reserve carbohydrates are being utilized to sustain the developing fruits (Goldschmidt, 6). He also reported that citrus trees are “source-limited” and that the availability of photosynthate restricts their growth and development. The spring flush, soon followed by floral development, anthesis, and fruit set, demands large amounts of photosynthate for organ growth as well as for high rates of respiration. The persistence of the previous year’s foliage in citrus undoubtedly plays a critical role in provision of photosynthate during the emergence of the spring flush, at least prior to full expansion of the

**Table 2 : Seasonal changes in the leaf sclerophylly of Nagpur Mandarin.**

| Seasons | Leaf area (cm$^2$/leaf) | Leaf fresh weight (g) | Leaf dry weight (g) | Specific leaf area (cm$^2$g$^{-1}$) | Specific leaf weight (gcm$^{-2}$) | Density of foliar tissue (gkg$^{-1}$) | Succulency (mg $H_2O$cm$^{-2}$) |
|---|---|---|---|---|---|---|---|
| Spring season | 16.79 | 0.35 | 0.13 | 129.15 | 0.007 | 371.42 | 0.013 |
| Rainy season | 19.64 | 0.46 | 0.18 | 109.11 | 0.009 | 391.30 | 0.014 |
| Winter fall | 14.36 | 0.41 | 0.19 | 75.57 | 0.013 | 463.41 | 0.015 |
| CD (P=0.05) | 1.181 | 0.043 | 0.047 | 4.75 | 0.002 | 14.37 | 0.003 |

new leaves (Shimizu *et al*., 9). High specific leaf area under spring season might be due to decreased density of foliar tissue of spring season flush. Similar findings are reported by (Dalal *et al*., 2) in Kinnow mandarin.

Fruit growth was measured periodically as fresh fruit weight, dry weight, moisture content, fruit diameter, peel and pulp thickness. Growth and development of citrus fruit follows a typical sigmoid growth curve, divided into three clear-cut stages (Bain, 1). A fruit diameter growth was rapid up to August and then progressively slows down till the harvest. The initial phase, or phase I, is an approximately two-month interval of cell division and slow growth including the period between an approximately two-month interval of cell division and slow growth including the period between anthesis and June drop. During initial stage in April month, peel thickness was highest in the month of April contributing approximately about two-thirds of the fruit radius (70.2%) while it got declined rapidly in July (38.9%). However in the month of September it was found drastically reduced to 2.61mm followed by increase in peel thickness reaching 3.52mm at maturity. The contribution of pulp tissue during April month was only 29.4% followed by a fast increase in pulp tissue thickness during months of May and June contributing approximately 69.18% and 81.48%, respectively of the fruit radius. Thereafter, the pulp tissue increased with a linear decreasing rate continuously up to fruit maturity. From September onwards, there is a very slow increase in pulp tissue growth up to December month. In Nagpur mandarin just after fruit set in the month of March end, initially for one month up to April, the increase in fruit diameter might be primarily due to increase in peel thickness and subsequently increased in fruit size may be due to increased pulp tissue. This may be chiefly due to increase in cell division during early stages leading to increase in peel tissue thickness. Thereafter, in the rapid growth period (phase II) fruit experiences a huge increase in size by cell enlargement and water accumulation during four to six months. Therefore, developing fruitlets become sinks during the cell division period and act rather as storage sinks during

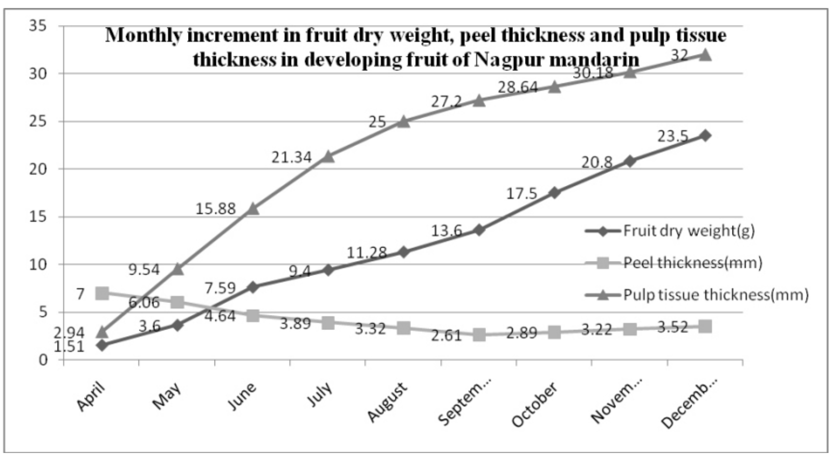


Fig.1. Average data of two years 2011-2012.

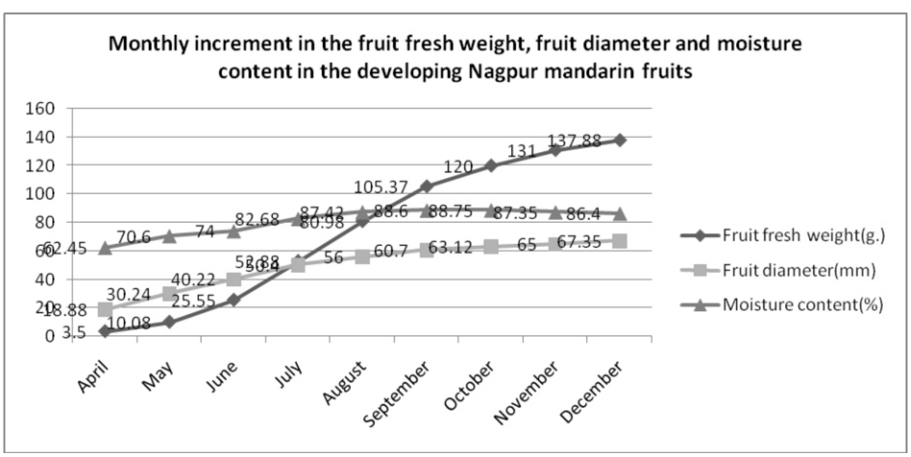


Fig. 2. Average data of two years 2011-12.

phase II (Mehouachi *et al*., 8).The decrease in peel thickness from May onwards may be due to the accelerated growth of the pulp tissue and development of juice sacs which stretches the peel tissue. Finally, in phase III or ripening period growth is mostly arrested and fruits undergo a non-climacteric process.

Fresh fruit weight and dry weight increased steadily up to maturity and harvest. Fresh fruit weight increased rapidly from May onwards to October and then the rate of increase was slow increased up to December. The graphical trend as depicted in Fig. 1 clearly reveals that dry weight gained rapidly up to June month followed by a comparatively slow increase in July, August and September months. Subsequently, rate of increase in dry weight was faster in October, November and December months. Moisture content of developing fruits increased progressively up to August, followed by little upsurge in September-October months and thereafter declining trend was noted up to harvest. Increased fruit weight might be attributed to increase in cell division and cell enlargement favouring continued formation of juice sacs during stage I. Growth of juice sacs during this phase might be primarily due to cell division. However, most of the volume of growth that occurs in Stage I might be due to peel growth. During the early parts of Stage II, the peel grew in thickness. The demarcation between stages is not abrupt, but Stage II had characteristic of very rapid growth and gain in fresh fruit weight from June to September months as depicted in Fig.2.

A similar finding has been reported by Bain (1) in Valencia orange. During maturation period i.e. Stage III, volume of fruit growth continues as long as the fruit remain attached on the tree but rate of growth was considerably lower than Stage II.

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**Citation :** Bhatnagar P., Singh J. and Meena C.B. (2014). Impact of seasonal variation flux on growth, leaf phenology and fruit development in Nagpur Mandarin of Jhalawar district. *HortFlora Res. Spectrum,* **3**(4) : 329-333

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 334-338 (December 2014) ISSN : 2250-2823

# GROWTH AND YIELD OF *KHARIF* ONION (*Allium cepa* L.) AS INFLUENCED BY DATES OF PLANTING AND CULTIVARS IN RED AND LATERITE ZONE OF WEST BENGAL

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**ABSTRACT :** An experiment was conducted at Horticulture Farm of Institute of Agriculture, Visva-Bharati, Sriniketan (West Bengal) to find out the optimum planting dates and cultivars of onion suitable for *kharif* season in this region. The treatments consisted of four dates of planting ($15^{th}$ and $30^{th}$ August and $15^{th}$ and $30^{th}$ September) and five cultivars (Agrifound Dark Red, Arka Kalyan, Arka Niketan, Indam Marshal and Red Stone). The experiment was laid out in factorial randomized block design with three replications. There was a significant increase in growth of plants and size of bulbs when planting delayed from August to September. The overall performance of *kharif* onion in red and laterite belt of West Bengal was highly satisfactory with average bulb yield 171.1q/ha. Data revealed that the cultivar Agrifound Dark Red when planted on $30^{th}$ September gave superior result in almost all yield parameters and yield.

***Keywords****: Kharif onion, planting date, cultivar, growth and yield.*

Onion (*Allium cepa* L.) is one of the most important vegetable crops among the various bulbs producing vegetables. It is generally grown as winter crop in India. Due to shortage of onion often from October onwards the market price hiked to a great extent. *Kharif* onion played a crucial role to meet this demand-supply gap and thereby reducing the price-rise of onion. Growing of onion during *kharif* season is somewhat a new strategy to be adopted in eastern India. Suitable agro-techniques are needed to get a remunerative return from large scale *kharif* season cultivation in West Bengal. In West Bengal, generally onion is cultivated during *rabi* season and the bulbs are made available from April onwards. The state has to depend on the other states which produce *kharif* and late *kharif* onion for supply of bulb during lean period (October to March). Such dependencies are sometimes resulted in abnormal increase in the prices. The situation may be improved to some extent, if the possibilities and potentialities of *kharif* onion cultivation are exploited. The growth and yield of cultivated crop plants are mainly influenced by two factors viz., genetical and cultural or management. Genetic makeup and environment are the factors which depict the performance of a cultivar by influencing all important traits (Brewster, 1). Planting time is one of important factor that greatly influence the growth and yield of onion (Mondal and Brewster, 12). Consequently, varieties should be screened for the area where they are to be grown. Thus, it is imperative to assess the performance of a cultivar for a specific location, especially for *kharif* onion which is a new venture to the growers of this locality. With this idea the present investigation was formulated to find out the optimum planting dates and cultivars of onion suitable for *kharif* season in red and laterite zone of West Bengal.

## MATERIALS AND METHODS

The experiment was conducted at the Horticulture Farm of Institute of Agriculture, Visva-Bharati, Sriniketan (West Bengal) during 2013-14. The treatment consisted of four different planting dates *viz.*, $15^{th}$ August ($D_1$), $30^{th}$ August ($D_2$), $15^{th}$ September ($D_3$) and $30^{th}$ September ($D_4$) and five cultivars *i.e.* Agrifound Dark Red ($V_1$), Arka Kalyan ($V_2$), Arka Niketan ($V_3$), Indam Marshal ($V_4$) and Red Stone ($V_5$). The planting was done 2m x 1.5m plots in 15cm x 10cm spacing. The experiment was laid in factorial randomized block design with three replications. Normal agronomic package of practices were adopted to raise the crop successfully. Data recorded at harvest on growth parameter (plant height, number of leaves/plant, leaf length, leaf diameter, neck length and neck diameter) and yield parameter (plant fresh weight, leaf fresh weight, average bulb weight, polar diameter and equatorial diameter and bulb yield).

## RESULTS AND DISCUSSION

### Plant height

Planting dates showed significant difference in plant height (Table 1). Late transplanted plants were

*Received : 12-11-2014* *Accepted : 08-12-2014*

**Table 1: Effect of date of planting and cultivar on growth parameters of onion.**

| | Plant height (cm) | Number of leaves /plant | Leaf length (cm) | Leaf diameter (mm) | Neck length (cm) | Neck diameter (mm) |
|---|---|---|---|---|---|---|
| **Dates of Planting** | | | | | | |
| $D_1$ | $65.4^{a}$ | $8.9^{b}$ | $55.0^{c}$ | $8.6^{c}$ | $5.9^{b}$ | $11.8^{c}$ |
| $D_2$ | $62.4^{b}$ | $8.8^{b}$ | $49.4^{d}$ | $10.2^{b}$ | $6.0^{b}$ | $12.3^{c}$ |
| $D_3$ | $64.4^{b}$ | $9.3^{a}$ | $60.7^{b}$ | $11.0^{a}$ | $6.7^{a}$ | $15.9^{b}$ |
| $D_4$ | $69.8^{a}$ | $9.6^{a}$ | $66.4^{a}$ | $11.4^{a}$ | $6.8^{a}$ | $17.9^{a}$ |
| C.D (P=0.05) | 2.7 | 0.4 | 2.5 | 0.9 | 0.3 | 0.8 |
| **Cultivars** | | | | | | |
| $V_1$ | $68.5^{b}$ | $9.5^{b}$ | $63.5^{a}$ | $11.3^{b}$ | $6.6^{a}$ | $16.8^{a}$ |
| $V_2$ | $61.6^{c}$ | $8.5^{c}$ | $53.0^{b}$ | $9.1^{c}$ | $6.1^{b}$ | $13.1^{b}$ |
| $V_3$ | $59.6^{c}$ | $8.6^{c}$ | $52.4^{c}$ | $9.3^{c}$ | $6.2^{b}$ | $13.5^{b}$ |
| $V_4$ | $77.8^{a}$ | $10.5^{a}$ | $65.0^{a}$ | $12.4^{a}$ | $6.7^{a}$ | $15.9^{a}$ |
| $V_5$ | $60.^{7c}$ | $8.6^{c}$ | $55.5^{b}$ | $9.4^{c}$ | $6.2^{c}$ | $13.3^{b}$ |
| C.D (P=0.05) | 3.0 | 0.4 | 2.5 | 1.0 | 0.4 | 1.0 |
| **Dates of Planting × Cultivar** | | | | | | |
| $D_1V_1$ | 67.9 | 9.3 | $57.6^{c}$ | 9.3 | 6.6 | $13.7^{d}$ |
| $D_1V_2$ | 61.5 | 8.3 | $52.5^{d}$ | 8.5 | 5.1 | $11.3^{e}$ |
| $D_1V_3$ | 61.7 | 8.3 | $52.4^{d}$ | 7.5 | 5.6 | $10.6^{e}$ |
| $D_1V_4$ | 76.2 | 9.7 | $59.0^{c}$ | 9.4 | 6.3 | $13.1^{d}$ |
| $D_1V_5$ | 59.9 | 8.7 | $53.3^{d}$ | 8.3 | 6.0 | $10.5^{e}$ |
| $D_2V_1$ | 64.9 | 9.3 | $53.3^{d}$ | 11.2 | 6.4 | $14.5^{c}$ |
| $D_2V_2$ | 59.0 | 8.0 | $47.7^{e}$ | 8.3 | 5.9 | $11.1^{e}$ |
| $D_2V_3$ | 55.8 | 8.3 | $47.1^{e}$ | 9.0 | 5.8 | $11.8^{e}$ |
| $D_2V_4$ | 74.5 | 9.9 | $51.0^{d}$ | 13.8 | 6.2 | $13.4^{d}$ |
| $D_2V_5$ | 57.9 | 8.0 | $47.8^{d}$ | 8.8 | 5.9 | $10.9^{e}$ |
| $D_3V_1$ | 68.3 | 9.7 | $67.3^{b}$ | 11.8 | 6.9 | $18.1^{b}$ |
| $D_3V_2$ | 62.4 | 8.7 | $53.7^{c}$ | 9.9 | 6.6 | $13.9^{d}$ |
| $D_3V_3$ | 58.2 | 8.7 | $53.5^{c}$ | 10.6 | 6.6 | $14.5^{c}$ |
| $D_3V_4$ | 76.2 | 10.7 | $74.4^{a}$ | 12.9 | 7.4 | $17.9^{b}$ |
| $D_3V_5$ | 59.2 | 8.7 | $54.6^{c}$ | 9.6 | 6.0 | $15.0^{c}$ |
| $D_4V_1$ | 73.0 | 9.7 | $75.7^{a}$ | 12.8 | 6.7 | 20.8a |
| $D_4V_2$ | 63.3 | 9.0 | $57.9^{c}$ | 9.8 | 6.7 | $15.9^{c}$ |
| $D_4V_3$ | 62.8 | 9.0 | $56.4^{c}$ | 10.1 | 7.0 | $17.0^{b}$ |
| $D_4V_4$ | 84.4 | 11.3 | $75.4^{a}$ | 13.2 | 6.9 | $19.1^{a}$ |
| $D_4V_5$ | 65.7 | 9.0 | $66.4^{b}$ | 10.8 | 6.8 | $16.8^{b}$ |
| GM | 65.6 | 9.1 | 57.9 | 10.3 | 6.3 | 14.5 |
| C.D (P=0.05) | NS | NS | 5.5 | NS | NS | 1.9 |
| CV (%) | 5.5 | 5.4 | 5.8 | 11.5 | 6.7 | 7.8 |

taller than early transplanted plants. Plants get more congenial weather in later date of planting that was helpful for better growth and development of onion plant. Ishwori *et al*. (5) and Khodadadi (7) reported that planting date had significant effect on plant height. Onion cultivars were significantly influenced the plant height. Indam Marshal produced maximum plant height throughout the growing period followed by Agrifound Dark Red. Jain and Sarkar (6) also reported different plant height for different cultivars of onion. Interaction effect was noted non-significant for plant height.

## Number of leaves/plant

Maximum number of leaves /plant was noted in 30th and 15th September planting. Two were found statistically at par. Das (3) also noted variation in leaf number in different dates of planting. Among the cultivars, Indam Marshal produced maximum number of leaves /plant (10.5), followed by the Agrifound Dark Red (9.5). Chandrika and Reddy (2) noted the varietal different of onion in leaf number per plant. Interaction effect was noted non-significant for leaf number per plant. Number of leaves per plant did not affected by combination of various planting materials and different date of planting as also reported by Nayee *et al*. (13). However, Mohanty (11) found significant relationship between planting dates and cultivars.

## Leaf length and diameter

Leaf length and diameter were significantly increased as planting dates progressed from August to September. Maximum leaf length and diameter were noted on 30th September planting, followed by planting on 15th September. Unfavourable weather condition due to heavy raining in earlier dates of planting may hamper proper growth of the plants that affected leaf length and diameter. This finding is in line with Khurana *et al.* (8). Cultivars also differed significantly for leaf length and diameter. Among five cultivars, maximum leaf length and diameter was noticed in cultivar Indam Marshal, followed by Agrifound Dark Red. The interaction effect was also significant for leaf length. Indam Marshal planted on 15th or 30th September and Agrifound Dark Red planted on 30th September resulted maximum leaf length. However, no significant interaction was noticed for leaf diameter.

## Neck length and diameter

Neck length and diameter are important traits having relation with bulb storage ability. Neck length and diameter varied significantly among the different planting dates. Maximum neck length and diameter was recorded on 30th September planting, followed by planting on 15th September. Increase in neck length and diameter owing to the overall increase in bulb size. Mahadeen (9) and Nayee *et al*. (13) also reported similar trends. Among fives cultivars, the maximum neck length and diameter was noted in Agrifound Dark Red and Indam Marshal. The interaction effect of date of planting and cultivar was non-significant for neck length, but significant for neck diameter (Table 1). The highest neck diameter was obtained in cultivar Agrifound Dark Red (20.8mm) and Indam Marshal (19.1mm) on 30th September planting.

## Plant and leaf fresh weight

Plant and leaf fresh weight (Table 2) revealed a significant difference, as a result of different planting dates, cultivars and their interactions, except for planting date on leaf fresh weight. Maximum plant fresh weight of 103.4g was obtained on 30th September planting. August plantings were significantly low in plant weight than September planting. Among the cultivars, Agrifound Dark Red produced the highest plant fresh weight (109.6g), followed by Indam Marshal (102.9g). With respect of interaction effect of planting date and cultivar, the highest plant fresh weight of 122.8g was obtained in Agrifound Dark Red, when planted on 30th September. On the other hand, cultivar Red Stone (32.1g), Indam Marshal (31.6g) and Agrifound Dark Red (30.4g) produced highest fresh leaves weight. Interaction effects on leaf fresh weight showed a wide variation. Maximum leaf fresh weight were noted in Agrifound Dark Red and Indam Marshal on 30th August planting, Red Stone on 15th September planting and Arka Kalyan and Red Stone on 30th September planting.

## Average bulb weight

Bulb weight is an important yield attributing character. It has been significantly influenced by different date of planting, various cultivars and their interactions. Planting dates influenced bulb weight in a significant manner. The maximum bulb weight (82.6g) was obtained on 30th September planting, followed by planting on 15th September (68.4g). Influence of planting dates on bulb weight was also reported by Singh and Singh (15) and Mahadeen (9). Among the cultivars, Agrifound Dark Red produced the highest bulb weight (80.9g), followed by Indam Marshal (71.8g). Lowest bulb weight was found on Arka Niketan (52.2g). A difference among cultivars for this trait was also noted by Mahanthesh *et al*. (10). With respect of interaction effect of planting dates and cultivars, the highest bulb weight (104.2g) was obtained in Agrifound Dark Red when planted on 30th September, which was noted significantly superior to others.

## Polar and equatorial diameter

Polar diameter and equatorial diameter of bulb is an important character which determines the shape and size of bulb. Polar and equatorial diameters of bulb were significantly influenced by planting dates and cultivars. The maximum polar and equatorial diameter was observed in 30th September planting, followed by planting on 15th September. Increased trend of bulb diameters were noted as planting delayed from August to September. Sharma *et al*. (14) also reported on

**Table 2 : Effect of date planting and cultivar on yield parameters.**

| | Plant fresh weight (g) | Leaf fresh weight of onion (g) | Average bulb weight (g) | Polar diameter (mm) | Equatorial diameter (mm) | Bulb yield (q/ha) |
|---|---|---|---|---|---|---|
| **Dates of Planting** | | | | | | |
| $D_1$ | 82.2c | 29.2 | 55.2c | 42.4b | 44.4c | 132.1d |
| $D_2$ | 83.1c | 32.0 | 50.8d | 43.0b | 44.2c | 154.2c |
| $D_3$ | 97.8b | 29.3 | 68.4b | 45.1a | 48.2b | 171.6b |
| $D_4$ | 103.4a | 29.1 | 82.6a | 46.5a | 52.7a | 226.5a |
| C.D (P=0.05) | 3.4 | NS | 3.6 | 1.7 | 1.4 | 13.6 |
| **Cultivars** | | | | | | |
| $V_1$ | 109.6a | 30.4a | 80.9a | 45.7a | 51.0a | 235.2a |
| $V_2$ | 85.9c | 28.4b | 58.5c | 43.9b | 45.4b | 139.3b |
| $V_3$ | 78.2d | 27.1b | 52.2d | 43.1b | 43.6c | 123.7c |
| $V_4$ | 102.9b | 31.6a | 71.8b | 46.2a | 50.0a | 231.4a |
| $V_5$ | 81.4d | 32.1a | 58.0c | 42.4b | 46.8b | 126.0b |
| C.D (P=0.05) | 3.8 | 3.5 | 4.1 | 1.9 | 1.5 | 15.2 |
| **Dates of Planting x Cultivars** | | | | | | |
| $D_1V_1$ | 93.4d | 31.2b | 66.2c | 42.7 | 50.5b | 185.5 |
| $D_1V_2$ | 80.1e | 29.5b | 51.7e | 44.4 | 43.9d | 109.4 |
| $D_1V_3$ | 57.0g | 21.9c | 38.9f | 41.9 | 37.5f | 91.3 |
| $D_1V_4$ | 92.1d | 35.1b | 56.3d | 43.2 | 46.3c | 188.0 |
| $D_1V_5$ | 88.5d | 28.1b | 63.0d | 39.9 | 44.1d | 86.4 |
| $D_2V_1$ | 110.8b | 42.7a | 67.7c | 42.9 | 47.9c | 213.7 |
| $D_2V_2$ | 74.6f | 30.6b | 44.2e | 43.3 | 40.9e | 117.5 |
| $D_2V_3$ | 69.7f | 26.8c | 43.0f | 42.9 | 44.2d | 113.7 |
| $D_2V_4$ | 98.4c | 38.7a | 59.8d | 44.7 | 46.7c | 205.3 |
| $D_2V_5$ | 62.1g | 21.4c | 39.5f | 41.3 | 41.1e | 120.6 |
| $D_3V_1$ | 111.4b | 25.6c | 85.5b | 46.0 | 48.1c | 229.6 |
| $D_3V_2$ | 85.7e | 30.5b | 55.8d | 43.7 | 45.1d | 124.0 |
| $D_3V_3$ | 80.5e | 23.7c | 55.1d | 43.3 | 44.7d | 130.5 |
| $D_3V_4$ | 107.6b | 25.3c | 81.9b | 47.3 | 53.6a | 238.1 |
| $D_3V_5$ | 103.6c | 41.4a | 63.7c | 45.1 | 49.5c | 135.8 |
| $D_4V_1$ | 122.8a | 22.1c | 104.2a | 51.2 | 57.6a | 311.9 |
| $D_4V_2$ | 103.3c | 23.1c | 82.2b | 44.3 | 51.5b | 206.5 |
| $D_4V_3$ | 105.8c | 35.9a | 71.7c | 44.1 | 48.1c | 159.2 |
| $D_4V_4$ | 113.4b | 27.2c | 89.1b | 49.7 | 53.6a | 294.1 |
| $D_4V_5$ | 71.4f | 37.3a | 65.6c | 43.4 | 52.7b | 161.0 |
| GM | 91.6 | 29.9 | 64.3 | 44.3 | 47.4 | 171.1 |
| C.D (P=0.05) | 7.5 | 7.0 | 8.2 | NS | 3.1 | NS |
| CV (%) | 5.0 | 14.2 | 7.7 | 5.1 | 4.0 | 10.8 |

similar line in *kharif* onion. Among the cultivars, the maximum bulb polar and equatorial diameters were measured in Indam Marshal, closely followed by Agrifound Dark Red. Haldar *et al*. (4) also reported similar trends. Interaction effect of planting date and variety on equatorial diameter was noted statistically significant. Agrifound Dark Red and Indam marshal, when planted on 30th September noted highest value of equatorial diameter.

## Bulb yield

In any performance trial with various factors, yield is the most important character to be taken under special consideration. In the present investigation the yield had showed significant response under different dates of planting and cultivars. However, interaction effect was noted non-significant. The highest yield of 226.5q/ha was resulted when the transplanting was undertaken on 30th September, followed by planting on

15th September (171.6q/ha). Data on yield (Table 2) clearly revealed that progressive delay in planting from August to September was benefitted by linear increase in yield. Heavy rain was received in the month of August. The weather condition particularly rainfall and R.H. prevailed during early dates of planting might have some unfavorable influences, which caused the reduction of bulb yield. Variation in yield due to varied planting dates also reported by Sharma *et al*. (14) and Mahadeen (9). Agrifound Dark Red, like other yield attributing characters, produced the maximum yield of 235.2q/ha, closely followed by Indam Marshal (231.4q/ha). Jain and Sarkar (6) identified Agrifound Dark Red as highest yielder. The highest yield was produced by Agrifound Dark Red might be as indication of its suitability to grow in *kharif* season in lateritic belt of West Bengal. The interaction effect of planting dates and cultivars exerted on yield was not statistically significant. On an average the projected bulb yield was 171.1q/ha for the entire study.

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**Citation :** Mohanta S. and Mandal J. (2014). Growth and yield of *Kharif* onion (*Allium cepa* L.) as influenced by dates of planting and cultivars in red and laterite zone of West Bengal. *HortFlora Res. Spectrum,* **3**(4) : 334-338

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 339-343 (December 2014) ISSN : 2250-2823

# EFFECT OF PLANT SPACING AND NITROGEN LEVELS ON QUANTITY AND QUALITY CHARACTERISTICS OF ASIATIC LILY (*Lilium* spp.)

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**ABSTRACT:** A field experiment was carried out as a Factorial Randomized Complete Block Design (RCBD) with 3 replications at UHSB, COH, Mudigere. Different plant spacing (30x15 cm, 30x30 cm, 40x15 cm) was the first factor and the second factor was the different levels of nitrogen (0, 100, 150 and 200 Kg/ha). The spacing between plants of 30x15 cm and 200 kg per ha of N had a significant effect on quantity and quality characteristics of Asiatic lily. Data showed that the plant spacing of 30x15 cm with nitrogen application of 200 Kg per ha obtained the maximum qualitative and quantitative characteristics of flowers.

***Keywords***: *Asiatic lily, bulb, flower quality, quantity, spacing, nitrogen.*

Asiatic lily (*Lilium* spp.) is one of the most important cut flowers in temperate and subtropical regions of the world. The turn over of the lilies went up by 10 per cent in 2000, but they still remain fourth in the Dutch auction cut flower ranking. There has been a large scale increase in the area of Asiatic lily grown in the Netherland, from 600 ha in 1975 to nearly 5000 ha in 2001 and now, represents 15 per cent of the total bulbs grown. It is produced both in greenhouses and in open spaces. Nutrients such as nitrogen play a major role in the growth and development of plants (Scott, 8). Nitrogen as an essential element that improves the chemical and biological properties of soil and thereby stimulates the production of higher yield in plants. Optimum plant density is another important factor for high plant growth and yield. Spacing between plants is particularly important for the cultivation of Asiatic lily to maximize flower quality and quantity characteristics. Therefore, inter and intra row spacing together with a balanced supply of nutrients such as nitrogen are important for obtaining optimum quality and quantity of Asiatic lily flowers.

## MATERIALS AND METHODS

A field experiment was carried out to study the influence of nitrogen levels, plant density and their interaction on growth and yield of Asiatic lily cv. Gironde, a member of the Liliaceae family. The experiment was conducted at the Department of FLA, College of Horticulture, Mudigere, Karnataka during the period from September 2012 to March 2013. The factors were as follows: plant spacing from $S_1$ to $S_3$ (30x15 cm, 30x30 cm and 40x15 cm) as first factor and nitrogen doses from $N_1$ to $N_4$ (0, 100, 150 and 200kg/ha) were considered as the second factor. Soil $p^H$ and EC were 5.39 and 0.17 dS per $m^2$ respectively. Experiment was laid out in Randomized Block Design (RCBD) with 3 replications. All the qualitative and quantitative characteristics (Table 1 and 2) were determined and subjected to analysis of variance (ANOVA).

*Received : 07-10-2014* *Accepted : 30-10-2014*

## RESULTS AND DISCUSSION

### Days to Bulb Spourting

The data pertaining to number of days taken for bulb sprouting in Asiatic lily (Table 1) revealed that spacing, nitrogen level and interaction of both did not had significant influence on the number of days taken for sprouting of bulbs.

Spacing, nitrogen level and interaction of both did not had significant influence on the number of days taken for sprouting of bulbs. It might be due to the fact that sprouting of bulb is an initial process of growth which is completed within 7-8 days after planting by utilizing the stored food materials and external application of nitrogen and spacing might not have influence the sprouting.

### Plant Height

The plant height was found to be maximum (51.94 cm) at 30x15 cm ($S_1$) spacing which was statistically on par with plant height (50.72 cm) at 40x15 cm ($S_3$) spacing, while minimum height of plant (47.83 cm) was recorded at ($S_2$) spacing 30x30 cm. (Table 1)

In the present study, plant height increased with the increasing levels of nitrogen. The tallest plant (41.04 cm) was recorded at 200 kg of nitrogen per hectare, followed by (39.73 cm) nitrogen at 150 kg per hectare. The results are inconsonance with Rathore and Singh (7). With respect to interaction, a vegetative character of Asiatic lily like plant height did not show any significant difference.

Tuberose. It has been observed that, with optimum supply of nitrogen there is an increase in synthesis of protein and as a consequence of which there is increased meristematic activity leading to higher plant

**Table 1: Growth and flowering characteristics of Asiatic lily as affected by spacing and nitrogen levels.**

| Treatment | Days to bulb sprout | Plant height (cm) | Number of leaves per plant | Days taken to flower bud emergence | Days to colour visibility in bud | Days taken to 50 per cent flowering |
|---|---|---|---|---|---|---|
| **Spacing (cm)** | | | | | | |
| $S_1$= 30X15 | 6.36 | 51.94 | 87.02 | 27.77 | 55.47 | 59.95 |
| $S_2$= 30X30 | 6.91 | 47.83 | 81.17 | 28.23 | 54.41 | 59.92 |
| $S_3$= 40X15 | 6.69 | 50.72 | 85.96 | 28.26 | 55.44 | 60.63 |
| C.D. (P=0.05) | NS | 3.23 | 4.84 | NS | NS | NS |
| **Nitrogen levels (kg/ha)** | | | | | | |
| $N_1$=0 | 4.63 | 32.64 | 59.39 | 19.38 | 39.02 | 41.55 |
| $N_2$=100 | 4.93 | 37.07 | 62.46 | 20.69 | 40.23 | 44.28 |
| $N_3$=150 | 5.06 | 39.73 | 64.66 | 21.14 | 42.18 | 46.61 |
| $N_4$=200 | 5.34 | 41.04 | 67.63 | 23.05 | 43.89 | 48.07 |
| C.D. (P=0.05) | NS | 3.72 | 5.59 | 1.98 | 3.61 | 3.95 |
| **Interaction (S x N)** | | | | | | |
| $S_1N_1$ | 5.93 | 44.37 | 83.55 | 25.13 | 51.85 | 55.29 |
| $S_1N_2$ | 6.13 | 52.47 | 84.04 | 27.33 | 54.73 | 59.12 |
| $S_1N_3$ | 6.33 | 54.20 | 87.44 | 27.73 | 56.80 | 61.07 |
| $S_1N_4$ | 7.03 | 56.73 | 93.02 | 30.88 | 58.50 | 64.34 |
| $S_2N_1$ | 6.33 | 42.93 | 73.47 | 26.33 | 52.03 | 55.71 |
| $S_2N_2$ | 6.93 | 44.39 | 81.84 | 27.70 | 52.13 | 58.57 |
| $S_2N_3$ | 7.03 | 51.67 | 83.86 | 28.23 | 54.33 | 62.12 |
| $S_2N_4$ | 7.33 | 52.33 | 85.51 | 30.67 | 59.13 | 63.28 |
| $S_3N_1$ | 6.23 | 43.27 | 80.55 | 26.03 | 52.20 | 55.20 |
| $S_3N_2$ | 6.67 | 51.43 | 83.93 | 27.73 | 54.07 | 59.43 |
| $S_3N_3$ | 6.87 | 53.07 | 87.33 | 28.60 | 57.57 | 63.24 |
| $S_3N_4$ | 7.00 | 55.10 | 92.00 | 30.67 | 57.93 | 64.67 |
| C.D. (P=0.05) | NS | NS | NS | NS | NS | NS |

Increased plant height and number of leaves at closer spacing and at higher dose of nitrogen might be due to the fact that optimum use of resources such as light, moisture, space and aeration for proper growth and development of plants and also to harness solar energy. This resulted in elongation of main stem, increase in stem length may be due to elongation of cells and number of cells due to cell division. Similar observations are also made by Mane *et al.* (4) in growth. Similar reports obtained by Naik (5) and Mallikarjuna (3) in marigold and China aster, respectively.

## Number of Leaves Per Plant

Leaf production varied significantly with respect to spacing and nitrogen levels. As for as interaction was concerned, the leaf production showed non-significant difference. The number of leaves per plant was found to be maximum (87.02) at 30 x15 cm spacing which was statistically on par (85.96) with 40x15 cm spacing and minimum (81.17) was recorded at 30x30 cm spacing. The results are in line of Ram *et al.* (6). The number of leaves per plant was found to be maximum (67.63) at 200 kgN/ha ($N_4$) which was statistically on par with 150 kg N per ha (64.66) and $N_2$ (62.46) but minimum number of leaves per plant (59.39) was recorded at control (0 kgN/ha).

## Days Taken to Flower Bud Emergence and Colour Visibility in Flower Bud

Spacing could not influence number of days taken for flower bud emergence and colour visibility in flower bud, but they were significantly influenced by nitrogen levels. Early emergence of flower bud (19.38 days) and early colour visibility in flower bud (39.02 days) were observed at 0 kgN/ha ($N_1$) level as compared to 100 kgN/ha (20.69 days and 40.23 days) and $N_3$ level (21.14 days and 42.18 days respectively). Delayed flower bud emergence (23.05 days) and colour visibility in flower bud (43.89 days) were found at 200 kg/ha ($N_4$) level. The interaction of spacing and nitrogen levels did not influence this parameter.

## Days Taken to 50 Per cent Flowering

Spacing did not influence number of days taken to 50 per cent flowering, but it was significantly influenced by nitrogen levels. The advanced 50 per cent flowering (41.55 days) was observed at $N_1$ level (0 kg/ha) as compared to $N_2$ level (44.28 days) and $N_3$ level (46.61 days), whereas at 200 kgN/ha ($N_4$) level of nitrogen delayed (48.07 days) the days taken for 50 per cent flowering.

The data on the number of days taken to flower bud emergence, colour visibility in flower bud, days taken to 50 per cent flowering and days taken to first harvesting were found to be significantly influenced by nitrogen. Generally, nitrogen in excess promotes vegetative growth and delays flower bud emergence, colour appearance in flower bud, also takes more number of days for 50 per cent flowering and delays harvesting while, deficient nitrogen causes thrifty growth and early flowering (Naik, 5).

## Days Taken to First Harvest

The time taken to first harvesting was not significantly influenced by spacing, however, significantly influenced by nitrogen levels. The minimum number of days taken for first harvest (46.83 days) was observed at $N_1$ level (0 kgN/ha) as compared to 100 kgN/ha (50.19 days) and 150 kgN/ha (51.35 days), whereas 200 kgN/ha ($N_4$) level of nitrogen took more number of days (52.84) for first harvesting. The interaction of spacing and nitrogen level did not influence the days taken for first harvesting.

## Days Taken for Flower Senescence on Plant

The time taken for flower senescence in the experimental plot was not significantly influenced by spacing, while it was significantly influenced by nitrogen levels. The maximum number of days taken for flower senescence (6.35 days) was observed at 200 kgN/ha level which was on par at 150 kgN/ha level (5.83 days) and advanced senescence occurred (4.51 days) at $N_1$ level (0 kgN/ha) of nitrogen. Days taken to flower senescence in experimental plot was significantly influenced by different levels of nitrogen. This might be due to availability and also uptake of optimum nutrients. The interaction of spacing and nitrogen level did not influence the days taken for flower senescence in the experimental plot.

## Number of Spikes per Square Meter

The number of spikes per square meter was significantly influenced by spacing, but it was not influenced by nitrogen levels and their interaction. Maximum production of spikes per square meter (21.22) was recorded at 30x15 cm spacing as compared to 30x30 cm spacing (10.44) and $S_3$ spacing (15.13). Maximum flower weight at the closer spacing may have been due to good plant establishment, which in turn resulted in the production of more and bigger sized flowers per spike, finally led to increased weight in flowers.Number of spikes per meter square increased with closer spacing might be due to that closer spacing occupying more number of plants per unit area. Number of spikes per meter square increased with closer spacing might be due to that closer spacing occupying more number of plants per unit area.

## Diameter of Flower

Flower diameter was influenced significantly by spacing, nitrogen levels and their interaction (Table 2). Maximum diameter of flower (9.94 cm) was recorded at 30x15 cm spacing but it was on par at 40x15 cm spacing (9.78 cm) and least diameter of flower (7.64 cm) was under $S_2$ spacing. The results are in consonance with Karthikeyan and Jawaharlal (1) who advocated that closer planting of carnation resulted quality flowers. Similarly, maximum diameter of flower (7.63 cm) was recorded at 200 kg/ha level of nitrogen which was on par at 150 kgN/ha (7.22 cm) and minimum mean diameter of flower (6.54 cm) was recorded at $N_1$ level. The biggest sized flowers (12.70 cm) were obtained from treatment combination of 200 kgN/ha and 30x15 cm spacing which was on par at $S_1N_3$ (11.33 cm) while, the lowest size (6.90 cm) was recorded in combination of $S_2N_2$ (100 kgN/ha + 30 x 30 cm).

## Number of Florets Per Spike

Spacing exhibited significant effect on number of florets per spike. 30x15 cm ($S_1$) spacing recorded maximum florets per spike (5.56) which was on par with $S_3$ (5.03), while the lowest florets per spike (4.93) was recorded with $S_2$ (Table 2). Nitrogen level also had significant effect on number of florets per spike. 200 kgN/ha yielded significantly higher florets per spike (4.60) followed by $N_3$ (4.09), while $N_1$ level recorded least florets per spike (3.11). Present findings are in agreement with Rathore and Singh (7) in tuberose. The interaction effect due to spacing and nitrogen level was also found to be significant. The florets per spike were highest (7.40) with the treatment combination of 30 x 15 cm + 200 kgN/ha ($S_1N_4$) followed by $S_1N_3$ (6.00). Whereas, the lowest number of florets (3.87) per spike was observed in a combination of $S_3N_1$.

An increase in number of florets may be due to possible role of nitrogen, less competition for nutrients and water, higher leaf number and area. More photosynthesis enhanced food accumulation which might have resulted in better plant growth and subsequently higher number of florets per spike. This finding is in agreement with that of Khalaj and Edrisi (2) and Ram *et al.* (6)

## Flower Weight

Flower weight was significantly influenced by spacing and nitrogen levels (Table 2). Maximum flower weight (7.22 g) was recorded at $S_1$ spacing followed by $S_2$ spacing (6.00 g) and least under $S_3$ spacing (5.74 g).

**Table 2: Flowering, quantity and quality parameters of Asiatic lily as affected by spacing and nitrogen levels.**

| Treatment | Days taken to first harvest | Days to flower senescence | Number of spikes per $m^2$ | Flower weight (g) | Diameter of flower (cm) | Number of florets per spike |
|---|---|---|---|---|---|---|
| **Spacing (cm)** | | | | | | |
| $S_1$= 30X15 | 66.01 | 7.60 | 21.22 | 7.22 | 9.94 | 5.56 |
| $S_2$= 30X30 | 67.58 | 6.74 | 10.44 | 6.00 | 7.64 | 4.93 |
| $S_3$= 40X15 | 67.63 | 7.42 | 15.13 | 5.74 | 9.78 | 5.03 |
| C.D. (P=0.05) | NS | NS | 1.21 | 0.66 | 0.79 | 0.53 |
| **Nitrogen levels (kg/ha)** | | | | | | |
| $N_1$=0 | 46.83 | 4.51 | 11.25 | 3.17 | 6.54 | 3.11 |
| $N_2$=100 | 50.19 | 5.06 | 12.00 | 4.70 | 5.97 | 3.73 |
| $N_3$=150 | 51.35 | 5.83 | 11.33 | 5.24 | 7.22 | 4.09 |
| $N_4$=200 | 52.84 | 6.35 | 11.83 | 5.84 | 7.63 | 4.60 |
| C.D. (P=0.05) | 4.23 | 0.84 | NS | 0.76 | 0.92 | 0.61 |
| **Interaction (S × N)** | | | | | | |
| $S_1N_1$ | 61.66 | 6.07 | 20.55 | 5.00 | 8.04 | 4.27 |
| $S_1N_2$ | 65.63 | 7.07 | 22.22 | 7.00 | 7.70 | 4.57 |
| $S_1N_3$ | 67.27 | 8.23 | 20.56 | 7.73 | 11.33 | 6.00 |
| $S_1N_4$ | 69.47 | 9.04 | 21.55 | 9.15 | 12.70 | 7.40 |
| $S_2N_1$ | 62.90 | 5.97 | 9.78 | 3.77 | 8.03 | 4.30 |
| $S_2N_2$ | 67.07 | 6.15 | 10.44 | 5.22 | 6.90 | 4.77 |
| $S_2N_3$ | 69.53 | 7.10 | 10.44 | 7.27 | 8.20 | 5.47 |
| $S_2N_4$ | 70.80 | 7.74 | 11.11 | 7.77 | 7.43 | 5.20 |
| $S_3N_1$ | 62.77 | 6.00 | 14.66 | 3.93 | 10.10 | 3.87 |
| $S_3N_2$ | 68.06 | 7.03 | 15.33 | 6.60 | 9.30 | 5.57 |
| $S_3N_3$ | 68.61 | 8.00 | 14.33 | 5.96 | 9.33 | 4.90 |
| $S_3N_4$ | 71.08 | 8.63 | 14.66 | 6.45 | 10.40 | 5.80 |
| C.D. (P=0.05) | NS | NS | NS | NS | 1.59 | 1.06 |

Among different nitrogen levels, maximum flower weight (5.84 g) was observed at $N_4$ level which was on par at $N_3$ (5.24 g) and minimum weight of flower (3.17 g) was observed at $N_1$ level of nitrogen. Interaction effect of spacing and nitrogen did not influence the flower weight significantly.

Maximum flower weight at the closer spacing may have been due to good plant establishment, which in turn resulted in the production of more and bigger sized flowers per spike, finally led to increased wight in flowers.

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**Citation :** Vedavathi R.S., Manjunatha B., Basavanagowda M.G., Thippana K.S. and Patil R.M. (2014). Effect of plant spacing and nitrogen levels on quantity and quality characteristics of Asiatic lily (*Lilium* spp.). *HortFlora Res. Spectrum,* **3**(4) : 339-343

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 344-348 (December 2014) ISSN : 2250-2823

# OPTIMIZATION OF FERTIGATION SCHEDULE FOR CUT CHRYSANTHEMUM (*Dendranthema grandiflora* Tzvelev)

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**ABSTRACT :** A greenhouse study was conducted in 2013 to optimize the fertigation schedule for cut chrysanthemum var. Amalfi. The experiment was laid out in a randomized block design (RBD) consisting of nine treatments with three replications which included fertilizer levels at 75, 100, 125 and 150 per cent of recommended dose of fertilizers along with foliar spray of 0.2 per cent EDTA chelated micronutrient mixture to each of the fertilizer levels. The results revealed that 75% recommended dose of fertilizers @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray significantly enhanced the growth, physiology and yield parameters. Also increased recommended dose of fertilizers i.e., 100 % per cent improved the total leaf area per plant, soluble protein content, flower diameter, flower stalk length and girth. Though certain flowering parameters were recorded high in 100 % RDF, Yield contributing parameters like plant height, root length and fresh weight, total chlorophyll contents, earliness in flowering, yield/$m^2$ and vase life showed superiority in 75 % RDF along with foliar spray of 0.2 per cent EDTA chelated micronutrient mixture.

**Keywords:** *Chrysanthemum, fertigation, improved growth, physiology, yield.*

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is one of the most important cut flower grown mainly for international and domestic markets. It ranks third among the cut flowers next to rose and tulips. Application of optimum quantity of fertilizers to the crop enhances the uptake of proper nutrients from growing media by the root hairs and also nutrient application at the required time prevented the crop suffering from hidden hunger. At present, the chrysanthemum growers are not able to obtain good quality, since the production cost of this flower is increased due to increase in fertilizer cost. Yield and quality is mainly dependant on the balanced application of macro and micronutrients. Fertilizer use efficiency is very less in the conventional practice of soil application. Most of the soils of hilly tracts of Tamil Nadu have low pH which hinders the absorption of micronutrients (Ahsan *et al*., 1). Foliar application of micronutrients may be 6 - 20 times more efficient than soil application in increasing crop production and other growth parameters (Younis *et al*., 16). Optimizing fertilizer dose is the alternative method for correction of nutrient deficit problems. So, to improve the growth, yield and quality of the crop, this study was taken up to optimize the fertigation schedule for chrysanthemum under the protected conditions.

## MATERIALS AND METHODS

The present study was carried out at M/s. Salem Green Plants Ltd., one of the leading commercial growers of cut chrysanthemum at Yercaud, Salem District. The experiment was laid out in a randomized block design (RBD) with three replications. The climate of the area is sub-tropical. A standard variety 'Amalfi' was selected for the study. The experiment was carried out under the greenhouse with nine treatments *viz.,* $T_1$: Control (without fertilizers), $T_2$: 75 % RDF @ 12 : 3 : 12 g NPK/$m^2$ , $T_3$: 100 % RDF @ 16 : 4 : 16 g NPK/$m^2$ , $T_4$: 125 % RDF @ 20 : 5 : 20 g NPK/$m^2$ , $T_5$: 150 % RDF @ 24 : 6 : 24 g NPK/$m^2$ $T_6$: $T_2$ + Foliar spray of 0.2 % EDTA chelated micronutrient mixture, $T_7$: $T_3$ + Foliar spray of 0.2 % EDTA chelated micronutrient mixture, $T_8$: $T_4$ + Foliar spray of 0.2 % EDTA chelated micronutrient mixture, $T_9$: $T_5$ + Foliar spray of 0.2 % EDTA chelated micronutrient mixture. 75 per cent of phosphorus was applied uniformly to the treatment plots i.e., $T_2$ to $T_9$ at the time of planting. Micronutrient mixture containing Zinc-2.5 %, Iron-2.0%, B-0.1%, Manganese-1.0%, Magnesium-4.0%, Copper-0.1% and Molybdenum- 0.01%) were given at fortnightly interval as foliar and 0.2 % humic acid was given along with fertilizers to each treatment except control. 100 per cent dose of fertilizers was adopted by the growers for commercial cultivation. The observation on growth parameters such as plant height (cm), root length (cm) and root fresh weight (g) were recorded at critical stages. The physiological parameters viz. chlorophyll contents (mg/g) and soluble protein (mg/g) and yield parameters such as days to first flower bud

*Received : 15-09-2014* *Accepted : 10-10-2014*

appearance, days to harvest, flower stalk length and girth (cm), weight of cut stem (g), opened flower circumference (cm), cut stem yield/$m^2$ and vase life (days) were recorded throughout the cropping period. The data were statistically analyzed as per the method suggested by Panse and Sukhatme (11). The critical differences were worked out for 5 per cent (0.05) probability and the mean differences were compared using LSD test.

## RESULTS AND DISCUSSION

The present experiment was taken up to have a scientific base pertaining to impacts of different levels of fertilizer levels adopted in chrysanthemum cultivation and to schedule the requirement of fertilizers to the crop.

### Growth parameters

The growth parameters *viz.*, plant height, root length and root fresh weight at critical stages such as vegetative growth, bud appearance and flowering stage were variably influenced by the fertigation levels and foliar application of micronutrient mixture (Table 1). The fertigation dose of 75 % RDF @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray ($T_6$) significantly influenced the plant height at all the three stages *viz.*, vegetative (76.40 cm), bud appearance (98.69 cm) and peak flowering stage (126.26 cm) ; This might be due to frequent application of fertilizers at convenient intervals, which increases the available nutrient status in the root zone thus increasing the uptake of nutrients and further influencing the growth of the plant. Sufficient supply of nutrients at frequent intervals might have increased the production of IAA which consequently would have shown stimulatory action, in terms of cell elongation and thus resulting in increased plant height. The root length was highest in the treatment $T_6$ i.e., 75 % RDF @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray by registering 60.57 cm at vegetative, 90.34 cm at bud appearance and 138.89 cm length at flowering stage respectively. In contrast, root length of control plants was very short and thin. Similar trend was observed at all the stages of plant growth. This was because fertigation system allows applying the nutrient exactly and uniformly to the wetted root volume, where the active roots are concentrated. This remarkably increases the efficiency in the application of fertilizer which allows reduction in the dosage of fertilizers. Similar trend was also reported by and Deng *et al.* (3) in lychee. The root fresh weight was increased significantly with increasing the concentration of Phosphorus ($T_7$). It was observed that plants fertigated with higher dose phosphorus had thicker roots. The improved effect of phosphorus was also observed by Xu *et al.* (15) in lettuce.

**Table 1 : Effect of fertigation levels on growth parameters of chrysanthemum at critical stages under greenhouse condition**

| Treatment | Plant height (cm) | | | Root length (cm) | | | Root fresh weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vegetative stage | Bud appearance stage | Flowering stage | Vegetative stage | Bud appearance stage | Flowering stage | Vegetative stage | Bud appearance stage | Flowering stage |
| $T_1$ | $52.06^{f}$ | $58.38^{f}$ | $68.59^{f}$ | $30.40^{g}$ | $45.97^{f}$ | $63.54^{f}$ | $1.34^{f}$ | $1.79^{h}$ | $1.85^{g}$ |
| $T_2$ | $65.82^{cd}$ | $80.67^{d}$ | $124.32^{b}$ | $54.40^{c}$ | $85.67^{b}$ | $132.59^{b}$ | $2.87^{d}$ | $3.16^{e}$ | $3.47^{e}$ |
| $T_3$ | $70.60^{b}$ | $92.11^{bc}$ | $121.35^{bc}$ | $52.67^{cd}$ | $88.57^{ab}$ | $131.24^{b}$ | $4.14^{b}$ | $5.06^{a}$ | $5.69^{b}$ |
| $T_4$ | $65.00^{d}$ | $80.69^{d}$ | $118.66^{cd}$ | $51.54^{de}$ | $70.33^{de}$ | $120.95^{cd}$ | $2.22^{e}$ | $2.97^{f}$ | $3.35^{e}$ |
| $T_5$ | $59.10^{e}$ | $75.82^{e}$ | $105.41^{e}$ | $49.27^{ef}$ | $73.68^{cd}$ | $112.35^{e}$ | $1.49^{f}$ | $2.13^{g}$ | $2.87^{f}$ |
| $T_6$ | $76.40^{a}$ | $98.69^{a}$ | $126.26^{b}$ | $60.57^{a}$ | $90.34^{a}$ | $138.89^{a}$ | $4.02^{b}$ | $4.87^{b}$ | $5.54^{b}$ |
| $T_7$ | $75.00^{a}$ | $94.16^{b}$ | $132.54^{a}$ | $57.12^{b}$ | $85.64^{b}$ | $135.76^{ab}$ | $4.90^{a}$ | $5.08^{a}$ | $6.12^{a}$ |
| $T_8$ | $64.60^{d}$ | $78.14^{de}$ | $115.03^{d}$ | $52.62^{cd}$ | $75.36^{c}$ | $122.35^{c}$ | $4.10^{b}$ | $4.57^{c}$ | $5.29^{c}$ |
| $T_9$ | $68.24^{bc}$ | $88.55^{c}$ | $108.18^{e}$ | $47.06^{f}$ | $69.67^{e}$ | $115.31^{de}$ | $3.32^{c}$ | $3.73^{d}$ | $4.44^{d}$ |
| CD (P=0.05) | 3.167 | 3.992 | 5.443 | 2.431 | 3.676 | 5.745 | 0.155 | 0.178 | 0.207 |

*Means followed by a common letter are not significantly different at the 5% level by LSD.

### Physiological parameters

Leaf area represents the foliage of plants that give excellent results for fertigation and foliar spraying of micronutrients (Fig 1.). In the present study, 100 % RDF @ 16 : 4 : 16 g NPK/$m^2$ along with 0.2 % EDTA

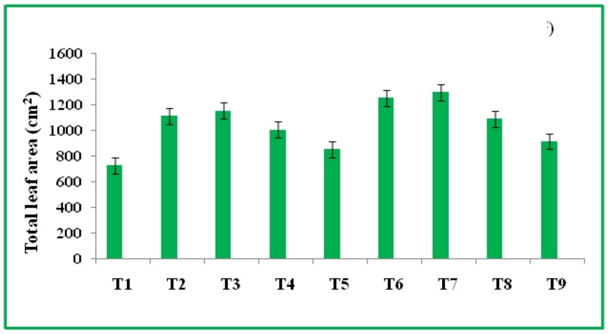


Fig. 1. Effect of fertigation levels on total leaf area per plant ($m^2$)

micronutrient mixture as foliar spray on 15 days interval ($T_7$) registered significantly the highest total leaf area per plant at the critical stages of the plant development *viz*., vegetative (968.49 $cm^2$), bud appearance (1256.59 $cm^2$) and flowering stage (1297.48 $cm^2$) and highest soluble protein content at the same critical stages (56.50, 67.19 and 71.66 mg $g^{-1}$ respectively). This increase in leaf area might be due to that the increased leaf numbers by the application of optimum dose of macronutrients at frequent intervals enhances the photosynthetic activity of the leaf ultimately increases leaf area. Increased vine length and girth as well as fruit size and quality due to fertifgation in cucumber was also reported by Tiwari (14). However, the treatment $T_6$, i.e., 75 % RDF @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray proved similar effect which was at par with $T_7$ for all the parameters at all the critical stages of plants.

The chlorophyll contents are mainly influenced by the amount of light intensities received by the plants

**Table 2 : Effect of fertigation levels on yield and quality parameters of chrysanthemum under greenhouse condition.**

| Treatment | Days to first flower bud appearance | Days to first harvest | Flower stalk length (cm) | Flower stalk girth (cm) | Open flower circumference (cm) | Cut stem yield /$m^2$ | Vase life (days) |
|---|---|---|---|---|---|---|---|
| $T_1$ | $59.38^{g}$ | $105.98^{i}$ | $62.36^{h}$ | $2.37^{f}$ | $6.55^{h}$ | $65.24^{i}$ | $4.56^{f}$ |
| $T_2$ | $53.14^{cd}$ | $97.19^{d}$ | $116.34^{cd}$ | $2.82^{d}$ | $8.23^{cd}$ | $70.19^{f}$ | $9.54^{cd}$ |
| $T_3$ | $51.87^{bc}$ | $96.54^{c}$ | $118.69^{ab}$ | $3.07^{bc}$ | $8.59^{c}$ | $71.65^{e}$ | $9.64^{c}$ |
| $T_4$ | $56.74^{ef}$ | $100.01^{e}$ | $115.34^{d}$ | $2.79^{d}$ | $7.45^{fg}$ | $69.64^{g}$ | $8.49^{e}$ |
| $T_5$ | $57.52^{fg}$ | $101.36^{g}$ | $100.84^{g}$ | $2.97^{c}$ | $7.09^{g}$ | $68.59^{h}$ | $9.19^{d}$ |
| $T_6$ | $48.35^{a}$ | $90.23^{a}$ | $117.33^{bc}$ | $3.48^{a}$ | $9.64^{b}$ | $76.50^{a}$ | $11.56^{a}$ |
| $T_7$ | $50.26^{ab}$ | $94.36^{b}$ | $120.15^{a}$ | $3.34^{a}$ | $10.59^{a}$ | $74.32^{b}$ | $10.23^{b}$ |
| $T_8$ | $54.87^{de}$ | $100.98^{e}$ | $110.89^{e}$ | $2.59^{e}$ | $8.01^{de}$ | $72.68^{d}$ | $8.35^{e}$ |
| $T_9$ | $55.63^{def}$ | $102.87^{h}$ | $105.64^{f}$ | $3.12^{bc}$ | $7.66^{ef}$ | $73.49^{c}$ | $8.17^{e}$ |
| CD (P=0.05) | 2.590 | 0.360 | 1.9532 | 0.141 | 0.394 | 0.155 | 0.435 |

*Means followed by a common letter are not significantly different at the 5% level by LSD

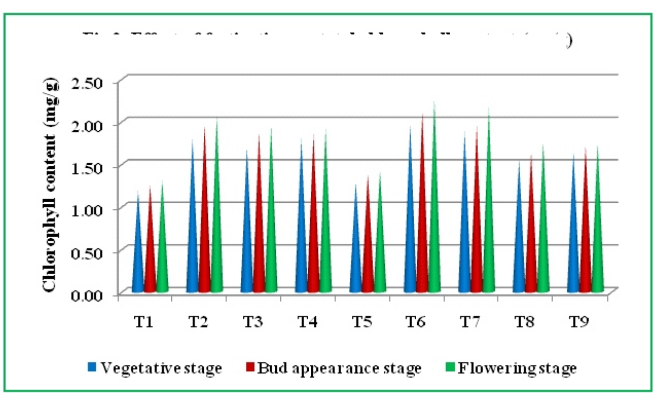


Fig. 2. Effect of fertigation on total chlorophyll content (mg/g).

(Fig 2.). Fertigation levels of 75 % RDF @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray influenced the total chlorophyll contents at the critical stages (1.96, 2.12 and 2.26 mg/g, respectively). The results are in agreement with Tiwari (14). In combination with micronutrients, it might have favoured the synthesis and accumulation of chlorophylls in plant system. Hebbar *et al*. (4) also revealed that being a constituent of chlorophyll, increased supply of nitrogen accelerate high synthesis of chlorophyll without altering the composition of chlorophyll *a* and *b.* The control ($T_1$) plants recorded the lowest chlorophyll contents at the critical stages.

Soluble protein content is a key factor in determining the photosynthetic efficiency of the crop plants. Soluble protein content was found to be recorded highest when 100 % RDF @ 16 : 4 : 16 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray on 15 days interval (Fig 3.). High N, P & K will intensify the protein synthesis by the way of supplying metabolic energy and also Zn present in the micronutrient mixture involved in the protein synthesis. Similar results were also obtained by Krishnamoorthy and Soorianathasundaram (8).

## Flowering and yield parameters

Days to flower bud appearance is an important parameter which decides the earliness of the crop yield (Table 2). In the present study, 75 % RDF @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray significantly advanced the time taken for first flower bud appearance. Early flowering might be due to the combined effect of fertigation and foliar application of micronutrients which could have made a conducive source sink relationship. Also the continuous availability of proteins, amino acids, nucleic acid and various enzymes and coenzymes associated with the increased shoot length and leaf area resulted in more photosynthesis and thus increased the transformation of manufactured food material from source (leaf) to sink (flower bud). These findings are in line with those of Beniwal *et al*. (2) in gladiolus Joshi *et. al.* (5) in chrysanthemum, and Singh and Tiwari (12) in tomato.

Stalk length and girth are the most important parameters of chrysanthemum which directly related to hold the flower and improve the vase life. Application of different schedules of fertilizer levels revealed that 100 % RDF @ 16 : 4 : 16 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture as foliar spray on 15 days interval ($T_7$) found to performed better for stalk length (120.15 cm) while 75 % RDF along with 0.2 % EDTA micronutrient mixture as foliar spray ($T_6$) registered the highest stalk girth (Table 2.). Combined application of fertigation and foliar application might have improved the length and girth of flower stalk and such influence could be described due to enhanced photosynthetic support optimized by presence of zinc and other micronutrients. This clearly indicated the necessity to provide combination of micronutrients to enhance the beneficial effects. Similar effects have also been documented in Kumar and Arora (10) and Singh *et al.* (13) in gladiolus. The beneficial effects of micronutrients have been clearly witnessed that 100 % RDF @ 16:4:16 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture spray ($T_7$) influenced opened flower circumference (10.59 cm). The results are in concurrence with Khosa *et al*. (7) in gerbera and Katiyar *et al.* (6) in gladiolus. The circumference of flower was significantly improved by the application of water soluble fertilizers (WSF) through drip fertigation as they boost the overall vegetative growth.

Increased flower yield/$m^2$ was obtained when 75 % RDF @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture spray ($T_6$) was used (Table 2). This might be attributed to the presence of soil organic acids inhibiting IAA oxidase enzyme and thereby increasing the flowering process. These findings are in agreement with those of Kumar (9) in chrysanthemum. The increase in flower yield by the application of iron and zinc elements producing healthy green leaves and in turn resulted in higher assimilate synthesis and partitioning of the flower growth. Per sq.m yield of 76.50 cut stems ($T_6$) in Amalfi was 17.26 per cent higher than control ($T_1$). Excellent flower quality with longer vase life fetches good market price. Longest vase life of flowers is the key issue in post harvest management of cut flowers and it assumed greater significance in flowers like chrysanthemum. The treatment of 75 % RDF @ 12:3:12 g NPK/$m^2$ along with 0.2 % EDTA micronutrient mixture spray at 15 days intervals resulted in the longest vase life. In chrysanthemum, the variation in vase life among the treatments might have attributed to the variation in levels of carbohydrate accumulation confirming to the reports of Joshi *et al.* (5). Continuous supply of micronutrients would have helped in maintenance of turgor in the leaf and flower and in turn favoured the higher vase life of carnation.

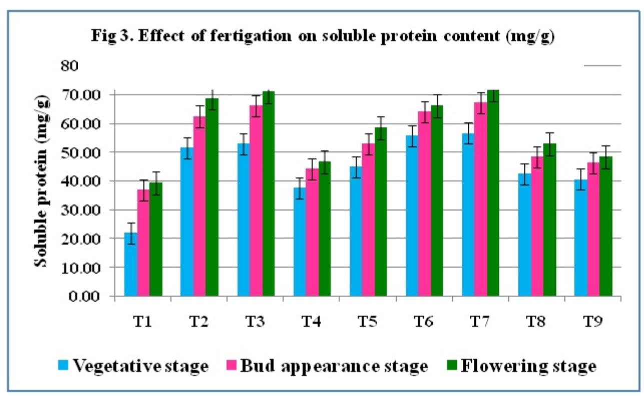


Fig. 3 : Effect of fertigation on soluble protein content (mg/g).

Based on the above results, it is recommended that 75 per cent of recommended dose of fertilizers at the rate of 12:3:12 g NPK/$m^2$ along with foliar spray of 0.2 per cent EDTA micronutrient mixture at 15 days intervals will improve the growth, physiology, yield and quality of cut chrysanthemum.

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**Citation :** Ganesh S., Kannan M. and Jawaharlal M. (2014). Optimization of fertigation schedule for cut chrystanthemum (*Dendranthema grandiflora* Tzvelev). *HortFlora Res. Spectrum,* **3**(4) : 344-348

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*HortFlora Research Spectrum*, 3(4): 349-352 (December 2014) ISSN : 2250-2823

# EFFECT OF POST-HARVEST APPLICATION OF DIPHENYLAMINE ON STORAGE LIFE AND QUALITY OF PUNJAB BEAUTY PEAR

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**ABSTRACT:** The study was conducted to assess the effect of antioxidant on post-harvest quality of pear fruits cv. Punjab Beauty with treatments of DPA (500, 1000 and 1500 ppm) during storage. After treatment the fruits were packed in corrugated fibre board (CFB) cartons and then stored in cold storage at 1-3°C temperature with 90-95% RH for 45, 60 and 75 days. The observations revealed that pear fruits treated with higher concentration of DPA i.e. 1500 ppm recorded lowest physiological loss in weight, spoilage losses, core browning and fruit colour degradation. Same concentration of diphenylamine (DPA) maintained higher fruit firmness, TSS, reducing sugars and acidity throughout storage period. With the prolongation of storage period physiological loss in weight (PLW%), spoilage percentage, core browning, fruit colour degradation, total soluble solids and reducing sugars followed an upward and acidity showed downward trend. Diphenylamine treated fruits could be cold stored for 75 days in CFB cartons with lowest weight loss, spoilage and better fruit quality. Fruits under control showed higher spoilage and shriveling due to loss of weight and firmness.

***Keywords :*** *Pear, post-harvest treatments, quality, diphenylamine*

Pears are among the most popular fruits in the world. Pear stands next after apples as the important tree fruit in the world, grown in all the continents of the world. There are over 3000 varieties of pears grown around the world. About 72% of all commercially cultivated species of genus *Pyrus* are native to Asia. They are an excellent source of fibre and a good source of vitamin C and K. Pears are free from sodium, fats, and cholesterol and are packed with energy producing natural sugars, potassium, copper, boron and healthy carbohydrates to promote proper organ function.

The pears are economically grown in the states like Jammu, lower hills of Himachal Pradesh, Punjab, Haryana and Uttarakhand. In Punjab, area under low-chilling pears is increasing due to release of a new semi-soft pear cv. Punjab Beauty. Punjab Beauty pear fruits mature in the third week of July, when temperature and humidity are high, which interferes with post-harvest quality and marketability of the fruits. Pear fruits are capable of developing good dessert quality upon ripening only when they are harvested at proper maturity. Pear fruit harvested with improper maturity are more susceptible to physiological disorders and have a shorter storage-life. Immature pear fruit are more susceptible to superficial scald, shriveling and friction discolouration while over mature fruits tend to have higher incidence of core breakdown and $CO_2$ injury (Mellenthin and Wang, 8). Physical changes and complex physiological reactions in pears depend upon fruit temperature. During storage, the tissue continues to respire and transpire during different metabolic processes, and looses a significant quantity of moisture and other chemical ingredients.

Diphenylamine (DPA) is commercially used in America and Europe on apple and pear cultivars as postharvest treatment against core browning and scald. DPA not only helpful in reducing weight loss, spoilage losses and core browning but also maintain fruit firmness, fruit colour and organoleptic rating (Singh, 9). Wax coatings containing diphenylamine (DPA) antioxidant in apples and pears significantly reduced rates of respiration, ethylene production, greener fruits and improved its external appearance (Farooqi and Hall, 4). In order to prevent the glut in the market and to curtail the post-harvest losses, quality storage of fruits is necessary. Therefore, efficacy of diphenylamine (DPA) on internal quality of Punjab Beauty pear grown under Punjab conditions was studied in order to improve its market quality and storage.

## MATERIALS AND METHODS

The present studies were conducted at Department of Horticulture, Punjab Agricultural University, Ludhiana during session 2006 and 2007. Disease free fruits of pear cv. Punjab Beauty having uniform shape and size were harvested on 15th July

*Received : 29-10-2014* *Accepted : 21-11-2014*

from New Orchard and post-harvest dip treatment in diphenylamine at three concentrations (500, 1000 and 1500 ppm) for 5 minutes was given. For the treatment as control, distilled water was used similarly as treated ones. Treatments were replicated thrice employing RBD factorial design. Two kg of fruits for each replication were packed in Corrugated Fibre Board (CFB) cartons and these cartons were placed in cool chamber at 1-3$^0$C and 90-95 per cent RH. After 45, 60 and 75 days of storage interval fruits were taken out for physical and biochemical observations. Physiological loss in weight (PLW), and spoilage and core browning were calculated on per cent basis. The fruit firmness was recorded with the help of 'Penetrometer' after removing about one square inch of skin from shoulder of the fruit and pressure reading was taken in Kg per square inch. TSS was determined with the hand refractrometer and acidity by titrating the juice against 0.1 per cent NaOH by using phenolphthalein indicator and expressed as per cent maleic acid. The reducing sugar contents were determined by method of Lane and Eynon (AOAC, 1).

**Table 1: Effect of diphenylamine on physiological loss in weight and firmness of Punjab Beauty pear fruits.**

| Treatments | Physiological loss in weight (%) | | | | Fruit firmness kg/Force) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 45 days | 60 days | 75 days | Mean | 0 days | 45 days | 60 days | 75 days | Mean |
| Control | 2.63 | 4.44 | 6.79 | 4.62 | 6.0 | 4.50 | 4.05 | 3.42 | 3.99 |
| DPA 500ppm | 1.34 | 2.94 | 5.49 | 3.26 | - | 4.80 | 4.37 | 3.73 | 4.30 |
| DPA 1000ppm | 0.50 | 2.10 | 4.39 | 2.33 | - | 4.92 | 4.44 | 4.04 | 4.46 |
| DPA 1500ppm | 0.26 | 1.33 | 4.14 | 1.91 | - | 5.13 | 4.76 | 4.26 | 4.71 |
| Mean | 1.18 | 2.70 | 5.20 | | - | 4.84 | 4.40 | 3.86 | |
| CD (P=0.05) | Treatment (T): 0.81<br>Storage Interval (SI): 0.70<br>T x SI: NS | | | | Treatment (T): NS<br>Storage Interval (SI): 0.6<br>T x SI: NS | | | | |

## RESULTS AND DISCUSSION

### Physiological Loss in Weight

The application of diphenylamine significantly influenced the physiological loss in weight (PLW) of Punjab Beauty pear fruits (Table1). PLW was significantly low after 45 days of cold storage whereas highest PLW was recorded after 75 days of storage. PLW was recorded with 1500 ppm DPA after 45 days of storage, which was significantly lower than control and found at par with DPA 1000 ppm and DPA 500 ppm. Similar findings have also been advocated by Farooqi and Hall (4) and Asrey *et al.* (2) who noticed the reduction of weight loss with coatings containing DPA and 1-MCP, respectively.

### Fruit firmness

The fruit firmness receded continuously with the storage days (Table 1). It was higher at the time of storage and decreased significantly after that up to 75 days where it was in low range. Among the different treatments, DPA 1500 ppm was found better in maintaining fruit firmness throughout the storage period and it was found at par with DPA 1000 ppm, whereas sharp decline in fruit firmness was recorded in control. Results are in confirmation with the findings of Mahajan and Chopra (7) in apple fruits. Higher fruit firmness in Kinnow mandarin due to 1-MCP treatment (Asrey *et al.,* 2) is in confirmity with present study.

### Fruit spoilage

The spoilage of fruits progressed gradually during storage as a results of different treatments and storage intervals (Table 2). Spoilage was lowest after 45 days while highest after 75 days of storage. Diphenylamine (1500 ppm) proved effective lowering the spoilage of fruits as compare to control. Drake *et al.* (3) also reported that in D'Anjou pears packed in boxes with ETH and Cu paper wraps developed less decay and scald than pears in polyethylene bags. Jawandha *et al.* (5) had also concluded that storage rot in Kinnow fruits can be reduced with boric acid (3%) + LDPE packaging treatmant.

### Core browning

Different treatments effected significantly with regard to core browning (Table 2). No core browning was observed in DPA (1500 ppm and 1000 ppm) treated fruits during cold storage. However core browning was occurred in fruits treated with DPA 500 ppm and control fruits. While considering days of storage intervals, no browning was recorded after 45 days in all the treatments. Fruits under control showed

**Table 2 : Effect of diphenylamine on spoilage (%) and organoleptic rating of Punjab Beauty pear fruits.**

| Treatments | Spoilage (%) | | | | Core browning (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | 45 days | 60 days | 75 days | Mean | 45 days | 60 days | 75 days | Mean |
| Control | 2.62 | 4.45 | 6.30 | 4.46 | 0 | 2.11 | 3.44 | 1.85 |
| DPA 500 ppm | 1.20 | 2.45 | 5.33 | 3.00 | 0 | 0 | 1.4 | 0.47 |
| DPA 1000 ppm | 0.00 | 2.23 | 4.25 | 2.16 | 0 | 0 | 0 | 0 |
| DPA 1500 ppm | 0.00 | 1.69 | 2.94 | 1.54 | 0 | 0 | 0 | 0 |
| Mean | 0.96 | 2.71 | 4.71 | | 0 | 0.53 | 1.21 | |
| CD (P=0.05) | Treatment (T): 0.37<br>Storage Interval (SI): 0.32<br>T x SI: 0.65 | | | | Treatment (T): 0.89<br>Storage Interval (SI): 0.77<br>T x SI: 0.35 | | | |

more browning percentage after 90 days of storage. The results are in accordance with findings of Kupferman and Gtuzwiler (6) whereported that shield DPA 2000 ppm and ethoxyquin 2700 ppm is effective to control the internal browning (IB) in Anjou Pear.

## Total Soluble Solids

An examination of the data (Table 3) clearly shows the effect of storage time and treatments on TSS contents of Punjab Beauty pear fruits. TSS level of cold stored fruits varied significantly when analyzed after different storage intervals (after 45, 60 and 75 days.) Different treatments showed their non-significant effect with regard to TSS. The level of TSS was lowest in fruits dipped in DPA 1500 ppm, DPA 1000 ppm and DPA 500 ppm while highest in control fruits. Singh (9) also observed that DPA 1500 ppm treated pear fruits showed higher TSS content as compared to the control.

## Titrable acidity

The titrable acidity (Table 3), measured in terms of total maleic acid content in the juice, showed a descending trend as the storage period advanced. Acidity was recorded at lower level after 75 days of storage and at higher after 45 days of cold storage. Effect of different treatments on acidity level was recorded maximum in the fruits dipped in DPA 1500 ppm followed by fruits treated with DPA 1000 ppm (0.301), however acidity was lowest (0.287%) in fruits under control after 75 days of storage. Apple fruits given dip treatment with DPA 1500 ppm + Frutox wax (6%) showed higher titratable acidity as compared to the untreated fruits (Mahajan and Chopra, 7).

**Table 3 : Effect of diphenylamine on TSS (%) and acidity (%) of Punjab Beauty pear fruits.**

| Treatments | TSS (%) | | | | | Acidity (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 days | 45 days | 60 days | 75 days | Mean | 0 days | 45 days | 60 days | 75 days | Mean |
| Control | 12.8 | 12.5 | 13.1 | 13.6 | 13.0 | 0.324 | 0.317 | 0.283 | 0.234 | 0.215 |
| DPA 500ppm | - | 12.7 | 12.5 | 13.5 | 13.5 | - | 0.338 | 0.312 | 0.268 | 0.232 |
| DPA 1000ppm | - | 12.3 | 12.7 | 13.3 | 13.0 | - | 0.344 | 0.320 | 0.296 | 0.244 |
| DPA 1500ppm | - | 12.1 | 12.4 | 13.1 | 13.1 | - | 0.347 | 0.331 | 0.308 | 0.268 |
| Mean | - | 12.4 | 12.7 | 13.4 | 13.1 | - | 0.336 | 0.311 | 0.276 | 0.240 |
| CD (P=0.05) | Treatment (T): NS<br>Storage Interval (SI): 0.31<br>T x SI: 0.54 | | | | | Treatment (T): NS<br>Storage Interval (SI): 0.21<br>T x SI: 0.37 | | | | |

## Reducing sugars

The data with respect to reducing sugars content recorded under various treatments and days of storage in pear fruits stored at cool temperature shows a steep increase up to 60 days and started decrease (Table 4). The high range of reducing sugar contents were recorded in fruits dipped in DPA 1500 and 1000 ppm. The lowest reducing sugars were recorded in fruits under control after 75 days of cold storage. The higher level of sugars in these treatments might be due to retained respiratory breakdown of polysaccharides. Singh (9) had advocated the similar findings in Patharnakh pear fruits.

**Table 4: Effect of diphenylamine on reducing sugar content of Punjab Beauty pear fruits.**

| Treatments | Days of storage | | | | |
|---|---|---|---|---|---|
| | 0 days | 45 days | 60 days | 75 days | Mean |
| Control | 7.54 | 5.68 | 6.40 | 5.95 | 5.28 |
| DPA 500 ppm | - | 5.51 | 6.05 | 6.46 | 5.37 |
| DPA 1000 ppm | - | 5.44 | 5.86 | 6.55 | 5.65 |
| DPA 1500 ppm | - | 5.38 | 5.86 | 6.59 | 5.74 |
| Mean | - | 5.50 | 6.04 | 6.39 | 5.51 |
| CD (P=0.05) | Treatment (T) : NS<br>Storage Interval (SI) : 0.36<br>T x SI: 0.65 | | | | |

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**Citation :** Kaur S. and Dhillon. W. S. (2014). Effect of post harvest application of diphenylamine on storage life and quality of Punjab Beauty pears. *HortFlora Res. Spectrum,* **3**(4) : 349-352

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 353-356 (December 2014) ISSN : 2250-2823

# EFFECT OF PRE-HARVEST SPRAY OF MH AND STORAGE CONDITIONS ON QUALITY OF BULBS OF SPIDER LILY (*Hymenocallis littoralis* L.) CV. LOCAL

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**ABSTRACT :** The present experiment on storage of bulbs of spider lily (*Hymenocallis littoralis* L.) cv. Local was carried out at Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh during 2011-2012. The experiment consisted of six levels of pre-harvest MH spray with four levels of storage conditions and it was laid out in Factorial Completely Randomized Design (FCRD) design with three replications. Pre harvest spray of MH 3000 ppm was found to be more effective for reducing weight of bulbs, size of bulbs, physiological loss of weight, sprouting of bulbs and spoilage of spider lily bulb. Similarly, biochemical parameters like TSS, total sugars, reducing sugar and non reducing sugar were also found better in MH 3000 ppm for storage of bulbs. During storage the bulbs should be kept in plastic carets at an ambient temperature having good circulation of air in the store room.

**Key words:** *Maleic hydrazide (MH), pre-harvest spray, spider lily, storage conditions.*

Spider lily (*Hymenocallis littoralis* L.) is native to South America and belongs to the family Amaryllidaceae. It is bulbous ornamental plant with 45-60 cm tall. It has long, broad and strap shaped light green leaves. It is cultivated for its white, fragrant spider shaped flowers for varied uses as loose flower for making *malas*, car decoration, bouquets, etc. An umbel produced 9-10 flowers on its head. 2-3 flower umbels are produced at a time on a single well developed plant. It is suitable for growing in the field as well as in pots. Also as cut flower it is attractive but the flowers do not last long. These are most suitable plants for border plantings in the greenhouse, alongside the boundary walls and water channels, in herbaceous border, alongside the lawn and also in beds in the gardens but these preferred sunny situations. As they are propagated through bulbs, during storage pre-planting sprouting and decay of bulbs are the serious problems. MH is a growth-regulatory substance that disrupts cell division. It spreads upwards and downwards. In stored bulbs it suppresses sprout and root growth. MH penetrates extensively into the plant and is transported in the phloem to actively growing tissues including the bulbs and tubers. Residues persist in these parts sufficiently to induce dormancy and hamper sprouting for fairly.

## MATERIALS AND METHODS

The experiment was carried out at Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh during 2011-2012. Three years old standing crop of spider lily was selected for pre harvest treatments. During the pre harvest spray the standing crop was under rest (leg phase of flowering). Spray of maelic hydrazide (MH) at different concentration was done as per treatments, one month before uplifting of bulbs The experiment consisted of six levels of pre-harvest MH spray $P_0$- Control (No MH treatment), $P_1$- 500 ppm, $P_2$- 1000 ppm, $P_3$- 2000 ppm, $P_4$- 3000 ppm and $P_5$- 4000 ppm. The bulbs were carefully dugout and uplifted. They were cleaned and separated from upper plant portion. Bavistin fungicide as treatment was given to these bulbs before storage study and stored in different four levels of storage conditions $S_0$- Plastic carets at 12°C, $S_1$- Net bags at 12°C, $S_2$- Plastic carets at an ambient temperature and $S_3$- Net bags at an ambient temperature and it was laid out in Factorial Completely Randomized Design (FCRD) design with three replications. Pre harvest treatment wise bulbs were stored at different conditions mentioned in treatments for storage study. During storage of five months at the end of each month the laboratory observations were recorded from February 2012 up to June month 2012.

## RESULTS AND DISCUSSION

### Effect of Pre-harvest MH Spray

#### *Physical parameters*

Treatment of MH 3000 ppm ($P_4$) resulted in outstanding effects on all vegetative parameters under trial (Table 1). Weight of bulbs was significantly

*Received : 27-11-2014* *Accepted : 14-12-2014*

decreased during initial month to fifth month (23.50g to 9.98g) in $P_4$ (MH 3000 ppm) but the decrease was minimum among all the MH treatments. Size of bulbs was also decreased from one month to fifth month storage (48.86mm to 43.88 mm). The decrease in the moisture content of the bulbs was also noticed. The pre-harvest spray of MH might be resulted in reduction in moisture content of the bulb was also noticed and thereby the hydrolysis of sugar minimises and ultimately resulted in highest dry matter content due to accumulation of more sugar (Mahadevaswamy, 4). Increase in physiological loss of weight (PLW) from one month to fifth month (2.10% and 46.28%, respectively) was found minimum with MH 3000 ppm ($P_4$). It might be due to the fact that MH acts as an inhibiting substance in reducing the respiration of the bulbs which in turn reduces the loss of moisture from the bulbs (Waskar *et al*., 10). The chemical has played a role in modifying the rate of gaseous exchange that takes place through the surface of the bulb by changing the balance of carbon dioxide and oxygen in the bulbs and, thus, minimizes the respiration and transpiration which in turn to reduce the rate of moisture loss and ultimately prevented the loss in weight (Mahadevaswamy, 4). Momin *et al.* (5) have also reported minimum weight loss in carnation cuttings stored for short duration. It might also be attributed to the beneficial effect of MH, an anti-auxin, which acts as mitotic inhibitor, chromosome breaking agent and growth suppressor (Pandey and Pandey, 6). Minimum sprouting percentage was found in $P_4$ (MH 3000 ppm) during storage of one months to fifth month (4.83% and 22.08%, respectively). This may be due to the prolonged dormancy or sprout inhibition for longer period after harvest by MH. This could be attributed to reduce neck thickness in sprayed bulbs and by way of minimized cell division and due to the removal of apical dominance inhibiting sprouts initiation. The residue of MH reduces mitotic activity in the cell and ultimate cell division and thereby reduced the length of sprouts in the bulbs (Singh and Dhankhar, 9). Among the MH treatments the minimum spoilage percentage during one month to fifth month storage was found in MH 3000 ppm (3.42% and 16.67%, respectively). The least spoilage per cent may be due to positive and beneficial effect of maleic hydrazide in reducing the neck thickness and preventing entry of microorganisms into the bulbs. Similar results were reported by Singh and Dhankhar (9) in onion.

**Table 1: Effect of pre harvest spray of MH concentrations and storage conditions on physical parameters of stored bulbs of spider lily.**

| Treatment | Storage period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Weight of bulb (g) | | Size of bulbs (mm) | | Physiological loss of weight (%) | | Sprouting percentage (%) | | Spoilage percentage (%) | |
| **Pre-harvest spray treatments** | Initial | Fifth month | Initial | Fifth month | One month | Fifth month | One month | Fifth month | One month | Fifth month |
| $P_0$ - 0 (Control) | 18.67 | 7.93 | 46.26 | 42.30 | 4.49 | 49.65 | 7.96 | 35.42 | 7.08 | 26.67 |
| $P_1$ - 500 ppm MH | 20.04 | 8.90 | 46.53 | 41.23 | 8.1 | 50.18 | 7.67 | 33.83 | 6.83 | 24.25 |
| $P_2$ - 1000 ppm MH | 21.54 | 9.79 | 46.82 | 39.63 | 17.69 | 54.56 | 7.88 | 31.17 | 6.50 | 23.17 |
| $P_3$ - 2000 ppm MH | 22.67 | 8.75 | 45.95 | 40.88 | 3.24 | 51.60 | 7.63 | 30.67 | 6.33 | 22.92 |
| $P_4$ - 3000 ppm MH | 23.50 | 9.98 | 48.86 | 43.88 | 2.10 | 46.28 | 4.83 | 22.08 | 3.42 | 16.67 |
| $P_5$ - 4000 ppm MH | 19.45 | 9.79 | 48.34 | 44.03 | 4.13 | 52.31 | 5.54 | 26.08 | 5.33 | 19.42 |
| C.D. (P=0.05) | 2.99 | 1.14 | 2.16 | 2.27 | 3.28 | 2.12 | 1.36 | 2.66 | 1.24 | 2.14 |
| **Storage conditions** | | | | | | | | | | |
| $S_1$ - Plastic carets at 12°C | 17.81 | 8.57 | 46.15 | 41.09 | 6.30 | 49.50 | 6.17 | 27.89 | 6.06 | 22.61 |
| $S_2$ - Net bags at 12°C | 20.23 | 9.31 | 46.14 | 42.35 | 06.82 | 53.98 | 5.72 | 27.67 | 6.28 | 23.56 |
| $S_3$ - Plastic carets at am ambient | 24.61 | 10.27 | 46.98 | 42.76 | 06.85 | 45.18 | 7.94 | 31.83 | 5.61 | 20.61 |
| $S_4$ - Net bags at an ambient temp. | 21.27 | 8.62 | 46.00 | 41.76 | 05.33 | 42.32 | 7.83 | 32.11 | 5.72 | 21.94 |
| C.D. (P=0.05) | NS | 0.93 | NS | NS | NS | 1.73 | 1.11 | 2.17 | NS | 1.75 |
| **Interactions: P × S** | | | | | | | | | | |
| C.D. (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| C.V.% | 17.35 | 15.04 | 5.58 | 6.58 | 35.00 | 9.13 | 23.98 | 10.84 | 25.51 | 11.74 |
| **Storage Period** | 20.98 | 9.19 | 47.13 | 41.99 | 5.40 | 48.24 | 6.92 | 29.88 | 5.92 | 22.18 |

**Table 2 : Effect of pre harvest spray of MH and storage conditions on chemical parameters of stored bulbs of spider lily.**

| Treatment | Storage period | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | TSS of bulb (ºBrix) | | Reducing sugar of bulb (%) | | Total sugar of bulb (%) | | Non-reducing sugar of bulb (%) | |
| **Pre-harvest spray treatments** | **Initial** | **Fifth month** | **Initial** | **Fifth month** | **Initial** | **Fifth month** | **One month** | **Fifth month** |
| $P_0$ - 0 (Control) | 9.83 | 6.96 | 1.80 | 0.62 | 3.61 | 5.01 | 1.81 | 4.37 |
| $P_1$ - 500 ppm MH | 10.25 | 7.43 | 1.86 | 0.77 | 3.86 | 5.07 | 2.00 | 4.30 |
| $P_2$ - 1000 ppm MH | 10.17 | 7.46 | 1.85 | 0.76 | 4.00 | 5.33 | 2.16 | 4.57 |
| $P_3$ - 2000 ppm MH | 10.25 | 7.58 | 1.80 | 0.74 | 4.09 | 5.65 | 2.30 | 4.91 |
| $P_4$ - 3000 ppm MH | 11.25 | 8.84 | 1.58 | 0.69 | 4.18 | 6.03 | 2.70 | 5.34 |
| $P_5$ - 4000 ppm MH | 10.75 | 8.24 | 1.47 | 0.76 | 4.17 | 5.92 | 2.60 | 5.16 |
| C. D. (P=0.05) | NS | 0.95 | 0.10 | 0.10 | 0.07 | 0.10 | 0.13 | 0.12 |
| **Storage conditions :** | | | | | | | | |
| $S_1$ - Plastic carets at 12°C | 10.00 | 7.24 | 1.74 | 0.68 | 3.97 | 5.46 | 2.24 | 4.70 |
| $S_2$ - Net bags at 12°C | 9.78 | 7.16 | 1.73 | 0.72 | 3.98 | 5.44 | 2.22 | 4.69 |
| $S_3$ - Plastic carets at am ambient | 11.72 | 9.03 | 1.77 | 0.76 | 4.02 | 5.59 | 2.33 | 4.96 |
| $S_4$ - Net bags at an ambient temp. | 10.17 | 7.58 | 1.67 | 0.73 | 4.00 | 5.51 | 2.23 | 4.75 |
| C.D. (P=0.05) | NS | 0.78 | NS | NS | NS | 0.08 | NS | 0.10 |
| **Interactions: P × S** | | | | | | | | |
| C.D. (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS |
| C.V.% | 11.65 | 14.92 | 7.33 | 16.58 | 2.15 | 2.18 | 7.04 | 3.01 |
| **Storage Period** | 10.42 | 7.75 | 1.72 | 0.72 | 3.99 | 5.50 | 2.26 | 4.77 |

### *Chemical parameters*

The highest T.S.S. was found in 3000 ppm maleic hydrazide (MH) in decreasing trend with advancing in storage period (11.25º Brix to 8.84, during fifth months), however, it was at par with $P_5$. This may be due to accumulation of more carbon dioxide and low oxygen inside the bulbs and its suicidal effect on respiration which ultimately reduces the respiration rate thereby reducing the losses of TSS (Mahadevaswamy, 4). Decreasing reducing sugar with lowest storage period and shortest reducing sugar was found in MH 3000 ppm (1.58% and 0.69%, respectively), this may be due to the utilization of reducing sugars, like glucose and fructose for respiration and sprouting during storage and thereby the level of these constituents decreased during on storage period (Patil and Kale, 7). Persual of Table 2 revealed that total sugar was significantly increased with increasing storage period (4.18% to 6.03%,) and it was the highest at 3000 ppm MH being at par with $P_5$. The decrease reducing sugars during storage in all treatments may be due to the utilization of reducing sugars, like glucose and fructose for respiration and sprouting during storage and thereby the level of these constituents decreased during of storage period. These results are in close agreement with the findings of Mahadevaswamy (4) in onion. Whereas, increasing in non-reducing sugar (2.70% to 5.34%,) was found with MH 3000 ppm ($P_4$), but it was at par with $P_5$. The maximum non-reducing sugar content was mainly due to less consumption of sugars in the process of respiration and minimum breakdown of non-reducing sugars results in increase in the non-reducing sugar content of the bulbs (Mahadevaswamy, 4).

## Effect of Storage Conditions

### *Physical parameters*

The spider lily bulbs stored in plastic carets at an ambient temperature of bulbs ($S_3$) were found superior with respect to minimum decrease in weight of bulb during one month to fifth month's storage (24.61g to 10.27g). This treatment also resulted in outstanding (lower) decrease of bulb size (46.98 mm to 42.76mm,) during five months storage (Table 1). This may be due to the maximum dry matter content during storage which could be reasoned due to the decreased moisture content of the bulbs and increased in chemical constituents in turn resulting in more bulb weight (Beukema and Vanderzaag, 1). Among the four storage conditions lowest physiological loss of weight during one month to fifth month storage (5.33% and 42.32%,) was found in net bags at an ambient temperature ($S_4$). Minimum PLW under cold conditions was probably due to less transpiration and respiration due to low temperature and high relative humidity in potato (Beukema and Vanderzaag, 1). Minimum sprouting percentage was found in net bags at 12ºC 5.72% to 27.67 %,) but it was at par with ($S_1$). Whereas, minimum spoilage percentage was found in plastic carets at an ambient temperature with lower rate in increasing spoilage percentage from initial to five months of storage. (5.61% to 20.61%). This may be due to proper ventilation as well as minimum fluctuation in storage temperature (Maini *et al.*, 3).

## *Chemical parameters*

Data in Table 2 revealed that maximum decrease in TSS was found in bulbs stored in plastic carets at an ambient temperature (11.72 ºBrix to 9.03 ºBrix,) Retaining of higher per cent of TSS may be due to more loss of moisture and increase in dry matter content of the bulb which leads to increase in TSS content. These results are in close conformity with findings of Saimbhi and Randhawa (8) in onion. Similarly, reducing sugar was found significantly highest in $S_3$ (plastic carets at an ambient temperature (1.77% to 0.76%) during fifth month. The higher per cent in loss of reducing sugar may be due to more loss of moisture and increase in dry matter content (Saimbhai and Randhawa, 8). Total sugar was found increasing with increase in storage period ($S_3$) in plastic carets at an ambient temperature (4.02% and 5.59%, respectively). This may be due to increase in total sugar content due to increase in pyruvic acid content which might have increased the synthesis of volatile compounds and enhanced non-reducing sugar (Kumar and Singh, 2). Similarly, non-reducing sugar was also found increasing with and increasing in storage period when stored in ($S_3$) plastic carets at an ambient temperature (2.33% to 4.96%)

From the foregoing discussion, it can be concluded that to get healthier and un-sprouted bulbs after five months of storage the standing lily crop must be sprayed with 3000 ppm MH before one month of harvesting (uplifting) of bulbs. Bulbs stored at an ambient temperature in plastic carets were also exhibited positive response for storage.

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**Citation :** Bhosale N. and Barad A.V. (2014). Effect of preharvest spray of MH and storage conditions on quality of bulbs of spider lily (*Hymenocallis littoralis* L.) cv. Local. *HortFlora Res. Spectrum,* **3**(4) : 353-356

www.hortflorajournal.com

*HortFlora Research Spectrum*, 3(4): 357-360 (December 2014) ISSN : 2250-2823

# IRRIGATION AND MULCHING EFFECTS ON LEMON PEEL PROPERTIES

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**ABSTRACT :** The peel is a natural package that protects the flesh from insect and microbial invasion and limits water loss and gas exchange. Marketing of lemon depends on the peel quality, thus, for the peel to become marketable, it must form and develop with few defects and be resilient enough to maintain its integrity on the tree and during postharvest storage. Moisture regulation is of utmost importance to get aimed fruit quality in lemon. As lemon is challenged with serious problem of fruit cracking which is directly related with peel parameters so timely scheduling of irrigation and moisture conservation needs to be emphasized on priority. To study the impact of moisture regulation, an experiment was laid out in Randomized Block Design comprising of six irrigation treatments with and without mulching at "Punjab Government Progeny Orchard & Nursery, Attari, Amritsar" during the fruiting years 2005 and 2006. Use of black polythene as mulch in combination with frequent irrigation after 3 days influenced the peel parameters the most.

***Keywords**: Lemon, black polythene, irrigation, mulching, peel.*

Lemon is principal acid citrus fruit used for culinary and non-culinary purposes throughout the world, primarily for its juice, though the pulp and peel are also used in cooking and baking. Lemon peel is an excellent source of fibre, potassium, magnesium, calcium, folate and beta carotene. Lemon peel contains about 5 to 10 times more vitamins than lemon juice. Lemon peel improves bone health as it contains high amount of calcium and vitamin C. When lemon peel is consumed it prevents various types of cancers, including skin cancer, colon cancer and breast cancer.

The fruit growers face many problems in cultivating lemon crop. One such problem is fruit cracking which is a long lasting problem and directly depends upon the peel parameters. The peel resistance and plasticity, determines the intensity of cracking and the location of the cracks (Knoche and Peschel, 9).It has been assessed that during the phase of cell enlargement, if the peel does not restart its growth, when the pulp expansion takes place, the fruit splits. The texture of peel attains ability to resist the pressure of the expanding juice vesicles. The moisture regulation and conservation creates favourable conditions for continued growth of peel for a longer span, making it sufficiently elastic to keep pace with the internal growth of pulp thereby, resisting pressure to split or crack.

Although a number of factors, both external and internal, are responsible for this malady but the peel parameters such as peel thickness are considered most responsible for the disorder. The soil moisture seemed to be major contributing factor in maintaining the peel quality. The weak peel offers stress on peel when pulp expands (Meng, 11), thus peel strength in terms of thickness is an important parameter. Morgan (12) advocated that sufficient water availability is a crucial factor for healthy citrus production. Peel thickness increases by avoiding the wide variation in soil moisture depletion, applying copious and regular irrigation during fruiting season (Measham, 10) along using some moisture conservation practices. As the fruit splitting is most likely to occur shortly before maturity when rain or irrigation follows a period of drought, thus, reducing the irrigation interval during peak summer period and the use of black polythene as mulch, results in healthy peel that restores appearance and storability (Bisht and Kumar, 2)

## MATERIALS AND METHODS

The plant material for investigation was selected from "Punjab Government Progeny Orchard & Nursery, Attari, Amritsar". In the trial, eight year old, uniform and disease free trees of lemon were selected to study the effect of various irrigation and mulching treatments on lemon peel. The experiment was laid out in Randomized Block Design having six treatments replicated thrice during both the experimental years (2005& 2006).

### Treatment details

$T_1$-Irrigation at 10-15 days interval (control)

$T_2$-Irrigation at 7 days interval

$T_3$-Irrigation at 3 days interval

*Received : 13-08-2014* *Accepted : 18-09-2014*

$T_4$-Irrigation at 10-15 days interval and mulching with black polythene sheet

$T_5$-Irrigation at 7 days interval and mulching with black polythene sheet

$T_6$-Irrigation at 3 days interval and mulching with black polythene sheet

The randomly harvested fruits were hand peeled and peel thickness was measured in millimeter with the help of Vernier Caliper. The mean peel thickness was calculated by taking the average of peel from 10 fruits. To determine the moisture content, the fruits were peeled off. The weight of peel was taken and then kept in the oven at 65ºC till a constant dry weight was obtained. The moisture content was expressed as the per cent of fresh weight of the peel of fruit. Chlorophyll 'a' and chlorophyll 'b' from the peel was determined by spectrophotometer (Arnon, 1). The spectrophotometer used was Hitachi U-2880, which is double beam spectrophotometer. The concentration of chlorophyll 'a' and 'b' was calculated by using the following formula :

Chlorophyll 'a' (mg/g of fresh weight)

$$= 12.7\,(A_{663}) - 2.89\,(A_{645}) \times \frac{V}{1000 \times W}$$

Chlorophyll 'b' (mg/g of fresh weight)

$$= 22.9\,(A_{645}) - 4.86\,(A_{663}) \times \frac{V}{1000 \times W}$$

Where, 'A' is the absorbance of chlorophyll extracts at the desired wavelength.

'V' is the final volume of the solution.

'W' is the weight of the sample taken.

Potassium and Calcium content of peel was determined by digesting these samples in di-acid mixture of nitric acid and perchloric acid in the ratio of 3:1. Potassium was estimated by flame photometer as described by Champman and Pratt (3) while Calcium was determined by atomic absorption spectrophotometer.

## RESULTS AND DISCUSSION

It can be clearly observed from the data (Table 1 and 2) that the peel thickness increased with every increase in the irrigation intensity and use of mulch during the two respective years of present investigation.The maximum peel thickness *viz.* 2.03 mm during 2005 and 2.06 mm during 2006 was recorded in the fruits of $T_6$ treatment while it was minimum (1.53 mm and 1.56 mm) in those trees irrigated at 10-15 days interval (control). Josan *et al.* (8) reported increase in peel thickness with increasing number of irrigations in lemon. Increase in peel thickness may be due to favourable change in the microclimate of the trees which were irrigated frequently. Better supply of water results in the prolonged growth of the peel. Decicco *et al*. (4) also reported increase in rind thickness of Navelina orange which was having more total available soil moisture. Mulching has significant effect on rind thickness of oranges (Ghali and Nakhalla, 6) as well as quality of strawberry (Singh *et al.,* 13). It is concluded that small increase in the rind thickness might have increased the resistance to fruit cracking.

Garcia-Luis *et al.* (5) studied the anatomy of the fruit in relation to the propensity of citrus species to split. The conflicting reports quoted by them indicate fruit splitting is a complex phenomenon which may be determined by a combination of factors. In this report, the anatomical characteristics of cultivars prone to splitting and those of cultivars which usually do not split have been compared. The relationship between anatomy of the fruit and splitting was further explored in hybrid Nova, comparing the characteristics of non-split and split fruits and the effect of hormone treatments both on splitting and the anatomy of the fruit. They described that fruit splitting results from the physical pressures of the rapidly expanding juice vesicles on the peel layers. These pressures stretch the albedo layer (mesocarp), whose cells enlarge tangentially during the period of rapid pulp growth while their radial diameter decreases and may lead eventually to peel collapse and cracking. The intensity of the stresses generated by the pressures, together with peel resistance and plasticity, determines the intensity of cracking and the location of the cracks. On theoretical grounds, it may be expected that an increase in peel thickness should increase the mechanical resistance of the peel and reduce splitting.

The moisture content of peel exhibited an increasing trend with increasing irrigation intensity. The highest moisture content of peel in lemon was reported in $T_6$ where it was recorded as 77.80 and 78.66 per cent respectively during both the trial years. Josan (7) reported increase in moisture content of peel with more irrigation. The increase in moisture content of peel might be due to better supply of water to various fruit parts during active growth period owing to ample availability of water with frequent irrigations. The present results of moisture content of peel and pulp in lemon are in corroboration with the findings of Josan (7). The practice of mulching also resulted in retaining soil moisture and better water supply resulting in increased moisture content of peel.

The maximum level of chlorophyll 'a' was recorded to the tune of 7.33 mg/100g fresh weight in first year and 7.28 mg/100g fresh weight during the second year with the application of irrigation at 3 days interval coupled with black polythene mulch. During both the years of study, the minimum chlorophyll 'a' content was obtained in control giving values 6.72 and 6.67 mg/100 g fresh weight. The trend for chlorophyll 'b' was also similar during both the evaluation years the highest value of 5.71 and 5.66 mg/100 g fresh weight in $T_6$ fruits. The content decreased with dryness or decreased irrigation intensity. Chlorophyll content of peel was higher under all irrigation and mulching treatments though it was maximum under treatment $T_6$ and minimum under control. The lower chlorophyll content of fruits under control was due to early maturation of the fruits in control than under various irrigation and mulching treatments where the maturation was delayed. Tomer and Singh (14) also reported increase in the chlorophyll content of leaves in Pant Lemon-1 when irrigation was done frequently.

The calcium content in peel was highest in fruits of control treatment $T_1$ viz. irrigation at 10-15 days interval, to the tune of 1.10 per cent during first trial year and 1.11 per cent during second year. The level of calcium content in peel was quite low in $T_6$ (1.02 per cent and 1.03 per cent). The perusal of the data presented in Table 1 and 2 clearly indicate that the irrigation and mulching treatments failed to produce any significant effect on potassium content of peel as majority of the treatments were statistically at par with each other. The highest value of potassium content of peel to the tune of 0.74 per cent during 2005 and 0.76 per cent during 2006 was recorded with application of irrigation at 3 days interval and mulching with black polythene sheet *viz.* $T_6$. Tromp (15) also reported similar findings in apple that uptake of potassium increased under increasing water availability so the increase in potassium content of peel as observed in the present investigations may also be because of enhanced uptake of potassium due to increased water supply as

**Table 1: Effect of irrigation and mulching on peel characters of lemon fruit during 2005.**

| Treatment | Peel thickness (mm) | Moisture content of peel (%) | Chlorophyll 'a' (mg/100g fresh weight) | Chlorophyll 'b' (mg/100 g fresh weight) | Calcium content of peel (%) | Potassium content of peel (%) |
|---|---|---|---|---|---|---|
| $T_1$ | 1.53 | 73.53 | 6.72 | 5.09 | 1.10 | 0.66 |
| $T_2$ | 1.73 | 75.00 | 6.97 | 5.30 | 1.08 | 0.69 |
| $T_3$ | 1.90 | 76.10 | 7.19 | 5.53 | 1.04 | 0.70 |
| $T_4$ | 1.73 | 74.85 | 6.96 | 5.28 | 1.09 | 0.68 |
| $T_5$ | 1.86 | 75.80 | 7.16 | 5.45 | 1.05 | 0.70 |
| $T_6$ | 2.03 | 77.80 | 7.33 | 5.71 | 1.02 | 0.74 |
| CD (P=0.05) | 0.11 | 0.30 | 0.12 | 0.15 | NS | 0.03 |
| CV % | 3.51 | 0.23 | 0.99 | 1.63 | 3.86 | 2.94 |

**Table 2 : Effect of irrigation and mulching on peel characters of lemon fruit during 2006.**

| Treatment | Peel thickness (mm) | Moisture content of peel (%) | Chlorophyll 'a' (mg/100g fresh weight) | Chlorophyll 'b' (mg/100 g fresh weight) | Calcium content of peel (%) | Potassium content of peel (%) |
|---|---|---|---|---|---|---|
| $T_1$ | 1.56 | 74.66 | 6.67 | 5.04 | 1.11 | 0.67 |
| $T_2$ | 1.76 | 76.13 | 6.92 | 5.22 | 1.10 | 0.70 |
| $T_3$ | 1.93 | 77.08 | 7.10 | 5.48 | 1.05 | 0.72 |
| $T_4$ | 1.73 | 76.07 | 6.91 | 5.23 | 1.11 | 0.68 |
| $T_5$ | 1.90 | 76.86 | 7.03 | 5.36 | 1.06 | 0.71 |
| $T_6$ | 2.06 | 78.66 | 7.28 | 5.66 | 1.03 | 0.76 |
| CD (P=0.05) | 0.08 | 1.37 | 0.13 | 0.12 | NS | 0.04 |
| CV % | 2.58 | 0.99 | 1.10 | 1.24 | 4.36 | 3.40 |

compared to control. The low level of calcium in peel may be due to its competitive absorption with potassium. In the present studies, low calcium content in peel could be attributed to less translocation of calcium than potassium.

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**Citation :** Khehra S. (2014). Irrigation and mulching effects on lemon peel properties. *HortFlora Res. Spectrum,* **3**(4) : 357-360

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 361-364 (December 2014) ISSN : 2250-2823

# INTEGRATED DISEASE MANAGEMENT FOR LATE BLIGHT AND BACTERIAL WILT IN POTATO AT DIFFERENT LOCATIONS OF ARUNACHAL PRADESH

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**ABSTRACT :** The demonstration programme of bio-control based IPM in potato was carried out at three locations of East Siang district of Arunachal Pradesh. Potato variety Kufri Pukhraj was used. The crops were planted at 4th, 10th and 15th November in the Farmer's practice, untreated control plot and IPM practice, at Jhampani. At Oyan, the crop was planted on 31st October in the Farmer's practice, 5th November in both untreated control plot and IPM practice and at Sille the crop was planted on 19th, 20th and 20th October in the IPM practice, Farmer's practice and untreated control plot, respectively. The crop was harvested at 90 days after planting. However, at 50 DAP, no significant difference was observed between the three treatments at Jhampani and between farmer's practice (4.00%) and control (10.00%) at Sille. Farmer's practice field recorded significantly lower incidence of late blight than the other two treatments in all the three locations at both 50 and 60 DAP. Highest incidence of the disease (70.07 per cent leaf area damage) was observed in untreated control (Sille) at 60 DAT. IPM practice recorded 20.60, 15.87 and 44.67 per cent leaf area damage at 60 DAP at Jhampani, Oyan and Sille and were significantly lower than the untreated control in their respective locations. The outcome compared with all the locations, Oyan was found better and also significantly superior over rest of the location against bacterial wilt incidence of potato.

**Keywords:** *Integrated disease management, late blight, bacterial wilt, potato.*

Potato (*Solanum tuberosum* L.) is one of the most important food crop after wheat, maize and rice; historically contributing to food and nutritional security in the world (Pandey *et al*., 9). It is used as vegetable, stock feed and in industries for manufacturing starch, alcoholic beverages and other processed products. Potato is also an important crop in the NEH region of India comprising the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. NEH region covers almost 9% of the area of the country and about 4.5% of its population. Potato crops suffer from several diseases at different stages of its growth. All the parts of the plants such as the branch, leaf, petioles and tubers are attacked by a number of pathogens including fungi, bacteria and viruses.

Late blight of potato caused by *Phytophthora infestans* is one of the most important and devastating diseases affecting potato crops (*Solanum tuberosum* L.) in different countries of the world (Fernandez-Northcote *et al*., 3; Namanda *et al*., 8). Historically, the disease has often resulted in destructive consequences and the most documented event is the great famine caused by this disease in Ireland (1845) when almost half of the potato crop was destroyed (Fernandez-Northcote *et al.*, 3).

This disease is favoured by wet conditions with high humidity (> 90%) but this fungus has great ability to adopt to variety of environments (Ahmad and Mirza, 1) that is why it is found in temperate as well as in subtropical regions. During moist weather, whole plants may be killed in a short time. (George and Preston, 5) and it spread very rapidly if kept unchecked (Khan *et al*., 7).

Bacterial wilt of potato is most serious disease caused by soil borne plant pathogen *Ralstonia solanacearum* E.F. Smith (Yabucchi *et al*., 11), cause a considerable amount of damage to potato and many other crops in tropical, subtropical and warm temperate region of the world (Ji *et al*., 6). The pathogen invades through wounds in roots, lateral root emergence points or stomata and colonizes the intercellular spaces of the root cortex and vascular parenchyma, eventually entering the xylem vessels. In the xylem vessels the pathogen dissolves the cell walls and produce highly polymerized polysaccharides that increase the viscosity of the xylem and results in plugging. Blocking of vessels by bacteria is the major cause of wilting. It is a very destructive pathogen that causes wilt on potato and many other solanaceous crops with incidence on potato as high as 63% in major potato growing areas (Bekele, 2).

*Received : 06-10-2014* *Accepted : 21-11-2014*

The present study was designed to assess the effects of various IPM based bio-control management for the bacterial wilt and late blight of potato in various locations and find out the best treatment for managing both the disease in such locations.

## MATERIALS AND METHODS

The present study was carried out at three locations of East Siang district of Arunachal Pradesh during 2011-12 and 2012-13. Potato variety "*Kufri Pukhraj*" was used. The crops were planted at 15$^{th}$ November, 4$^{th}$ November and 10$^{th}$ November in the IPM practice, Farmer's practice and untreated control plot at Jhampani village. At Oyan village, the crop was planted on 5$^{th}$ Nov., 31$^{st}$ October and 5$^{th}$ November in the IPM practice, Farmer's practice and untreated control plot and at Sille village the crop was planted on 19$^{th}$, 20$^{th}$ and 20$^{th}$ October in the IPM practice, Farmer's practice and untreated control plot, respectively. The crop was harvested at 90 days after planting at all the villages. The IPM practice included dipping of potato tuber in 2% *Pseudomonas florescence* solution (SU-Mona, Pest Control India, Maharashtra) before planting, spraying of 3% neem oil (Multineem, Multiplex Agricare Karnataka) at 20, 30, 40 and 50 DAP. Farmer's practice included soil treatment with bleaching powder @ 20 kg/ha and spraying of Ridomil (Metalaxyl 8% + Mancozeb 64%, Syngenta, Mumbai, Maharashtra)/ Matco (Metalaxyl 8% + Mancozeb 64%, Indofil Chemicals Company, Mumbai, Maharashtra)@ 2g /lit at 20, 30, 40, 50 and 60 DAP. In all the three locations, three treatments were maintained. The bacterial wilt (*Ralstonia solanecea-rum*) infestation was recorded by randomly selecting 20 plants and counting the total number of wilted plants from 5 different areas of each treatment considering as five replications. The blight infestation was recorded as average of five plants/ plot from 5 randomly selected leaves of each plant as of three different areas of each treatment. The data on disease infection was recorded using 0-9 disease rating scale given by Shutong *et al*. (10) as shown in Table1.

**Table 1 : Rating scale for the assessment of late blight severity on potato leaves (Shutong *et al.*, 10)**

| Disease severity rating grade | Disease incidence (%) | Level of resistance/ Susceptibility |
|---|---|---|
| 0 | 0.0 | No Disease |
| 1 | 10% | Small lesion on the inoculated point with the lesion area less than 10 % of the whole leaflet |
| 3 | 10% and 20% | Lesion area between 10% and 20% of the whole leaflet |
| 5 | 20% and 30% | Lesion area between 20% and 30% of the whole leaflet |
| 7 | 30% and 60% | Lesion area between 30% and 60% of the whole leaflet |
| 9 | Over 60% | Lesion area over 60% of the whole leaflet |

## RESULTS AND DISCUSSION

The data were recorded for disease incidence of late blight of potato at all the three locations given in (Table 2) at Jhampani, negligible mean percentage of wilt plant was recorded in the Farmer's practice (2.07 %) followed by in IPM (7.53 %) and maximum (16.47 %) in untreated control. However, highest yield (239.73 q/ha) was obtained in Farmer's practice followed by IPM practices yield (224.41 q/ha) and least yield (186.35 q/ha) and was recorded in untreated control.

At Oyan, mean incidence of late blight was less recorded in Farmer's practice (2.67 %) followed by IPM (5.93 %) and maximum (9.80 %) in untreated control. However, highest yield (250.77 q/ha) was obtained in Farmer's practice followed by IPM practices yield (230.60 q/ha) and lowest yield (200.60 q/ha) and was recorded in untreated control.

At Sille, mean incidence of late blight was less recorded in Farmer's practice (4.33%) followed by IPM (19.29 %) and maximum (36.05 %) in untreated control. However, highest yield (234.95 q/ha) was obtained in Farmer's practice followed by IPM practices yield (193.93 q/ha) and lowest yield quintal / ha (156.51) and was recorded in untreated control. The outcome compared with all the locations, Oyan was found better and also significantly superior over rest of the location against late blight incidence of potato.

However, at 50 DAP, no significant difference was observed between the three treatments at Jhampani and between farmer's practice (4.00%) and control (10.00%) at Sille. Farmer's practice and IPM practice were at par in all the locations. Farmer's practice field recorded significantly lower incidence of late blight than the other two treatments in all the three locations at both 50 and 60 DAP. Highest incidence of the disease (70.07 per cent leaf area damage) was observed in untreated control (Sille) at 60 DAT. IPM practice recorded 20.60, 15.87 and 44.67 per cent leaf area damage at 60 DAP at Jhampani, Oyan and Sille and were significantly lower than the untreated control in their respective locations.

**Table 2 : Bio efficacy of IPM against late blight of potato during *Rabi*, 2011-12.**

| Treatments | Per cent infection/ leave | | | | Tuber yield (q/ha) |
|---|---|---|---|---|---|
| | 40 DAT | 50 DAT | 60 DAT | Mean | |
| **At Jhampani** | | | | | |
| (i) IPM | 0.00 (0.00) | 2.00 (8.06) | 20.60 (26.98) | 7.53 (11.68) | 224.41 |
| (ii) Farmer's practice | 0.00 (0.00) | 0.00 (0.00) | 6.20 (14.14) | 2.07 (4.71) | 239.73 |
| (iii) Control | 1.47 (6.84) | 13.07 (21.10) | 35.67 (36.64) | 16.74 (21.20) | 186.35 |
| **At Oyan** | | | | | |
| (i) IPM | 0.00 (0.00) | 1.93 (7.98) | 15.87 (23.45) | 5.93 (10.48) | 230.60 |
| (ii) Farmer's practice | 0.00 (0.00) | 0.67 (4.63) | 7.33 (15.58) | 2.67 (6.74) | 250.77 |
| (iii) Control | 0.00 (0.00) | 8.87 (17.21) | 20.53 (26.88) | 9.80 (14.70) | 200.60 |
| **At Sille** | | | | | |
| (i) IPM | 0.00 (0.00) | 13.20 (21.30) | 44.67 (41.91) | 19.29 (21.07) | 193.93 |
| (ii) Farmer's practice | 0.00 (0.00) | 4.67 (12.36) | 8.33 (16.69) | 4.33 (9.68) | 234.95 |
| (iii) Control | 4.40 (12.08) | 32.67 (34.86) | 71.07 (57.62) | 36.05 (34.85) | 156.51 |
| CD (P=0.05) | 1.15 | 2.47 | 4.87 | 11.27 | 15.15 |
| CV% | 28.95 | 10.06 | 9.73 | 39.77 | 4.11 |

**Table 3 : Bio efficacy of IPM against bacterial wilt of potato during *Rabi*, 2011-12 and 2012-13**

| Treatments | Per cent wilted plant | | | Tuber yield (q/ha) |
|---|---|---|---|---|
| | 40 DAT | 50 DAT | Mean | |
| **At Jhampani** | | | | |
| (i) IPM | 1.00 (2.58) | 2.00 (5.17) | 1.50 (3.88) | 224.41 |
| (ii) Farmer's practice | 1.00 (2.58) | 2.00 (5.17) | 1.50 (3.88) | 239.73 |
| (iii) Control | 5.00 (9.91) | 4.00 (8.86) | 4.50 (9.39) | 186.35 |
| **At Oyan** | | | | |
| (i) IPM | 2.00 (5.17) | 1.00 (2.58) | 1.50 (3.88) | 230.60 |
| (ii) Farmer's practice | 1.00 (2.58) | 1.00 (2.58) | 1.00 (2.58) | 250.77 |
| (iii) Control | 4.00 (8.78) | 6.00 (12.54) | 5.00 (10.66) | 200.60 |
| **At Sille** | | | | |
| (i) IPM | 2.00 (5.17) | 3.00 (6.27) | 2.50 (5.72) | 193.93 |
| (ii) Farmer's practice | 2.00 (5.17) | 4.00 (8.86) | 3.00 (7.02) | 234.95 |
| (iii) Control | 8.00 (14.52) | 10.00 (16.62) | 9.00 (15.57) | 156.51 |
| CD (P=0.05) | NS | 9.11 | 5.30 | 15.15 |
| CV% | | 90.58 | 34.41 | 4.11 |

**Figures in the parentheses are angular transformed values.*

The data were recorded for disease incidence of bacterial wilt of potato at all the three locations given in (Table 3) at Jhampani, negligible mean percentage of wilt plant was recorded in the IPM as well as Farmer's practice (1.50 %) and maximum (4.50 %) in untreated control. However, highest yield (239.73 q/ha) was obtained in Farmer's practice followed by IPM practices yield (224.41 q/ha) and least yield (186.35 q/ha) and was recorded in untreated control.

At Oyan, mean incidence of bacterial wilt was less recorded in Farmer's practice (1.00 %) followed by IPM

(1.50 %) and maximum (5.00 %) in untreated control. However, highest yield (250.77 q/ha) was obtained in Farmer's practice followed by IPM practices yield (230.60 q/ha) and lowest yield (200.60 q/ha) and was recorded in untreated control.

At Sille, mean incidence of bacterial wilt was less recorded in IPM (2.50 %) followed by Farmer's practice (3.00 %) and maximum (9.00 %) in untreated control. However, highest yield (234.95 q/ha) was obtained in Farmer's practice followed by IPM practices yield (193.93 q/ha) and lowest yield quintal / ha (156.51) and was recorded in untreated control. The outcome compared with all the locations, Oyan was found better and also significantly superior over rest of the location against bacterial wilt incidence of potato.

Delaying the date of planting reduced the bacterial wilt incidence. This was attributes to decreasing temperature during cropping period (French, 4). Among the locations, higher incidence of the disease was recorded at Sille and it may be due to late planting of the crop. In all the locations, higher tuber yield was recorded in Farmer's practice field and it was followed by IPM practice.

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**Citation :** Singh K.M., Shakywar R.C. and Kumawat M.M. (2014). Integrated disease management for late blight and bacterial wilt in potato at different locations of Arunachal Pradesh. *HortFlora Res. Spectrum,* **3**(4) : 361-364

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 365-368 (December 2014) ISSN : 2250-2823

# EFFECT OF NITROGEN SOURCES AND PHOSPHORUS ON BULBS AND BULBLETS PRODUCTION OF TUBEROSE CV. DOUBLE

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**ABSTRACT :** An experiment was laid during two consecutive years in Horticulture garden of CSAUA&T, Kanpur.There were three nitrogenous sources *viz.* urea ammonium sulphate and calcium ammonium nitrate,four levels of nitrogen *viz* 0,50,100 and 150 kg/ha, and four levels of phosphrus *viz* 0,100,200 and 300 kg/ha thus consisting total number of forty treatments replicated thrice in Factorial Randomized Block Design. Calcium ammonium nitrate treatments revealed greater harvest of bulbs/clump both by number (9.43, 8.97) and weight (229.90, 235.0g) and bulblets/clump (10.56,10.80 and 115.78,123.14g) in first and second year, respectively. Nitrogen @100kg/ha produced highest bulblets per clump (10.50 and 11.09) during both the years of investigation. This trend was same regarding the weight which revealed 106.60 and 115.91 g respectively. The weight of bulbs and bulblets greatly influenced by application of phosphorus at the rate of 200 kg/hectare It also induced maximum number and weight of bulblets (10.44,10.81 and 104.74,113.47 g) during both the years The highest dose of phosphorus 300 kg/ha reduced the number and weight of bulblets (10.19,10.29 and 93.75,105.60 g) during both the years of investigation.

**Keywords:** *Tuberose, nitrogen,phosphorus, source of nitrogen,bulb, bulblets.*

Tuberose (*Polianthes tuberosa* L.), a native of Maxico, belongs to the family Amaryllidacease. It is cultivated on large scale in France, Italy, South Africa, North Carolina, U.S.A. and in India in many tropical and sub-tropical areas such as Maharashtra, West Bengal, Tamil Nadu and Karnataka. It is, however, well adopted to North Indian climatic conditions yet its growth well in Uttar Pradesh. The tuberose occupies very selective and special position among the ornamental bulbous plants for flower loving people because of its prettiness elegance and pleasantly sweet fragrance.It has great economic potential for cut flower trade and essential oil industries.

## MATERIALS AND METHODS

The present investigation entitled "Effect of nitrogen sources and phosphorus on bulbs and bulblets production of tuberose (*Polianthes tuberosa* L.)" was conducted under the eco-edaphic conditions prevailing at Horticulture Garden of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.),India during the two consecutive years, 1998-99 and 1999-2000. Uniform and healthy bulbs of tuberose cv. Double having 2.5-3.0 cm diameter were procured from N.B.R.I.Lucknow.In order to assess to exat nature and composition of soil,samples up to 20 cm depth were collected and anaylised in the Department of Agriculture Chemistry and Soil Science for physico-chemical components. The required dose of nitrogen 50kg ($N_1$),100kg ($N_2$) and 150kg ($N_3$) per hectare; and phosphorus 100kg ($P_1$),200kg ($P_2$) and 300kg ($P_3$) per hectare as per treatments were applied. Control plots were not given any fertilizer treatment. The sources of nitrogen were Urea ($S_1$), Ammonium Sulphate ($S_2$) and Calcium Ammonium Nitrate ($S_3$). Phosphorus as per treatment and potash as per recommendation were applied in form of single superphosphate and muriate of potash, respectively. Full dose of phosphorus and half dose of nitrogen were applied as basal dressing ,and remaining half dose of N was applied as split doses at 60 and 90 days after planting. All the recommended cultural and plant protection measures were applied. The experiments were laid out by following Factorial Randomized Block Design in both consecutive years of experimentation with three replications. Thus, 120 plots (1.0x 1.0m size) were used for 40 treatment combinations. Biometric observations for stock production i.e., number and weight of bulbs and bulb lets were taken for both the experimental years. Data were analyzed through computer as suggested by Panse and Sukhatme (7).

## RESULTS AND DISCUSSION

The number of bulbs per clump was counted at harvest under both the trials. It is obvious that nitrogen applied @ 100 kg/ha and 150 kg/ha increased the number of bulbs per clump (8.99, 8.62, and 8.92,9.06) in tuberose significantly during first and second year, respectively (Table 1). The plants under control

*Received : 15-10-2014* *Accepted : 11-11-2014*

revealed poorest harvest (6.89 and 7.26 bulbs) during both corresponding years. These findings are in agreement with the reports of Bhattacharjee (1), Chaudhary (4), Kumar and Singh (5) and Rathore and Singh (8) in gladiolus and tuberose. Phosphorus application @ 300 kg/ha gave the highest number of bulbs (9.70 and 9.18) followed by its 200kg treatment (8.73 and 8.80). All the levels of P significantly brought lower production of bulbs when compared with its control (7.17 and 7.40 bulbs/clump) barring $P_1$ (100 kg/ha) during second year of trial. These findings are in line with the reports of Bhattacharjee (1) and Mostafa *et al.(*6) in gladiolus and tuberose. Among, sources of nitrogen fertilization, calcium ammonium nitrate caused significantly higher number of bulbs per clump (9.43 and 8.97) followed by ammonium sulphate (8.59 and 8.74) during both the years, respectively. However, both of these fertilizers being superior than urea remained significantly at par when compared with themselves. Results are inconsonance with Chaudhary (4) and Mostafa *et al.*(6) in tuberose.

production of bulbs weight (219.10,225.50 and 229.90,235.00 g) during both corresponding years of investigation. Increasing levels of nitrogen significantly improved the weight of tuberose bulbs per clump.The maximum weight of bulbs were revealed by application of 150 kg N/ha, *i.e.* 227.40 and 233.70 g and the control produced by the significantly poorest bulb weight (180.70 and 188.90 g) during both the years of investigations. Results are similar with the reports of Chaudhary (4), Mostafa *et al.* (6), Rathore and Singh (8), Bhattacharjee (1) and Singh (10) in tuberose and gladiolus. Increasing doses of P increased the weight of tuberose bulbs during both the years and highest dose i.e. 300 kg/ha revealed the maximum bulb weight (231.50 and 236.40 g) followed 200 kg/ha treatment (220.70 and 227.50 g).The plants under its control ($P_0$ ) expressed significantly poorest yield of bulbs (187.90 and 193.90 g) during both the years of trials.These findings are in agreement with the reports of Mostafa *et al. (79), Bhattarcharjee et al.* (2) in tuberose and Bhattacharjee (1) and Shalska (9) in gladiolus.

**Table 1: Effect of nitrogen and phosphorus with influence of nitrogen sources on bulbs and bulbelts production in tuberose cv. Double.**

| Treatments | Number of bulbs per clump | | Weight of bulb per clump(g) | | Number of bulbelts per clump | | Weight of bulbelts per clump(g) | |
|---|---|---|---|---|---|---|---|---|
| | 1998-99 | 1999-2000 | 1998-99 | 1990-2000 | 1998-99 | 1999-2000 | 1998-99 | 1999-2000 |
| Urea ($S_1$) | 7.74 | 7.83 | 200.80 | 206.40 | 9.72 | 10.12 | 82.75 | 92.81 |
| Amonium Sulphate($S_2$) | 8.59 | 8.74 | 219.10 | 225.50 | 10.48 | 10.55 | 99.73 | 109.19 |
| Calcium Ammonium Nitrate ($S_3$) | 9.43 | 8.97 | 229.90 | 235.00 | 10.56 | 10.80 | 115.78 | 123.14 |
| 0 kg N/ha ($N_0$) | 6.98 | 7.26 | 180.70 | 188.90 | 8.28 | 9.60 | 73.52 | 82.37 |
| 50 kg N/ha ($N_1$) | 7.85 | 7.85 | 206.00 | 210.70 | 9.92 | 9.93 | 93.70 | 103.12 |
| 100 kg N/ha ($N_2$) | 8.99 | 8.62 | 216.40 | 222.40 | 10.50 | 11.09 | 106.60 | 115.91 |
| 150 kg N/ha ($N_3$) | 8.92 | 9.06 | 227.40 | 233.70 | 10.33 | 10.45 | 97.90 | 106.11 |
| 0 kg P/ha ($P_0$) | 7.17 | 7.40 | 187.90 | 193.90 | 9.55 | 9.92 | 90.63 | 98.84 |
| 100 kg P/ha ($P_1$) | 8.09 | 8.17 | 212.10 | 218.00 | 10.32 | 10.60 | 98.21 | 105.22 |
| 200 kg P/ha ($P_2$) | 8.73 | 8.80 | 220.70 | 227.50 | 10.44 | 10.81 | 104.74 | 113.47 |
| 300 kg P/ha ($P_3$) | 9.70 | 9.18 | 231.50 | 236.40 | 10.19 | 10.29 | 93.75 | 105.60 |
| CD (P=0.05) | | | | | | | | |
| S | 0.98 | 0.54 | 9.47 | 12.46 | 0.65 | N.S. | 3.41 | 3.46 |
| N | 0.98 | 0.55 | 9.45 | 12.40 | N.S. | N.S. | 3.43 | 3.46 |
| P | 1.14 | 0.63 | 10.54 | 14.39 | NS | NS | 3.93 | 3.99 |

The weight of bulbs per clump of each treatment were recorded. Urea treatment, however gave significantly poorest harvest (200.80 and 206.40 g) whereas, other fertilizers i.e. ammonium sulphate and calcium ammonium nitrate caused significantly greater

It is obvious from the mean values (Table 1) that out of three sources of nitrogen nutrition,calcium ammonium nitrate proved most effective as compared to rest of sources producing 115.78 and 123.14 g bulblets per clump during both the years of study,

**Table 2: Interactive effect of phosphorus and source of nitrogen (P X S) on bulbs and bulblets production in tuberose cv.Double.**

| Treatment | Number of bulbs per clump | | Weight of bulbs per clump (g) | | Number of bulbets per clump | | Weight of bulblets per clump (g) | |
|---|---|---|---|---|---|---|---|---|
| | 1998-99 | 1999-2000 | 1998-99 | 1999-2000 | 1998-99 | 1999-2000 | 1998-99 | 1999-2000 |
| $P_0S_1$ | 6.68 | 7.17 | 175.90 | 182.90 | 9.07 | 9.62 | 74.05 | 86.66 |
| $P_0S_2$ | 7.72 | 7.79 | 197.70 | 204.70 | 10.07 | 10.36 | 94.04 | 101.56 |
| $P_0S_3$ | 8.09 | 8.20 | 216.10 | 219.30 | 10.58 | 10.69 | 116.23 | 119.83 |
| $P_1S_1$ | 7.76 | 7.66 | 203.10 | 209.20 | 9.97 | 10.21 | 82.24 | 90.33 |
| $P_1S_2$ | 8.32 | 8.61 | 217.10 | 221.90 | 10.59 | 10,85 | 99.16 | 106.43 |
| $P_1S_3$ | 8.71 | 8.61 | 226.90 | 232.80 | 10.69 | 10.92 | 120.50 | 127.03 |
| $P_2S_1$ | 8.15 | 8.14 | 207.60 | 214.50 | 10.18 | 10.50 | 89.10 | 99.03 |
| $P_2S_2$ | 9.01 | 9.12 | 223.70 | 231.90 | 10.75 | 10.82 | 110.03 | 119.40 |
| $P_2S_3$ | 9.27 | 9.34 | 234.60 | 239.50 | 10.46 | 11.16 | 122.04 | 128.92 |
| $P_3S_1$ | 8.37 | 8.36 | 216.80 | 218.90 | 9.66 | 10.16 | 85.60 | 95.23 |
| $P_3S_2$ | 9.30 | 9.44 | 238.00 | 243.50 | 10.52 | 10.20 | 95.70 | 109.36 |
| $P_3S_2$ | 11.64 | 9.72 | 242.10 | 248.40 | 10.51 | 10.46 | 104.36 | 116.80 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | 6.82 | 6.92 |

respectively. However, application of urea gave significantly lesser weight of bulblets under both the trials. These findings are in agreement with reports of Mostafa *et al.* (6) and Chaudhary (4) in tuberose. Among the three levels of nitrogen,100 kg/ha dose maximized the weight of bulblets (106.60 and 115.91 g) significantly when compared with rest of doses followed by 150 kg/ha level (97.90 and 106.11 g).It was noted significantly minimum under control (73.52 and 82.37 g) during both the year of investigation. These findings are in line with reports of Bhattacharjee (1), Shalska (9), Singh (10) and Kumar and Singh (8) in gladiolus and tuberose. Phosphorus levels induced significant variation on the weight of bulblets per clump during both the years. Application of 200 kg P/ha level expressing 104.74,113.47 g weight of bulblets proved significantly superior than its lower and higher both the doses (100 and 300 kg/ha).All the P concentration when compared with its control (93.63,98.84) showed significantly greater weight of bulblets per clump. Results are in line with reports of Bose *et al.* (3) in amaryllis, and Chaudhary (4) and Mostafa *et al.* (6) in tuberose.

Among the first order interactive treatments, $P \times S$ was found to exert significant influence on the weight of bulblets whereas, $P \times N$ and $S \times N$ though increased values numerically but failed to touch the level of significance under both the years of experimentation. Similarly, the second order interaction also did not cause significant difference in this regard (Table 2). Among the interaction of phosphorus levels and sources of nitrogen, $P_2O_5$@200kg/ha and nitrogen from CAN ($P_2S_3$) resulted in significantly the highest weight of bulblets/clump (122.04 g and 128.92g) during both the years respectively, followed by ($P_1S_3$) (120.50g; 127.03g) and $P_0S_3$ (116.23g; 119.83g).

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**Citation :** Gangwar A.P.S., Singh J.P. and Yadav I.P. (2014). Effect of nitrogen sources and phosphorus on bulbs and bulblets production of tuberose cv. Double. *HortFlora Res. Spectrum,* **3**(4) : 365-368

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 369-372 (December 2014) ISSN : 2250-2823

# EFFECT OF MODIFIED ATMOSPHERE ON BIO-CHEMICAL PARAMETERS AND SHELF LIFE OF GUAVA (*Psidium guajava* L.) CV. HISAR SAFEDA AND L-49

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**ABSTRACT:** An experiment was conducted to study the effect of different durations of modified atmosphere on bio-chemical parameters and shelf life of guava under ambient conditions. Fruits were packed in perforated polyethylene bags (LDPE) of thickness 300 gauge and then stored at 8ºC in BOD incubator for the periods 1, 2, 3 and 4 days. After respective durations of storage under MA at 8ºC, fruits were removed from MA and packed in CFB and stored at ambient temperature. Fruits were sampled at every day for various bio-chemical pigments of guava. Among different durations of MA storage, the maximum total sugars and reducing sugars was recorded in the fruits stored for 0, 1 and 2 days and minimum in the fruits stored in MA for 4 days. The fruits stored in MA for different durations maintained high phenol contents and recorded maximum phenol in the fruit stored in MA for 4 days and minimum in control fruits. Higher retention of chlorophyll was recorded in the fruits stored in MA for 4 days while lesser carotenoids were recorded in fruit stored in MA for 4 days. Carotenoids content increased and chlorophyll content decreased with the increase in storage period in both the cvs Hisar Safeda and L-49 (Sardar).

***Keywords :*** *Guava, modified atmosphere, shelf life, phenol, chlorophyll, carotenoid.*

Guava 'Apple of tropics' [*Psidium guajava* L.] is a popular fruit, grown successfully throughout tropical and sub-tropical regions. Guava is the fourth most important fruit crop after mango, banana, and citrus in India and occupies the area of 24.4 lakh ha and production 33.18 lakh MT with average productivity of 11.1 MT/ha (Indian Horticulture Database, 4). It is considered as one of the exquisite, nutritionally valuable, and remunerative crop. Guava is one of the most common fruits which are liked by both the rich and the poor because of its high nutritive value, availability at moderate price. It is a rich source of vitamin C and pectin (Patel *et al.,* 7). Guava is normally consumed as fresh as desert fruit but it is also processed into several products in fruit processing industry. A number of delicious products like jam, jelly, cheese, and RTS beverages are being prepared from guava fruits. Guava fruit is a climacteric fruit. It exhibits a climacteric pattern of respiration and ethylene production. Usually the fruits are harvested at different stage of maturity depending on the situation. After reaching the physiological maturity it ripens fast within 1or 2 days resulting in early senescence of the fruit (Chundawat *et al.,* 1). The ripening of the fruits corresponds to a series of physiological, biochemical, and structural changes, which make the fruit attractive for consumption, so bio-chemical changes during ripening of fruit is also the most important attribute because in addition to defining the quality of the fruit for consumption. Being highly perishable and very short post- harvest shelf life, a result of the loss of all quality attiributes, which limits transportation and storage period. Packing of fruits in sealed polybags is the simplest way to attain MA (Neeraj *et al.,* 6), however, it may not always enhance the shelf life (Mahadeviah, 5). Thus there is a need to find out the suitable MA storage condition to enhance the shelf life and reduces the huge post harvest losses. Therefore, the present studies were carried out to find out the effect of various durations of MA on the subsequent shelf life quality and ripening behaviour of guava fruit cv. L-49 and Hisar Safeda.

## MATERIALS AND METHODS

The fruits of rainy season crop were harvested at green mature stage. The fully green matured and healthy fruits cv. Hisar Safeda and L-49 were procured from the orchard of the Department of Horticulture, CCS HAU, Hisar, Haryana. The fruits were packed in imperforated polyethylene bags of thickness 300 gauge and stored at 8°C for 1, 2 ,3 and 4 days. After respective durations of storage under MA at 8°C, fruits were removed from MA and packed in corrugated fiber board (CFB) and stored at ambient temperature. Control fruits packed directly in CFB boxes with

*Received:26-06-2014; Revised:20-09-2014; Accepted:01-08-2014*

newspaper lining and stored at ambient conditions until they become unmarketable. Each treatment was comprised of four replications under complete randomized design. Fruits were sampled at every day for various bio-chemical parameters. Sugars were estimated by the method of Hulme and Narain (3). Total phenolic content was estimated by the method of Van Buren (8). The chlorophyll and carotenoids were estimated by the method given by Wellburn (9).

## RESULTS AND DISCUSSION

From the results obtained from the present investigation it can be concluded that exposure of fruits for < 2 days to MA resulted in enhanced shelf life of fruits up to 8 days whereas fruits exposure to MA more than 3 days, fruits remained high phenol, high Chlorophyll and low caroteniod contents and still remained green, hard and did not ripen when further stored under ambient conditions. Gupta and jawandha (2) and Mahadeviah (5) have also reported similar findings in their respective study.

**Table 1 : Effect of modified atmosphere on total sugars (%) of different cvs. of guava fruitsduring storage.**

| MA (Days)* | Period of storage (days) | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| | | **Hisar Safeda** | | | | | | | | |
| 0 | 5.44 | 6.20 | 7.13 | 7.54 | 7.65 | 6.53 | 6.10 | 5.53 | 4.92 | 6.33 |
| 1 | **5.44** | 5.40 | 6.05 | 6.91 | 7.22 | 7.53 | 6.74 | 5.94 | 5.75 | 6.33 |
| 2 | **5.44** | **5.40** | 5.37 | 6.07 | 6.71 | 7.14 | 7.58 | 6.91 | 6.33 | 6.33 |
| 3 | **5.44** | **5.40** | **5.37** | 5.57 | 5.88 | 6.02 | 6.11 | 5.79 | 5.15 | 5.63 |
| 4 | **5.44** | **5.40** | **5.37** | **5.57** | 5.16 | 5.33 | 5.46 | 5.53 | 5.40 | 5.40 |
| Mean | 5.44 | 5.56 | 5.85 | 6.33 | 6.52 | 6.51 | 6.40 | 5.94 | 5.51 | |
| CD (P=0.05) | Treatments = 0.08 | | Storage = 0.11 | | Treatments × Storage = 0.24 | | | | | |
| | | | | | **Lucknow-49** | | | | | |
| 0 | 5.99 | 6.97 | 8.18 | 8.18 | 6.85 | 6.28 | 5.64 | 5.26 | 4.96 | 6.48 |
| 1 | **5.99** | 5.83 | 6.72 | 7.98 | 8.20 | 6.95 | 5.91 | 5.77 | 5.51 | 6.54 |
| 2 | **5.99** | **5.83** | 5.86 | 6.74 | 7.58 | 7.62 | 7.50 | 6.46 | 6.32 | 6.66 |
| 3 | **5.99** | **5.83** | **5.86** | 5.43 | 5.88 | 6.28 | 5.48 | 5.54 | 5.02 | 5.70 |
| 4 | **5.99** | **5.83** | **5.86** | **5.43** | 4.95 | 5.36 | 5.83 | 5.26 | 4.79 | 5.48 |
| Mean | 5.99 | 6.06 | 6.49 | 6.75 | 6.69 | 6.50 | 6.07 | 5.66 | 5.32 | |

CD (P=0.05) Treatments = 0.11 Storage = 0.14 Treatments × Storage = 0.32

*Bold figures indicate assumed values, which are similar to the values of fruits from bags opened on that day * at $8^0$C

**Table 2 : Effect of modified atmosphere on reducing sugar (%) of different cvs. of guava fruits during storage.**

| MA (Days)* | Period of storage (days) | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| | | | | | **Hisar Safeda** | | | | | |
| 0 | 3.69 | 3.79 | 3.95 | 4.11 | 4.53 | 3.73 | 3.17 | 3.05 | 2.95 | 3.66 |
| 1 | **3.69** | 3.71 | 3.82 | 3.98 | 4.04 | 4.37 | 3.61 | 3.06 | 2.59 | 3.65 |
| 2 | **3.69** | **3.71** | 3.70 | 3.78 | 3.82 | 3.71 | 3.73 | 3.27 | 3.39 | 3.64 |
| 3 | **3.69** | **3.71** | **3.70** | 3.72 | 3.76 | 3.78 | 3.36 | 3.41 | 2.93 | 3.56 |
| 4 | **3.69** | **3.71** | **3.70** | **3.72** | **3.72** | 3.73 | 3.20 | 3.04 | 2.76 | 3.47 |
| Mean | 3.69 | 3.73 | 3.77 | 3.86 | 3.97 | 3.86 | 3.41 | 3.16 | 2.92 | |
| CD (P=0.05) | Treatments = 0.09 | | Storage = 0.12 | | Treatments x Storage = 0.26 | | | | | |
| | | | | | **Lucknow-49** | | | | | |
| 0 | 3.81 | 4.21 | 5.06 | 5.62 | 4.82 | 3.97 | 3.66 | 3.09 | 3.02 | 4.28 |
| 1 | **3.81** | 3.76 | 4.07 | 5.12 | 5.30 | 5.12 | 4.03 | 3.61 | 2.93 | 4.25 |
| 2 | **3.81** | **3.76** | 3.59 | 3.97 | 4.48 | 5.16 | 5.48 | 4.31 | 3.57 | 4.24 |
| 3 | **3.81** | **3.76** | **3.59** | 3.07 | 3.52 | 3.81 | 3.98 | 4.23 | 3.78 | 3.73 |
| 4 | **3.81** | **3.76** | **3.59** | **3.07** | 3.10 | 2.93 | 2.97 | 3.08 | 2.58 | 3.21 |
| Mean | 3.81 | 3.85 | 3.98 | 4.17 | 4.24 | 4.20 | 4.02 | 3.66 | 3.17 | |

CD (P=0.05) Treatments = 0.09 Storage = 0.12 Treatments x Storage = 0.26

*Bold figures indicate assumed values, which are similar to the values of fruits from bags opened on that day * at $8^0$C

**Table 3 : Effect of modified atmosphere on total phenols (g/100g fruit pulp) of different cvs. of guava fruits during storage.**

| MA (Days)* | Period of storage (days) | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| **Hisar Safeda** | | | | | | | | | | |
| 0 | 0.79 | 0.74 | 0.64 | 0.60 | 0.55 | 0.49 | 0.43 | 0.40 | 0.34 | 0.55 |
| 1 | **0.79** | 0.76 | 0.70 | 0.62 | 0.58 | 0.54 | 0.49 | 0.44 | 0.39 | 0.59 |
| 2 | **0.79** | **0.76** | 0.76 | 0.71 | 0.66 | 0.61 | 0.56 | 0.50 | 0.43 | 0.64 |
| 3 | **0.79** | **0.76** | **0.76** | 0.75 | 0.71 | 0.68 | 0.64 | 0.59 | 0.57 | 0.69 |
| 4 | **0.79** | **0.76** | **0.76** | **0.75** | 0.71 | 0.68 | 0.67 | 0.63 | 0.61 | 0.70 |
| Mean | 0.79 | 0.76 | 0.72 | 0.68 | 0.64 | 0.60 | 0.56 | 0.51 | 0.47 | |

CD (P=0.05) Treatments = 0.01 Storage = 0.01 Treatments × Storage = 0.02

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lucknow-49** | | | | | | | | | | |
| 0 | 0.69 | 0.67 | 0.62 | 0.58 | 0.55 | 0.51 | 0.48 | 0.45 | 0.42 | 0.55 |
| 1 | **0.69** | 0.67 | 0.65 | 0.62 | 0.60 | 0.57 | 0.53 | 0.50 | 0.46 | 0.59 |
| 2 | **0.69** | **0.67** | 0.65 | 0.64 | 0.59 | 0.58 | 0.55 | 0.53 | 0.48 | 0.60 |
| 3 | **0.69** | **0.67** | **0.65** | 0.66 | 0.64 | 0.61 | 0.58 | 0.54 | 0.49 | 0.61 |
| 4 | **0.69** | **0.67** | **0.65** | **0.66** | 0.62 | 0.62 | 0.61 | 0.59 | 0.57 | 0.63 |
| Mean | 0.69 | 0.67 | 0.65 | 0.63 | 0.60 | 0.58 | 0.55 | 0.52 | 0.48 | |

CD (P=0.05) Treatments = 0.01 Storage = 0.01 Treatments × Storage = 0.02
Bold figures indicate assumed values, which are similar to the values of fruits from bags opened on that day * at $8^0C$

**Table 4 : Effect of modified atmosphere Chlorophyll (mg/g of peel) of different cvs. of guava fruits during storage.**

| MA (Days)* | Period of storage (days) | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| **Hisar Safeda** | | | | | | | | | | |
| 0 | 1.32 | 1.21 | 1.11 | 1.04 | 0.92 | 0.65 | 0.51 | 0.39 | 0.33 | 0.83 |
| 1 | **1.32** | 1.32 | 1.18 | 1.05 | 0.86 | 0.67 | 0.50 | 0.36 | 0.34 | 0.84 |
| 2 | **1.32** | **1.32** | 1.33 | 1.19 | 1.07 | 0.82 | 0.67 | 0.49 | 0.43 | 0.96 |
| 3 | **1.32** | **1.32** | **1.33** | 1.34 | 1.28 | 1.20 | 1.06 | 1.06 | 1.01 | 1.21 |
| 4 | **1.32** | **1.32** | **1.33** | **1.34** | 1.34 | 1.28 | 1.28 | 1.24 | 1.18 | 1.29 |
| Mean | 1.32 | 1.29 | 1.26 | 1.19 | 1.09 | 0.92 | 0.80 | 0.70 | 0.66 | |

CD (P=0.05) Treatments = 0.02 Storage = 0.02 Treatments × Storage = 0.05

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lucknow-49** | | | | | | | | | | |
| 0 | 1.50 | 1.22 | 1.02 | 0.87 | 0.67 | 0.56 | 0.44 | 0.34 | 0.32 | 0.77 |
| 1 | **1.50** | **1.35** | 1.25 | 1.14 | 0.94 | 0.68 | 0.56 | 0.46 | 0.37 | 0.91 |
| 2 | **1.50** | **1.35** | 1.44 | 1.28 | 1.10 | 1.02 | 0.78 | 0.59 | 0.46 | 1.06 |
| 3 | **1.50** | **1.35** | **1.44** | 1.46 | 1.37 | 1.27 | 1.21 | 1.15 | 1.11 | 1.32 |
| 4 | **1.50** | 1.35 | **1.44** | **1.46** | 1.42 | 1.40 | 1.35 | 1.33 | 1.24 | 1.39 |
| Mean | 1.50 | 1.32 | 1.32 | 1.24 | 1.10 | 0.99 | 0.87 | 0.77 | 0.70 | |

CD (P=0.05) Treatments = 0.02 Storage = 0.04 Treatments × Storage = 0.08
Bold figures indicate assumed values, which are similar to the values of fruits from bags opened on that day * *at* $8^0C$

**Table 5 : Effect of modified atmosphere on total carotenoids (mg/g of peel) of different cvs. of guava fruits during storage**

| MA (Days)* | Period of storage (days) | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| | | | | | **Hisar Safeda** | | | | | |
| 0 | 0.72 | 0.79 | 0.83 | 0.91 | 0.99 | 1.13 | 1.25 | 1.40 | 1.48 | 1.05 |
| 1 | **0.72** | 0.69 | 0.80 | 0.85 | 0.92 | 1.00 | 1.11 | 1.26 | 1.45 | 0.98 |
| 2 | **0.72** | **0.69** | 0.71 | 0.79 | 0.86 | 0.94 | 1.05 | 1.16 | 1.22 | 0.90 |
| 3 | **0.72** | **0.69** | **0.71** | 0.69 | 0.72 | 0.76 | 0.80 | 0.83 | 0.85 | 0.75 |
| 4 | **0.72** | **0.69** | **0.71** | 0.69 | **0.66** | 0.70 | 0.72 | 0.75 | 0.80 | 0.71 |
| Mean | 0.72 | 0.71 | 0.75 | 0.78 | 0.83 | 0.90 | 0.99 | 1.08 | 1.16 | |
| CD (P=0.05) | Treatments = 0.01 | | Storage = 0.02 | | Treatments × Storage = 0.04 | | | | | |
| | | | | | **Lucknow-49** | | | | | |
| 0 | 0.80 | 0.98 | 1.07 | 1.20 | 1.37 | 1.41 | 1.49 | 1.56 | 1.66 | 1.28 |
| 1 | **0.80** | 0.79 | 1.01 | 1.11 | 1.16 | 1.33 | 1.39 | 1.46 | 1.59 | 1.18 |
| 2 | **0.80** | 0.79 | 0.78 | 0.97 | 1.08 | 1.14 | 1.26 | 1.36 | 1.50 | 1.08 |
| 3 | **0.80** | **0.79** | **0.78** | 0.76 | 0.79 | 0.80 | 0.82 | 0.84 | 0.87 | 0.81 |
| 4 | **0.80** | **0.79** | **0.78** | **0.76** | 0.75 | 0.76 | 0.77 | 0.79 | 0.81 | 0.78 |
| Mean | 0.80 | 0.83 | 0.89 | 0.96 | 1.03 | 1.08 | 1.15 | 1.20 | 1.29 | |

CD (P=0.05) Treatments = 0.01 Storage = 0.02 Treatments × Storage = 0.04

*Bold figures indicate assumed values, which are similar to the values of fruits from bags opened on that day* at* $8^0C$

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**Citation :** Bishnoi C., Sharma R.K.. and Siddiqui S. (2014). Effect of modified atmosphere on bio-chemical parameters and shelf life of guava (*Psilium guajava* L.) cv. Hisar Safeda and L-49. *HortFlora Res. Spectrum,* **3**(4) : 369-372

www.hortflorajournal.com

*HortFlora Research Spectrum*, 3(4): 373-376 (December 2014) ISSN : 2250-2823

# EFFECT OF MICRONUTRIENTS SPRAY ON GROWTH, YIELD AND FLOWER QUALITY OF GLADIOLUS CV. WHITE PROSPERITY

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**ABSTRACT :** The present investigation on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity was undertaken in the Department of Horticulture, SHIATS, Allahabad. The experiment was laid out in RBD (5 x 5 Factorial), having five levels each of zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%), consisting a total of 25 treatment combinations. Results showed that the foliar application of boron and zinc alone at all rates and as combination significantly influenced plant growth, spike yield and flower quality with maximum value at 0.4% boron and 0.4% zinc levels. As a result of interaction between boron and zinc, the best results regarding plant growth, spike yield and flower quality were obtained with treatment combination $B_3$ $Z_3$ (B 0.4% + Zn 0.4%).

***Keywords :*** *Gladiolus, micronutrient, boron, zinc, growth, flower yield, quality.*

The requirement of fertilizers like other crops has vital role in growth, quality of flowers, and corm and cormel production. Gladiolus is highly responsive to chemical fertilizers. It has been reported that nitrogen, phosphorus, potassium with micro-nutrients especially boron and zinc remarkably increased weight and number of corms and cormels per hill (Halder *et al*. 1; and Singh and Singh, 7). Micronutrients such as boron and zinc (Halder *et al.* 1, and Jauhari *et al.* 2) had greatly affected the plant growth and development. The main function of boron is related to cell wall strength and development, cell division, sugar transport, and hormones development, RNA metabolism, respiration, IAA metabolism and as part of the cell membranes (Marschner, 5). The availability of micronutrients to plants is determined by both the total amount of the nutrients in the soil and the soil's properties. Other factor such as crop species and variety, can also influence the degree of which micronutrients levels affect crop production.

## MATERIALS AND METHODS

The present investigation on effect of micronutrients spray on growth, yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity was undertaken in the experimental field of the Department of Horticulture, SHIATS, Allahabad during 2012-2013. Allahabad is situated at an elevation of 78 m MSL at $25.87^0$ N latitude and $81.15^0$ E longitude. The area of Allahabad district comes under subtropical belt in the south -east of Uttar Pradesh, which experiences extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 $^0$C – 48 $^0$C and seldom falls as low as 4 $^0$C – 5 $^0$C. The relative humidity ranges between 20 to 94%. The study was laid out in RBD (5x 5 Factorial), having five levels each of Zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and Boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%), consisting a total of 25 treatment combinations. Foliar spray of zinc and boron was done at 15 days intervals up to flowering of plant. Observations were recorded on three randomly selected plants of each treatment to assess the effect of treatments on plant growth, spike yield and flower quality of the flower. Average data (Table 1 & 2) were analyzed statistically.

## RESULTS AND DISCUSSION

### Effect of boron on growth, yield and flower quality

A perusal of Table 1 shows that maximum plant height (94.19cm) and number of leaves/plant (22.44) were obtained with boron spray @ 0.4% followed by with boron @0.5% (87.05cm height, 20.67 leaves), and the minimum plant height (77.59 cm) and number of leaves per plant (18.47) were recorded under control. The findings are in conformity with reports made by Jauhari *et al.* (2) in gladiolus. Maximum number of shoots per corm (2.20) was recorded with boron level of 0.4% followed by with $B_4$ (1.95) and the minimum shoots (1.39) remained with control. Minimum days to spike initiation (62.89 days) as well as days to opening of first floret (74.07days) were obtained with Boron @ 0.4% followed by Boron @ 0.5% (64.73 days and 76.24 days), and the maximum days to spike emergence

*Received : 07-10-2014* *Accepted : 30-10-2014*

**Table 1: Effect of different levels of boron and zinc on plant growth, spike and corn yield and flower quality of gladiolus cv. White Prosperity.**

| Treatments | Plant height | No. of leaves / plant | No. of shoot/ corm | Days to spike initiation | Days to opening of first floret | No. of spikes/ plant | Spike yield/ha (lakh) | No. of corms/ plant | Corm yield/ ha (lakh) | No. of cormlets/corm | Cormel yield/ ha (lakh) | Floret size (cm) | Shelf life of spike (Days) | First floret durability (Days) | Spike length (cm) | No. of florets per spike |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Levels of Boron (B) | | | | | | | | | | | | | | | | |
| $B_0$-Boron 0.0% | 77.59 | 18.47 | 1.39 | 68.39 | 80.57 | 1.12 | 1.96 | 1.43 | 2.50 | 7.75 | 13.56 | 7.81 | 9.56 | 8.69 | 72.09 | 13.87 |
| $B_1$-Boron 0.2% | 81.44 | 19.36 | 1.56 | 67.08 | 79.04 | 1.23 | 2.15 | 1.59 | 2.78 | 9.27 | 16.22 | 8.21 | 10.09 | 9.15 | 74.31 | 15.41 |
| $B_2$-Boron 0.3% | 83.57 | 19.92 | 1.71 | 66.03 | 77.75 | 1.36 | 2.38 | 1.72 | 3.01 | 10.48 | 18.34 | 8.49 | 10.45 | 9.41 | 75.93 | 16.12 |
| $B_3$-Boron 0.4% | 94.19 | 22.44 | 2.20 | 62.89 | 74.07 | 1.75 | 3.06 | 2.24 | 3.92 | 12.63 | 22.10 | 9.33 | 11.48 | 10.47 | 79.61 | 17.97 |
| $B_4$-Boron 0.5% | 87.05 | 20.67 | 1.95 | 64.73 | 76.24 | 1.55 | 2.71 | 1.96 | 3.43 | 11.40 | 19.95 | 8.79 | 10.77 | 9.84 | 77.45 | 16.83 |
| C. D. (P = 0.05) | 0.23 | 0.06 | 0.10 | 0.12 | 0.14 | 0.05 | 0.09 | 0.05 | 0.09 | 0.04 | 0.08 | 0.05 | 0.05 | 0.05 | 0.12 | 0.05 |
| Levels of Zinc (Z) | | | | | | | | | | | | | | | | |
| $Z_0$- Zinc 0.0% | 75.56 | 17.91 | 1.21 | 70.28 | 82.79 | 1.07 | 1.87 | 1.25 | 2.19 | 6.85 | 11.99 | 7.60 | 9.28 | 8.41 | 70.97 | 13.35 |
| $Z_1$- Zinc 0.2% | 85.23 | 20.28 | 1.83 | 65.36 | 76.97 | 1.41 | 2.47 | 1.84 | 3.22 | 10.57 | 18.50 | 8.59 | 10.56 | 9.60 | 76.33 | 16.24 |
| $Z_2$-Zinc 0.3% | 86.36 | 20.56 | 1.87 | 64.95 | 76.48 | 1.47 | 2.57 | 1.87 | 3.27 | 10.95 | 19.16 | 8.69 | 10.67 | 9.69 | 76.77 | 16.60 |
| $Z_3$-Zinc 0.4% | 89.23 | 21.29 | 1.99 | 63.96 | 75.35 | 1.56 | 2.73 | 2.03 | 3.55 | 11.81 | 20.67 | 8.96 | 11.05 | 10.04 | 78.00 | 17.21 |
| $Z_4$-Zinc 0.5% | 87.47 | 20.81 | 1.91 | 64.57 | 76.08 | 1.49 | 2.61 | 1.95 | 3.41 | 11.33 | 19.83 | 8.80 | 10.80 | 9.81 | 77.32 | 16.80 |
| C. D. (P = 0.05) | 0.23 | 0.06 | 0.10 | 0.12 | 0.14 | 0.05 | 0.09 | 0.05 | 0.09 | 0.04 | 0.08 | 0.05 | 0.05 | 0.05 | 0.12 | 0.05 |

(68.39days) and days to opening of first floret (80.57 days) were recorded under control. Yield of spikes/plant and per unit area was also influenced significantly by micronutrient's spray. Maximum number of spikes/ plant (1.75) as well as highest yield of spikes/hectare (3.06 lakh spikes) were recorded by the spray of 0.4% boron followed by $B_4$ level (1.55 spike/plant; 2.71 lakh spikes/ha), and the minimum yield of spikes/plant (1.12) and per hectare (1.96 lakh) were observed in control plots. These findings are in agreement with Reddy and Chaturvedi (6). The maximum number of daughter corms/plant (2.24) and corm yield/ hectare (3.92 lakh) were found in treatment $B_3$ (Boron @0.4%) and they were minimum in control plots. Like this, yield of cormels was also found maximum (12.63 cormels/ planted corm, and 22.10 lakh cormels/ha) with spray of boron @0.4% and control plots showed minimum values for cormlets production. The results are in agreement with the results of Singh and Singh (7) and Kumar and Arora (4) in gladiolus.

Spike length, flower size and durability of flower are the most important traits to determine the quality of a flower. It is obvious from Table 1 that the maximum floret size (9.33cm), longest shelf life of spike (11.48 days) as well as durability of first floret (10.47 days) were recorded under the flowers obtained from plants sprayed with boron @0.4% followed by boron spray of 0.5% (8.79cm flower size, 10.77 days and 9.84 days) while control plants showed the minimum values for these parameters. The longest spike length (79.61 cm) and maximum number of florets/spike (17.97) were resulted in plants treated with boron @0.4%) followed by boron @ 0.5% (77.45 cm long spike and 16.83 florets/spike) and least values were recorded in control. These findings are in consonance with Katiyar *et al.* (3) and Singh *et al.* (8)

## Effect of zinc on plant growth, yield and flower quality

A perusal of Table 1 shows that maximum plant height (89.23cm) and number of leaves/plant (21.29) were obtained with zinc spray @ 0.4% followed by with zinc @ 0.5% (87.47 cm height, 20.81 leaves), and the minimum plant height (75.56 cm) and number of leaves per plant (17.91) were recorded under control. The findings are in conformity with reports made by Jauhari *et al.* (2) and Singh and Singh (7). Number of shoots/mother corm were also produced maximum (1.99) in plants sprayed with 0.4% zinc followed by 0.5% zinc (1.91

**Table 2: Interaction effect of different levels of Boron and Zinc growth, spike yield and flower quality of Gladiolus (Gladiolus grandiflorus L.) cv. White Prosperity.**

| Treatment | Plant height | No. of leaves / plant | No. of shoot / corm | Days to spike initiation | Days to opening of first floret | No. of spikes/ plant | Spike yield/ hectare (lakh) | No. of corms/ plant | Corm yield/ ha (lakh) | No. of cormlets/ha corm | Cormlet yield/ ha (lakh) | Floret size (cm) | Shelf life of spike (Days) | First floret durability (Days) | Spike length (cm) | Number of florets per spike |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_0$ $B_0Z_0$ | 67.67 | 15.93 | 1.00 | 71.87 | 84.67 | 1.00 | 1.75 | 1.07 | 1.87 | 6.33 | 11.08 | 6.73 | 8.13 | 7.67 | 65.67 | 11.33 |
| $T_1B_0Z_1$ | 79.07 | 18.87 | 1.47 | 68.27 | 80.40 | 1.13 | 1.98 | 1.47 | 2.57 | 7.53 | 13.18 | 8.00 | 9.80 | 8.87 | 73.33 | 14.33 |
| $T_2B_0Z_2$ | 79.80 | 19.07 | 1.47 | 67.60 | 79.60 | 1.13 | 1.98 | 1.47 | 2.57 | 7.87 | 13.77 | 8.07 | 9.87 | 8.93 | 73.53 | 14.47 |
| $T_3B_0Z_3$ | 81.07 | 19.33 | 1.53 | 66.93 | 78.93 | 1.20 | 2.10 | 1.60 | 2.80 | 8.73 | 15.28 | 8.13 | 10.07 | 9.07 | 74.13 | 14.67 |
| $T_4B_0Z_4$ | 80.33 | 19.13 | 1.47 | 67.27 | 79.27 | 1.13 | 1.98 | 1.53 | 2.68 | 8.27 | 14.47 | 8.13 | 9.93 | 8.93 | 73.80 | 14.53 |
| $T_5B_1Z_0$ | 76.53 | 18.07 | 1.13 | 70.67 | 83.27 | 1.07 | 1.87 | 1.13 | 1.98 | 6.67 | 11.67 | 7.67 | 9.33 | 8.47 | 71.33 | 13.60 |
| $T_6B_1Z_1$ | 81.73 | 19.47 | 1.60 | 66.60 | 78.47 | 1.20 | 2.10 | 1.67 | 2.92 | 9.13 | 15.98 | 8.20 | 10.13 | 9.13 | 74.53 | 14.87 |
| $T_7B_1Z_2$ | 82.47 | 19.67 | 1.67 | 66.33 | 78.13 | 1.27 | 2.22 | 1.67 | 2.92 | 9.73 | 17.03 | 8.33 | 10.20 | 9.27 | 74.87 | 16.07 |
| $T_8B_1Z_3$ | 83.60 | 19.87 | 1.73 | 65.73 | 77.47 | 1.33 | 2.33 | 1.73 | 3.03 | 10.67 | 18.67 | 8.47 | 10.47 | 9.47 | 75.67 | 16.33 |
| $T_9B_1Z_4$ | 82.87 | 19.73 | 1.67 | 66.07 | 77.87 | 1.27 | 2.22 | 1.73 | 3.03 | 10.13 | 17.73 | 8.40 | 10.33 | 9.40 | 75.13 | 16.20 |
| $T_{10}$ $B_2Z_0$ | 77.27 | 18.33 | 1.20 | 70.20 | 82.67 | 1.07 | 1.87 | 1.20 | 2.10 | 6.93 | 12.13 | 7.80 | 9.53 | 8.53 | 72.27 | 13.73 |
| $T_{11}$ $B_2Z_1$ | 84.13 | 20.07 | 1.80 | 65.47 | 77.07 | 1.33 | 2.33 | 1.80 | 3.15 | 10.93 | 19.13 | 8.53 | 10.53 | 9.53 | 76.07 | 16.47 |
| $T_{12}$ $B_2Z_2$ | 84.73 | 20.20 | 1.80 | 65.13 | 76.67 | 1.40 | 2.45 | 1.80 | 3.15 | 11.13 | 19.48 | 8.67 | 10.67 | 9.53 | 76.67 | 16.60 |
| $T_{13}$ $B_2Z_3$ | 86.33 | 20.67 | 1.87 | 64.47 | 75.93 | 1.53 | 2.68 | 1.93 | 3.38 | 11.87 | 20.77 | 8.73 | 10.80 | 9.80 | 77.60 | 17.00 |
| $T_{14}$ $B_2Z_4$ | 85.40 | 20.33 | 1.87 | 64.87 | 76.40 | 1.47 | 2.57 | 1.87 | 3.27 | 11.53 | 20.18 | 8.73 | 10.73 | 9.67 | 77.07 | 16.80 |
| $T_{15}$ $B_3Z_0$ | 78.53 | 18.73 | 1.40 | 69.00 | 81.27 | 1.13 | 1.98 | 1.53 | 2.68 | 7.27 | 12.72 | 7.93 | 9.73 | 8.73 | 72.93 | 14.13 |
| $T_{16}$ $B_3Z_1$ | 93.47 | 22.13 | 2.27 | 62.33 | 73.40 | 1.80 | 3.15 | 2.27 | 3.97 | 13.13 | 22.98 | 9.33 | 11.47 | 10.53 | 79.73 | 18.27 |
| $T_{17}$ $B_3Z_2$ | 96.07 | 22.87 | 2.33 | 61.93 | 72.93 | 1.87 | 3.27 | 2.33 | 4.08 | 13.67 | 23.92 | 9.47 | 11.67 | 10.67 | 80.27 | 18.53 |
| $T_{18}$ $B_3Z_3$ | 104.07 | 24.93 | 2.60 | 59.80 | 70.40 | 2.00 | 3.50 | 2.67 | 4.67 | 14.93 | 26.13 | 10.27 | 12.67 | 11.53 | 83.40 | 20.13 |
| $T_{19}$ $B_3Z_4$ | 98.80 | 23.53 | 2.40 | 61.40 | 72.33 | 1.93 | 3.38 | 2.40 | 4.20 | 14.13 | 24.73 | 9.67 | 11.87 | 10.87 | 81.73 | 18.80 |
| $T_{20}$ $B_4Z_0$ | 77.80 | 18.47 | 1.33 | 69.67 | 82.07 | 1.07 | 1.87 | 1.33 | 2.33 | 7.07 | 12.37 | 7.87 | 9.67 | 8.67 | 72.67 | 13.93 |
| $T_{21}$ $B_4Z_1$ | 87.73 | 20.87 | 2.00 | 64.13 | 75.53 | 1.60 | 2.80 | 2.00 | 3.50 | 12.13 | 21.23 | 8.87 | 10.87 | 9.93 | 78.00 | 17.27 |
| $T_{22}$ $B_4Z_2$ | 88.73 | 21.00 | 2.07 | 63.73 | 75.07 | 1.67 | 2.92 | 2.07 | 3.62 | 12.33 | 21.58 | 8.93 | 10.93 | 10.07 | 78.53 | 17.33 |
| $T_{23}$ $B_4Z_3$ | 91.07 | 21.67 | 2.20 | 62.87 | 74.00 | 1.73 | 3.03 | 2.20 | 3.85 | 12.87 | 22.52 | 9.20 | 11.27 | 10.33 | 79.20 | 17.93 |
| $T_{24}$ $B_4Z_4$ | 89.93 | 21.33 | 2.13 | 63.27 | 74.53 | 1.67 | 2.92 | 2.20 | 3.85 | 12.60 | 22.05 | 9.07 | 11.13 | 10.20 | 78.87 | 17.67 |
| CD (P=0.05) | 0.52 | 0.12 | - | 0.27 | 0.32 | 0.11 | 0.20 | 0.12 | 0.21 | 0.10 | 0.17 | 0.12 | 0.12 | 0.11 | 0.26 | 0.12 |

shoots) and minimum shoots/corm (1.21) were recorded under control. Days to spike emergence (63.96 days) and days to opening of first floret (75.35 days) were recorded significantly minimum with spray of 0.4% zinc. Jauhari *et al.* (2), Singh *et al.* (8) and Reddy and Chaturvedi (6) had also reported similar findings regarding above characters studied. Yield of spikes and daughter corms and cormels were also influenced significantly due to spray of zinc. Maximum number of spikes/plant (1.56) and daughter corms/plant (2.03), higher spike and corm yield per hectare (2.73 lakh and 3.55 lakh, respectively) as well as cormels yield (11.81/plant and 20.67 lakh/ha) were also found with the application of 0.4% zinc followed zinc @0.5% (1.49 spikes/plant, 2.61 lakh spikes/ha, 1.95 corms/plant, 3.41 lakh corms/ha, and 11.33 cormels/plant and 19.83 lakh cormels/ha). Similar findings due to application of macro and micro nutrients had also been reported by Halder *et al.* (1), Kumar and Arora (4) and Singh and Singh (7).

The maximum floret size (8.96 cm), maximum shelf life of spike (11.05 days) and durability of first floret 10.04 days), longest spike (78.00 cm) and highest number of florets/spike (17.21) were also obtained due to spray of zinc at 0.4% level followed by 0.5% zinc as compared to control and other lower levels of zinc. These findings are in consonance with reports of Katiyar *et al.* (3), and Singh *et al.* (8).

## Interaction effect of boron and zinc:

A perusal of data revealed that combined spray effect of both the micronutrients *i.e.* boron and zinc had influenced significantly to all the parameters studied (Table 2). Gladiolus cv. White Prosperity crop sprayed with boron and zinc each at 0.4% level resulted in highest plant height (104.07 cm), number of leaves and shoots per plant (24.93 and 2.60, respectively), earliest spike emergence (59.80 days) and opening of first floret (70.40 days). Control plants showed minimum values for these parameters confirming to reports of Katiyar *et al.* 3). Spike yield/plant (2.0) and per hectare (3.50 lakh), yield of corms/plant (2.67) and per hectare (4.67 lakh) as well as cormels yield/mother corm (13.67) and per hectare (23.92 lakh) were also found maximum due to interaction of 0.4% each of boron and zinc confirming to the reports of Halder *et al.* (1) and Singh *et al.* (8).

Results revealed that longet spike (83.40 cm), maximum number of florets/spike (20.13), largest sized floret (10.27 cm), and maximum shelf life of spike (12.67 days) as well as durability of first floret (11.53 days) were obtained due to interaction of boron and zinc at 0.4% level each. The results are in support of Halder *et al.* (1) and Katiyar *et al.* (3).

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**Citation :** Singh C.M. and Prasad V.M. (2014). Effect of micronutrients spray on growth, yield and flower quality of gladiolus cv. White Prosperity. *HortFlora Res. Spectrum,* **3**(4) : 373-376.

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 377-379 (December 2014) ISSN : 2250-2823

***Research Note* :**

# EFFECT OF SPACING AND NITROGEN ON BULB FORMATION AND GROWTH OF ASIATIC LILY UNDER HILL ZONE

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**ABSTRACT :** Bulbs of Asiatic lily (*Lilium* spp.) cv. Gironde were planted under open field condition in hill zone of Karnataka (Mudigere) to study the impact of spacing and nitrogen levels on bulb formation and growth. Treatments comprised of three levels of spacing (30x15 cm, 30x30 cm and 40x15 cm) and four levels of nitrogen (0, 100, 150 and 200 kg per ha). The plant spacing of 30x15 cm and 200 kg per ha nitrogen level showed resulting in a significant effect on weight, size and yield of bulb, and weight and number of bulblets per plant, the maximum qualitative and quantitative characteristics of bulbs and bulblets.

***Keywords*** *: Asiatic lity bulb, bulblets, spacing, nitrogen.*

Asiatic lily is one of the most important bulbous flowering plants belonging to the family Liliaceae. Asiatic lilies are excellent for forcing, growing in beds, border, indoor garden and for naturalization in grass under trees and shrubs. The current interest in growing Asiatic lily commercially is gaining movement in India. The information regarding spacing and nutrient management for bulb production under open field conditions is lacking under hill zones of Karnataka, which is of prime concern. The cut flower trade of Asiatic lily is lagging behind in this region, owing to the non availability of quality planting materials at larger scale. Therefore, the present study was undertaken to study the response of spacing and nitrogen levels on various bulb formation and production parameters in Asiatic lily cv. Gironde.

The present investigation was carried out at the Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere during the period from September 2012 to March 2013. The soil of the experimental site was loamy having the $p^H$ of 5.39. The experiment was laid out in open field with factorial randomized complete block design (FRCBD). There were three replications and twelve treatment combinations in the experiment. Bulbs were planted in each plot with different plant densities with the spacing of 30 × 15 cm ($S_1$) 30 × 30 cm ($S_2$) and 45 × 15 cm ($S_3$) as per treatments.

Full dose of $P_2O_5$ in form of rock phosphate (28.0% $P_2O_5$) and $K_2O$ in form of muriate of potash (60.0% $K_2O$) were applied at the time of planting. Fertilizers were applied separately to individual plots as per the treatments. Four levels of nitrogen, 0 Kg ($N_0$), 100 kg ($N_1$), 150 kg ($N_2$) and 200 kg ($N_3$) per hectare were applied in form of urea (46.4% N). Nitrogen treatments in form of urea were applied in 4 split doses.

## Average weight of bulbs

Plant geometry and nitrogen levels influenced weight of bulbs significantly (Table 1). Maximum weight of individual bulb (28.99 g) was recorded at $S_1$ (30x15 cm) spacing which was on par at $S_3$ (40x15 cm) spacing (27.46 g) and least bulb weight (24.03 g) was recorded at $S_2$ (30x30 cm) spacing . Karthikeyan and Jawaharlal (2) had also recommended dense planting (36 plants/$m^2$) of carnation for getting better quality of flowers. Among the different nitrogen levels, maximum bulb weight (22.79 g) was observed at $N_4$ (200 kg/ha) level which was on par at $N_3$ (150 kg/ha) level (21.18 g) and minimum bulb weight (16.59 g) was observed at $N_1$ (0 kg/ha). The interaction effect of both nitrogen and spacing levels showed non-significant differences with respect to weight of bulbs.

## Size of bulbs

Average size of bulbs was significantly influenced by spacing and nitrogen levels. The largest size of bulbs (9.65 cm) was recorded at $S_1$ (30x15 cm) spacing followed by $S_3$ (40x15 cm) spacing (8.43 cm) and the smallest size (7.81 cm) was registered under $S_2$ (30x30 cm) spacing. Among different nitrogen levels, maximum size of bulbs (7.82 cm) was recorded at $N_4$ (200 kg/ha) level followed by 150 kgN/ha (6.61 cm), while minimum size of bulbs (5.40 cm) was recorded at $N_1$ (0 kg/ha) level. The interaction effect of both nitrogen and spacing levels showed non-significant differences with respect to average size of bulbs.

*Received : 16-09-2014* *Accepted : 11-10-2014*

**Table 1: Effect of spacing and nitrogen levels on bulb and bulblet parameters in Asiatic lily.**

| Treatment | Weight of bulb (g) | Bulb size (cm) | Yield of bulbs per $m^2$ | Number of bulblets per plant | Weight of bulblet (g) |
|---|---|---|---|---|---|
| **Spacing (cm)** | | | | | |
| $S_1$= 30X15 | 28.99 | 9.65 | 21.22 | 1.04 | 1.05 |
| $S_2$= 30X30 | 24.03 | 7.81 | 10.44 | 0.91 | 0.93 |
| $S_3$= 40X15 | 27.46 | 8.43 | 14.74 | 0.99 | 1.02 |
| C.D. (P=0.05) | 1.87 | 0.69 | 1.21 | 0.07 | 0.05 |
| **Nitrogen levels (kg/ha)** | | | | | |
| $N_1$=0 | 16.59 | 5.40 | 11.25 | 0.63 | 0.67 |
| $N_2$=100 | 19.92 | 6.07 | 12.00 | 0.71 | 0.73 |
| $N_3$=150 | 21.18 | 6.61 | 11.33 | 0.75 | 0.76 |
| $N_4$=200 | 22.79 | 7.82 | 11.83 | 0.85 | 0.84 |
| C.D. (P=0.05) | 2.15 | 0.80 | NS | 0.08 | 0.06 |
| **Interaction (S x N)** | | | | | |
| $S_1N_1$ | 24.00 | 8.03 | 20.55 | 0.86 | 0.89 |
| $S_1N_2$ | 29.30 | 9.00 | 22.22 | 0.97 | 1.02 |
| $S_1N_3$ | 30.10 | 10.09 | 20.56 | 1.04 | 1.05 |
| $S_1N_4$ | 32.54 | 11.49 | 21.55 | 1.32 | 1.23 |
| $S_2N_1$ | 19.80 | 6.51 | 9.78 | 0.83 | 0.88 |
| $S_2N_2$ | 23.33 | 7.26 | 10.44 | 0.92 | 0.91 |
| $S_2N_3$ | 25.37 | 7.68 | 10.44 | 0.93 | 0.96 |
| $S_2N_4$ | 27.63 | 9.78 | 11.11 | 0.96 | 0.96 |
| $S_3N_1$ | 22.57 | 7.03 | 14.66 | 0.85 | 0.89 |
| $S_3N_2$ | 27.03 | 8.03 | 15.33 | 0.95 | 0.99 |
| $S_3N_3$ | 29.23 | 8.67 | 14.33 | 1.04 | 1.01 |
| $S_3N_4$ | 31.00 | 10.00 | 14.66 | 1.13 | 1.17 |
| C.D. (P=0.05) | NS | NS | NS | 0.14 | 0.10 |

## Yield of bulbs/$m^2$

The yield of bulbs/$m^2$ was significantly influenced by spacing. Maximum yield of bulbs/$m^2$ (21.22) was recorded at $S_1$ (30x15 cm) spacing compared to $S_2$ (30x30 cm) and $S_3$ (40x15 cm) spacing. Yield of bulb per meter square was not significantly influenced by nitrogen levels alone and interaction of nitrogen levels and spacing.

## Number of bulblets per plant

Bulblets production per plant was significantly influenced by spacing, nitrogen levels and their interaction. Maximum number of bulblets per plant (1.04) was recorded in $S_1$ (30x15 cm) spacing which was on par at $S_3$ (40x15 cm) spacing (0.99) and least number of bulblets was recorded at $S_2$ spacing (0.91). Among different nitrogen levels, maximum number of bulblets (0.85) were recorded at $N_4$ (200 kg/ha) level followed by 150 kgN/ha (0.75) and 100 kgN/ha (0.71), while minimum number of bulblets (0.63) were recorded at $N_1$ (0 kg/ha) level.

With respect to interaction, maximum number of bulblets per plant (1.32) were recorded at $S_1N_4$ (30x15 cm + 200 kg N/ha) combination followed by $S_3N_4$ (40x15 cm + 200 kg N/ha) (1.13), $S_1N_3$ (30x15 cm + 150 kg N/ha) (1.04) and $S_3N_3$ (40x15 cm + 150 kg N/ha) (1.04) and least number of bulblets (0.83) were recorded at $S_2N_1$ (30x30 cm + 0 kg N/ha) treatment combination.

## Average weight of bulblets

Average weight of bulblets was also significantly influenced by spacing, nitrogen levels and their interaction. Maximum weight of bulblets (1.05 g) was recorded at $S_1$ (30x15 cm) spacing which was at par with $S_3$ (40x15 cm) spacing (1.02 g) and least weight (0.93 g) was observed under $S_2$ (30x30 cm) spacing.

Among different nitrogen levels, maximum weight of bulblets (0.84 g) was recorded at $N_4$ (200 kg N/ha) level which was at par with $N_3$ (150 kg N/ha) (0.76 g) and $N_2$ (100 kg N/ha) (0.73 g) level, while minimum weight of bulblets (0.67 g) was recorded at $N_1$ level (0 kg N/ha). With respect to interaction, maximum weight of bulblets per plant (1.23 g) was recorded at $S_1N_4$ (30x15 cm + 200 kg N/ha) treatment combination which was on par with $S_3N_4$ (40 x 15 cm + 200 kg N/ha) (1.17 g) and least weight of bulblets was recorded at $S_2N_1$ (30x30 cm +0 kg/ha) treatment combination (0.88 g).

## Bulb size, bulb weight and bulblet weight

The weight of bulbs, bulblets and size of bulbs were increased significantly with a decrease in plant spacing. This might be due to fact that the use of resources efficiently could helped in synthesis of more photosynthates which are further diverted to bulb growth. These findings are in parallel to the reports of Bhat *et al.* (1).

Nitrogen levels had a significant effect on bulb size, bulb and bulblet weight of Asiatic lily. Data showed that by increasing doses of nitrogen, bulb size and weight of bulb and bulblet increased also. When optimum nitrogen was supplied to a plant, greater translocation of photosynthetic material occurred from the leaves to sink sites (bulbs) resulting in better formation and growth of bulb and bulblets. These findings are similar to the findings of Khalaj and Edrisi (3) in Tuberose. The optimum spacing of 20 × 20 cm was also found superior for, enhancing growth and quality flowering in gladiolus (Ram *et al.,* 5).

## Bulb yield per meter square

The number of bulbs/$m^2$ increased with closer spacing (30x15 cm) might be due to that closer spacing occupying more number of plants per unit area, which in turn increased number of bulbs/$m^2$. Klasman *et al.* (4) reported similar views in gladiolus.

## Number of bulblets per plant

In the present study, maximum production of bulblets per plant (1.04) was recorded with closer spacing (30x15 cm). This might be due to fact that plants face less competition from each other for light, water and nutrients and as a consequences show better physiological activity, which inturn is reflected in improvement of bulblets yield. Klasman *et al* (**4**) reported similar observations in gladiolus.

Among the different nitrogen levels, maximum number of bulblets per plant was increased with increased nitrogen levels. This might be due to the fact that plants grow more vigorously and produce more metabolites which might result in more bulblets per plant. Similar results were expressed by Singh and Mahadevamma (**6**) in tuberose.

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**Citation :** Vedavathi R.S., Basavanagowda M.G., Patil R.M. and Thipanna K.S. (2014). Effect of spacing and nitrogen on bulb formation and growth of Asiatic lilly under hill zone. *HortFlora Res. Spectrum,* **3**(4) : 377-379

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 380-382 (December 2014) ISSN : 2250-2823

***Research Note*** :

# ECO-FRIENDLY MANAGEMENT OF RHIZOME ROT (SOFT ROT) DISEASE OF GINGER UNDER PASIGHAT CONDITION OF ARUNACHAL PRADESH

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**ABSTRACT :** Rhizome rot of ginger, caused by *Pythium aphanidermatum* (Edson) Fitz, is a major constraint for the production of healthy rhizome, sometimes causing total failure of crop. Chemical control of this pathogen is not economical and non-ecofriendly. Thus, the treatment with bio-control agent (*Trichoderma viride*) may offer practical and economical alternative for eco-friendly management of this disease. The lowest disease incidence (18.00 %) was recorded in $T_5$ - Rhizome treated with *Trichoderma viride* @ 10g/l of water + Three foliar sprays of *Trichoderma viride* @ 4 kg/ha followed by $T_4$-Rhizome treated with *Trichoderma viride* @ 10g/l of water + Two foliar sprays of *Trichoderma viride* @ 4 kg/ha with disease incidence of 24.33 %. The highest disease incidence (86.33%) was recorded in $T_6$ (control) which was raised without any rhizome treatment and foliar sprays.

**Keywords :** *Ginger, management, Pythium aphanidermatum, rhizome rot, Trichoderma spp.*

Ginger (*Zingiber officinale* Rosae L.) is an important spice crop belonging to family *Zingiberaceae*. Rhizome rot of ginger caused by *Pythium aphanidermatum* (Edson) Fitz is a major constraint for the production of healthy rhizome, sometimes causing total failure of crop (Fagaria *et al.*, 2). Chemical control of this pathogen is not economical because of high cost of chemicals; break down of resistance, environmental pollution, deleterious effect to non target beneficial soil micro-organisms and ultimately the choice of the consumer for organic product. In biological control, disease suppression/ control is the consequences of interactions between the plant, pathogen and microbial community (Singh and Sachan, 6). Thus, the treatment with bio-control agent (*Trichoderma viride*) may offer practical and economical alternative for eco-friendly management of this disease.

The present investigation was carried out at Herbal Garden of Department of Botany, J. N. College, Pasighat, Arunachal Pradesh, India during *Kharif*, 2012-13. The rhizomes were planted in field at 25 x 15 cm spacing with three replications in randomized block design. The six treatments were applied in treated plots along with control (water soaked/sprayed).

## Isolation, purification and identification of *Trichoderma* spp.

Fifteen soil samples collected from different agricultural fields, forests and deep forest of East Siang District of Arunachal Pradesh were inoculated on to potato dextrose agar (PDA) and rose bengal agar and incubated at 28 $^0$C for 5 days. After incubation period, colonies determined to be *Trichoderma spp.* (Watts *et al.* 9, and Rifai, 5) were purified for further experiment.

The treatment details were as below :

$T_1$-Rhizome treatment with *Trichoderma viride* @ 10g/l of water

$T_2$-Two foliar spray of *Trichoderma viride* @ 4 kg/ha

$T_3$-Three foliar spray of *Trichoderma viride* @ 4 kg/ha

$T_4$-Rhizome treatment with *Trichoderma viride* @ 10g/l of water + Two foliar spray of *Trichoderma viride* @ 4 kg/ha

$T_5$-Rhizome treatment with *Trichoderma viride* @ 10g/l of water + Three foliar spray of *Trichoderma viride* @ 4 kg/ha

$T_6$-Control (Water spray)

**Rhizome treatment**–Rhizomes were dipped in the suspension prepared @ 10 g /l of water. They were shade dried for 15 minutes before planting.

**Foliar application** - Made a paste by adding 10 g in 15 ml water and then the paste was added to 1.5 litre of water and mixed properly before spraying on the plant parts.

In control, rhizomes were soaked in water instead of *Trichoderma viride*. The treated and untreated rhizomes were sown separately in the experimental plots as well in plastic pots filled with sterilized sand being used for seed quality traits assessment. Foliar sprays of *Trichoderma viride* were done at weekly

*Received:16-08-2014; Revised:02-09-2014; Accepted:23-09-2014*

interval starting just after apparent symptom appeared in the field for the first time. The symptomatology and disease incidence was recorded by the formula of (Verma and Awasthi, 8).

The results obtained (Table 1) clearly showed that native bio-control agent *Trichoderma viride* (Rhizome treatment and foliar spray) significantly reduced the growth of the fungus.

**Table 1: Effect of rhizome treatment and foliar spray with *Trichoderma viride* on rhizome rot (soft rot) disease of ginger.**

| Treatments | Disease incidence (%) | Disease reduction (%) |
|---|---|---|
| $T_1$-Rhizome treatment with *Trichoderma viride* 10g/l of water | 28.33 (32.16)* | 67.18 (54.85) |
| $T_2$-Two foliar spray of *Trichoderma viride* @ 4 kg/ha | 44.67 (41.94) | 48.14 (43.93) |
| $T_3$-Three foliar spray of *Trichoderma viride* @ 4 kg/ha | 40.67 (39.60) | 52.96 (46.70) |
| $T_4$- ($T_1$+$T_2$) | 24.33 (29.49) | 71.84 (58.00) |
| $T_5$-($T_1$+$T_3$) | 18.00 (25.04) | 79.19 (62.92) |
| $T_6$-Control (Water spray) | 86.33 (68.44) | 0.00 (02.87) |
| CD (P = 0.05) | 4.10 | 4.20 |

*Figures in parenthesis are arcsine transformed values.

Minimum disease incidence (18.00 %) was recorded in $T_5$ - Rhizome treatment with *Trichoderma viride* @ 10g/l of water + Three foliar spray of *Trichoderma viride* @ 4 kg/ha followed by $T_4$ Rhizome treatment with *Trichoderma viride* @ 10g/l of water + Two foliar spray of *Trichoderma viride* @ 4 kg/ha (24.33 % incidence), $T_1$-Rhizome treatment with *Trichoderma viride* @ 10g/l of water (28.33 %), $T_3$-Three foliar spray of *Trichoderma viride* @ 4 kg/ha (40.67 %) and $T_2$-Two foliar spray of *Trichoderma viride* @ 4 kg/ha (44.67% disease incidence).

Results pertaining to the efficacy of rhizome treatment and foliar sprays with *Trichoderma viride* indicated the superiority of rhizome treatment plus three foliar sprays of *Trichoderma viride* resulting in to minimum disease incidence having rhizome treatment with *Trichoderma viride* @ 10g/l of water + Two foliar spray of *Trichoderma viride* @ 4 kg/ha. The maximum disease incidence (86.33%) was recorded in $T_6$ (control) which was raised without any rhizome treatment and foliar sprays, served as control.

Application of *Trichoderma viride* as seed treatment as well soil amendment was found most effective. These results are in agreement with Joseph and Prasad (3) and Srivastava *et al*. (7), who isolated native antagonist *T. viride* from healthy ginger plants and evaluated against rhizome rot. Two isolates *viz*., isolate no. 12 and 7 stimulated plant growth and isolate no. 12 gave higher rhizome yield, better biomass production and disease suppression also. Formulations of antagonistic organisms when once introduced into the soil survive for a longer period. There is also circumstantial report that native antagonists are more efficient than introduced antagonists (Kulkarni and Sagar, 4). Soil amendments alter the soil reaction, change the spectrum of soil microflora, and thus affect the proportion of pathogens existing in soil (Dohroo and Pathania, 1). Addition of organic matter favourably improves crop yield mainly by enhancing soil fertility rather than through provision of nutrients to the plants. Considerable improvements in soil structure, water retention capacity and aeration in different types of soils have been observed following the addition of green manures, farm yard manures and other organic matter. Another additional advantage of using organic matter is the activation of many beneficial microbes antagonistic to soil borne pathogens, leading to disease suppression.

## ACKNOWLEDGEMENT

We are highly thankful to Department of Biotechnology (DBT) for giving a project Biotech HUB at Jawarhar Lal Nehru, College, Pasighat (Arunachal Pradesh).

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**Citation :** Chaturvedi R.C. (2014). Eco-friendly management of rhizome rot (soft rot) disease of ginger under Pasighat condition of Arunachal Pradesh. *HortFlora Res. Spectrum,* **3**(4) : 380-382

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 383-385 (December 2014) ISSN : 2250-2823

***Research Note*** **:**

# EFFECT OF NPK AND POTTING MEDIA ON PLANT GROWTH AND SPIKE YIELD OF *DENDROBIUM ORCHID* CV. SONIA HISKULA

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**ABSTRACT :** An experimental was laid out in the CRB Design having 10 treatment and 3 replications. The treatment $T_9$ (10:30:30 NPK + 0.3% Brick pieces + Gravel + Poultry manure) was found to be statistically significant over other treatments which recorded highest plant height (29.61cm), number of leaves (9.69), leaf area (36.11cm$^2$), number of new shoots per plant (4.58), shoot girth (3.16 cm), root length (16.73cm), number of root per plant (20.25), total number of spikes per plant (3.47), number of florets per spike (10.69), spike length (33.91cm), and longevity of spike (42.91 days) under shade net condition.

**Keywords:** *Orchid, NPK, potting media, growth, spike, shelf life.*

*Dendrobium,* the second largest genus in family Orchidaceae with nearly 1600 species of orchids, is one of the most important genera with many horticulturally interesting species. The plants are epiphytic in nature showing great variability for plant and flower characters. India is bestowed with wide range of environment to grow almost all types of orchid species and one of the richest centre of diversity for orchids in the world. Inspite of this fact, the commercial exploitation of orchids is still in nascent stage in the country. In Tamil Nadu, cultivation of orchids on a commercial scale was first started by private growers at Chengalpet, near Chennai. The government of Kerala itself actively engaged in the cultivation and marketing of orchids through Horticultural Corporation (Chadha, 1). *Dendrobium spp.* of orchids is being successfully grown under agroclimatic conditions of central Uttar Pradesh. Therefore, an attempt has been made to study the effect of NPK and potting media on plant growth and spike field of *Dendrobium* orchid cv. Sonia Hiskula under the agro-climatic conditions of Allahabad.

This experiment was conducted in Floriculture Unit, Department of Horticulture, Allahabad School of Agriculture, SHIATS, Allahabad during 2012. The experiment was laid out in Complete Randomized Block Deign (CRBD) with three replications. Among total 10 treatments comprised of NPK and potting media at different level of each *viz.*$T_1$ : 20:20:20 NPK + (0.3 % Coconut fibre + FYM+ Wheat husk), $T_2$:10:30:20 NPK + (0.3% Charcoal + Coconut fibre + Brick pieces), $T_3$:15:15:15 NPK + (0.3% Brick pieces + FYM + Leaf mould), $T_4$: 20:15:15 NPK + (0.3% Wheat husk + FYM + Gravel), $T_5$: 20:10:20 NPK + (0.3% Coconut fibre + Poultry manure + Brick pieces), $T_6$: 19:19:19 NPK + (0.3% Brick pieces + Rice husk + Charcoal), $T_7$ : 10:15:20 NPK + (0.3% FYM + Poultry manure + Brick pieces), $T_8$ : 20:10:10 NPK + (0.3% Leaf mould + Gravel + Rice husk) and $T_9$ : 10:30:30 NPK + (0.3% Brick pieces + Gravel + Poultry manure) alongwith a control ($T_0$ : Rice husk + leaf mould + gravel were adopted. The plants were collected from Sheel Bio-tech limited, Tughalakabad New Delhi. Procured plants of uniform size were transferred in perforated 12 inch earthen pots under shed net house. The pots were placed over 5 cm sand surface. The growth and yield parameters for each treatment were observed in three plants selected by random sampling method. The data were statistically analyzed and critical differences were worked to draw statistical conclusions.

Results revealed that the maximum plant height (29.61 cm) of *Dendrobium cv.* Sonia Hiskula was recorded in $T_9$-10:30:30 NPK+ (0.3% Brick pieces + Gravel + Poultry manure) followed by $T_8$, $T_7$ and $T_6$. The shortest plants (23.42 cm) were recorded in control at 180DAP. The increase in plant height might be due to improved aeration and water holding capacity of the potting media that modified the physical and chemical properties (Savithri and Khan, 5). The maximum number of leaves (9.69 leaves/plant) at 180 DAP were registered in $T_9$-10:30:30 NPK + (0.3% Brick pieces + Gravel + Poultry manure) and the minimum number of leaves (7.25 leaves/plant) was recorded in control. The high lignin content and wide C : N ratio of

*Received:10-07-2014; Revised:15-10-2014; Accepted:03-11-2014*

**Table 1 : Effect of NPK and potting media on plant growth and spike yield of *Dendrobium Orchid* cv. Sonia Hiskula.**

| Treatments | Plant height (cm) | Number of leaves / plant | Leaf area ($cm^2$) | Number of shoots per plant | Shoot girth (cm) | Root length (cm) | Number of roots per plant | Total number of spike yield per plant | Number of florets per spike | Spike length (cm) | Longevity of spike per plant (Days) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_0$ | 23.42 | 7.25 | 24.50 | 1.91 | 2.41 | 10.79 | 15.25 | 1.25 | 9.25 | 21.91 | 31.91 |
| $T_1$ | 25.82 | 7.36 | 25.38 | 1.91 | 2.66 | 12.32 | 16.25 | 1.47 | 9.47 | 23.58 | 34.58 |
| $T_2$ | 25.65 | 7.36 | 25.21 | 2.58 | 2.55 | 12.09 | 15.91 | 1.36 | 9.36 | 22.91 | 33.58 |
| $T_3$ | 25.87 | 7.80 | 25.71 | 2.91 | 2.66 | 12.88 | 16.58 | 1.56 | 9.69 | 24.58 | 35.91 |
| $T_4$ | 26.25 | 8.47 | 26.68 | 3.91 | 2.71 | 14.04 | 18.25 | 1.67 | 10.25 | 28.58 | 37.58 |
| $T_5$ | 25.91 | 8.25 | 24.78 | 3.58 | 2.82 | 12.88 | 16.91 | 1.58 | 9.80 | 25.58 | 36.91 |
| $T_6$ | 26.48 | 9.36 | 32.65 | 3.25 | 3.01 | 15.34 | 19.25 | 2.47 | 10.47 | 31.58 | 40.91 |
| $T_7$ | 26.30 | 8.58 | 30.01 | 2.25 | 2.91 | 14.77 | 18.58 | 2.25 | 10.36 | 30.91 | 40.58 |
| $T_8$ | 28.25 | 9.47 | 33.75 | 4.25 | 3.09 | 15.52 | 19.58 | 2.47 | 10.47 | 32.91 | 42.25 |
| $T_9$ | 29.61 | 9.69 | 36.11 | 4.58 | 3.16 | 16.73 | 20.25 | 3.47 | 10.69 | 33.91 | 42.91 |
| C. D. (P = 0.05) | 0.789 | 0.747 | 1.070 | 0.234 | 0.132 | 0.005 | 0.441 | 0.234 | 0.145 | 0.088 | 0.909 |

rice husk + leaf mould + gravel made the decomposition rate very slow compared to other media (Dematte, 2). In the present study, the efficiency of different media was assesed in terms of the number of leaves produced per plant. The maximum leaf area (36.11 $cm^2$) was also noted under $T_9$ followed $T_8$ (33.75 $cm^2$) and $T_6$ (32.65 $cm^2$). The potting mixture of Brick pieces + Gravel +Poultry manure produced the highest leaf area due to the capability of absorbing nutrient slowly and moisture retaining capacity. The maximum number of new shoots (4.58) was seen in $T_9$ followed by $T_8$, $T_4$, $T_5$ and $T_6$ and it was minimum (1.91) in control. The plant which would helped in better production of frame work (source) for better metabolic activities especially with regard to production of photoassimilates as well as root formed hormone such as cytockinin which would have favoured more production of shoot. The maximum shoot girth (3.16 cm) was recorded in $T_9$ followed by $T_8$, $T_6$, $T_7$. The minimum shoot girth (2.41 cm) was recorded in control (rice husk + leaf mould + gravel). At 180 DAP root length was significantly affected by NPK and potting media. Application of 10:30:30 NPK + (0.3% Brick pieces + Gravel + Poultry manure) showed the maximum root length (16.73 cm) which was closely followed by $T_6$, $T_8$, $T_7$ and $T_5$. For proper shoot and root growth, a medium must serve four functions *viz.,* to provide water, to supply NPK, to permit gas exchange (respiration) and to provide support for the plant. Among the different NPK and potting media applied the treatment $T_9$ {10:30:30 NPK + (0.3% Brick pieces + Gravel + Poultry manure} was found to be superior in the production of number of roots per plant (20.25) followed by $T_8$, $T_6$, $T_7$ and $T_4$. It was the lowest (15.25 roots/plant) in control (Rice husk + leaf mould + gravel). Paul and Rajeevan (3) had also reported similar findings in *Dendrobium*. The highest total number of spikes per plant (3.47) was observed in $T_9$ 10:30:30 NPK + (0.3% Brick pieces + Gravel + Poultry manure) followed $T_8$, $T_6$ and $T_7$. The least total number of spikes per plant (1.25) was observed in control. Plants grown in granulated stone gave the lowest spike yield. The highest number of florets per spike (10.69) was observed in $T_9$ {10:30:30 NPK + (0.3% Brick pieces + Gravel + Poultry manure} followed $T_8$, $T_6$ and $T_7$. The least number of florets per spike (9.25) was observed in $T_0$. The number of florets per spike in Brick pieces + Gravel +Poultry manure which consists of mainly lignocellulosic material may be due to the fact that it is free from any admixture of heavy metals (Sathyanarayana *et al.,* 4). Whereas Sonia Hiskula registered a maximum spike length (33.91 cm) in $T_9$ which was statistically superior to next best treatment $T_8$ (32.91 cm) being on par which $T_6$ (31.58 cm). The minimum spike length (21.91 cm) was recorded in $T_0$. The maximum longevity of spike (42.91 days) was observed in $T_9$ which was statistically superior to next best treatment $T_8$ (42.25 days) being on par with $T_6$ (40.91 days). The minimum longevity of spike (31.91 days) was recorded in $T_0$. It is attributed to its moisture retention capacity and the maintenance of temperature under tropical condition (Shanthi *et al.,* 6)

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**Citation :** Ahmad G. and Saravanan S. (2014). Effect of NPK and potting media on plant growth and spike yield of *Dendrobium* orchid cv. Sonia Hiskula. *HortFlora Res. Spectrum,* **3**(4) : 383-385

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 386-387 (December 2014) ISSN : 2250-2823

***Research Note* :**

# ROLE OF PROLINE AS COADJUTANT ON DIRECT REGENERATION OF CITRUS ROOTSTOCK ROUGH LEMON (*Citrus jambhiri* Lush.)

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**ABSTRACT:** At present, about 61 per cent area of fruit crops in the Punjab state is occupied by Kinnow mandarin which is mainly propagated on rough lemon rootstock. Polyembryony, sterility, poor viability of hybrid seeds, unknown mode of inheritance and long juvenility present major problems in citrus improvement through conventional breeding programme. Tissue culture and biotechnological methods provide fast improvement to a particular crop and their success rests upon the reproducible and efficient regeneration protocols. The experiment carried out on effect of proline on tissue culture aspects of rough lemon *(Citrus jambhiri)* revealed that proline might have reduced the effect of NAA and can replace ABA in direct regeneration of citrus rootstock rough lemon.

***Keywords:*** *Rough lemon, root stock, regeneration, biotechnology, protocol.*

In India, citrus is the third largest fruit industry after mango and banana, covering approximately 0.91 m ha area with an annual production of 7.9 MT (Anon, 1). In Punjab, citrus ranks first with an area of 49,244 ha and annual production of 10,15,628 MT (Anon, 2). At present, about 61 per cent area of fruit crops in the Punjab state is occupied by Kinnow mandarin which is mainly propagated on rough lemon rootstock. It is a fast growing rootstock, induces large fruit size, higher yield besides, being also tolerant to drought, exocortis and tristeza viruses. Rootstock is a major contributor to tree performance and longevity, as it determines tolerance to various biotic and abiotic stresses. Although, this rootstock has well adapted under Punjab conditions, but its susceptibility to *Phytophthora* fungus has become a major cause of citrus decline (Castle and Baldwin, 3). Polyembryony, sterility, poor viability of hybrid seeds, unknown mode of inheritance and long juvenility present major problems in citrus improvement through conventional breeding programme.

Tissue culture and biotechnological methods provide fast improvement to a particular crop and their success rests upon the reproducible and efficient regeneration protocols. Tissue culture and micro propagation protocols have been described for a number of citrus species and explant sources (Duran-Vila *et al.,* 4). However, very little work has been carried out on effect of proline on tissue culture aspects of rough lemon and therefore, this study was planned accordingly.

Fresh fruits of citrus rootstock rough lemon (*Citrus jambhiri* Lush.) were first washed with Teepol solution and then used for extracting seeds, which were made free of testa (outer covering) and surface sterilized under aseptic conditions with 0.1 per cent mercuric chloride ($HgCl_2$) for 10 minutes. The seeds were thoroughly washed with sterile distilled water thrice before inoculation to circumvent the deleterious effects of mercuric chloride. The seedlings of rough lemon were raised *in vitro* on MS (basal) medium by aseptic culturing of surface sterilized seeds.Three week old epicotyl segments excised from *in vitro* raised seedlings were used as explants. MS (Murashige and Skoog, 1962) media fortified with single concentration of BAP and NAA and different concentrations of proline were used for the study. The culture vessels were incubated at 25±2°C temperature in continuous fluorescent white light (2000 lux) with 16h/8h light /dark periods. The response to per cent callusing and adventitious bud formation was recorded.

## Effect of proline on rough lemon epicotyls

Media composition $C_1$ [MS + NAA (10 mgl$^{-1}$) + BAP (1.0 mgl$^{-1}$)] was considered as control as it gives the good quality callus and proline was added to improve callus quality. Proline was added at 280, 420, 560 and 700 mgl$^{-1}$ to the $C_1$ and it was observed that with the increase in dose of proline there is a decrease in callus induction and increase in adventitious bud formation (Table 1). Proline dose of 280 mgl$^{-1}$ induced 5.50 per cent callus in 20.50 days, whereas, no other

*Received:26-07-2014; Revised:20-09-2014; Accepted : 30-08-2014*

**Table 1: Effect of proline on callus induction in *Citrus jambhiri* using epicotyl segments as explant.**

| Treatment | Media composition | Sucrose (%) (w/v) | Proline ($mgl^{-1}$) | Induction (%) | Days to initiation | Results |
|---|---|---|---|---|---|---|
| $C_1$ (Control) | MS + NAA ($10 mgl^{-1}$) + BAP ($1 mgl^{-1}$) | 3 | - | 79.43 | 10.50 | Creamish callus formed |
| $CP_1$ | | 3 | 280 | 5.50 | 20.50 | Creamish callus formed |
| $CP_2$ | | 3 | 420 | 8.00 | 23.40 | Adventitious buds formed |
| $CP_3$ | | 3 | 560 | 35.00 | 26.50 | Adventitious buds formed |
| $CP_3$ | | 3 | 700 | 41.00 | 29.00 | Adventitious buds formed |

Plate 1 : Adventitious bud formation on epicotyl segments of *Citrus jambiri* Lush when cultured on MS + NAA ($10\ mgl^{-1}$) + BAP ($1.0\ mgl^{-1}$) + Proline ($560\ mgl^{-1}$).

supplementation did the same. The callus growth was more on the upper surface of explant and it was friable and whitish in colour. It was interesting to note that addition of 560 ppm proline to $C_1$ induced adventitious buds formation in 35 per cent explants near the cut ends within 26.50 days of culturing [Plate 1]. Whereas, the increase in addition of proline to 700 ppm induced adventitious buds formation in 41.0 per cent explants within 29.00 days of culturing.The buds were of slow growth and required frequent subculturing.

Sub-cultured calli of *C. sinensis* cv. Valencia Late had the best embryogenic callus response from proline ($150\ mgl^{-1}$), when the source of ammonium was reduced to 75 per cent and MS salts diluted to half (Rodriguz and Villalobos, 7). Similarly, Prerez and Ochoa (6) reported adventitious bud formation in Mexican lime (96%) and mandarin cv. Monica (88%), when internodal segments were cultured on MS with vitamins from $B_5$ medium, sucrose (5%), BAP ($33.3\ \mu Ml^{-1}$) and NAA ($5.4\ \mu Ml^{-1}$). The highest adventitious bud regeneration frequency (85.2%) and bud formation efficiency (3.7 per responsive inter-nodal stem segment) in Newhall Navel orange was obtained (Huang *et al.* 5) in the media supplemented with BAP ($1.0\ mgl^{-1}$) + NAA ($0.5\ mgl^{-1}$) + ABA ($0.2\ mgl^{-1}$). Hence, in this study it became clear that proline might have reduced the effect of NAA and can replace ABA in direct regeneration of citrus rootstock rough lemon.

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**Citation :** Sidhu G.S. and Rattanpal H.S. (2014). Role of proline as coadjutant on direct regeneration of citrus rootstock rough lemon (*Citrus jambhiri* Lush.). *HortFlora Res. Spectrum,* **3**(4) : 386-387

www.hortflorajournal.com
*HortFlora Research Spectrum*, 3(4): 388-389 (December 2014) ISSN : 2250-2823

***Research Note*** :

# EVALUATION OF CHRYSANTHEMUM GENOTYPES FOR FLOWERING TRAITS UNDER OPEN GROWN CONDITION

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**ABSTRACT :** An experiment was carried out to evaluate seven genotypes of chrysanthemum for flower quality traits at IIHR, Bengaluru from 2010-11 to 2012-13. Significantly wide variation was recorded in all floral traits. Results revealed that maximum number of flowers/plant (81.51) and flowering duration (43.14 days) were recorded in Anmol. Maximum plant height (47.25 cm) and flower diameter (5.03 cm) were recorded in Garden Beauty. However, maximum average weight of flower (2.59 g) and flower yield/plant (131.43 g) were recorded in Autumn Joy. The genotype Winter Queen recorded maximum number of sprays/plant (6.89). On the basis of three years observations, genotypes Winter Queen, Garden Beauty and Autumn Joy found promising for garden display.

***Keywords:*** *Chrysanthemum, evaluation, flowering, quality.*

Chrysanthemum (*Chrysanthemum morifolium* Ramat.), belongs to the family Asteraceae, is a popular flower crop used for cut flower, loose flower, garland making, garden display, pot plant etc.. It occupies prime position among commercial flower crops which has high demand in both domestic and international market. Chrysanthemum is very rich in varietal wealth and every year there is an addition of new varieties. The performance of any crop or variety largely depends on interaction between genotype and environment. As a result, varieties, which perform well in one region, may not perform same in other regions of varying climatic conditions. Hence, it necessary to evaluate the new genotypes for their quality traits under varying climatic conditions. In view of the above, an experiment was carried out to evaluate the performance of the newly released six varieties with 'Local Yellow Semi-Double' as check, under AICRP on Floriculture for three consecutive years from 2010-11 to 2012-13.

A field experiment was carried out to evaluate the performance of seven genotypes viz., Anmol, Winter Queen, Garden Beauty, Yellow Delight, Autumn Joy, Pusa Anmol and Local Yellow Semi-Double in RBD with three replications at ICAR-Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bengaluru 560 089 for three consecutive years from 2010-11 to 2012-13. The experimental site was geographically located at 13$^{o}$ 58' N Latitude, 78$^{o}$ E Longitude and at an elevation of 890 m above mean sea level. Terminal rooted cuttings of all seven genotypes were planted at 30 cm x30 cm in a plot size of 2.7 m x 1.2 m accommodating 32 plants per plot. Uniform cultural practices were followed to all the genotypes throughout the experiment. Five randomly selected plants per genotype per replication were labeled for recording observations on plant height (cm), number of flowers per plant, number of sprays per plant, flower diameter (cm), average weight per flower (g), flower yield per plant (g) and duration of flowering (days). Statistical package 'Biostat IIHR, version 1.0' was used for statistical analysis of data.

Significant differences were recorded in all the genotypes for flowering characters (Table 1). Results revealed that maximum plant height was recorded in Garden Beauty (47.25 cm) followed by Local Yellow Semi-Double (46.27 cm) and Pusa Anmol (40.00 cm), whereas, it was recorded minimum in Winter Queen (26.26 cm). The variation in plant height is mainly due to their genetic make up of individual genotype. Similar variation in plant height due to genotypes has also been reported (Kulkarni and Reddy, 3; Gantait and Pal, 2). Maximum number of flowers per plant was recorded in Anmol (81.51) followed by Winter Queen (64.90), Local yellow Semi-Double (46.27) and Autumn Joy (48.15), whereas minimum number of flowers per plant was recorded in Yellow Delight. The genotype Winter Queen recorded maximum number of sprays/plant (6.89) while it was recorded minimum in Yellow Delight (5.47). Maximum flower diameter (5.03 cm) was recorded in Garden Beauty, whereas maximum average flower weight was recorded in Autumn Joy (2.59 g). The flower yield per plant ranged from 60.25 g

*Received : 02-11-2014* *Accepted : 28-11-2014*

**Table 1: Performance of chrysanthemum genotypes for growth and flowering under open grown condition (pooled data of three years, 2010-11 to 2012-13)**

| Genotype | Plant height (cm) | No. of flowers/ plant | No. of spray/ plant | Flower diameter (cm) | Average weight/ flower(g) | Flower yield/ plant (g) | Duration of flowering (days) |
|---|---|---|---|---|---|---|---|
| Anmol | 29.22 | 81.51 | 6.60 | 3.00 | 1.33 | 82.61 | 43.14 |
| Winter Queen | 26.26 | 64.90 | 6.89 | 4.49 | 1.37 | 92.95 | 41.29 |
| Garden Beauty | 47.25 | 40.28 | 6.24 | 5.03 | 2.48 | 102.45 | 37.09 |
| Yellow Delight | 28.68 | 27.14 | 5.47 | 4.23 | 2.17 | 42.67 | 37.71 |
| Autumn Joy | 31.53 | 48.15 | 6.62 | 4.97 | 2.59 | 131.43 | 41.33 |
| Pusa Anmol | 40.00 | 45.72 | 5.51 | 4.05 | 1.42 | 60.25 | 20.55 |
| Local Yellow Semi-Double | 46.27 | 48.38 | 5.61 | 4.97 | 1.88 | 64.61 | 37.76 |
| C.D. (P=0.05) | 3.96 | 6.18 | 0.52 | 0.27 | 0.34 | 6.18 | 4.16 |

(Pusa Anmol) to 131.43 g (Autumn Joy). Variation in number of flowers per plant and weight of flowers per plant due to genotypes has also been reported (Barigidad and Patil, 1; Saud and Talukdar, 4; Gantait and Pal, 2). The maximum flowering duration was recorded in Anmol (43.14 days) followed by Autumn Joy (41.33 days) and Winter Queen (41.29 days). Variation in flowering duration in various genotypes of chrysanthemum as reported by Barigidad and Patil (1) also confirms present findings. On the basis of three yeas observations, genotypes Winter Queen, Garden Beauty and Autumn Joy found promising and suitable for garden display.

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**Citation :** Kumar R. (2014). Evaluation of chrysanthemum genotypes for flowering traits under open grown condition. *HortFlora Res. Spectrum,* **3**(4) : 388-389

www.hortflorajournal.com

*HortFlora Research Spectrum*, 3(4): 390-391 (December 2014) ISSN : 2250-2823

***Research Note* :**

# FIRST EVALUATION OF TARO (*Colocasia esculenta*) GENOTYPES AGAINST LEAF BLIGHT (*Phytophthora colocasiae*) IN GHANA

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**ABSTRACT :** Taro genotypes were collected and evaluated to determine their resistance in the Aowin Suaman district of Ghana. Twenty five (25) genotypes of taro from both the Ashanti and Western Region were evaluated for six months in a location for resistance to the leaf blight disease in the study area. The Randomized Complete Block Design was used with each accession replicated three times. The results revealed that of the 25 accessions evaluated, no accession was completely resistant to the disease in the study area, though some were moderately resistant, and that the only solution to the disease is to breed for resistance.

***Keywords:*** *Colocasia, genotype, accession, Phytophthora, colocasiae, resistance.*

Taro (*Colocasia esculenta*) is an important staple crop for several hundred million small-scale farmers and is widely grown throughout Asia and the Pacific, the Americas and Africa. About 10% of the world's population uses taro or taro-like plants (Araceae) as a staple food in their diets, and for 100 million people this is an important daily food (Jeri and Barry, 4). It is an important food crop cultivated for its edible corms in Ghana. Its corms are baked, roasted, or boiled and the leaves are frequently eaten as a vegetable and represent an important source of vitamins, especially folic acid.

Taro is affected by at least 10 major diseases and pests in different parts of the World (Kohler *et al.,* 5). Of the various taro diseases, taro leaf blight (TLB) caused by the fungus-like Oomycete *Phytophthora colocasiae* Racib is of prime importance (Jackson, 3). It has been found in various parts of Asia and the Pacific (Brooks, 2), and has also been reported in some countries in Africa including Nigeria, Cameroun and Ghana (Bandyopadhyay *et al.,* 1; Omane *et al.,* 6).

Though some fungicides have been reported to be effective in managing this disease, they are generally too expensive for the majority of growers, besides most farmers in Ghana cultivate them on subsistence bases and normally around water bodies. The use of resistant genotypes is considered to be the best method for disease management. That was the purpose for the evaluation of germplasm from two major taro growing areas in the country.

Twenty four (25) taro accessions were collected from twelve communities in two Regions in Ghana (Ashanti and the Western region). They were then established in Yakasi, a hot spot area of the disease in the Aowin Suaman District of Ghana. The Randomized Complete Block Design was used with three replications of each genotype. Data collection was started two weeks of establishment when the leaves had started unfolding and at two weeks interval for twelve weeks. All the recommended package and practices were followed for raising a good crop except plant protection. The disease was scored on 0-5 scale (Prasad, 7). Disease incidence was determined by given formula by Shakywar *et al*. (8).

$$\text{Disease Incidence} = \frac{\text{Infected plants}}{\text{Total plants}} \times 100$$

Table 1 shows the resistance and the susceptibility levels of the 25 taro genotypes evaluated on a 0-100% incidence scale against TLBD. An incidence level of less than 5% represents resistance and more than 24% also represents susceptibility (Shakywar *et al.,* 8). It was clear that none of the accessions was completely resistant against the disease with an incidence of less than 5%. Seven out of the 25 accessions were moderately resistant with an incidence range of 6-25%. All the rest were susceptible because they recorded an incidence level of more than 25%.

*Received : 07-10-2014* *Accepted : 30-10-2014*

**Table 1 : Level of resistance of taro accessions against the taro leaf blight disease on field condition.**

| Scale | Range of DI (%) | Level of Resistance | Number of accessions | Accession number |
|---|---|---|---|---|
| 0 | 0.00 | HR | NIL | |
| 1 | 1-5 | R | NIL | |
| 2 | 6-25 | MR | 7 | FKA12/AJ001, FKA12/E002, FKA12/J001, FKA12/NT001, FKA12/NT003, FKA12/OK001, FKA12/P004 |
| 3 | 26-50 | MS | 16 | FKA12/AB001,FKA12/AG001,FKA12/AK001,FKA12/AK002,FKA12/E001,FKA12/NT002,FKA12/P001,FKA12/P002,FKA12/P005,FKA12/P006,FKA12/T001 SAO12/NY001, SAO12/NY002,SAO12/NY004,SAO12/NY005,SAO12/NY006 |
| 4 | 51-75 | S | 1 | SA012/NY003 |
| 5 | 76-100 | HS | 1 | FKA12/P003 |

*DI=Disease Index, HR=Highly Resistance, H=Resistance, MR=Moderately Resistance, MS=Moderately Susceptible, S=Susceptible, HS=Highly Susceptible. Level of Resistance was Determined using the scale of Shakywar et al. (8).*

Evaluation of genotypes in this study revealed that some cultivars with meaningful resistance can be found in local germplasm in Ghana. It was evident that none of the germplasm evaluated in this study was completely resistant to the disease. The findings also indicates that there may be no accession of taro in both the Western and Ashanti Region of Ghana that may be completely resistant to the taro leaf blight disease. With the current spread of the TLBD in the country, there is the likelihood that all taro genotypes may be attacked. This corroborates finding of Shakywar *et al* (8), who after evaluating ninety taro genotypes in India observed that none was completely resistant. Sugha and Gurung (9) made similar studies and reported that none of the genotypes evaluated in India were free from the taro leaf blight disease.

However, the identification of genotype to be moderately resistant to the disease is encouraging. It is recommended that these seven genotypes are evaluated further in taro leaf blight endemic areas to examine the durability of this moderate resistance. If these genotypes continue to show moderate resistance, then they could be use alongside fungicides and farm sanitation in an integrated management system. Evaluating a greater number of genotypes from a wider region would contribute to identification of resistant materials. Taro genotypes from production areas in different countries with known resistance to taro leaf blight could be collected and evaluated in Ghana to facilitate the search for resistance materials.

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**Citation :** Ackah, F. K., Puije, G.C. van der and Moses, E. (2014). First evaluation of taro (*Colocasia esculenta*) genotypes against leaf blight (*Phytophthora cololosiae*) in Ghana, *HortFlora Res. Spectrum,* **3**(4) : 390-391

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**The support provided by above reviewers and all the members of Editorial Board (2014) by the way of peer review of the papers published in *'HortFlora Research Spectrum'* Vol. 3 (1-4), 2014 is duly acknowledged and appreciated. We look forward to their continued assistance.**

**(Dr. V.K. Umrao)**
**Chief Editor, HRS**
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International Impact:- ICV: 27.39; GIF: 0.364

# HortFlora Research Spectrum

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*Published under the Auspices of*

**BIOSCIENCES & AGRICULTURE ADVANCEMENT SOCIETY (BAAS), Meerut (Regd.)**

'Shivalay' 98-A, Somdutt Vihar, Garh Road, Meerut-250 004 (U.P.) India

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2. Johnson, D.A. (1940). *Plant Microtechnique.* McGraw- Hill Publishing Co. Ltd., New York. PP-29
3. Kapil, R.N. and Arora, S. (1990). Some fascinating features of orchid pollen. *J. Orchid Soc.*, **4** (1): 9-28.
4. Rashid, S., Ashraf, M., Bibi, S. and Anjum, R. (2000). Antibacterial and antifungal activities of *Launaea nudicaulis* Roxb. and *Launaea resedifolia* L. *Pakistan J. Biol. Sci.*, **3** (4) :630-632.

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**Printed & Published by :** Dr. Vandana Umrao and **Edited by :** Dr. Vijai Kumar Umrao, Secretary, BAAS
'Shivalay' 98-A, Somdutt Vihar, Garh Road, Meerut-250 004 (U.P.) INDIA. **Mob.:** +91-9412833903
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**Website:** www.hortflorajournal.com
Printed at : New Rishabh Offset Printers, Delhi Road, Meerut.

ISSN 2250-2823
9 772250 282000