Effect of different mycorrhizal strain on growth and yield characteristics of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

काशी हिन्दू विश्वविद्यालय

BANARAS HINDU UNIVERSITY

Thesis submitted in partial fulfilment of the requirements for the degree of

Master of Science (Agriculture)

in

Horticulture

Supervisor
Prof. Anand Kumar Singh

Submitted by
Suraj Singh Gour

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Through: The Head, Department of Horticulture

Dear Sir,

I have great pleasure in forwarding the thesis entitled **"Effect of different mycorrhizal strain on growth and yield characteristics of bottle gourd [*Laganaria siceraria* (Mol.) Standl.]"** submitted by **Mr. Suraj Singh Gour, (I.D. No.H-14124)** in partial fulfilment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Horticulture**, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

This is to certify that this work has been carried out solely by **Mr. Suraj Singh Gour** under my guidance and data forming the basis of this thesis, to the best of my knowledge are genuine and original.

Thanking you,

Yours faithfully,

(Anand Kumar Singh)
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FORWARDED

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Date:

Place: Varanasi ***(Suraj Singh Gour)***

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LIST OF ABBREVIATIONS

%	:	per cent
@	:	at the rate of
°C	:	degree centigrade
CD (p = 0.05)	:	critical difference at 5 per cent probability
cm	:	centimetre
cv.	:	cultivar
DAS	:	days after sowing
et al.	:	et alii (and others)
etc.	:	etcetera
Fig.	:	figure
g	:	gram
h	:	hours
ha	:	hectare
i.e.	:	that is
K	:	Potassium
Kg	:	kilogram
l	:	litre
m	:	metre
m^2	:	square metre
ml	:	millilitre
MT	:	metric tonnes
N	:	nitrogen
no.	:	number
P	:	phosphorus
q	:	quintal
RBD	:	randomised block design
RH	:	relative humidity
SE.m ±	:	standard error of mean

Chapter I

INTRODUCTION

All parts of herbaceous plants eaten as food by humans, whole or in part, are generally considered vegetables. It's contain water soluble vitamins like vitamin B and C, fat-soluble vitamins including vitamin A and D, and also contain carbohydrates and minerals. Vegetables play major role in the national development programmes to alleviate hunger and malnutrition population. The crops used for vegetable purpose in the world belong to 1200 species under 78 families and out of them, more than 860 species under 59 families belong to dicot and about 340 species under 90 families belong to monocot. In the tropical and subtropical parts of world, about 90 species of vegetable crops are cultivated but hardly 40 of them are commercially important.

The importance of vegetable crops in India can be judged from the fact that the majority of Indian population is vegetarian. India occupies a prime position in the world in vegetable production and is the 2nd largest producer of vegetables next to China. India produces about 162896.9 thousand MT of vegetables from an area of 9396 thousand ha, and productivity is 17.3 MT, which is far below the desired requirement to fulfil the need of the growing population (Anonymous, 2014). According to dieticians, an adult individual requires 300 g of vegetables (125 g leafy vegetables, 100 g root and tuber vegetables and 75 g other vegetables) daily for maintaining proper health. However, per capita consumption of vegetables in India is only 175 g which is very low as compared to the recommended dose. Vegetables are generally low in calorific value but chief and rich source of carbohydrate, proteins, vitamins and minerals depending up on the species to species. Some vegetables like, peas bean, sweet potato, cluster bean, potato, carrot and sugar beet are rich source of carbohydrate. Leaves of mustard, fenugreek, spinach and fruit of pea, cow pea, beans and pointed gourd are rich source of proteins. All leafy vegetables are rich in vitamin A. Brussels sprout, leaves of corianders, bitter gourd, chillies, sweet pepper, tomato, cauliflower, cabbage and sugar beet are rich source of minerals. The productivity of vegetable crops is much higher as compared to other cereals crops. Moreover it is also possible to grow 3-4 crops of vegetables in a year as compared to only two in cereals. Thus

vegetables give more profit per unit area. Further vegetables provide nutritional security, while is of prime importance as a large part of our population is malnourished. Many of the vegetable crops possess high medicinal value for curing certain diseases. For instance, onion and garlic are found to possess medicinal properties and are also involved in controlling blood sugar and act as blood purifier. White brinjal is found to be useful against diabetes.

Cucurbits are vegetable crops, belonging to the family Cucurbitaceae, which consists of 118 genera and 825 species. Most of these species are consumed as food worldwide. It is the largest group of summer season vegetables of which, more than 20 are cultivated commercially in India (Choudhary *et al.*, 2002). Cucurbits are an excellent fruit in nature having composition of all the essential constituents required for good health of humans. Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is a tropical and subtropical vine which belongs to the family Cucurbitaceae, sub family Cucurbitoideae and tribe Benincaseae (Richardson, 1972), and is considered to be one of the earliest species of plants to be domesticated by humans.The genus *Lagenaria* consists of five other species, namely *L. Brevifilora* (Benth) Roberty, *L. Rufa* (Gilg) C Jeffrey, *L. sphaerica* E Mey, *L. abyssinia* (Hook. F.) C Jeffrey and *L. guineensis* (G Den) C Jeffrey, of which *L. siceraria* is the most cultivated (Erickson *et al.* 2005). Within the species *siceraria*, two morphologically distinct sub-species of bottle gourd have been recognized viz. *L. siceraria* ssp. *siceraria* and *L. siceraria* ssp. *asiatica* (Heiser, 1979). Bottle gourds are regularly grown and consumed in various parts of the world, particularly Asia. Fruits of bottle gourds are harvested young and used as a vegetable and sometimes dried bottle gourds used as a utensil in households. Bottle gourds is one of the earliest vegetables cultivated by man. It appears to have originated in Africa where it occurs spontaneously as it also does in India. It is now widely cultivated throughout the tropics, especially India, Sri Lanka, Indonesia, Malaysia, Philippines, China, tropical Africa and South America. The bottle gourd is a warm season crop and grows best in a warm humid climate. Bottle gourd is an important home garden vegetable. Bottle gourd or calabash gourd has been reported to be the only cultigen most widely dispersed and common both to the old world and new world since ancient historic times. It is also called alabu in Sanskrit, kaddu, lauki, and tumri in Hindi, sorakaya in Telugu, shorakkai in Tamil, sorekayi and halagumbala in Kannada, lau in Bengali and Assamese, lauka in Nepali and ghiya in Punjabi. It has medicinal value with enormous impact on the treatment of high

blood pressure and heart disease along with nutritional value having a rich source of minerals and vitamins. It contains many healing and medicinal properties too. The cooked vegetable is not only easy to digest but also contains cooling, calming (or sedative), diuretic properties. It contains low calories, possesses iron, Vitamin C and B complex. Regular consumption of this vegetable provides relief to people suffering with digestive problems, diabetics and convalescents and helpful in shedding extra calories.

Composition and food value of bottle gourd fruits:

Its contains higher concentrations of dietary fibre, vitamin A, C, K, E and B6, potassium, manganese, protein, thiamine, riboflavin, pantothenic acid, calcium, iron, magnesium, phosphorus and selenium. It also contains 96.1% moisture, 0.2% protein, 0.1% fat, 0.5% minerals, 0.6% fibre, *2.5%* carbohydrate, 20mg/100g calcium, 10mg/100g phosphorous, 0.7mg/100g iron and calorific value is 12.

"Mycor-rhiza" literally means "Fungus-root" and describe the mutually beneficial relationship between the plant and root fungus. These specialized fungi colonize plant root and extend far into the soil. Mycorrhizal fungal filaments in the soil are truly extensions of root systems and are more effective in nutrient and water absorption then the root themselves. More than 90 percent of plant species in natural areas from a symbiotic relationship with the beneficial mycorrhizal fungi. Mycorrhizal fungi increase the surface absorbing area of roots 100 to a 1,000 times, thereby greatly improving the ability of the plant to access soil resources. Several mile of fungal filaments can be present in less than a thimbleful of soil. Mycorrhizal fungi increase nutrient uptake not only by increasing the surface area, but also release powerful enzymes into the soil that dissolve hard-to-capture nutrient, such as organic nitrogen, phosphorus, iron and other "tightly bound" soil nutrient. This extraction process is particularly important in plant nutrient and explain why non-mycorrhizal plant require high levels of fertilization to maintain their health. Mycorrhizal fungi from an intricate web that capture and assimilates nutrients, conserving the nutrient capital in soils.

Mycorrhizal association changes several aspects of plant physiology, nutritional and physical properties of the rhizosphere soil. Different types of mycorrhizal association have been observed in a wide range of land plants. Endomycorrhizae (arbuscular

mycorrahizal fungi) belong to phylum Glomeromycota. The plant symbionts range from bryophytes to angiosperms. Septate hyphae enter the root cortical cells and form characteristic arbuscules and vesicles but, they do not enter the vascular system. VAM fungi colonize the fine absorbing roots of plants, invade into the cytosol of cortical cells and form specialized structures intracellular and intercelluarly known as arbuscules and vesicles, respectively. VAM fungi act as soil conditioner and play an important role in preventing rapid degradation of environment (Gosal *et al*., 2000). It is well known that VAM fungi enhance the plant growth by providing extra absorptive surface which takes up relatively immobile compounds in the soil (Bagyaraj, 1992). Mycorrhizal association benefits higher plants by improving water and nutrient uptake storage of carbohydrates and oils. VAM fungal association protects the plants from soil-borne diseases and detoxifies soil contaminants of certain metals. The spore count, root colonization, species diversity and dominant species, varies with the region and soil nutrient conditions. VAM fungi increases tolerance to heavy metals, salinity and drought (Henning, 1993). VAM fungi have been proved to increase the productivity of several cereals, pulses, oilseed crops, vegetable crops, medicinal plants and also ornamental plants. The VAM fungi are obligate symbionts and not host specific (Bonfonte, 1987). In the present work VAM fungi associated with vegetable and fruit yielding plants were investigated to understand their qualitative composition.

Keeping in view the above facts, the present investigation entitled "Effect of different mycorrhizal strain on growth and yield characteristics of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was carried out with following objectives:

- ✓ To evaluate the growth parameters of bottle gourd as affected by different mycorrhizal strain.
- ✓ To evaluate the yield and yield parameters of bottle gourd as affected by different mycorrhizal strain.

Chapter II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to review the research work done so far in India and abroad by different worker on the effect of different mycorrhizal strain on growth and yield of bottle gourd.

The information available on the research work done regarding the mycorrhizal strain use in bottle gourd to increasing growth and yield is reviewed in the following paragraphs.

Review related to growth and yield

Miceli, (2016) study the combined effect of grafting with Vesicular-Arbuscular Mycorrhizal Fungi (AMF) inoculation on fruit yield and quality of mini-watermelon [*Citrullus lanatus* (Thumb.) Matsum and Nakai]. Ungrafted plants or grafted onto rootstock RS 841 (*Cucurbita maxima*×*C. moschata*) were transplanted to the field. Grafting and AMF inoculation caused significant increases in yield and fruit weight. Qualitative characteristics of watermelon fruits were significantly affected mainly by grafting. The combined use of grafting with mycorrhizal inoculation may increase the yield of mini-watermelon fruit, maintaining good quality characteristics.

Semra *et al.* (2015) reported that the effects of arbuscular mycorrhizal fungi (AMF), application on wilt disease caused by *Verticillium dahlia* (Kleb.) in tomato and eggplant. Single, dual, and triple applications of AMF (2.5 g of either *Glomus mosseae* or *G. intraradices*) were found to improve the morphological growth and nutritional status of both host species.

Rizvi *et al*. (2015) conducted a pot study to screen and to select potential arbuscular mycorrhizal fungi (AMF) for tomato (*Lycopersicon esculentum* Mill.) var. Pusa Ruby in sandy clay loam soil of Aligarh. Six different AMF were evaluated for their efficacy in term of growth characteristics, nutrient status. Tomato responded to its best to inoculation with *Glomus mosseae*, followed by *G. constrictum, G.*

fasciculatum, G. aggregatum, Acaulospora scrobiculata and *Gigaspora gigantea* in terms of plant weight (fresh and dry), mycorrhizal colonization, sporulation and nitrogen, phosphorus and potassium content.

Rouphael *et al.* (2015) were carried out two greenhouse experiments and reported that arbuscular mycorrhizal (AM) inoculation overcome to soil alkalinity problems, to determine yield, fruit quality, and mineral composition of two Cucurbitaceae species: cucumber (*Cucumis sativus* L.) and summer squash (*Cucurbita pepo* L.). The AM cucumber and squash plants under alkaline conditions had higher marketable yield, and fruit mean weight than non AM plants. Mycorrhizal cucumber and summer squash plants grown under alkaline conditions had a higher macro (P and K) and micro (Fe) concentration in leaf tissue compared to non AM plants.

Hijri, 2015 studied on the effect of Arbuscular mycorrhizal fungi (AMF) to enhance crop yield in potato and reported that the inoculation was performed using a liquid suspension of AMF spores that was sprayed on to potato seed pieces, yielding a calculated 71 spores per seed piece. Statistical analysis showed a highly significant increase in marketable potato yield for inoculated fields (42.2 tons/ha) compared with non-inoculated controls (38.3 tons/ha). The average yield increase was 3.9 tons/ha, representing 9.5 % of total crop yield. Inoculation was profitable with a 0.67 tons/ha increase in yield, a threshold reached in almost 79 % of all trials. This finding clearly demonstrates the benefits of mycorrhizal-based inoculation on crop yield.

Adavi *et al.* (2014) studied on growth and yield of potato (*Solanum tuberosum* L.) in Esfahan, Iran during 2013 growing season. Four phosphorus fertilizer levels of 25%, 50% 75% and 100% P recommended with two levels of mycorrhiza: with and without Mycorrhiza. Results showed that tuber size, number of tuber per plant, tuber yield, and starch yield were significantly higher in inoculated plants than in non-inoculated plants. According to the results, application of mycorrhiza in the presence of 50% P recommended had a favorable result and could increase tuber yield and starch production to an acceptable level.

Hadi *et al*. (2014) conducted an experiment in field to study the influence interaction of *B. subtilis* bacteria and *T. harzianum* fungi with AM fungi *G. mosseae*

in growth and yield parameters of cucumber particularly male and female ratio and no. of fruits per plants. The result showed that the interaction between *B. subtilis* and *T. harzianum* give significant increase in the growth and yield parameters, and all treatments with or without mycorrhiza increased the growth and yield of cucumber plant.

Olawuyi *et al.* (2014) worked on the effect of arbuscular mycorrhiza (AM) fungi and NPK fertilizer on the growth and yield of cucumber plants and showed that plants treated with 500 kg/ha fungi produced higher cumulative weight of harvested fruits per plant. This yield was significantly higher than other treatments. It thus appeared that 500 kg/ha is the optimum level of AM fungi that is required for cucumber cultivation above which to a waste. The fruit yield of cucumber was optimized with 500 kg/ha AM fungi and it reduced P toxicity in the soil.

Saha *et al*. (2013) found that mycorrhizal treatments showed almost two times higher ex vitro survival than the control plantlets. Mycorrhization plantlet showed increase in vine length in Pusa Vishesh (194.02 cm) in mixed strain, leaf area in Pusa Vishesh (107.91 cm2) in *Acaulospora scorbiculata*, chlorophyll in Pusa Do Mausami (3.29 mg/g FW) in *A. scorbiculata* and total phenols content in Pusa Do Mausami (7.84 µg/g FW) in *E. columbiana*. Photosynthetic rates were enhanced in arbuscular mycorrhizal fungi (AMF) treated plant in Pusa Do Mausami (10.75 µmol CO2/m2 /s1) in mixed strain in comparison to an uninoculated control. Among the AMF species, mixed strain (Nutrilink®) showed good as high as 38% root colonization for all the cultivars. In this experiment the mixed AMF strain has contributed significantly in survival of the plantlets and plant establishment in the field.

Hajra *et al*. (2013) reported that arbuscular mycorrhizal (AM) fungi (*Glomus spp*. and *Gigaspora spp*.) works as bioprotectant against root-knot nematode (*Meloidogyne incognita*) in sponge gourd. Comparative study clearly indicates the significant variations in all parameters, leaf area and plant height were increased in mycorrhizal plants than non-mycorrhizal, while it showed a sharp decrease in nematode infected plants, same plants also showed less water content due to xylem vessels damage.

Tanwar *et al.* (2013) studied on the effect of two arbuscular mycorrhizal fungi [G. mosseae (G) and A. laevis (A)] with P. fluorescence (Pf) in the presence of super phosphate (P) fertilization on growth and yield of bell pepper (Capsicum annuum var. California Wonder and reported that with the prevalence of AM colonization was highest in G+A+Pf with F1 and bio inoculants (G+A+Pf) along with right dose of P fertilizer (half of the recommended P) during seedling transplantation to increase overall growth and yield performance of bell pepper and could be considered as a sustainable substitute to higher phosphorus fertilizer for bell pepper cultivation.

Srivastava *et al*. (2012) investigated ten vegetable plants for VAM fungal association. The vegetables were ash gourd, water melon, ivy gourd, musk melon, cucumber, pumpkin, bottle gourd, ridged gourd, bitter gourd and snake gourd. Presence of 23 VAM fungi associated with these plants were identified up to species level. Data on qualitative composition and specific association with host plants has been generated. *Glomus* was represented by 10 species, *Acaulospora* by six species, *Scutellospora* by three species.

Han *et al.* (2012) studied that effects of inoculating arbuscular mycorrhiza fungi (AMF) on the plant growth, fruit yield, and fruit quality of cucumber (var. Jinchun No. 2) under salt stress and reported AMF mitigate the effect of salt stress on the plant growth, made the plant N, P, K, Cu, and Zn contents increased by 7.3%, 11.7%, 28.2%, 13.5%, and 9.9%, respectively, plant K+/Na+ ratio, fruit yield, and fruit soluble protein, total sugar, and vitamin C contents have an obvious increase and the fruit nitrate content have a significant decrease. It was suggested that AMF could promote the plant growth and nutrient uptake of cucumber under salt stress, increase the plant salt tolerance, and improve the fruit yield and its nutrient quality.

Ortas. (2010) reported that Mycorrhiza inoculation significantly increased cucumber seedling survival, fruit yield, P and Zn shoot concentrations. Indigenous mycorrhiza inoculum was successful in colonizing plant roots and resulted in better plant growth and yield. The most relevant result for growers was the increased survival of seedlings.

Ciftci *et al*. (2010) carried out a studied to determine the effects of three different Arbuscular Mycorrhizal Fungi (AMF) species (*Glomus mosseae*, *Glomus*

intraradices and *Glomus fasciculatum*) on the growth and nutrient contents of four bean cultivars (Onceler, Seker, Terzibaba and Sehirali) grown under salt stress. The constant amount of NaCl (50 ppm) was added the autoclaved growth medium containing 1:1:1: ratios of soil, sand and manure. The AMF species had positive effects on the plant growth and nutrient intake. Among the bean cultivars, Onceler and Terzibaba, and among the AMF species, *G. mosseae* had the best results for plant growth.

Rouphael *et al.* (2010) studied the effects of AMF inoculation on 2 cucumber genotypes (the hybrid Ekron and the open-pollinated Marketmore) and reported significant effects of genotype on most of the investigated traits and also reported that mycorrhizal cucumber plants had a higher macronutrient concentration in the leaf tissue compared to non inoculated ones. They also observed that *Glomus intraradices* enhanced the uptake and translocation of Fe toward the shoot.

Tufenkci *et al.*(2010) studied to evaluate colonization, nutrient uptake, dependency, and other seedling traits of 4 cucumber hybrids (Ceren F1, Beta F1, Silyon F1 and Maraton F1) inoculated by 3 different AMF [*Glomus intraradices* (Gi), *Glomus etunicatum* (Ge) and *Gigaspora margarita* (Gm)]. AMF-inoculated cucumber seedlings had shorter hypo cotyledons and wider and longer cotyledons than non-inoculated seedlings. Gm-inoculated seedlings had the narrowest stem diameter and lowest leaf number. AMF-inoculated seedlings had shorter shoots and longer roots than non inoculated ones. There was significant mycorrhizal effect on the iron (Fe) content of shoots and the mycorrhizal colonization rate in roots. Relative mycorrhizal dependency (RMD) varied widely among the hybrid cucumber cultivars tested.

Claudia *et al.* (2009) worked on experiment to compare effectiveness of two AMF, a commercial mycorrhizal inoculant (IC, *Glomus intraradices*) and another native (IN, *Glomus claroideum*) with a control without inoculation (-I) on the production and quality of Chilli at 45 days after sowing (DAS) transplanting was carried out and at 90 fruit quality, fungal and edaphic parameters were evaluated and reported that inoculation with native fungi decreased transplanting stress thus accelerating the maturation stage of plants and resulting in higher and better yield quality.

Aly and Hussein, (2009) study the effects of vesicular-arbuscular mycorrhiza (VAM) and *Trichoderma virdi* fungi as deterrents against *Rhizoctonia solani* and *Fusarium solani* infections on the growth and quality of sugar beet. The results showed that mycorrhizal and *T. virdi* inoculation significantly restricted the spread of both soil-borne pathogens in the host root tissues. Disease incidence of sugar beet roots was reduced to 6.2 and 5.2% for mycorrhiza with *Rhizoctonia* and 5 and 4.5% with *Fusarium* in the 1st and 2nd seasons respectively. Furthermore, the same treatments increased yield and quality traits of sugar beet (sucrose, total soluble solids and purity percentage).

Zhi-yu *et al.* (2008) carried out an experiment on tomato (*Lycopersicon esculentum* Mill.) cultivar Hansheng, to study the effects of inoculating Arbuscular mycorrhizal fungi(AMF) *Glomus mosseae* and *Nicolson Gerdemann* on growth, photosynthetic parameters and mineral element contents of tomato seedlings leaves. The results indicated that growth vigor, chlorophyll content, photosynthetic parameters and N, P, K, Ca, Mg Zn contents of leaves were markedly increased by inoculating AMF. Effects of inoculating AMF on plant height, leaf area, shoot growth, chlorophyll content, photosynthetic rate and Zn content were more significant. This trial initially showed that inoculating tomato with AMF was feasible in cultivating seedlings.

Wang *et al.* (2008) studied on cucumber (*Cucumis sativus* L. cv. Jinlu No. 3) seedlings were each inoculated with one of three arbuscular mycorrhizal fungi (AMF), *Glomus mosseae, Glomus intraradices,* and *Glomus versiforme*. The results indicated that growth of seedlings was significantly enhanced by *G. mosseae,* inhibited by *G. versiforme,* and not significantly influenced by *G. intraradices*. The dry weight of seedlings inoculated with *G. mosseae* was 1.2 times its counterparts. The concentrations of nitrogen (N) and phosphorus (P) in roots and magnesium (Mg), copper (Cu), and zinc (Zn) concentration in shoots were increased by inoculating the three AMF, and potassium (K) and iron (Fe) concentrations in shoots decreased significantly. The weights of single fruit of plants pre inoculated with *G. mosseae* and *G. versiforme* were about 1.4 and 1.3 times higher than those from the uninoculated treatment, respectively.

Westphal *et al*. (2008) reported that mycorrhizal fungi have been enhanced plant growth in watermelon and muskmelon under soil born diseases and nematodes prone land, enhanced root growth and function and colonization of watermelon roots. mycorrhizal fungi inoculations improved early plant establishment and increased the most valuable early fruit yield under some environmental stress conditions.

Zhiyu *et al.* (2008) Studied the effect of inoculating Arbuscular mycorrhizal fungi (AMF), *Glomus mosseae* and *Nicolson Gerdemann* on cucumber (*Cucummis sativus* L.) cultivar Jinyou No.2, and found that inoculating AMF on leaf area, shoot growth weight, chlorophyll content, transpiration rate, Mn and Zn contents were more significant. This trial initially showed that inoculating cucumber with AMF was feasible in cultivating seedlings.

Yongjuan *et al*. (2007) observed the effect of Arbuscule mycorrhizal fungi on growth and Fusarium wilt of cucumber in the greenhouse. Results showed that inoculating with AM could increase seedling growth significantly reduced the pathogen propagula in roots and the rhizosphere soil, as well as root infection percentage and disease incidence and disease index. Controlling effects of the disease on high susceptible cultivars was greater than those on high resistance cultivars.

Yao *et al.* (2002) worked on two micro propagated potato cultivars, Goldrush and LP89221. In Goldrush, only inoculation with *G. etunicatum* led to a significant reduction in disease severity 60.2% to 71.2%, on both shoot and crown, inoculation of Goldrush with *G. etunicatum* or *G. intraradices* reduced significantly the mortality rate by 77% and 26%, respectively. In Goldrush, inoculation with *G. etunicatum* significantly increased shoot fresh weight, root dry weight and the number of tubers produced per plant, whereas *G. intraradices* only significantly increased the number of tubers.

Xiangxia et *al.* (2001) studied on mycorrhizal dependence (MD) of five vegetables in Cucurbitaceae to two Arbuscular mycorrhizal fungi *Glomus mosseae* and *Gigaspora rosea* under greenhouse conditions. Results showed that the growth, leaf area, photosynthetic rate and dry mass were significantly enhanced and the stomatal resistance was reduced by the fungi, with the order of MD of the vegetables

being cucumber, watermelon, balsam pear, bottle gourd and squash. There was a positive correlation between MD and infecting rate.

Koch *et al.* (1997) reported that VAM inoculated plants were larger, had more green leaves, an increased photosynthesis rate, especially at low light intensities, and higher fresh and dry weights than plants in uninoculated plots. The mean bulb weights of garlic from uninoculated and VAM-treated plots were 27 g and 51 g respectively.

Swaminathan and Verma (1997) revealed that *Glomus macrocarpus* helps potato plants to assimilate more phosphorus from the soil and thereby produce larger amounts of dry matter. Inoculating the seed tuber with a slurry of the spores was decidedly more successful than inoculating the soil directly. In an infertile soil, mycorrhizal plants took up 8 times more phosphorus and put forth five times greater growth than non-mycorrhizal ones.

O'Keefe and Sylvia, (1993) studied on the growth of roots, root hairs, storage-root growth and VAM colonization of inoculated and non inoculated sweet potato plants and reported that storage-root yields of inoculated plants were higher than non inoculated plants. Root length density, percentage of root length with root hairs, VAM colonization were highest and percentage of root length colonization by VAM fungi was highest in the E2 horizon.

Rosendahl (1992) worked on the influence of vesicular-arbuscular mycorrhizal (VAM) *Glomus* species on the activity of enzymes in the roots of *Cucumis sativus*. The results showed that only minor changes in the activity of the host root enzymes occurred after VAM inoculation. Glucose 6-phosphate dehydrogenase was stimulated by VAM and phosphorus, and one of the fungi decreased the activity of glutamate dehydrogenase in the host plant when both parts of the root system were colonized.

Furlan and Cardou (1989) studied the effects of N, P, K and the vesicular-arbuscular mycorrhizal fungus *Gigaspora calospora* and *Gerdemann* on root colonization, spore production, dry biomass and shoot mineral content of onion and reported that nitrogen fertilization stimulates root colonization, spore production is higher on plants fertilized with K and biomass of endomycorrhizal plants is higher

than that of non-mycorrhizal plants. Optimal ratio of available nutrients in the soil is essential for the host plant-VAM fungus system to be most efficient.

Bhattarai and Mishra (1984) worked on establishment and development of vesicular-arbuscular mycorrhizal (VAM) fungi in three cultivars of potato, which differed in susceptibility to 'Late blight', and reported that the cultivars 'SSC 1174' (highly resistant) and 'Kufri Jyoti' (resistant) showed an earlier stablishment and more rapid development of VAM fungi than 'up-to-date' (highly susceptible). The first mycorrhizal infection in both 'SSC 1174' and 'Kufri Jyoti' was observed after 12 days whereas in 'Up-to-Date' it was observed after 19. The mycorrhizal infection increased with the age of the plants in all the three cultivars.

Powell *et al.* (1982) studied the growth response of four onion cultivars to five different VA mycorrhizal fungi. The plant growth and P-uptake were greatly stimulated by mycorrhizal fungi and interactions between fungi and onion cultivars were significant.

Krishna and Bagyaraj (1982) studied the effect of VA mycorrhiza and soluble phosphorus on okra in a phosphorus deficient sandy loam soil with pH 5.5, and reported that root, shoot and total plant dry weight were significantly greater in mycorrhizal plants than in non-mycorrhizal controls, at all levels of added soluble P. Mycorrhizal dependency was found to decrease with increase in added soluble P. Depression of growth, as compared with growth at 100% was noticed in mycorrhizal plants when 200% of the recommended P was added.

Graham *et al*. (1976) obtained a significant increase in the dry weight of tops and roots by inoculating the rooted potato tubers with VA mycorrhizae. However, the mean number of tubers formed on mycorrhizal plant was nearly two times more than un-inoculated plants.

Chapter III

MATERIALAND METHODS

The present experiment entitled "Effect of different mycorrhizal strain on growth and yield characteristics of bottle gourd (*Lagenaria siceraria*) (Mol.) Standl.)" was carried out at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the rainy season of 2015. The detail of materials used and methodology adopted in the experiment is given below.

3.1 LOCATION

The Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi is situated in South-Eastern part of Varanasi city at 25^{o} 25' North latitude and 83^{o} 03'E Longitudeat an elevation of 75.7m above mean sea level and almost centre of the Indo-Gangetic belt.

3.2 CLIMATIC CONDITION

Varanasi is situated in the eastern part of Uttar Pradesh and lies in the centre of north alluvial plain on the left side of river the Ganges and enjoys a humid subtropical climate with large variation in summer and winter temperature *i.e.* extreme of hot weather in summer and cold in winter. On the basis of climatic condition the entire year could be divided into three distinct seasons *i.e*. summer season start from last week of March to third week of June, rainy season from last week of June to middle of October and winter season from end of October to February. The temperature ranges in summer from 32^{o}Cto 46^{o}C. Winters in Varanasi have very large diurnal variations, with warm day and cold night. Fog is common in winter season while hot dry winds, called loo blow in summer. The average rainfall is about 1110mm. The major portion of precipitation about 85 to 90% is received during July to October and the metrological data is presented in table 3.1.

Table 3.1: Meteorological data during the experiment period

Month	Rainfall (mm)	Temperature ˚C		Relative humidity %		Wind Speed km/hr	Sunshine hours	Evapora-tion (mm)
		Max.	Min.	Morning	Evening			
July	83.52	32.28	26.48	85.4	70.8	5.08	4.94	3.82
Aug	56.65	33.32	26.55	87.75	72.5	3.87	5.4	4.27
Sep	11.9	30.9	26.12	83.25	60.75	3.87	7.95	3.85
Oct	23.00	32.12	20.44	85	60	1.26	7.82	2.8

3.3 EXPERIMENTAL SITE

A homogenous piece of land was selected from the composite block of the experimental farm, keeping in view the irrigation facilities. All management practices were applied equally for all the plots.

3.4 WEATHER CONDITIONS

Varanasi possesses sub-tropical climate with an average rainfall of 780 mm mostly received during rainy season.

3.5 CHARACTERISTICS OF EXPERIMENTAL SOIL

The soil was of sandy loam with good drainage and moderate water holding capacity. Soil samples were collected before sowing the crop seed from five randomly selected spots at a depth of 30 cm from the experimental plot. The soil was air-dried and ground to pass through 20 mm sieve before analysis.

Table 3.1: Presented physico-chemical properties of soil

Property	Quantity	Method of analysis
Soil fractions %		International pipette method (Piper, 1966).
Sand	50.96	
Silt	29.81	
Clay	19.23	
Chemical composition		
Soil pH	7.3	Digital pH meter (DI-707) (Jackson, 1967)
Electrical Conductivity(dS per m)	0.37	Conductivity bridge (Jackson,1967)
Organic Carbon (%)	0.58	Wet digestion procedure (Walkley and Black, 1934)
Available N (kg per ha)	87	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available P (kg per ha)	32	Olsen's method (Olsen *et al.*, 1954)
Available K (kg per ha)	142	Flame photometer method (Mehr *et al.*, 1965)

3.6 EXPERIMENTAL MATERIAL USED

EXPERIMENTAL DETAILS

Cultivar

Bottle gourd cultivar (Pusa Summer Prolific Long) was used for the present study. This is a leading variety of the bottle gourd with yield potential of 270-280 q/ha in *rainy* and 230-340 q/ha in summer season with duration of 90 days.

Treatments

The present experiment was conducted with using different Mycorrhizal strain.

Table 3.2: Name of Mycorrhiza and there doses in different experimental plots.

Treatments	
T_1	Untreated Control
T2	Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP
T3	Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP
T4	Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP
T5	Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP
T6	Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP
T7	Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP
T8	Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP
T9	Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP
T10	Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP
T11	Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP
T12	Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP
T13	Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP

3.7 EXPERIMENTAL DESIGN AND LAYOUT

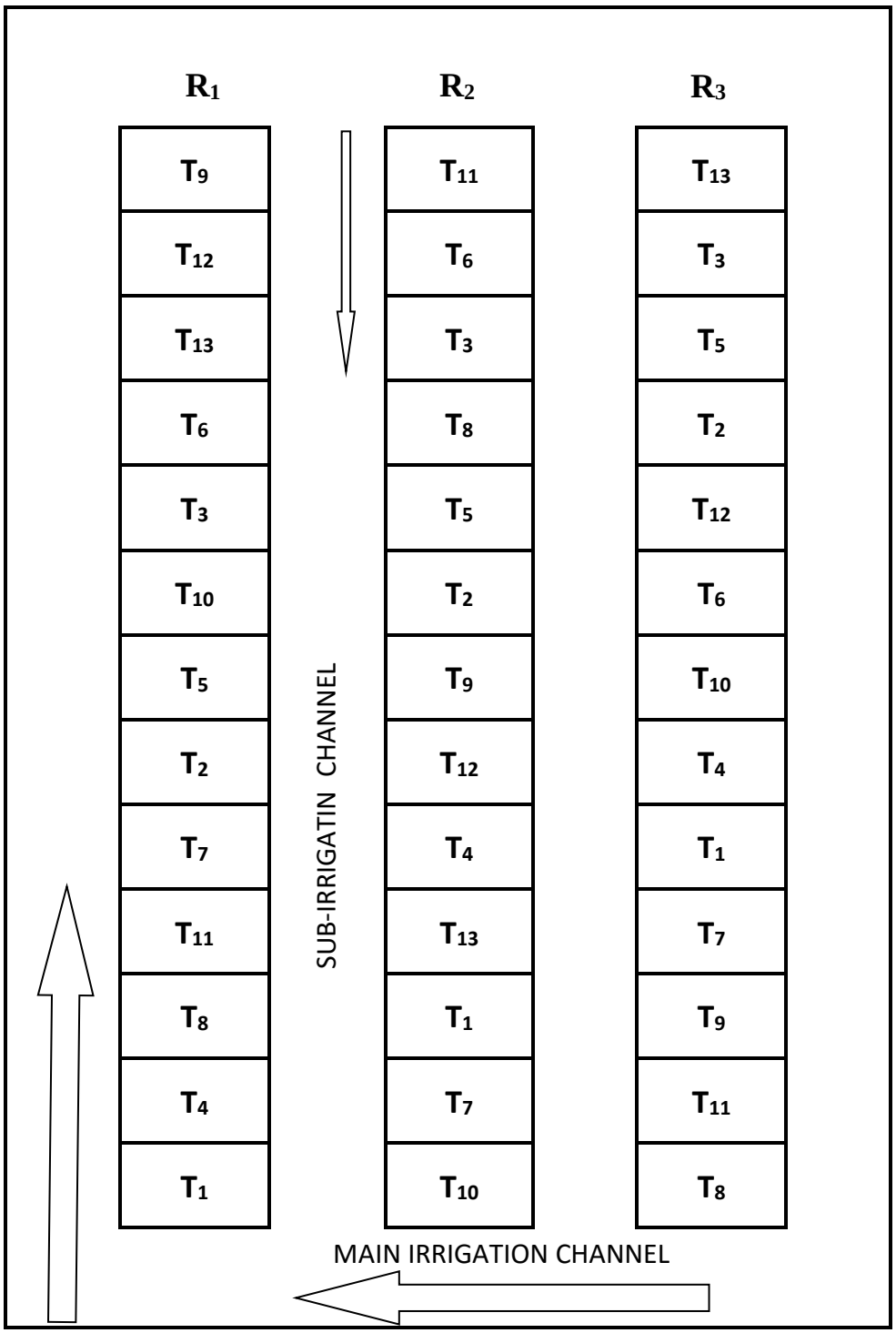
A. Experimental design

The experiment was laid out in randomized block design with three replications. The experiment was conducted at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, BHU, Varanasi.

B. Details of the layout plan

Experimental design	:	RBD
Number of genotypes	:	1
No of Treatments	:	13
Number of replications	:	3
Total number of plots	:	3×13=39
Size of plot	:	4 ×3.5 m
Field border	:	1 m
Block border	:	0.5 m
Main channel	:	1 m
Sub-channel	:	0.3 m
Date of sowing	:	8th July 2015
Spacing	:	2× 0.6 m
Fertilizers	:	Recommended dose N:P:K (100:75:60 kg/ha)
Duration of harvesting	:	6th September to 2nd November 2015

Fig. 3.2: LAYOUT PLAN OF THE EXPERIMENTAL FIELD



3.8 CULTIVATIONAL OPERATION

3.8.1 Soil and field preparation

After deciding the experimental field, the field was irrigated to have optimum level of moisture condition. First, deep ploughing was done with disc plough and subsequent light ploughings were done with cultivator followed by planking. Then the required area was marked and 39 plots were prepared according to the layout plan.

3.8.2 Fertilizer application

Recommended dose of fertilizers (100 kg N, 75 kg P_2O_5 and 60 kgK_2O per hectare) was applied to the soil. The entire quantity of phosphorus and potassium and half quantity of nitrogen were mixed thoroughly and broadcasted in each plot uniformly as basal dose before sowing. Two topdressings with nitrogen at 30 to 35DAS and 50 to 55 DAS was done.

3.8.3 Selection of seed and sowing

Pure and healthy seeds were collected before sowing. The seeds were soaked in water for 12 hours to get good germination. The distance of 0.6m between plant to plant and 2m between rows to row was maintained. The sowing was done on 8thJuly 2015.

3.8.4 Intercultural operation

The experimental plot was irrigated during the cropping period with light irrigations. Weeding was done three times according to the requirement of maintaining uninterrupted growth of the crop.

3.8.5 Selection of plant for observation

In a field experiment, detailed study of the entire population is rather difficult. Since all the plants get identical environment, *i.e*. some plants from the population were randomly selected for detailed investigation, then five plants were selected at

random in each plot and tagged for identification and recording their observations on the traits mentioned earlier.

3.9 OBSERVATIONS RECORDED

Observations on all the characters were made on five random plants of individual plots and in each treatment and replication. The observations recorded on the five plants were averaged to get mean value. For other traits, as specified above, the procedure is described under the respective sub-headings.

3.9.1 Days to 50% germination

Number of days from date of sowing to the days to 50% germination in a plot was recorded as the number of days required for days to 50% germination.

3.9.2 Days to first staminate flower anthesis

Number of days from date of sowing to the anthesis of first staminate flower in a plot was recorded as the number of days required for anthesis of first staminate flower.

3.9.3 Days to first pistillate flower anthesis

Number of days from date of sowing to the anthesis of first pistillate flower in a plot was recorded as the number of days required for anthesis of first pistillate flower.

3.9.4 Number of node at which first staminate flower anthesis

The node number from the base of the plant at which first staminate flower appeared was recorded as the number of node at which first staminate flower appears

3.9.5 Number of node at which first pistillate flower anthesis

The node number from the base of the plant at which first pistillate flower appeared was recorded as the number of node at whichfirst pistillate flower appears

3.9.6 Days to first fruit harvesting

Number of days from date of sowing to days to first fruit harvesting in a plot was recorded as the number of days required for days to first fruit harvesting.

3.9.7 Fruit length (cm)

Fruit length of edible fruits was recorded on five randomly selected fruits of a plot in each replication. The length of each fruit was measured as perpendicular distance between the points of attachment of the stalk and centre of the blossom end with the help of measuring tape in centimetres and mean value was worked out

3.9.8 Fruit girth (cm)

Fruit girth of edible fruits was recorded on same five randomly selected fruits of a plot in each replication on which fruit girth was measured. The measurement of fruit girth at the thickest portion of the fruit was taken with the help of measuring tape in centimetre and mean value was worked out.

3.9.9 Vine length (m)

The vine length was measured in meter from the ground level to the tip of the vine at the time of last picking.

3.9.10 Number of primary branches on main axis of plant.

Total number of primary branches of each plant of a plot was counted at the time of last picking on main axis.

3.9.11 Number of node on main axis of plant

No. of nodes are counted from ground to top of the main axis of plant.

3.9.12 Number of fruits per plant

Number of edible fruits was counted at each picking and summed up for all the pickings of a plot. Number of fruits per plant was calculated after dividing total number of fruits in a plot by total number of plants in a plot.

3.9.13 Average fruit weight (g)

Through electronic weighting machine, individual fruit weight of five fruit was taken in grams from all the treatments and average value was worked out.

3.9.14 Fruit yield per plant (kg)

The total fruit yield over all the pickings was recorded in kilogram for each plot and divided by total number of plant to obtain fruit yield per plant.

3.9.15 Fruit yield per plot (kg)

The total fruit yield over all the pickings was recorded in kilogram for each plot to obtain fruit yield per plot (kg).

3.9.16 Fruit yield (q/ha)

Total fruit yield (q/ha) of bottle gourd was based on the fruit yield per plot. The size of plot was 14 square metre and according to this total bottle gourd fruit yield recorded in q/ha.

3.10 STATISTICAL ANALYSIS

The results obtained from field observations were analysed statistically as per Panse and Sukhatme (1985) for Randomised Block Design. The significance was tested by referring to 'F' tables of Fisher and Yates (1963).

The results from RBD can be arranged in two way table according to the replications (blocks) and treatments; there will be `rk' observations in total. The data can be arranged in the following table

Treatments	Blocks b_1…..b_2 ……b_j…….. ..b_r	Treatment Totals	Means
t_1	y_{11} y_{12}, … y_{1j}……y_{1r}	T_1	$\overline{T}_1$
t_2	y_{21} y_{22}, … y_{2j}……y_{2r}	T_2	$\overline{T}_2$
.	. . . .	.	.
.	. . . .	.	.
.	. . . .	.	.
t_i	y_{i1} y_{i2}, … y_{ij}…….. y_{ir}	Ti	$\overline{T}$ i
.	. . . .	.	.
.	. . . .	.	.
t_k	y_{k1} y_{k2}, … y_{kj}……. y_{kr}	T_k	$\overline{T}_k$
Block totals	B_1 B_2 .....B_j …. …B_r	G.T.	
Means	$\overline{B}_1$ $\overline{B}_2$ ..... $\overline{B}_j$ …. .$\overline{B}_r$		

Mathematical model:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij} \qquad (i = 1,2,....k;\ j = 1,2,.....r)$$

Where y_{ij} is the response of the j^{th} block and i^{th} treatment

μ = general mean effect

α_i = the effect due to i^{th} treatment

β_j = the effect due to j^{th} block

ε_{ij} is the error effect ($\varepsilon_{ij} \sim N(0,\sigma^2)$)

Null hypothesis: i) H_{01} : There is no significant difference between the treatment effects.

i.e. $\alpha_1 = \alpha_2 = \ldots\ldots\ldots\ldots\ldots = \alpha_k$

ii) H_{02}: There is no significant difference between the block effects

i.e. $\beta_1 = \beta_2 = \ldots\ldots\ldots\ldots\ldots = \beta_r$

The null hypothesis can be verified by applying the ANOVA procedure. The different steps are in the analysis of data are:

1) Correction factor $= \dfrac{(G.T)^2}{rk}$

2) Treatment Sum of Squares (Tr.S.S.) $= \dfrac{(T_1)^2 + (T_2{}^2) + \ldots\ldots\ldots\ldots + (T_K{}^2)}{r} - CF$

$$= \frac{\sum_{i=1}^{k} T_k{}^2}{r} - CF$$

3) Block Sum of Squares (BSS) $= \dfrac{(B_1{}^2) + (B_2{}^2) + \ldots\ldots\ldots\ldots + (B_r{}^2)}{k} - CF$

$$= \frac{\sum_{j=1}^{r} B_j{}^2}{k} - CF$$

4) Total Sum of Squares (TSS) $= \{y_{11}{}^2 + y_{12}{}^2 + y_{13}{}^2 + \ldots\ldots\ldots + y_{kr}{}^2\} - CF$

$$= \sum_{i=1}^{k}\sum_{j=1}^{r} y_{ij}{}^2 - CF$$

5) Error Sum of Square (ESS) $= TSS - Tr.S.S. - SSB$

ANOVA TABLE

Sources of variation	D.F	S.S	M.S.	F-Cal.Value	F-table value At 5% LOS
Treatments	*k-1*	*Tr.S.S.*	$TMS = \frac{Tr.S.S.}{k-1}$	$F_t = \frac{TMS}{EMS}$	*F[k-1,{(r-1)(k-1)}]*
Blocks (Replications)	*r-1*	*BSS*	$BMS = \frac{BSS}{r-1}$	$F_b = \frac{BMS}{EMS}$	*F[r-1, {(r-1)(k-1)}]*
Error	*(r-1)(k-1)*	*ESS*	$EMS = \frac{ESS}{(r-1)(k-1)}$		
Total	rk-1	TSS			

i. If the calculated value of F (Treatments) < table value of F, we accept H_0, and hence we may conclude that there is no significant difference between the treatment means.

ii. If calculated value of F (Treatments) > table value of F, we reject H_0 and hence we may conclude that there is significant difference between the treatment means.

iii. If the treatments are significantly different, the comparison of the treatments is carried out on the basis of Critical Difference (C.D.).

C.D. = SED (Tr) x $t_{(r-1)(k-1)}$ at α level of significance

Where SED = $\sqrt{\frac{2xEMS}{r}}$

F (Blocks) should be not significant, if the planning of experiment is well manner.

Chapter IV

EXPERIMENTAL FINDINGS

The present experiment entitled "Effect of different Mycorrhizal strain on growth and yield characteristics of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was designed to study the efficacy of different Mycorrhiza strain on growth and yield of bottle Gourd. The results obtained are presented under following heads.

Days to 50% germination

Data on days to 50% germination are presented in the **Table 4.1** and **Fig.4.1** The number of days taken to 50% germination ranged between 8.00 to 11 days. Among the treatments T_2, T_6, T_8 ,T_9 and T_{12} recorded minimum number of days (8.00 days) followed by T_3 (8.33 days) and T_4 (8.67 days). However maximum number of days to 50% germination (11.00 days) was noted in T_7 and T_{10} followed by treatment T_{13} (10.00 days), T_1, T_5, and T_{11} (9.00 days). The population mean of this parameter was 8.92 days.

Days to first staminate flower anthesis

Data presented in the **Table 4.1** and **Fig. 4.2** had revealed that days to first staminate flowering had significant differences among the treatments. The number of days taken to first staminate flowering ranged between 48.33 to 53.33 days. Among the treatments, T_8 recorded minimum number of days (48.33 days) followed by T_2 and T_6 (50.00 days),while T_{13} took maximum number of days *i.e.* 53.33 for appearance of first staminate flower. Across the treatments, mean value of days to first staminate flowering was 51.18 days.

Days to first pistillate flower anthesis

The results of observations on days to first pistillate flower appearance are presented in **Table 4.2** and **Fig. 4.3.** The results revealed significant differences among the treatments for the trait. The number of days taken to first pistillate flower anthesis ranged between 49.67 to 57.67 days. Among the treatments, T_8 recorded minimum number of days (49.67) followed by T_9 (51.33 days) and T_6. Maximum number of days (56.67 days) to first pistillate flowering was observed in T_{13}. The population mean of these parameters was 53.62 day.

Number of node at which first staminate flower appears

Data for the trait are presented in the **Table4.2** and **Fig.4.4.** The results obtained showed that number of node at which first staminate flower appears showed significant differences among the treatments. The number of node at which first staminate flower appears ranges between 11.33 to 17.00 node**,** and the treatment T_8 produced staminate flower on the earliest node *i.e.* (11.33 node) followed by T_{11} (11.67), T_2 and T_6 (12.33). The maximum node for this trait (17.00) was observed by treatment T_{10}. The population mean across the treatment was 13.69 nodes.

Number of node at which first pistillate flower appears

The results on node number at which first pistillate flower appeared are presented in **Table.4.3 and Fig.4.5.** The number of node at which first pistillate flower appeared ranges between 17.33 to 23.33 node, and the Analysis of variance revealed that the treatment T_8 produced pistillate flower on the earliest node *i.e.* (17.33) followed by T_2, T_5, and T_9 (18.00 node), while the treatment T_{12} and T_{13} produced pistillate flower on a higher node number (23.33 node). The population mean for this character was found 19.51 nodes.

Days to first fruit harvesting

Data on days to first fruit harvesting are presented in the **Table 4.3** and **Fig.4.6.** The number of days taken to first fruit harvesting ranged between 60.00 to

66.67 days. Among the treatments, T_5 recorded minimum number of days (60.00 days) followed by T_{11} (61.33 days) and T_8 (62.33 days). Whereas maximum number of days to first fruit harvesting (66.67 days) was noted in T_{10}. The population mean of this parameter was 64.13 days.

Fruit length (cm)

Data for fruit length was range between (55.00 to 40.00 cm) and are presented in the **Table 4.4** and **Fig. 4.8** revealed that fruit length was affected significantly by the treatments. The treatment T_8 produced longest fruit (55.00 cm) followed by T_4 (53.00 cm) and T_{10} (51.33 cm). Shortest fruit were found in the treatment T_6 and T_7 (40.00 cm)). In the present study population mean observed for this character was 47.54 cm.

Fruit girth (cm)

Data for fruit girth are presented in the **Table 4.4** and **Fig.4.7.** Among different treatments, fruit girth was rage between 15.00 to 19.33 cm whereas T_5 recorded minimum girth of fruits (15.00 cm) followed by T_7 (15.33) and T_6 (15.67). While treatment T_2 produced maximum girth of fruit (19.33 cm).The population mean for this character was found to be 17.21 cm.

Vine length (m)

Data presented in the **Table 4.5** and **Fig.4.9** had shown that vine length was significantly affected by the treatments and which range between 3.69 to 5.90 m. longest vines was produced by treatment T_8 (5.90 m) and was significantly different with all other treatments. The next longest vine was recorded by treatment T_{10} (5.33 m) followed by T_2 (4.63 m) and T_5 (4.50 m). Treatment T_1 and T_{13} recorded shortest vine lengths of 3.69 m and 3.70 m, respectively. Vine length showed a population mean of 4.34 m.

Number of primary branches on main axis of plant

Number of primary branches on main axis of plant was ranges between 9.60 to 11.67 and are presented in the **Table 4.5** and **Fig.4.10** indicated that the maximum number of branches per plant was recorded in T_{10} (11.67) followed by T_8 (11.60) and T_9 (11.13). The treatment T_{12} and T_{13} recorded minimum number of branches (9.60). The population mean of this parameter was 10.48.

Number of node on main axis of plant

Data presented in the **Table 4.6** and **Fig.4.11** revealed that the no of node on main axis of plant was range between 19.80 to 23.13 and the maximum number of node on mane axis per plant was recorded in treatment T_8 (23.13) and was significantly superior to all other treatments. This was followed by treatment T_9 (22.47) and T_{10} (22.13). The minimum nodes were observed in treatment T_1 and T_3 (19.80).The population mean value of this parameter was found to be 21.48.

Number of fruits per plant

The data on number of fruits per plant is presented in the **Table 4.7** and **Fig.4.13** showed that the number of fruits per plant was significantly affected by the treatments. Which was ranged between 4.53 to 8.33. On the basis of mean performance, it was revealed that highest number of fruits was produced by treatment T_8 (8.33). This was superior to all other treatments. The next best treatment was T_9 with 7.53 fruits per plant followed by T_{10} (7.30). Minimum no of fruits were observed in T_1 (4.53). The population mean for this trait was 6.33.

Average fruits weight (g)

The data on average fruits weight is presented in the **Table 4.7** and **Fig.4.14** indicated that among the different treatments fruit weight varied between 582 to 742 g. Maximum fruit weight were produced by treatment T_2 (742 g) followed by T_8 (730 g), while treatment T_1 produced fruits with least weight (582g). The population mean for this character was 678 g.

Fruit yield per plant (kg)

The data on fruit yield per plant is presented in the **Table 4.6** and **Fig.4.12.** The population mean for this character was (4.39 kg) and which range between 2.62 to 6.18 kg. The treatment T_8 produced highest fruit yield per plant (6.18 kg) and was significantly superior to all other treatments. The next best treatment was T_2 (5.25 kg) and T_9 (5.17 kg). T_1 was found to be the lowest yielder with a fruit yield per plants of 2.62 kg.

Fruit yield per plot (kg)

Fruit yield per plot was range between 26.20 to 61.77 kg and are presented in the **Table 4.8** and **Fig. 4.15.** The treatment T_8 produced highest fruit yield per plot *i.e.* 61.77 kg followed by T_2 (52.50 kg) and T_9 (51.67 kg). The treatment T_1 was found to be the lowest yielder with a fruit yield per plot of 26.20 kg. The population mean for this character was 43.91 kg.

Fruit yield (q/ha)

The data recorded for fruit yield (q/ha) are presented in the **Table 4.8** and **Fig. 4.16.** The results revealed that fruit yield (q/ha) was significantly affected by the treatments. The fruit yield (q/ha) ranged between 187.14 to 441.19 (q/ha). Among the treatments T_8 recorded maximum fruit yield (441.19 q/ha) followed by T_2 (374.99 q/ha) and T_3 (370.14 q/ha). The treatment T_1 recorded minimum fruit yield (187.14 q/ha). Population mean of this parameter was 313.50 (q/ha).

Table 4.1 : Effect of different mycorrhizal strain on days to 50% germination and days to first staminate flower anthesis

Treatment	Doses	D50%G	DFSFA
T_1	**Untreated Control**	9.00	51.67
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	8.00	50.00
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	8.33	50.67
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	8.67	52.00
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	9.00	50.67
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	8.00	50.00
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	11.00	53.00
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	8.00	48.33
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	8.00	50.33
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	11.00	52.33
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	9.00	52.00
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	8.00	51.00
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	10.00	53.33
GRAND MEAN		**8.92**	**51.18**
SE.M.±		**0.555983**	**0.994644**
CD		**1.622799**	**2.90316**

D50%G : Days to 50% germination

DFSFA : Days to first staminate flower anthesis

Table 4.2 : Effect of mycorrhizal strain on Days to first pistiliate flower anthesis and Nodes no. of first staminate flower anthesis.

Treatment	Doses	DFPFA	NFSFA
T_1	**Untreated Control**	56.00	13.33
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	52.33	12.33
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	53.00	14.00
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	55.00	14.00
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	53.00	13.00
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	52.00	12.33
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	55.00	16.00
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	49.67	11.33
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	51.33	13.67
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	53.33	17.00
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	52.00	12.00
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	56.67	13.00
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	57.67	16.00
GRAND MEAN		**53.62**	**13.69**
SE.M.±		**1.084073**	**0.812123**
CD		**3.164184**	**2.37042**

DFPFA : *Days to first pistillate flower anthesis*

NFSFA : *Nodes no. of first staminate flower anthesis*

Table 4.3 : Effect of mycorrhizal strain on nodes no. of first pistillate flower anthesis and Days to first fruits harvesting.

Treatment	Doses	*NNFPFA*	DFFH
T_1	**Untreated Control**	19.67	66.33
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	18.00	64.67
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	19.00	65.67
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	21.00	66.67
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	18.00	60.00
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	18.33	64.00
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	20.00	65.00
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	17.33	62.33
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	18.00	64.00
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	19.67	66.67
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	19.00	61.33
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	22.33	63.00
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	23.33	64.00
GRAND MEAN		19.51	64.13
SE.M.±		0.810807	0.763763
CD		2.366577	2.229265

NNFPFA : *Nodes no. of first pistillate flower anthesis*

DFFH : *Days to first fruits harvesting*

Table 4.4 : Effect of mycorrhizal strain on Fruit girth (cm) and Fruit length (cm).

Treatment	Doses	Fruit girth	Fruit length
T_1	**Untreated Control**	18.00	47.00
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	19.33	48.33
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	18.67	49.33
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	18.33	53.00
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	15.00	43.00
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	15.67	40.00
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	15.33	40.00
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	18.33	55.00
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	16.67	48.33
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	18.00	51.33
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	18.00	48.00
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	16.00	47.67
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	16.33	47.00
GRAND MEAN		17.21	47.54
SE.M.±		0.799751	0.922958
CD		2.334307	2.693924

Table 4.5 : Effect of mycorrhizal strain on Vine length (m) and Number of primary branches on main axis of plant.

Treatment	Doses	Vine length	NPBMA
T_1	**Untreated Control**	3.69	10.20
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	4.63	10.40
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	4.25	9.67
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	3.85	9.73
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	4.50	10.93
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	3.78	10.53
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	4.45	10.93
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	5.90	11.60
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	4.16	11.13
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	5.33	11.67
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	4.08	10.20
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	4.11	9.60
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	3.70	9.60
GRAND MEAN		4.34	10.48
SE.M.±		0.301439	0.506145
CD		0.879839	1.477331

NPBMA : Number of primary branches on main axis of plant

Table 4.6: Effect of mycorrhizal strain on Number of node on main axis of plant and Fruit yield per plant (Kg).

Treatment	Doses	*NMA*	Fruit yield per plant (Kg)
T_1	**Untreated Control**	19.80	2.62
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	21.33	5.25
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	19.80	5.07
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	20.73	4.92
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	20.93	4.27
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	21.80	3.52
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	21.87	3.60
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	23.13	6.18
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	22.47	5.17
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	22.13	5.13
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	21.07	4.22
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	22.20	3.63
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	22.00	3.52
GRAND MEAN		21.48	4.39
SE.M.±		0.552565	0.099123
CD		1.612822	0.289319

NMA : *Number of node on main axis of plant*

Table 4.7 : Effect of mycorrhizal strain on fruits per plant and Average fruit weight (g).

Treatment	Doses	*fruits per plant*	Average fruit weight (g)
T_1	**Untreated Control**	4.53	0.582
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	7.20	0.742
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	6.90	0.719
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	6.82	0.710
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	6.13	0.697
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	5.40	0.653
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	5.23	0.648
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	8.33	0.730
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	7.53	0.686
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	7.30	0.668
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	6.13	0.689
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	5.53	0.657
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	5.27	0.634
GRAND MEAN		6.33	0.678
SE.M.±		0.652529	0.013408
CD		1.904597	0.039136

Table 4.8 : Effect of mycorrhizal strain on Fruit yield per plot (kg) and Yield (q/ha).

Treatment	Doses	*Fruit yield per plot (kg)*	Yield (q/ha)
T_1	**Untreated Control**	26.20	187.14
T2	**Soil drench with BOLT SP @ 250 g/ha, 1 application @ 20DAP**	52.50	374.99
T3	**Soil drench with BOLT SP @ 500 g/ha, 1 application @ 20DAP**	50.67	370.14
T4	**Soil drench with BOLT SP @ 750 g/ha, 1 application @ 20DAP**	49.17	361.83
T5	**Soil drench with NZBBA9048 @ 250 g/ha, 1 application@ 20DAP**	42.70	305.00
T6	**Soil drench with NZBBA9048 @ 500 g/ha, 1 application @ 20DAP**	35.20	251.42
T7	**Soil drench with NZBBA9048 @ 750 g/ha, 1 application @ 20DAP**	36.00	247.38
T8	**Soil drench with NZBBA9049 @ 250 g/ha, 1 application @ 20DAP**	61.77	441.19
T9	**Soil drench with NZBBA9049 @ 500 g/ha, 1 application @ 20DAP**	51.67	369.04
T10	**Soil drench with NZBBA9049 @ 750 g/ha, 1 application @ 20DAP**	51.33	362.99
T11	**Soil drench with NZBBA9050 @ 250 g/ha, 1 application @ 20DAP**	42.20	301.42
T12	**Soil drench with NZBBA9050 @ 500 g/ha, 1 application @ 20DAP**	36.30	260.61
T13	**Soil drench with NZBBA9050 @ 750 g/ha, 1 application @ 20DAP**	35.17	242.29
GRAND MEAN		43.91	313.50
SE.M.±		0.991229	6.1435122
CD		2.893194	17.931642

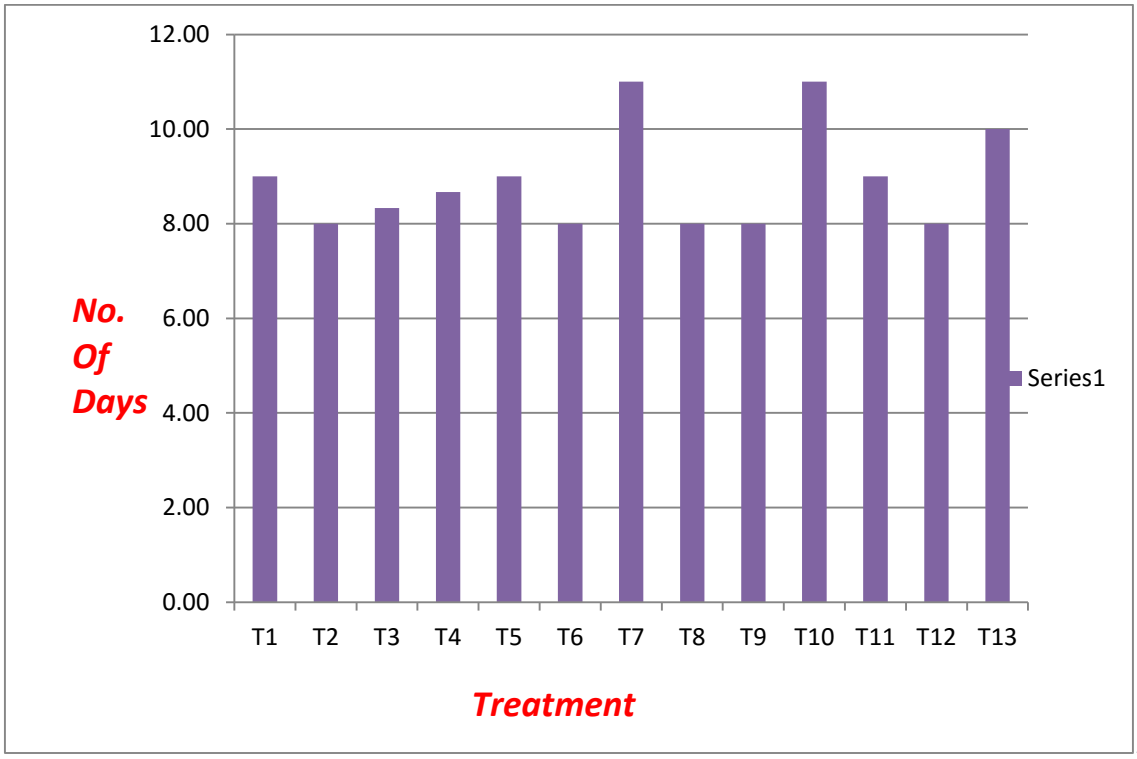


Fig. 4.1 : Days to 50% germination

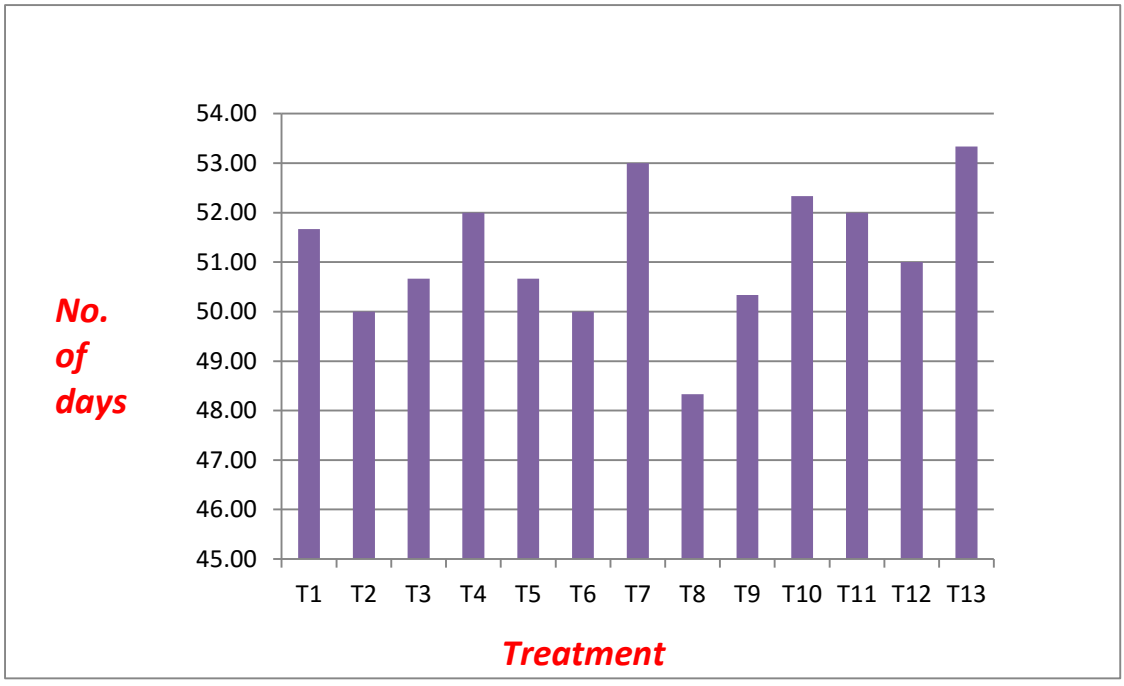


Fig. *4.2: Days to first staminate flower anthesis*

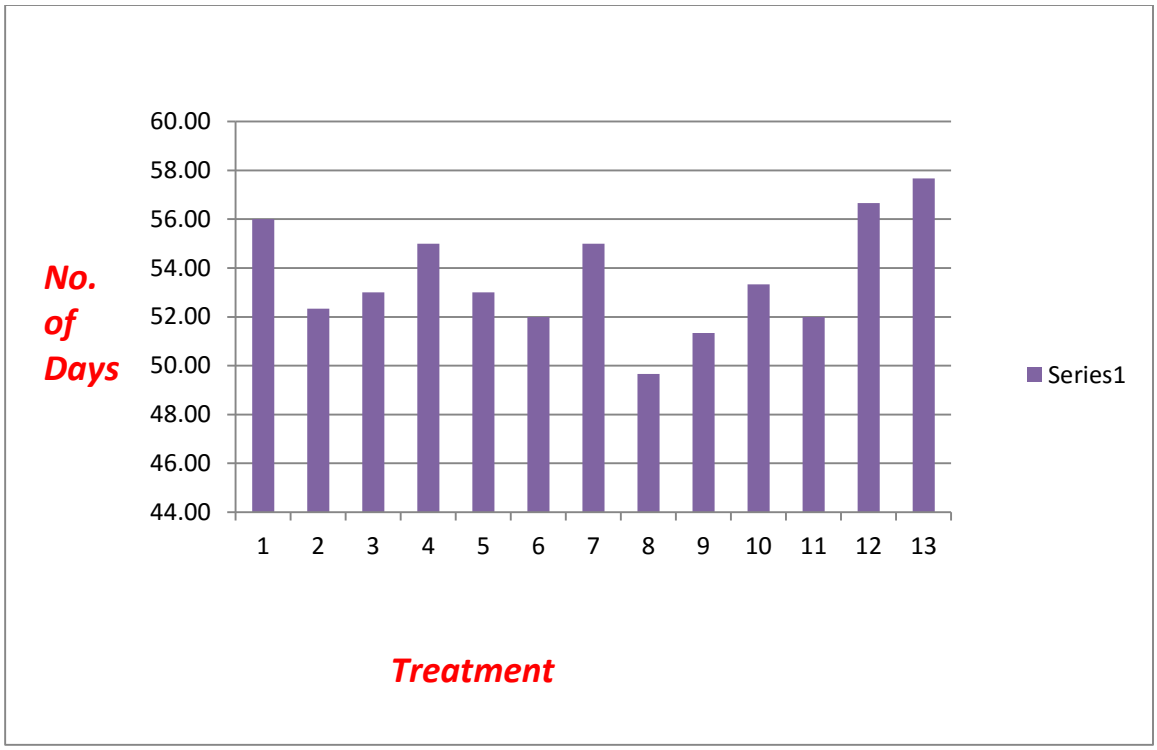


Fig. 4.3: Days to first pistillate flower

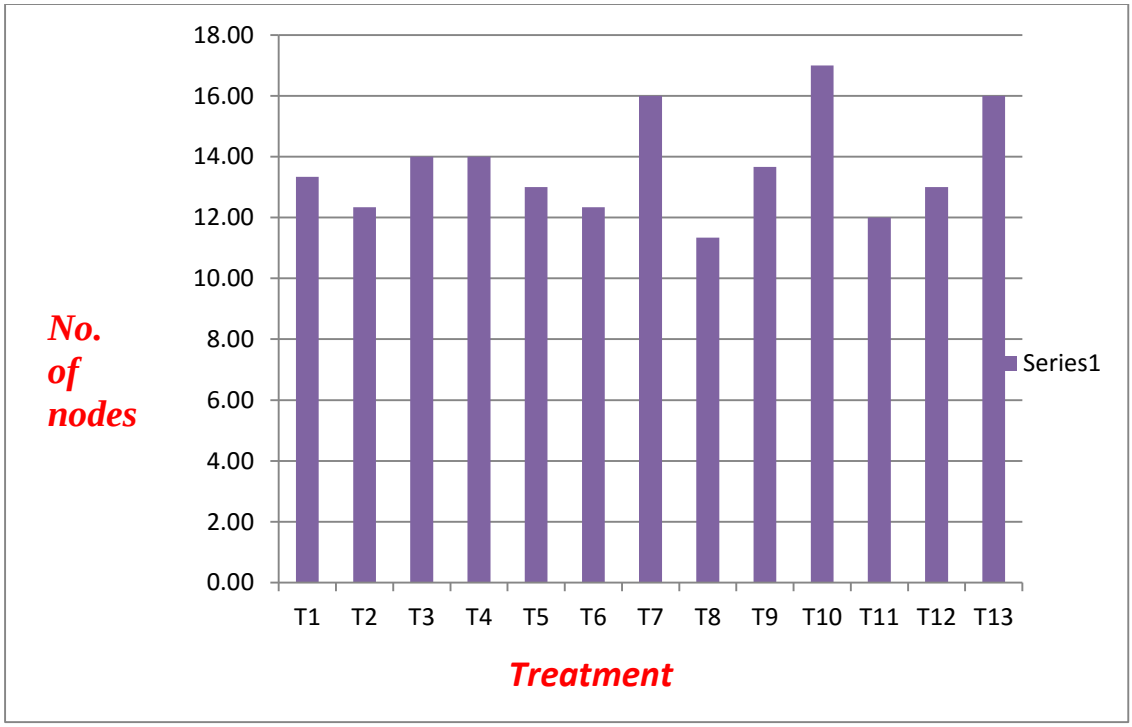


Fig. 4.4: Nodes no. of first staminate flower

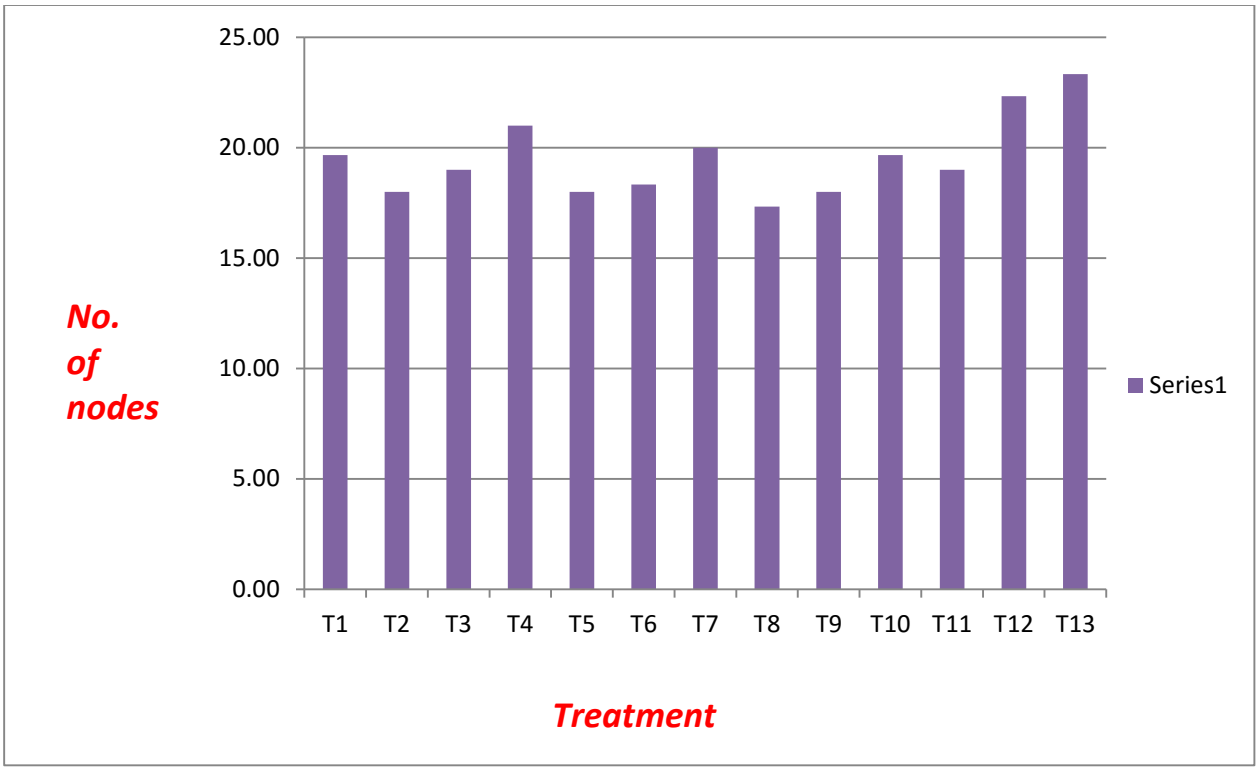


Fig. 4.5: Nodes no. first pistillate flower

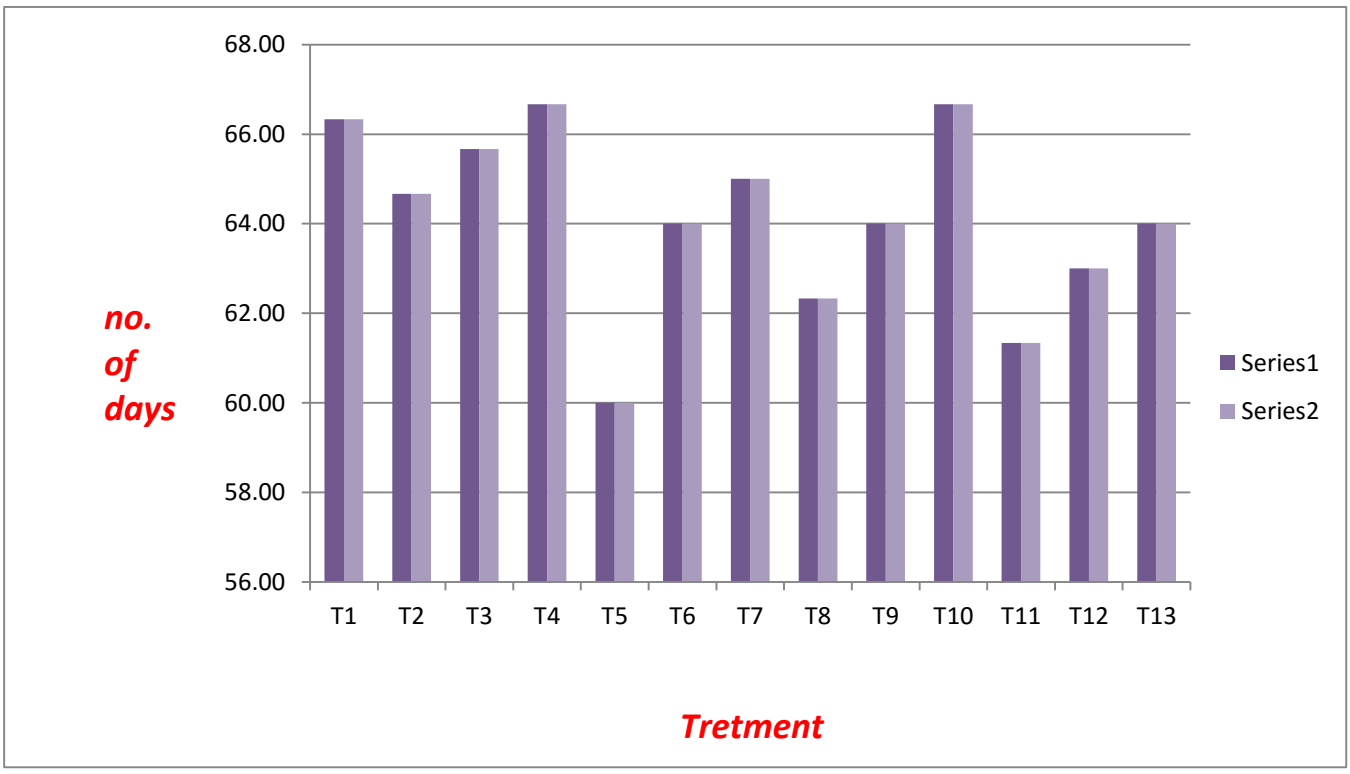


Fig. 4.6 Day to first fruit harvesting

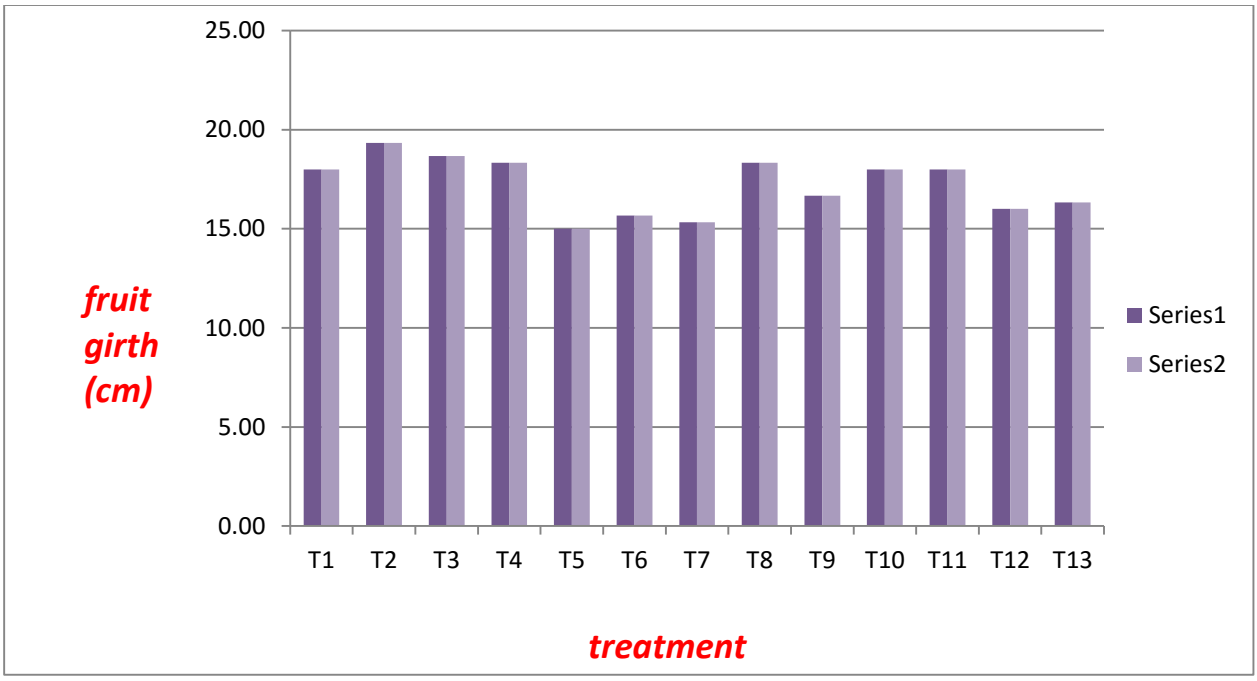


Fig. 4.7 Fruit girth (cm)

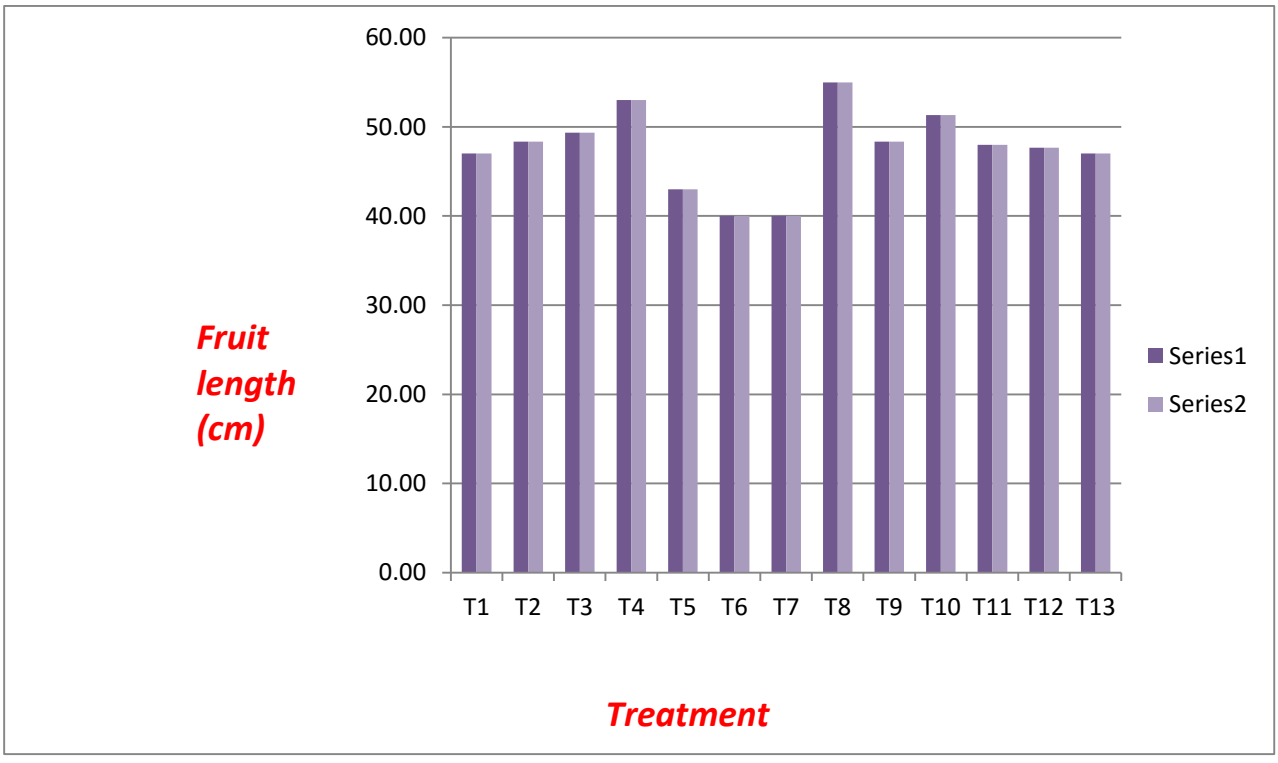


Fig.4.8: Fruit length (cm)

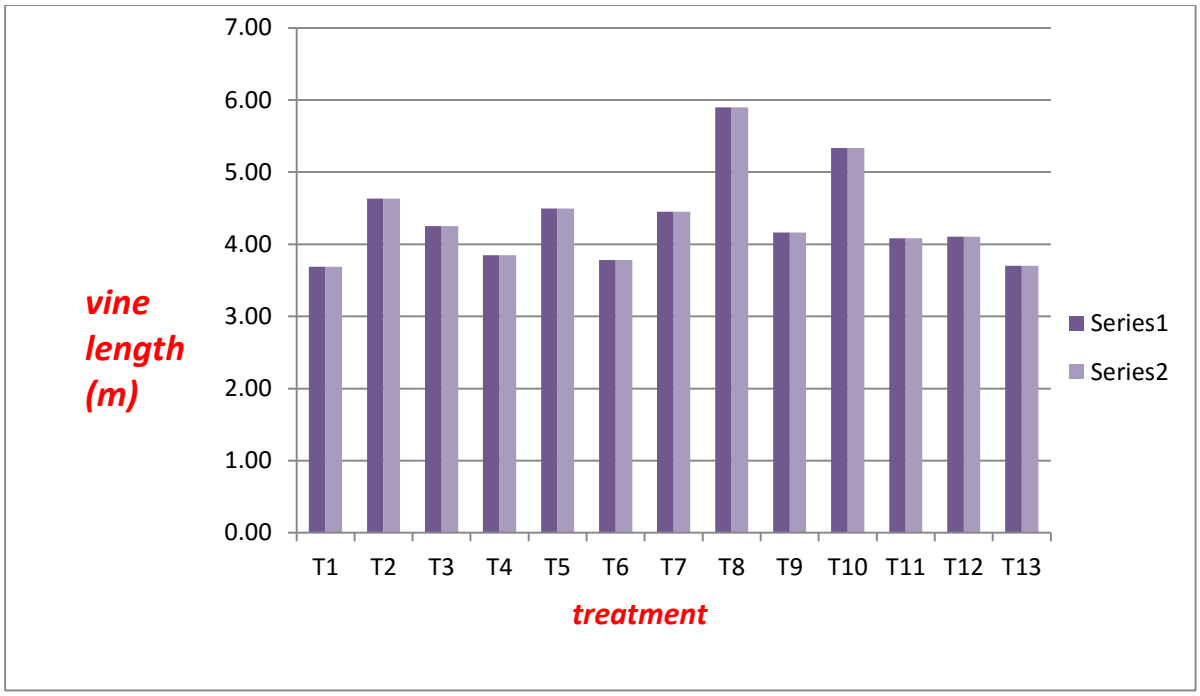


Fig.4.9: Vine length (m)

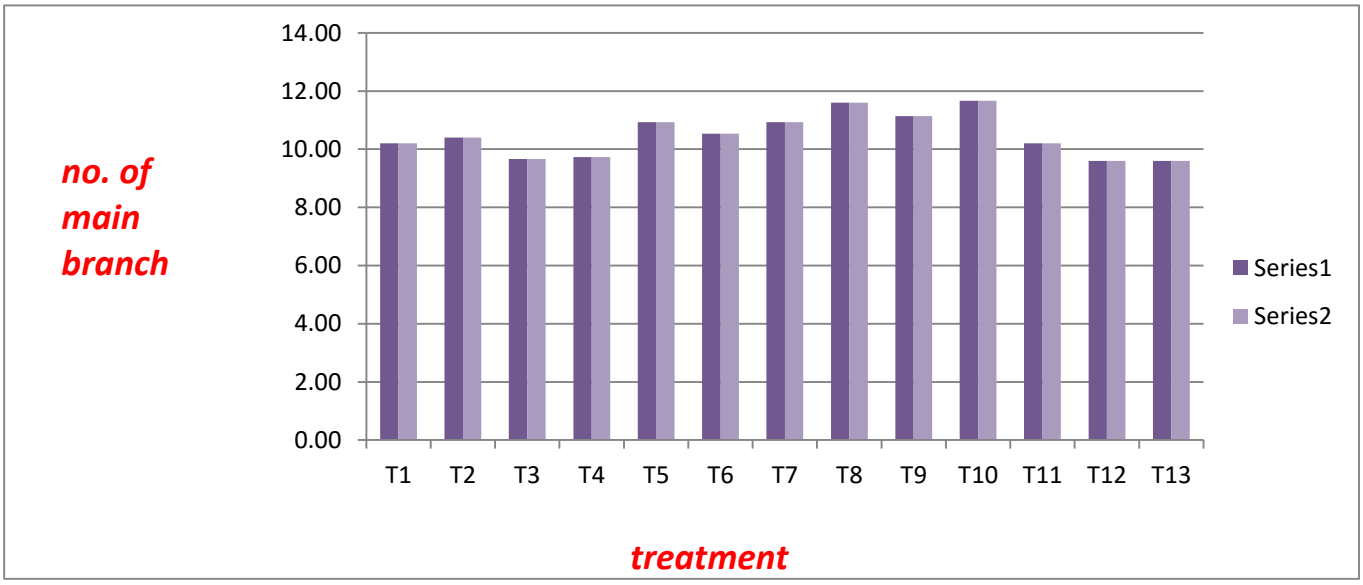


Fig.10: No. of primary branches on main axis of plant

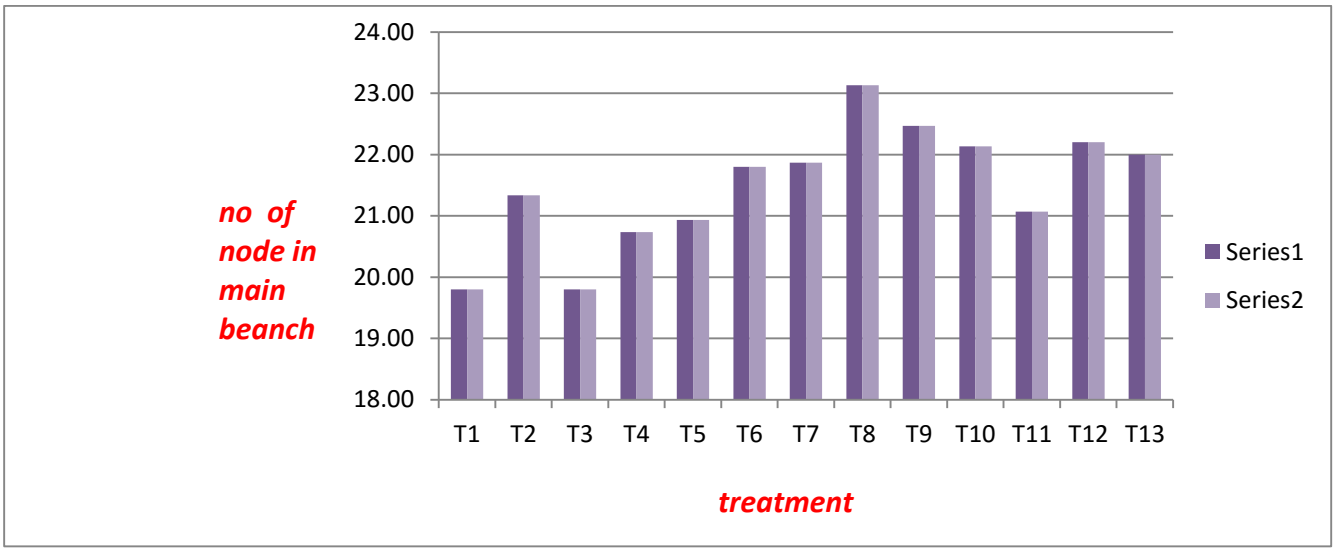


Fig. 4.11: No. of nodes on main axis of plant

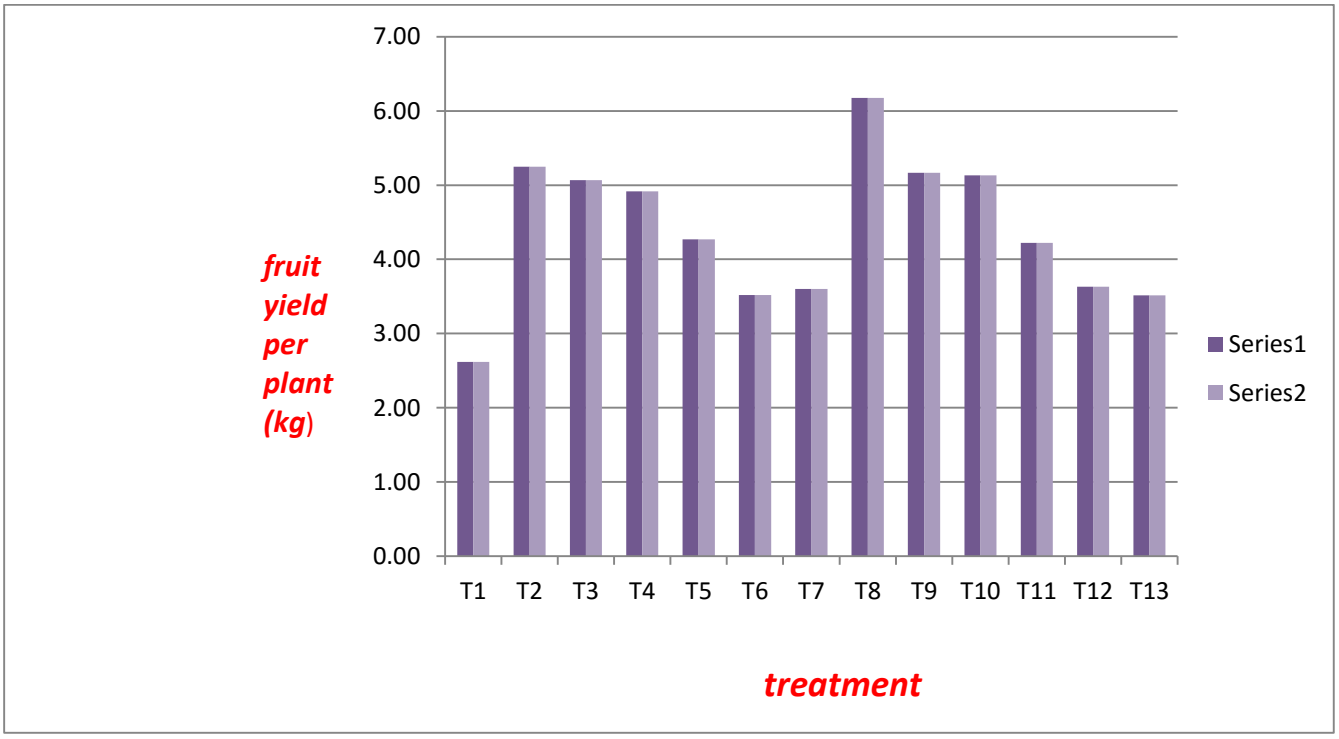


Fig. 4.12: Fruit yield per plant (kg)

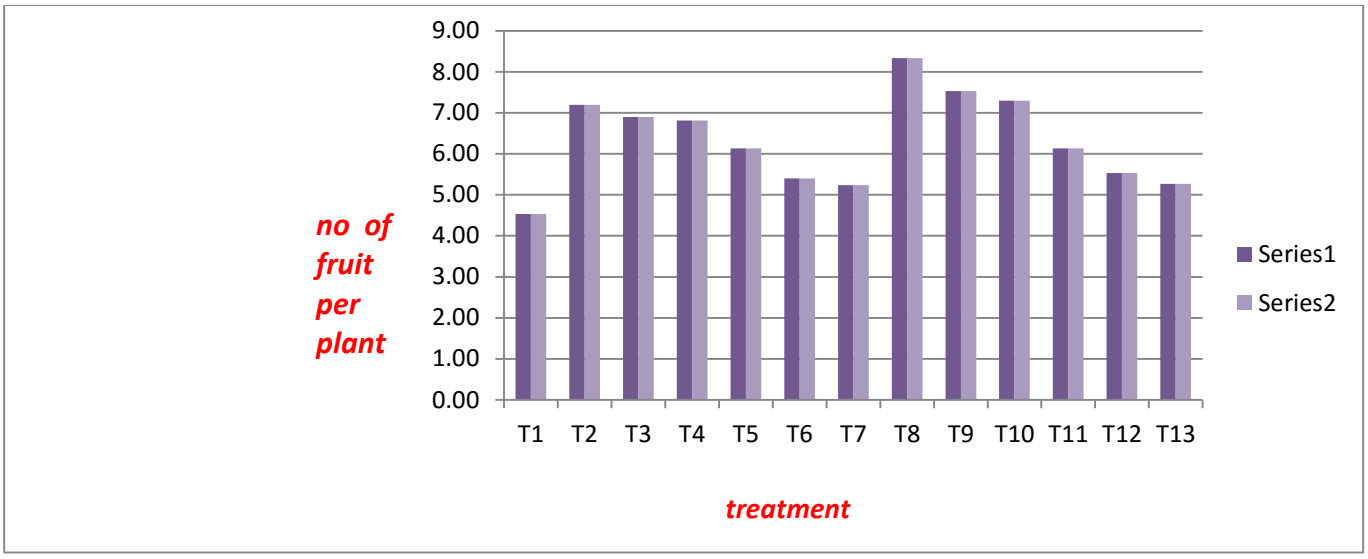


Fig. 4.13 : No. of fruit per plant

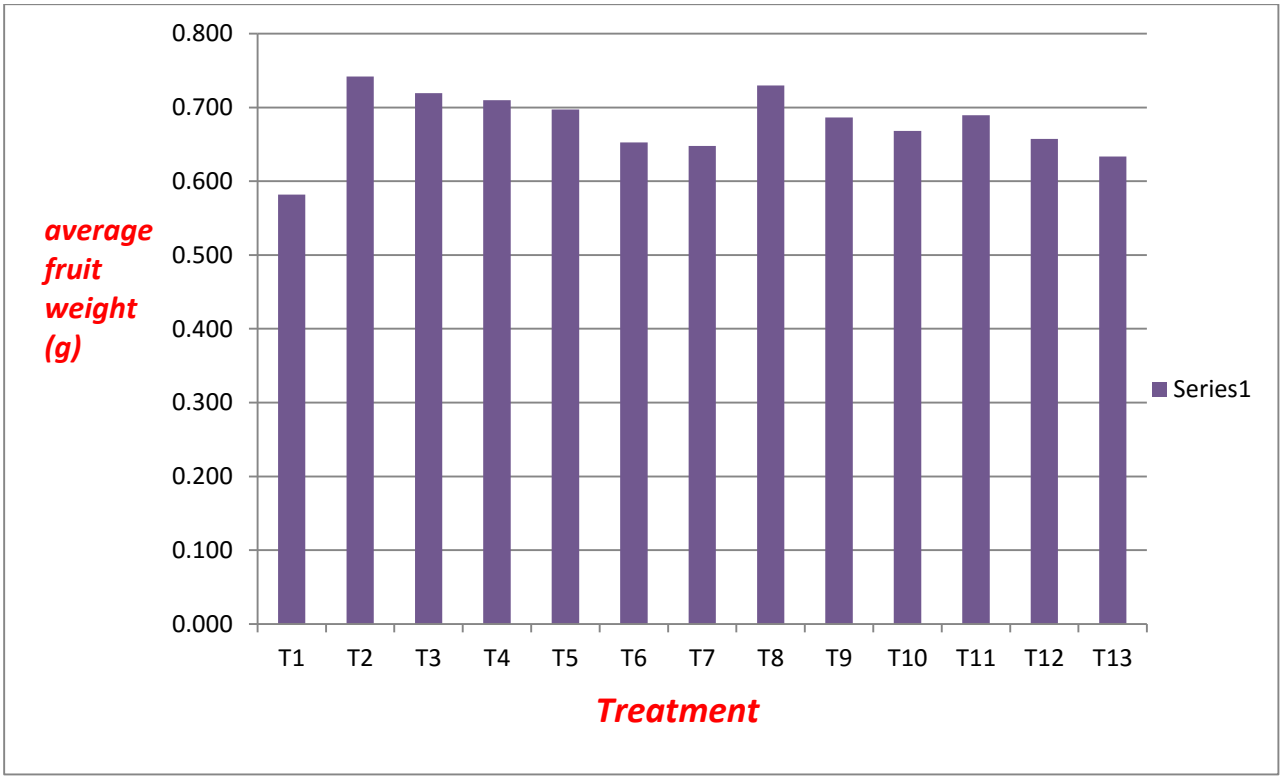


Fig. 4.14 : Average fruit weight (g)

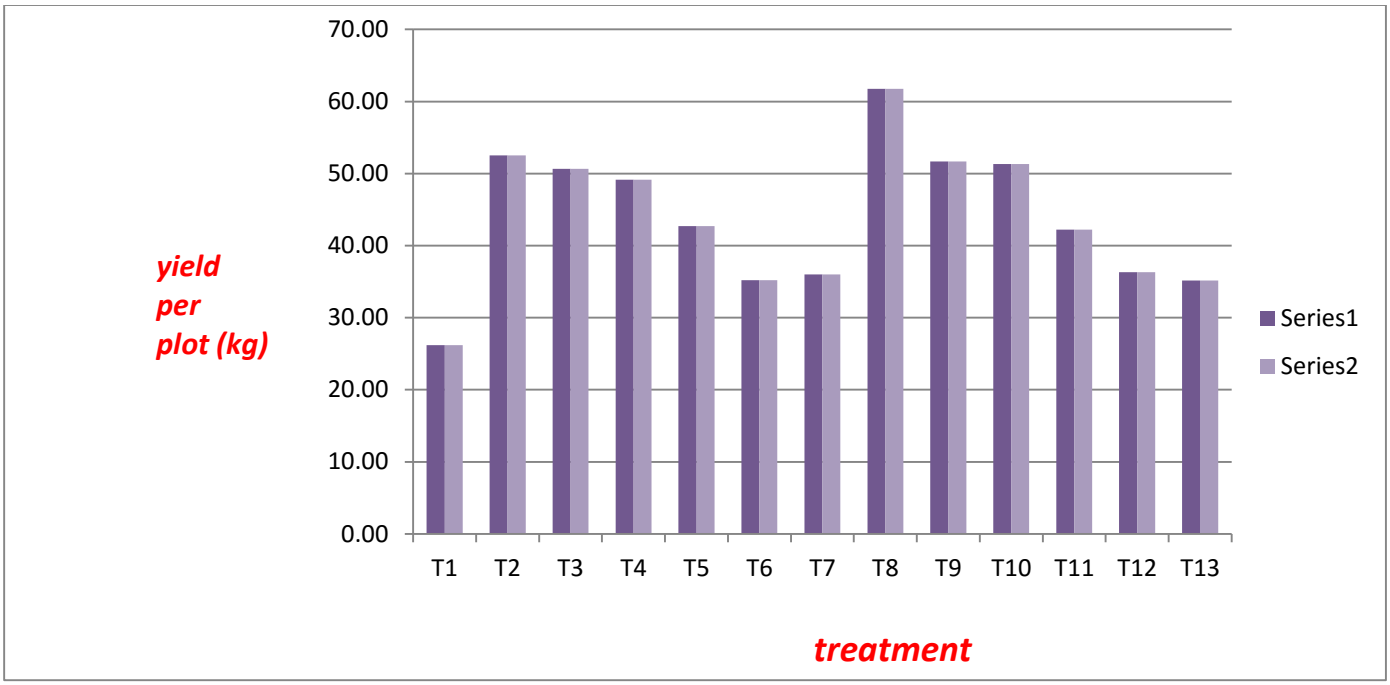


Fig. 4.15 : Yield per plot (kg)

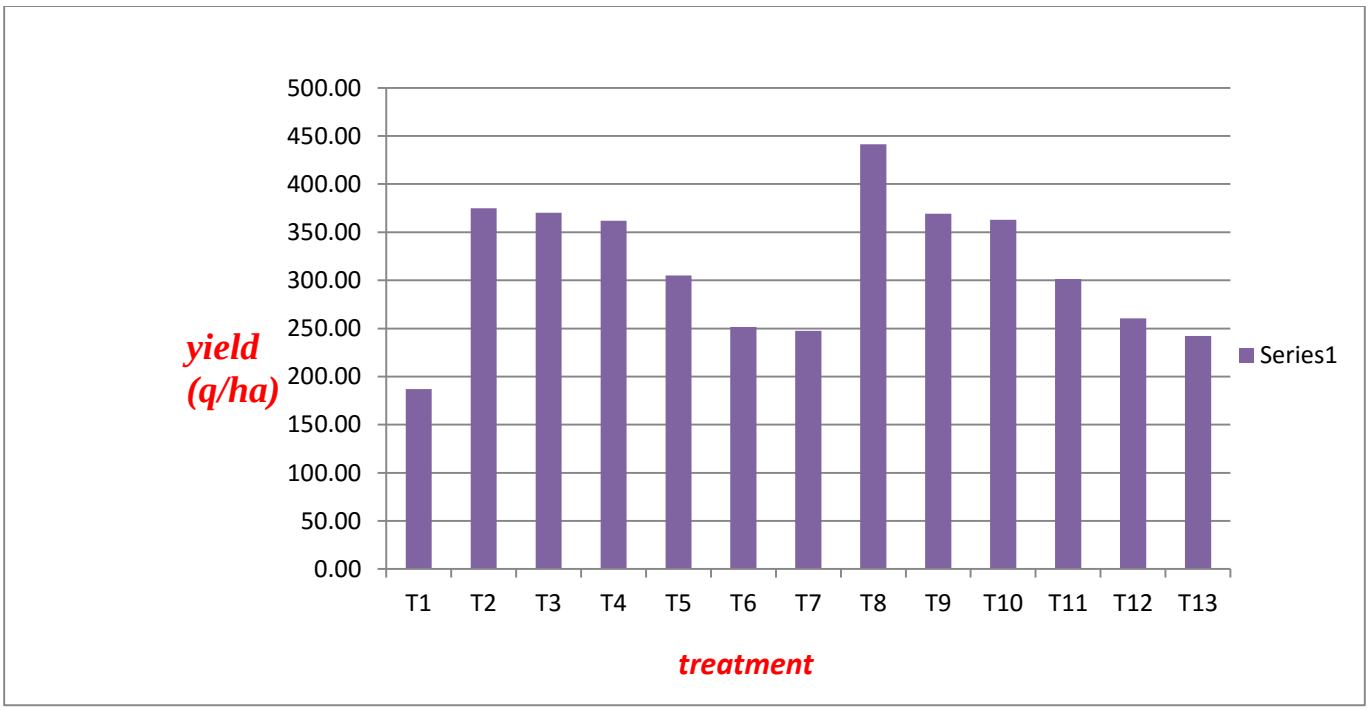


Fig.4.16 :Yield (q/ha)

Chapter V

DISCUSSION

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is an important home garden vegetable and occupies unique position among cucurbits in India. Bottle gourd is one of the excellent vegetable gifted by nature to human beings having composition of all the essential constituents that are required for good health and quality human life. The effects of mycorrhizal inoculation on plant P and Zn concentrations were determined: Mycorrhiza inoculated plants had a higher nutrient content than non inoculated plants. It can be suggested to the farmers that arbuscular mycorrhizal fungus inoculated seedlings can be used under field conditions for high yield and quality.

The results obtained from the present experiment entitled "Effect of different Mycorrhizal strain on growth and yield characteristics of bottle gourd (*Lagenaria siceraria*) (Mol.) Standl.)" are discussed as under:

Among the different treatments, T_2 (BOLT SP @ 250 g/ha), T_6 (NZBBA9048 @ 500 g/ha), T_8 (NZBBA9049 @ 250 g/ha), T_9 (NZBBA9049 @ 500 g/ha), and T_{12} (NZBBA9050 @ 500 g/ha), taken minimum number of days for 50% germination. It's because of that mycorrhiza work as modification of soil-plant-water relations, promoting better adaptation of plant to adverse environment conditions (drought, metals). At elevated heavy metal concentrations in soils, mycorrhizal fungi have been shown to detoxify the environment for plant growth. Similar result were also reported by Broadbent *et al.* (1977).

In bottle gourd, staminate flower came earlier than pistillate flower. Mycorrhiza increases the nutrient uptake and induce early flowering. Among the different treatments, T_8 (NZBBA9049 @ 250 g/ha) recorded minimum number of days to first staminate and pistillate flower anthesis.

The present study indicated the role of mycorrhiza strain in induction of early staminate and pistillate flowers. The higher doses of NZBBA9050 @ 750 g/ha had delaying effect on the induction of both staminate and pistillate flowers.

Bottle gourd is a monoecious crop in which staminate flower are borne at lower nodes than pistillate flower. The data on this trait revealed that treatment T_8 (NZBBA9049 @ 250 g/ha) produced staminate and pistillate flower at earliest nodes.. The results demonstrated that NZBBA9049 @ 250 g/ha was effective and desirable as it resulted into appears of staminate and pistillate flowers at earliest nodes.

Mycorrhiza induce early pistillate flower anthesis, and is directly related with days to require in harvesting. Among the different treatments, T_5 (NZBBA9048 @ 250 g/ha) recorded minimum no. of days to first fruit harvesting.

The treatment T_8 (NZBBA9049 @ 250 g/ha) produced longest fruits, while the treatment T_2 (BOLT SP @ 250 g/ha) produced fruits with maximum girth. The results are accordance with Naik and Srinivas (1992) and Nurlaeny *et al.* (1996).

Longer vines are important feature because it is one of the important yield contributing traits. Treatment T_8 (NZBBA9049 @ 250 g/ha) was more effective having maximum vine length as compared to other and the same result obtain by inoculating with *Glomus macro carpun* reported by Shrihari and Sreenivasan (1998).

The maximum no. of branches per plant was recorded in treatment T_{10} (NZBBA9049 @ 750 g/ha). Phosphorus is an essential nutrient element for plant growth in muskmelon (Brantley and Warren, 1961). And the inoculation with mycorrhiza stimulated the plant growth and 'P' uptake in tropical acid soil reported by Nurlaeny *et al*. (1996).

The maximum number of nodes per plant was recorded in treatment T_8 (NZBBA9049 @ 250 g/ha). More number of nodes on main axis might be increase vine length and longer vine length cover large surface area and more number of leaves will be there that is good for photosynthesis and accumulate more carbohydrates.

Number of fruit per plant is one of the most important yield attributing traits in bottle gourd. Higher the number of fruits resulted more yield. The analysis of data demonstrated that maximum no. of fruits per plant was recorded in treatment T_8 (NZBBA9049 @ 250 g/ha). The inoculation with mycorrhiza increase in the number of leaves and number of fruits per plant. The results are in accordance with Arora (1989) and Senapati *et al.* (1987).

The results demonstrated that treatments T_8 (NZBBA9049 @ 250 g/ha) produced highest fruit yield per plant. The treatment T_8 (NZBBA9049 @ 250 g/ha) resulted into highest fruit yield (kg/plot). The results demonstrated that treatment T_8 (NZBBA9049 @ 250 g/ha) produced highest fruit yield/ha. Mycorrhiza play a vital role in the increases to bottle gourd fruit yield it is because due to mycorrhiza increases phosphorus uptake Powell (1982), growth, soil biological activities and stress resistant, Sundara Rao and Sinha (1963) in tomato, Dhesi et al. (1964) in squash melon, Sreeramulu and Bagyaraj, (1986) in chilli, Sreenivasan, M.N. and S.B. Gurumurthy (1997), Riazihamadani *et al.* (1977) and Graham *et al.* (1976) also reported similar type results.

Chapter VI

SUMMARY AND CONCLUSION

The present study entitled "Effect of different Mycorrhizal strain on growth and yield characteristics of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was conducted at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during rainy season of 2015 in Randomized Block Design (RBD) with three replications. The treatments included soil drenching with different strain of mycorrhiza.

A total of 16 characters including growth, yield and yield trait were studied. Growth and yield parameters included days to 50% germination, days to first staminate flower anthesis, days to first pistillate flower anthesis, number of node at which first staminate flower appears, number of node at which first pistillate flower appears, vine length (m), number of primary branches per plant, number of node on main axis, days to first fruit harvesting, fruit length (cm), fruit girth (cm), number of fruits per plant, average fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg) and yield (q/ha).

The results indicated that treatment T_2 (BOLT SP @ 250 g/ha), T_6 (NZBBA9048 @ 500 g/ha), T_8 (NZBBA9049 @ 250 g/ha), T_9 (NZBBA9049 @ 500 g/ha), and T_{12} (NZBBA9050 @ 500 g/ha) resulted minimum number of days in 50% germination.

Earliest days for anthesis of first staminate and pistillate flowers were recorded in T_8 (NZBBA9049 @ 250 g/ha). The present study indicated the role of mycorrhiza strain in induction of early staminate and pistillate flowers. The higher doses of NZBBA9050 @ 750 g/ha had delaying effect on the induction of both staminate and pistillate flowers.

Staminate and Pistillate flower at earliest node reported in T_8 (NZBBA9049 @ 250 g/ha). The results demonstrated that NZBBA9049 @ 250 g/ha was effective and desirable as it resulted into appears of staminate and Pistillate flowers at earliest nodes.

The decrease in days to first fruit harvesting was recorded with different mycorrhizal application. Among the different treatment minimum number of day to first fruit harvesting recorded in T_5 (NZBBA9048 @ 250 g/ha).

Mycorrhiza application increased fruit length among different mycorrhiza strain (NZBBA9049 @ 250 g/ha) significant increase in fruit length. Maximum girth of fruit produced by treatment T_2 (BOLT SP @ 250 g/ha).

Longer vines are important feature because it is one of the important yield contributing traits. Mycorrhiza application significantly increase vine length among the different treatment, treatment T_8 (NZBBA9049 @ 250 g/ha) was more effective as compare to other treatment to increase vine length. The maximum number of branches per plant was recorded in T_{10} (NZBBA9049 @ 750 g/ha). The treatment T_8 (NZBBA9049 @ 250 g/ha) recorded maximum number of nodes per plant. Maximum fruits size recorded in T_2 (BOLT SP @ 250 g/ha).

Number of fruits per plant, fruit yield per plant, fruit yield per plot, fruit yield/ha was significantly affected by the application of different strain of mycorrhiza. Among the different treatment T_8 (NZBBA9049 @ 250 g/ha) are more significantly increase the yield.

Conclusion

On the basis of results obtained in the present investigation it is concluded that soil drenching with mycorrhiza strain **(NZBBA9049 @ 250 g/ha)** was found to be most potential treatment for maximum increase in days to 50% germination, early anthesis of first staminate and pistillate flower, early number of node at which first staminate and pistillate flower appears, longest fruits, maximum vine length, maximum number of branches per plant, maximum number of nodes per plant, highest fruit yield per plant, maximum number of fruits per plant, fruit yield per plot and highly fruit yield q/ha of bottle gourd was highly significant as compared to untreated control and second most significant treatment are T_2 (BOLT SP @ 250 g/ha) in maximum fruits size and all other character.

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