Yield attributes and yield of cluster bean as affected by varieties and micronutrient foliar application under teak based agroforestry system

ABSTRACT

Agroforestry is an approach to land use that combines agriculture with forestry, ensuring both forest cover and food security. In the present study, teak based agroforestry system was used for the production potential of cluster bean in response to varieties and micronutrient foliar application. The study was conducted in the summer season for two years. The experiment was laid out in Randomized Block Design with Factorial concept consisting of 3 factors *viz*., varieties, foliar application of micronutrient iron and zinc at 2 levels each in 4 replications. Two different varieties of cluster bean *viz.* Pusa Navbahar (V_1), Local Variety (V_2), foliar application of iron *viz.* No foliar application of iron (F_0), foliar application of iron [0.5 % $FeSO_4$ (F_1)] at 30 and 45 days after sowing (DAS) and foliar application of zinc *viz.* No foliar application of zinc (Z_0), foliar application of zinc [0.5 % $ZnSO_4$ (Z_1)] at 30 and 45 DAS. Were tested for yield attributes of cluster bean separately under teak based agroforestry system and open condition. Among two tested varieties, variety Pusa Navbahar perform well as compared to local variety. Foliar application of 0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ individually increased yield attributes and yield as compare to their control condition. Further, results of the investigation showed decline in the yield attributes and yield of cluster bean under teak based agroforestry system in comparison to open condition. The interaction effect of different treatment combinations was found nonsignificant for all yield attributes except the number of pods per plant under teak based agroforestry system and open condition.

Keywords: Cluster bean, Yield, Variety, Micronutrient, Foliar application, Teak, Agroforestry System

INTRODUCTION

Agroforestry is a land management technique that uses woody perennial crops and/or animals on farms to promote productivity, diversity, and long-term production, and improved economic and environmental benefits at various stages to the land users (Dhyani and Handa, 2013). Agroforestry has been seen as a holistic approach in recent years because of the rising appreciation of the importance of the trees outside the forest. In India, they are a major source of various products, i.e., fodder, timber, fuelwood and other miscellaneous supplies derived from the agroforestry area (Ndayambaje and Mohren, 2011). Agroforestry is helpful in enhancing tree cover and reducing stress on natural forests and is the preferred land-use system for improving and restoring unproductive lands (Dager, 2013).

In agroforestry practices, the common tendency is to raise fast growing economically important timber species which do not require any special management or inputs. Throughout the tropics, teak (*Tectona grandis* L. f.) is one such candidate species that is most sought after and also yields highly valued timber (Pandey and Brown, 2000). Teak is a large, deciduous tree that can grow to be

over 30 m tall in ideal conditions. The crown is open with many small branches; the branch is often buttressed and may be fluted, reaching up to 15 m below the first branches. The root system is shallow, often no more than 50 cm deep, but roots can extend laterally up to 15 meters from the stem. During the latter half of the dry season, the very large, 4-sided leaves shed for 3-4 months, leaving the branchlets bare. Teak is produced in industrial plantations in more than 43 countries (Roshetko *et al.*, 2013).

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] is an annual legume crop mostly grown under resource constrained conditions in arid and semi-arid regions (Kumar, 2005). Cluster bean is a deep-rooted plant of Leguminosae (Fabaceae) family known for drought and high temperature tolerance (Kumar and Rodge, 2012). The major cluster bean cultivating countries are India, Pakistan, USA, Italy, Morocco, Germany, and Spain (Punia *et al.*, 2009). India produces about 80 % of the world's cluster bean production (Tripathy and Das, 2013). Cluster bean is grown especially in the arid regions of India (Rajasthan, Haryana, Gujarat and Punjab) for gum purpose, whereas it is grown for vegetable purpose in other parts of India (Rai and Dharmatti, 2013). Cluster bean can be used for a variety of purposes, including vegetable, cattle feed/fodder, and green manure. Cluster bean is primarily grown during the rainy (kharif) season, but it can also be grown under irrigation during the summer. Sowings can be made from the second week of July to the first week of August, and during the summer from the last week of February to the first week of March.

Legume crops require not only adequate macronutrients but also micronutrients. Therefore, an optimum supply of micronutrient under balanced condition is very important for achieving higher productivity; research report on the foliar nutrition effect cluster bean is still scarce. Micronutrients have played vital roles in the improvement of growth, yield and quality of legumes crops (Reinbott and Blevins, 1995). Hallock (1978) observed that foliar application of micronutrient is better than soil application for increasing yield.

The present study was aimed to see the performance of cluster bean crop under teak based agroforestry system and in open condition with the effect of varieties and foliar application of micronutrient.

MATERIALS AND METHODS

Study site

The investigation was carried out in the summer season of the year 2021 and 2022 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, which, lies between 20°55'25"N latitude and 72°54'29"E longitude with an average elevation of 10 m above mean sea level.

Variety details of cluster bean

The Pusa Navbahar cultivar was used in the current investigation. Pusa Do-mausami and Pusa Sadabahar were crossed to create this hybrid. It's a high-yielding, photo- resistant and vegetable-purpose cultivar. In general, the leaves are light green, delicate, and meaty, with abundant bearing in the branches. The mature seeds are usually pale grey in colour. This variety's certified seed was obtained

from the Anand Agricultural University's Main Vegetable Research Station. Check (Local) variety seed was purchased from local commercial market.

Treatments details

The experiment was laid out in Randomized Block Design with Factorial concept consisting of 3 factors *viz*., variety, foliar application of micronutrient iron and zinc at 2 levels each in 4 replications. Two different varieties of cluster bean *viz.* Pusa Navbahar (V_1), Local Variety (V_2), Iron application *viz.* No foliar application of iron (F_0), foliar application of iron [0.5 % $FeSO_4$ (F_1)] at 30 and 45 days after sowing (DAS), and zinc application *viz.* No foliar application of zinc (Z_0), foliar application of zinc [0.5 % $ZnSO_4$ (Z_1)] at 30 and 45 DAS were tested for yield attributes of cluster bean. All treatments were given to cluster bean crop separately in teak based agroforestry system and open condition.

Data collection

The number of clusters per plant was counted at each picking, and an average was calculated. The number of pods counted per cluster at each picking was averaged to obtain the number of pods per cluster. The number of pods per plant was counted at each picking and then averaged to get the total number of pods per plant. The length of each pod was measured in centimeters by thread from the stalk to the apex, and the mean pod length was determined by adding the lengths of all ten pods and dividing by ten. Pods that were used to measure length were also used to estimate pod diameter. The pod diameter was measured in millimeters. Ten marketable, fresh pods were randomly chosen from each treatment for weighing, and the average weight was recorded as the pod weight in grams. By adding up the pod weight of all the pods that were taken from the net plot throughout all of the pickings, the pod yield was calculated. The pod yield values were converted to kg ha^{-1}. All the data related to yield parameters were recorded for two consecutive years in both growing conditions separately.

Statistical analysis

The data regarding the yield of cluster bean recorded for each treatment during the experiment were subjected to statistical analysis of variance technique as described by Panse and Sukhatme (1985). The experiment was laid out in Randomized Block Design (RBD) with factorial concept. The significance of treatment differences was tested by 'F' test as 5 % level of significance. The Critical Difference (CD) were calculated when the difference among treatments were found significant for making the comparison among treatment means. The Standard Error of mean [SEm (±)] was also worked out for each parameter. The Coefficient of Variance [CV (%)] was calculated. A T-test using equal variance was used to see the statistical significance between teak based agroforestry system and open condition for yield attributes of cluster bean.

RESULTS

Pod physical quality (Pod length and diameter)

A glance of data presented in Tables 1 and 2 respectively showed the effect of varieties, foliar application of iron and zinc on pod length (cm) and pod diameter (mm) of cluster bean during individual year and pooled analysis.

Effect of varieties

Pod length and diameter of cluster bean were significantly affected by two different varieties. Pusa Navbahar variety observed maximum pod length and diameter over local variety, respectively under teak based agroforestry system and open condition in consecutive years as well as pooled analysis.

Effect of foliar application of iron

Data of pod length and diameter showed significant difference due to foliar application of iron. Foliar application of 0.5% $FeSO_4$ increased the pod length and diameter over no application of iron, respectively under teak based agroforestry system and open condition in individual year as well as pooled analysis

Effect of foliar application of zinc

During both the years and pooled analysis, increased pod length and diameter were observed with foliar application of 0.5% $ZnSO_4$ as compared to its control condition, respectively under teak based agroforestry system and open condition

Interaction effect

All interaction effect of different treatment combinations was found nonsignificant for pod length and diameter in both growing conditions.

Yield attributes

The data pertaining to yield attributes *viz.* number of clusters per plant, number of pods per cluster and number of pods per plant is shown in Tables 3, 4 and 5a, respectively as influenced by varieties and foliar application of iron and zinc.

Effect of varieties

The difference among two varieties for yield attributes was significant. Pusa Navbahar variety recorded increased number of clusters per plant, number of pods per cluster and number of pods per plant over local variety, respectively under teak based agroforestry system and open condition during both the years and pooled analysis.

Effect of foliar application of iron

Yield attributes were varied with foliar application of 0.5% $FeSO_4$ and no application of iron. Number of clusters per plant, number of pods per cluster and number of pods per plant were recorded higher with foliar application of 0.5% $FeSO_4$ respectively, as compare to control condition (no iron), under teak based agroforestry system and open condition during year 2021, 2022 and pooled analysis.

Effect of foliar application of zinc

The result describes that during both the years and pooled analysis, number of clusters per plant, number of pods per cluster and number of pods per plant were observed maximum with foliar application of 0.5% $ZnSO_4$ as compare to control condition (no zinc), respectively under teak based agroforestry system and open condition

Interaction effect

Number of clusters per plant and number of pods per cluster were not significantly affected by different interaction effect in both the years and pooled analysis in both growing conditions. However, under teak based agroforestry system, the interaction effect of variety and foliar zinc (V x Z) was found significant for number of pods per plant for the year 2021 and pooled analysis and non-significant in the year 2022. Variety, Pusa Navbahar with foliar application of 0.5% $ZnSO_4$ (V_1Z_1) observed higher number of pods per plant for the year 2021 and pooled analysis (Table 5b).

In open condition, the interaction effect of foliar application of iron and zinc (F x Z) was found significant for year 2022 and pooled analysis and non-significant for the year 2021. Foliar application of iron with zinc (F_1Z_1) attained highest number of pods per plant during the year 2022 and pooled analysis (Table 5c).

Moreover, rest all interaction were nonsignificant for number of pods per plant in both growing conditions.

Pod yield (kg ha^{-1})

The information regarding variation in pod yield of cluster bean as influenced by varieties, foliar application of iron and zinc is shown in table 6.

Effect of varieties

Yield performance of two different varieties was tested. The result showed that among two varieties, Pusa Navbahar variety recorded significantly maximum pod yield in both the years and pooled analysis under teak based agroforestry system and open condition.

Effect of foliar application of iron

Foliar application of iron significantly affected the pod yield. Significantly higher pod yield was observed with foliar application of 0.5% $FeSO_4$ and lower with no application of iron in consecutive year and pooled analysis in both growing conditions (teak based agroforestry system and open condition).

Effect of foliar application of zinc

The pod yield was increased significantly with foliar application of 0.5% $ZnSO_4$ as compare to no application of zinc in years 2021, 2022 and pooled analysis in both growing conditions.

Interaction effect

Interaction effect of different combination of verities (V), foliar application of iron (F) and foliar application of zinc (Z) were not influenced pod yield significantly during both the year of study and pooled analysis in both growing conditions.

T-Test analysis for yield parameters

Statistical significance was tested by using two-sample t-test assuming equal variances for yield attributes and yield of cluster bean between both growing conditions. The result from table 7 indicate that pod length (cm), pod diameter (mm) and number of pods per cluster were not significantly ($P > 0.05$) affected by both growing conditions. However, number of clusters per plant, number of pods per plant, and pod yield (kg ha^{-1}) were significantly recorded maximum ($P < 0.05$) in open condition as compared to teak based agroforestry system.

DISCUSSION

The variation in yield attributes and yield of two different cultivars of cluster bean could be assigned to their varying genetical makeup. These findings corroborate with the findings of Kalyani (2012), Kumar *et al.* (2015 a), Anupama *et al.* (2016), Kumar *et al.* (2017), Naik *et al.* (2019), Rajamanickam (2019), Kgasudi *et al.* (2020), Balakumbahan *et al.* (2020) and Nanthakumar *et al.* (2021).

Zinc and iron are having the stimulatory effect on most of the physiological and metabolic processes. The foliar application of nutrients helps specially treatment of zinc and iron sulfate responsible for efficient translocation of photosynthate from source to sink, this cause higher number of pod formation.

Foliar spraying resulted in effective absorption of the nutrients during critical stages of growth and in turn contributed to increased pod length (Krishna and Kaleeswari, 2018). Nadergholi *et al.* (2011) reported highest pods per plant due to foliar application could be attributed to the significant effect of microelements on reproductive organs, such as stamens and pollens. Prasanna *et al.* (2014) observed increased yield attributes of cluster bean with foliar application of zinc. Singh *et al.* (2013) documented that yield and yield attributes of mung bean were increased with foliar feeding of iron and zinc. Pathak *et al.* (2012) observed that foliar application of Zn at the time of initiation of flower reversed the adverse effects of Zn deficiency on pollen system morphology and pollen fertility and

resulted in increased grain yield in chickpea. Shivay *et al.* (2015) found maximum grain yield with foliar application of zinc in chickpea. Significant increase in yield and yield attributes of mungbean were observed under foliar feeding of iron sulphate (Meena and Meena, 2013). Solanki *et al.* (2017) reported increase in yield and yield parameters of cluster bean by foliar application of iron sulfate. Ali *et al.* (2014) documented that application of iron sulphate increases the yield of mung bean.

Higher yield of cluster bean was recorded under open condition, which may attribute to the higher cropping area in open condition and better availability of light as compared to teak based agroforestry system where a considerable area is occupied by the overstorey component and less availability of light. In agroforestry, the crop yield is influenced by the beneficial and harmful interaction of tree and crop (Newaj *et al.*, 2005). Oladele *et al.* (2012) recorded higher ginger foliage production outside teak plantation. Rajalingam *et al.* (2016) reported lower yield of cluster bean under ailanthus-based agroforestry system. The detrimental effect of silvi-medicinal land use system on herbage yield may be ascribed to negative tree-crop interface (above ground) *i.e.* competitive effect of teak (light) by Kumar *et al*. (2015 b). Similar results were also found by Saroj *et al.* (2003), Chauhan *et al.* (2012), Kaushik *et al.* (2016), Kaushik *et al.* (2017) and Hulke *et al.* (2019).

CONCLUSION

The result of the investigation shows that variety Pusa Navbahar with foliar application of 0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ can be used for higher yield attributes and yield of cluster bean in both growing conditions. Further, result shows reduction in yield attributes and yield of cluster bean under teak based agroforestry system. The yield of cluster bean was found significantly higher in open condition.

REFERENCES

Ali, B.; Ali, A.; Tahir, M. and Ali, S. (2014). Growth, Seed yield and quality of mungbean as influenced by foliar application of iron sulfate. *Pak. J. Life Soc. Sci.*, **12**(1): 20-25.

Anupama; Dolkar, R.; Vadodaria, J. R. and Verma, P. (2016). Effect of different varieties of cluster bean [*Cyamopsis tetragonaloba* (L.) Taub.] and biofertilizers on growth, yield and quality parameters. *Eco. Env. Cons.*, **22**(December Suppl.):457-462.

Balakumbahan, R.; Prabukumar, G. and Sivakumar, V. (2020). The evaluation of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] genotypes for fruit and gum yield. *Eur. Jr. Agri. Food Sci.*, **2**(5): 1-3.

Chauhan, S. K.; Brar, M. S. and Sharma, R. (2012). Performance of poplar (*Populus deltoides* bartr.) and its effect on wheat yield under agroforestry system in irrigated agro-ecosystem, India. *Caspian J. Env. Sci.*, **10**(1): 53-60.

Dager, J. C. (2013). Agroforestry: A way forward for rehabilitation of salty lands for livelihood security and carbon sequestration. *Indian J. Agrofor.* **15**: 10–25.

Dhyani, S. K. and Handa, A. K. (2013). Area under agroforestry in India: An assessment for present status and future perspective. *Indian J. Agrofor*. **15**: 1–11.

Hallock D. L. (1978). Relative effectiveness of several Mn sources on Virginia type peanuts. *Agron. J.*, **71**: 685–688.

Hulke, V.; Harne, S.; Ujjainkar, V.; Mane, V. and Taide, Y. (2019). Influence of microclimatic parameters on growth and yield of cotton in teak based agroforestry system. *Multilogic sci.*, **3**(A): 20-23.

Kalyani, D. L. (2012). Performance of cluster bean genotypes under varied time of sowing. *Legume Res.*, **35**(2): 154-158.

Kaushik, N.; Deswal, R. P. S.; Tikkoo, A.; Kumari, S.; Malik, S. and Kumar, K. (2016). *Pongamia pinnata* L. (Karanja) based agri-silviculture system under rainfed conditions of south-west Haryana. *J. Appl. Nat. Sci.*, **8**(1): 31-34.

Kaushik, N.; Tikkoo, A.; Yadav, P. K.; Deswal, R. P. S. and Singh, S. (2017). Agri–Silvi–Horti systems for semiarid regions of North-West India. *Agric. Res.*, **6**(2):150-158.

Kgasudi, B. K.; Rekha, G. K.; Jyothi, K. U. and Sasikala, K. (2020). Performance of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] genotypes for growth, yield and quality characters. *Electron. J. Plant. Breed.*, **11**(02): 373-381.

Krishna, O. N. and Kaleeswari, R. K. (2018). Response of pulses to foliar application of multinutrients on yield, quality, uptake and soil nutrient status. *Madras Agric. J.*, **105**(4-6): 176-181.

Kumar, D. (2005). Status and direction of arid legumes research in India. *Indian J. Agric. Sci*., **75**: 375-391.

Kumar, D. and Rodge, A.B. (2012). Status, scope and strategies of arid legumes research in India: A Review. *J. Food Leg*., **25**: 255-272.

Kumar, M.; Patel, H. K.; Patel, C. N.; Umale, A. A. and Patel, J. J. (2015 a). Varietal response of summer cluster bean (*Cyamopsis tetragonoloba* L.) to different irrigation scheduling (IW: CPE ratios) under middle Gujarat conditions. *Eco. Env. Cons.*, **21**: 159-163.

Kumar, M.; Thakur, N. S. and Hegde, H. T. (2015 b). Growth, herb yield and financial flows from *Ocimum* spp. intercropped under teak (*Tectona grandis* L. f.)-*Ocimum* spp. based silvi-medicinal system in Gujarat, India. *Int. J. Innov. Hortic.*, **4**(2): 113-118.

Kumar, S.; Luther, M. M.; Kumar, V. and Hemalatha, K. (2017). Effect of dates of sowing and varieties on yield and quality of cluster bean (*Cyamopsis tetragonoloba* L.). *J. Appl. Nat. Sci.*, **9**(2): 1081-1084.

Meena, K. K. and Meena R. S. (2013). Effect of sulfur and iron fertilization on growth parameters, yield attributes, yields and nutrient uptake of mungbean in arid western Rajasthan. *J. environ. ecol.*, **31**(1A):227-231.

Nadergholi M. S.; Yarnia, M and Rahimzade K. F. (2011). Effect of zinc and manganese and their application method on yield and yield components of common bean (*Phaseolus vulgaris* L. CV. Khomein). Middle-East *J. Sci. Res*., **8**(5): 859-865.

Naik, M. T.; Srihari, D.; Dorajeerao, A. V. D.; Sasikala, K.; Umakrishna, K.; Suneetha, D. R. S. and Pradeepkumar, C. M. (2019). Influence of plant growth regulators on growth and development of cluster bean varieties. *Plant Archives*, **19**(2): 2551-2555.

Nanthakumar, S.; Amudharaj, N. and Sasikumar, K. (2021). Seasonal variation on growth and yield parameter of certain cluster bean culitvars (*Cyamopsis tetragonoloba* (L.) Taub.). *J. Pharm. Innov.*, **10**(9): 125-127.

Ndayambaje, J. D. and Mohren G. M. (2011). Fuelwood demand and supply in Rwanda and the role of agroforestry. *Agrofor. Syst.* **83**: 303–320.

Newaj, R., Bhargava, M. K., Shanker, A. K., Yadav, R. S., Ajit, and Rai, P. (2005). Resource capture and tree-crop interaction in *Albizia procera* based agroforestry system. *Arch. Agron. Soil Sci.*, **51**(1): 51-68.

Oladele, A. T.; Popoola, L., and Jimoh, S. O. (2012). Effects of teak canopy cover and NPK fertilizer application on growth of ginger in agroforestry trial, Ile-Ife, Nigeria. *J. Agric. Soc. Sci.*, **12**(2): 147-157.

Pandey D, Brown C (2000) Teak: a global overview. *Unasylva*, **201**(51):3–13.

Panse, V. G. and Sukhatme, P. V. (2006). Statistical methods for agricultural workers. New Delhi, India, Indian Council of Agricultural Research 152-161.Pathak, G. C.; Gupta, B. and Pandey, N. (2012). Improving reproductive efficiency of chickpea by foliar application of zinc. *Braz. J. Plant Physiol.*, **24**(3):173–80.

Prasanna, K. L.; Selvaraj, S. and Reddy, P. M. (2014). Dry matter production, yield attributes, yield and quality of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] as influenced by nitrogen and zinc application. *Indian J. Agric. Res.*, **48**(1): 9-15.

Punia, A.; Yadav, R.; Arora, P. and Chaudhary, A. (2009). Molecular and morphophysiological characterization of superior cluster bean (*Cyamopsis tetragonoloba*) varieties. *J. Crop Sci. Biotech.*, **12**: 143-148.

Rai, P. S. and Dharmatti, P. R. (2013). Genetic divergence studies in cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]. *Global J. Sci. Frontier Res. Agric. Vet*., **13**: 1-5.

Rajalingam, G. V.; Divya, M. P.; Prabaharan, C. and Parthiban, K. T. (2016). Performance of vegetable crops under *Ailanthus excelsa* based agroforestry system. *Indian J. Agrofor.*, **18**(1): 16-20.

Rajamanickam, C. (2019). Assessment of Cluster Bean (*Cyamopsis tetragonoloba*) varieties for growth and yield characters. *J. krishi vigyan*, **7**(2): 7-10.

Reinbott, T.M. and Blevins, D.G. (1995). Response of soybean to foliar applied boron and magnesium and soil applied boron. *J. Plant Nutr.*, **18**:179-200.

Roshetko, J. M.; Rohadi, D.; Perdana, A.; Sabastian, G.; Nuryartono, N.; Pramono, A. A.; Widyani, N.; Manalu, P.; Fauzi, M. A.; Sumar-damto, P. and Kusumowardhani, N. (2013). Teak agroforestry systems for livelihood enhancement, industrial timber production, and environmental rehabilitation. *For. Trees Livelihoods*, **22**(4):251–256.

Saroj, P. L.; Dhandar, D. G.; Sharma, B. D.; Bhargava, R. and Purohit, C. K. (2003). Ber (*Ziziphus mauritiana* L.) based agri-horti system: A sustainable land use for arid ecosystem. *Ind. J. Agroforestry*, **5**(1-2): 30-35.

Shivay, Y. S.; Prasad, R. and Pal, M. (2015). Effects of source and method of zinc application on yield, zinc biofortification of grain, and Zn uptake and use efficiency in chickpea (*Cicer arietinum* L.). *Commun. Soil Sci. Plant Anal.*, **46**(17): 2191-2200.

Singh, V.; Yadav, R. K.; Yadav, R.; Malik, R. S.; Yadav, N. R.; Singh, J., and Meena, M. D. (2013). Effect of different iron and zinc application on growth, yield and quality parameters of mung bean (*Vigna radiata* L.). *Annals of Agric. Bio Res.*, **18**(2): 164-175.

Solanki, R. B.; Yadav, L. R.; Gupta, A.; and Yadav, S. S. (2017). Correlation studies in cluster bean as influenced by varieties and foliar application. *J. Pharmacogn. Phytochem.*, **6**(5): 289-291.

Tripathy, S. and Das, M. K. (2013). Guar gum: present status and applications. *J. Pharm. Scientific Innov.*, **2**: 24-28.

Table 1: Effect of varieties, foliar application of micronutrient on pod length (cm) of cluster bean under teak based agroforestry system and in open condition

Pod length (cm)						
Treatments	**Teak Based Agroforestry System**			**Open Condition**		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
Variety (V)						
V_1 (Pusa Navbahar)	9.60	10.24	9.92	10.46	10.95	10.70
V_2 (Local Variety)	7.56	8.19	7.88	8.65	9.09	8.87
Foliar Application of Micronutrient Iron (F)						
F_0 (No Iron)	8.15	8.77	8.46	9.13	9.62	9.37
F_1 (0.5% $FeSO_4$)	9.01	9.66	9.34	9.98	10.42	10.20
Foliar Application of Micronutrient Zinc (Z)						
Z_0 (No Zinc)	8.10	8.74	8.42	9.06	9.55	9.30
Z_1 (0.5% $ZnSO_4$)	9.06	9.69	9.38	10.04	10.49	10.27
#S.Em.±	0.19	0.20	0.14	0.21	0.22	0.15
#C.D. at 5%	0.56	0.60	0.40	0.63	0.67	0.44

C.V. (%)	8.98		8.94		8.97		9.00		9.13		9.07	
	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Year (Y)					0.14	0.40					0.15	0.44
Y x V					0.19	NS					0.22	NS
Y x F					0.19	NS					0.22	NS
Y x Z					0.19	NS					0.22	NS
V x F	0.27	NS	0.29	NS	0.19	NS	0.30	NS	0.32	NS	0.22	NS
Y x V x F					0.28	NS					0.31	NS
V x Z	0.27	NS	0.29	NS	0.19	NS	0.30	NS	0.32	NS	0.22	NS
Y x V x Z					0.28	NS					0.31	NS
F x Z	0.27	NS	0.29	NS	0.19	NS	0.30	NS	0.32	NS	0.22	NS
Y x F x Z					0.28	NS					0.31	NS
V x F x Z	0.38	NS	0.41	NS	0.28	NS	0.43	NS	0.45	NS	0.31	NS
Y x V x F x Z					0.39	NS					0.44	NS
# CD and SEm values are same for the individual effect of Variety, Foliar application of Iron and Zinc												

Table 2: Effect of varieties, foliar application of micronutrient on pod diameter (mm) of cluster bean under teak based agroforestry system and in open condition

Treatments	Pod diameter (mm)					
	Teak Based Agroforestry System			Open Condition		
	2021	2022	Pooled	2021	2022	Pooled
Variety (V)						
V_1 (Pusa Navbahar)	7.98	8.10	8.04	8.54	8.63	8.58
V_2 (Local Variety)	7.19	7.28	7.23	7.39	7.49	7.44
Foliar Application of Micronutrient Iron (F)						
F_0 (No Iron)	7.33	7.40	7.37	7.70	7.80	7.75
F_1 (0.5% $FeSO_4$)	7.84	7.97	7.91	8.23	8.33	8.28
Foliar Application of Micronutrient Zinc (Z)						
Z_0 (No Zinc)	7.29	7.37	7.33	7.66	7.76	7.71
Z_1 (0.5% $ZnSO_4$)	7.89	8.01	7.95	8.27	8.36	8.31
#S.Em.±	0.15	0.15	0.11	0.15	0.17	0.11
#C.D. at 5%	0.46	0.44	0.31	0.44	0.52	0.33
C.V. (%)	8.35	7.94	8.15	7.67	8.82	8.28

	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Year (Y)					0.11	NS					0.11	NS
Y x V					0.15	NS					0.16	NS
Y x F					0.15	NS					0.16	NS
Y x Z					0.15	NS					0.16	NS
V x F	0.22	NS	0.21	NS	0.15	NS	0.21	NS	0.25	NS	0.16	NS
Y x V x F					0.22	NS					0.23	NS
V x Z	0.22	NS	0.21	NS	0.15	NS	0.21	NS	0.25	NS	0.16	NS
Y x V x Z					0.22	NS					0.23	NS
F x Z	0.22	NS	0.21	NS	0.15	NS	0.21	NS	0.25	NS	0.16	NS
Y x F x Z					0.22	NS					0.23	NS
V x F x Z	0.31	NS	0.30	NS	0.22	NS	0.30	NS	0.35	NS	0.23	NS
Y x V x F x Z					0.31	NS					0.33	NS
# CD and SEm values are same for the individual effect of Variety, Foliar application of Iron and Zinc												

Table 3: Effect of varieties, foliar application of micronutrient on number of clusters per plant of cluster bean under teak based agroforestry system and in open condition

Number of clusters per plant												
Treatments	**Teak Based Agroforestry System**						**Open Condition**					
	2021		**2022**		**Pooled**		**2021**		**2022**		**Pooled**	
Variety (V)												
V_1 (Pusa Navbahar)	21.87		25.78		23.82		38.77		43.65		41.21	
V_2 (Local Variety)	16.85		19.19		18.02		32.73		36.23		34.48	
Foliar Application of Micronutrient Iron (F)												
F_0 (No Iron)	18.16		21.38		19.77		34.22		38.07		36.15	
F_1 (0.5% $FeSO_4$)	20.55		23.59		22.07		37.29		41.80		39.54	
Foliar Application of Micronutrient Zinc (Z)												
Z_0 (No Zinc)	17.78		20.75		19.27		33.54		37.42		35.48	
Z_1 (0.5% $ZnSO_4$)	20.93		24.22		22.58		37.96		42.46		40.21	
#S.Em.±	0.48		0.54		0.36		0.72		0.73		0.51	
#C.D. at 5%	1.42		1.60		1.04		2.14		2.17		1.48	
C.V. (%)	9.99		9.69		9.85		8.15		7.40		7.76	
	S.Em.±	C.D.	S.Em.±	C.D.	S.Em.±	C.D.	S.Em.±	C.D.	S.Em.±	C.D.	S.Em.±	C.D.

		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%
Year (Y)					0.36	1.04					0.51	1.48
Y x V					0.51	NS					0.73	NS
Y x F					0.51	NS					0.73	NS
Y x Z					0.51	NS					0.73	NS
V x F	0.68	NS	0.77	NS	0.51	NS	1.03	NS	1.04	NS	0.73	NS
Y x V x F					0.72	NS					1.03	NS
V x Z	0.68	NS	0.77	NS	0.51	NS	1.03	NS	1.04	NS	0.73	NS
Y x V x Z					0.72	NS					1.03	NS
F x Z	0.68	NS	0.77	NS	0.51	NS	1.03	NS	1.04	NS	0.73	NS
Y x F x Z					0.72	NS					1.03	NS
V x F x Z	0.96	NS	1.09	NS	0.72	NS	1.45	NS	1.47	NS	1.03	NS
Y x V x F x Z					1.03	NS					1.46	NS
# CD and SEm values are same for the individual effect of Variety, Foliar application of Iron and Zinc												

Table 4: Effect of varieties, foliar application of micronutrient on number of pods per cluster of cluster bean under teak based agroforestry system and in open condition

Number of pods per cluster												
Treatments	**Teak Based Agroforestry System**						**Open Condition**					
	2021		**2022**		**Pooled**		**2021**		**2022**		**Pooled**	
Variety (V)												
V_1 (Pusa Navbahar)	3.68		3.79		3.74		3.99		4.17		4.08	
V_2 (Local Variety)	2.96		3.21		3.08		3.29		3.40		3.35	
Foliar Application of Micronutrient Iron (F)												
F_0 (No Iron)	3.15		3.30		3.23		3.40		3.52		3.46	
F_1 (0.5% $FeSO_4$)	3.50		3.69		3.59		3.89		4.06		3.97	
Foliar Application of Micronutrient Zinc (Z)												
Z_0 (No Zinc)	3.06		3.23		3.15		3.38		3.51		3.45	
Z_1 (0.5% $ZnSO_4$)	3.58		3.77		3.67		3.91		4.07		3.99	
#S.Em.±	0.08		0.08		0.05		0.09		0.09		0.06	
#C.D. at 5%	0.24		0.24		0.16		0.27		0.27		0.19	
C.V. (%)	10.07		9.48		9.77		10.40		19.98		10.19	
	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%

Year (Y)					0.05	0.16					0.06	NS
Y x V					0.08	NS					0.09	NS
Y x F					0.08	NS					0.09	NS
Y x Z					0.08	NS					0.09	NS
V x F	0.11	NS	0.11	NS	0.08	NS	0.13	NS	0.13	NS	0.09	NS
Y x V x F					0.11	NS					0.13	NS
V x Z	0.11	NS	0.11	NS	0.08	NS	0.13	NS	0.13	NS	0.09	NS
Y x V x Z					0.11	NS					0.13	NS
F x Z	0.11	NS	0.11	NS	0.08	NS	0.13	NS	0.13	NS	0.09	NS
Y x F x Z					0.11	NS					0.13	NS
V x F x Z	0.16	NS	0.16	NS	0.11	NS	0.18	NS	0.18	NS	0.13	NS
Y x V x F x Z					0.16	NS					0.18	NS
# CD and SEm values are same for the individual effect of Variety, Foliar application of Iron and Zinc												

Table 5a: Effect of varieties, foliar application of micronutrient on number of pods per plant of cluster bean under teak based agroforestry system and in open condition

Number of pods per plant												
Treatments	**Teak Based Agroforestry System**						**Open Condition**					
	2021		**2022**		**Pooled**		**2021**		**2022**		**Pooled**	
Variety (V)												
V_1 (Pusa Navbahar)	79.37		82.85		81.11		146.81		155.86		151.33	
V_2 (Local Variety)	49.68		55.63		52.65		114.21		119.76		116.99	
Foliar Application of Micronutrient Iron (F)												
F_0 (No Iron)	57.80		61.74		59.77		120.13		125.07		122.60	
F_1 (0.5% $FeSO_4$)	71.24		76.74		73.99		140.89		150.56		145.72	
Foliar Application of Micronutrient Zinc (Z)												
Z_0 (No Zinc)	53.31		58.11		55.71		116.90		123.01		119.95	
Z_1 (0.5% $ZnSO_4$)	75.74		80.37		78.05		144.12		152.62		148.37	
#S.Em.±	1.69		1.72		1.21		3.25		2.68		2.10	
#C.D. at 5%	4.97		5.08		3.45		9.57		7.88		6.01	
C.V. (%)	10.48		9.99		10.23		9.97		7.78		8.89	
	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Year (Y)					1.21	3.45					2.10	6.01

Y x V					1.71	NS					2.98	NS
Y x F					1.71	NS					2.98	NS
Y x Z					1.71	NS					2.98	NS
V x F	2.39	NS	2.44	NS	1.71	NS	4.60	NS	3.79	NS	2.98	NS
Y x V x F					2.41	NS					4.21	NS
V x Z	2.39	7.03	2.44	NS	1.71	4.88	4.60	NS	3.79	NS	2.98	NS
Y x V x Z					2.41	NS					4.21	NS
F x Z	2.39	NS	2.44	NS	1.71	NS	4.60	NS	3.79	11.15	2.98	8.51
Y x F x Z					2.41	NS					4.21	NS
V x F x Z	3.38	NS	3.45	NS	2.41	NS	6.50	NS	5.36	NS	4.21	NS
Y x V x F x Z					3.42	NS					5.96	NS
# CD and SEm values are same for the individual effect of Variety, Foliar application of Iron and Zinc												

Table 5b: Interaction effect of variety (V) and micronutrient zinc (Z) on number of pods per plant of cluster bean under teak based agroforestry system

Treatment (V x Z)	Number of pods per plant			
	Year 2021		Pooled	
	Z_0	Z_1	Z_0	Z_1
V_1	65.66	93.08	67.92	94.30
V_2	40.97	58.40	43.50	61.81
S.Em.±	2.39		1.71	
C.D. at 5 %	7.03		4.88	

Table 5c: Interaction effect of micronutrient iron (F) and zinc (Z) on number of pods per plant of cluster bean in open condition

Treatment (F x Z)	Number of pods per plant			
	Year 2022		Pooled	
	Z_0	Z_1	Z_0	Z_1
F_0	106.06	144.07	105.14	140.06
F_1	139.95	161.16	134.76	156.69
S.Em.±	3.79		2.98	
C.D. at 5 %	11.16		8.51	

Table 6: Effect of varieties, foliar application of micronutrient on pod yield (kg ha^{-1}) of cluster bean under teak based agroforestry system and in open condition

Pod yield (kg ha^{-1})												
Treatments	**Teak Based Agroforestry System**						**Open Condition**					
	2021		**2022**		**Pooled**		**2021**		**2022**		**Pooled**	
Variety (V)												
V_1 (Pusa Navbahar)	3309.22		3676.04		3492.63		9837.28		10248.97		10043.12	
V_2 (Local Variety)	2488.18		2755.53		2621.86		8090.16		8686.12		8388.14	
Foliar Application of Micronutrient Iron (F)												
F_0 (No Iron)	2714.91		3012.62		2863.77		8594.11		9067.29		8830.70	
F_1 (0.5% $FeSO_4$)	3082.48		3418.95		3250.72		9333.33		9867.80		9600.57	
Foliar Application of Micronutrient Zinc (Z)												
Z_0 (No Zinc)	2592.89		2973.83		2783.36		8380.36		8825.60		8602.98	
Z_1 (0.5% $ZnSO_4$)	3204.50		3457.74		3331.12		9547.08		10109.49		9828.29	
#S.Em.±	84.90		76.66		57.19		190.82		189.76		134.56	
#C.D. at 5%	249.76		225.50		163.30		561.32		558.21		384.19	
C.V. (%)	11.71		9.53		10.58		8.51		8.01		8.26	
	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Year (Y)					57.19	163.30					134.56	384.19
Y x V					80.89	NS					190.29	NS
Y x F					80.89	NS					190.29	NS
Y x Z					80.89	NS					190.29	NS
V x F	120.07	NS	108.41	NS	80.89	NS	269.86	NS	268.37	NS	190.29	NS
Y x V x F					114.39	NS					269.12	NS
V x Z	120.07	NS	108.41	NS	80.89	NS	269.86	NS	268.37	NS	190.29	NS
Y x V x Z					141.19	NS					269.12	NS
F x Z	120.07	NS	108.41	NS	80.89	NS	269.86	NS	268.37	NS	190.29	NS
Y x F x Z					114.39	NS					269.12	NS
V x F x Z	169.81	NS	153.23	NS	114.39	NS	381.65	NS	379.53	NS	269.12	NS
Y x V x F x Z					161.78	NS					380.59	NS
# CD and SEm values are same for the individual effect of Variety, Foliar application of Iron and Zinc												

Table 7: Effect of growing conditions on yield attributes and yield of cluster bean

Growing conditions	Pod length (cm)	Pod diameter (mm)	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod Yield (kg ha^{-1})
Teak based agroforestry system	8.90	7.64	20.92	3.41	66.88	3057.24
Open condition	9.79	8.01	37.85	3.72	134.16	9215.63
t stat	-1.41	-1.08	-7.85	-1.16	-5.55	-13.19
P (T<=t) Two-tail	0.18	0.30	0.00	0.26	0.00	0.00