

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 production potential of cluster bean in response to varieties and micronutrient foliar application. The study was conducted in 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 compare 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 investigation showed decline in the yield attributes and yield of cluster bean under teak based agroforestry system in comparison to open condition. Interaction effect of different treatment combination was found nonsignificant for all yield attributes except number of pods per plant under teak based agroforestry system and open condition.

Keywords: Cluster bean, Yield, Variety, Micronutrient, foliar application

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 during 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 most 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 metres 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 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 macronutrient but also micro nutrient. Therefore, an optimum supply of micronutrient under balanced condition is very important for achieving higher productivity; research report on foliar nutrition effect cluster bean is still scarce. Micronutrients have played vital roles in the improved 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 under teak based agroforestry system and open condition in the summer season of year 2021 and 2022 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, which, lies between 20⁰55'25"N latitude and 72⁰54'29"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 (V₁), Local Variety (V₂),

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.

Statistical analysis

The data regarding the yield of cluster bean recorded for each treatment during 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 (\pm)] was also worked out for each parameter. The Co-efficient of Variance [CV (%)] was calculated. 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 Table 1 & 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 year 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 compare to its control condition, respectively under teak based agroforestry system and open condition

Interaction effect

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

Yield attributes

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

Effect of varieties

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% FeSO₄ 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% FeSO₄ as compare to control condition (no iron), respectively 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% FeSO₄ 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, interaction effect of variety and foliar zinc (V x Z) was found significant for number of pods per plant for year 2021 and pooled analysis and non-significant in the year 2022. Variety, Pusa Navbahar with foliar application of 0.5% ZnSO₄ (V₁Z₁) observed higher number of pods per plant for year 2021 and pooled analysis (Table 5a).

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 (F₁Z₁) attained highest number of pods per plant during the year 2022 and pooled analysis (Table 5b).

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% FeSO₄ 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% ZnSO₄ 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 varieties (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. 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 compare to teak based agroforestry system.

DISCUSSION

The variation in yield attributes and yield of two different cultivar of cluster bean could be assigned to their varying genetical makeup. These finding 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 (2020) and Nanthakumar *et al.* (2021).

The direct effect of micronutrients on cluster bean yield may be attributable to higher rates of photosynthesis and sugar formation because of the translocation of more photosynthates, which ultimately resulted in higher production of dry matter and greater yield. Additionally, micronutrients catalyse the different metabolic reactions in plants. Auxin biosynthesis in the active source would have been encouraged by zinc, an important catalyst in the synthesis of auxin from tryptophan. The effect of Fe may be attributed to higher rate of chlorophyll synthesis, cytochrome photoxidase activity and enhanced rate of photolysis of water, all of which contribute to more photosynthetic activity and higher production of sugars and ultimately a greater number of pods per plant. 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 sulphate and iron sulphate 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 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 sulphate. Ali *et al.* (2014) documented that application of iron sulphate increase 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 considerable area occupied by the overstorey component and less availability of light. In agroforestry, the crop yield is influenced by 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 investigation shows that variety Pusa Navbahar with foliar application of 0.5 % FeSO₄ and 0.5 % ZnSO₄ 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.

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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

| Pod diameter (mm) | | | | | | | | | | | | |
|--|--------------------------------|------------|--------|------------|--------|------------|----------------|------------|--------|------------|--------|------------|
| Treatments | 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. 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) | | | | | 0.36 | 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 5: 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 5a: 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 5b: 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: Two sample t-test assuming equal variances for yield attributes and yield of cluster bean between teak based agroforestry system and open condition

| Growing condition | 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 |