Original Research Article

Effect of Mode of Micronutrients Application on Growth and Yield of Pigeon Pea (Cajanus cajan L.) in Sandy Loam Soil

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A B S T R A C T

A field experiment was conducted during Kharif season 2018 to evaluate the effect of mode of micronutrients application on growth and yield of pigeon pea (Cajanus cajan L.) in sandy loam soil. Nine treatments consisting of micronutrients (Zn, Fe and B) viz, T1 [Control (NPK)], T2 (ZnSO4 @ 25 kg/ha), T3 (FeSO4 @ 40 kg/ha), T4 (Borax @ 10 kg/ha), T5 (ZnSO4+ FeSO4+ Borax), T6 (foliar spray ZnSO4 @ 0.5%), T7 (foliar spray FeSO4 @ 1%), T8 (foliar spray Borax @ 0.2%), T9 (foliar spray ZnSO4+ FeSO4+ Borax) were tested in RBD with three replications. NPK was commonly applied in all the plots. The experimental results revealed that growth attributes (plant height, number of primary branches), yield attributing traits (pods plant−1, grains pod−1, test weight, dry matter accumulation), yields viz., grain, straw and biological in pigeon pea differ significantly among different treatments and were maximum with the foliar spray of ZnSO4+ FeSO4+ Borax followed by soil application of ZnSO4+

Keywords
Pigeon pea, Micronutrients, Borax, Foliar spray, Yield attributing traits

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Introduction

Pigeon pea (Cajanus cajan L. millsp.) belongs to family Fabaceae or Leguminosae. It has many names in India such as red gram, arhar, tur etc. In various parts of world it is known by many names such as arhar dal (India), guandula (Puerto Rico), pois’d’angola (French), arvega de angola (Spanish), piselloD’angola (Italian) and taubenerbse (German) (El- Seifi et al., 2013). Arhar is cultivated for various uses such as food crop (dried, flour or green vegetable), forage/cover crop, fuel wood (stalks). Pigeon pea had
originated in South Asia and it is now growing in tropical and sub-tropical regions also. It is grown throughout the tropical and sub-tropical regions of the world, between 30° N and 35° S latitudes. However, major area under pigeon pea in India is lying between 14° S and 28° N latitudes. After chickpea, pigeon pea is the second most important pulse crop in India, grown in an area of 56.02 lakh hectares with 32.90 lakh tones production (Annual Report 2016-17, GOI). This is one of the most popular pulse crops here which is being grown in almost all parts of the country. Maharashtra (7 lac tonnes) ranks first among all states in its area and production followed by Uttar Pradesh (5 lac tonnes), Madhya Pradesh (3 lac tonnes), Karnataka (3 lac tonnes) and Gujarat (1 lac tonnes) (Anonymous, 2017). Many agronomic practices for pigeon pea production should be standardized for getting ultimate yield potential, among them are soil application of micronutrients and foliar spray of nutrients are most important ones. It is to be noted that in our country, the productivity of pigeon pea is quite low due to number of factors i.e. agronomic, genetic, pathogenic and entomological as well as their interaction with environment. Although India stands first in area and production of this crop, still there is need to import this pulse crop from other countries, it is mainly due to the higher domestic consumption demands in our country. In pulses, the limited nitrogen fixation by legume–rhizobium symbiosis is the result of mineral nutrient deficiencies. There is deficiency of both macronutrients as well as micronutrients (Zn, Fe, B, Mo etc.) take place which inhibits or limits the legume production (Bhuiyan et al., 1999). Although micronutrients are required in limited amount for crop growth and development but they are as useful and important as macronutrients. They take part in redox reactions, serves as co-factor for enzyme activity and some other vital functions in plants. The low yield of pigeon pea is mainly attributed to their cultivation on poor soils with inadequate and imbalanced macronutrients as well as micronutrients like zinc, iron and boron application.

**Materials and Methods**

In order to further study the “Effect of Mode of Micronutrients Application on Growth and Yield of Pigeon pea (Cajanus cajan) in Sandy Loam Soil” a field experiment was carried out during the kharif season 2018 at Crop Research Centre of Sardar Vallabhbhai Patel of Agriculture and Technology, Meerut (U.P) which is situated at 29°8’1 NE latitude and 77°40’E longitude at an altitude of 237 m above the mean sea level and comes in semi-arid and sub-tropical climatic zone. UPAS-120 variety of pigeon pea crop was grown in randomized plot design in three replications with 9 treatments. The plot area was 12.6 m² with 60 cm x 25 cm spacing. Growth observations were recorded at 35, 75 DAS and at harvest days after sowing of the crop. Yield attributes were recorded at harvest.

The height was measured with the help of meter scale from the base of plant to the tip of the tallest leaf. Average plant height was computed and expressed in cm. Plant height, total numbers of branches and dry matter accumulation were recorded at 35, 75 DAS and at harvest from three tagged plants and mean branches plant⁻¹ was counted. Three plants from each plot were randomly uprooted from the side rows along with a soil block of about 25 cm diameters at pre-flowering stage (75 DAS). Adhered soil was washed off from the roots by washing with tap water by keeping the roots of the plants in sieve to return the detached nodules, if any nodules were removed from the roots carefully and counted. The mean value of three plants was expressed as the number of nodules plant⁻¹. To calculate dry matter accumulation (in grams), three plants were taken from each plot.
Sample plants were cut close to ground level and samples were kept in a dryer for 48 hours at 72°C. Therefore, dry weight of samples was recorded with the help of an electronic balance.

The observation on yield and yield attributing characteristics were recorded using standard methods as total pods on the three tagged plants were counted and averaged to get number of pods plant⁻¹. Randomly selected 10 pods from the three tagged plants of each plot were threshed and the total numbers of grains obtained were counted and the average number of grains pod⁻¹ was computed. A representative sample of 1000 air-dried grains irrespective of shape and size was taken from the net plot produce and their weight was recorded on an electrical digital balance. Pods obtained from three tagged sample plants were threshed and the grains obtained were weighed after winnowing. Grain yield plant⁻¹ was thus obtained by averaging. For calculating biological yield after harvesting, the pigeon pea crop was sun-dried and then weight of net plot area harvested was recorded in kg and expressed as kg ha⁻¹. The weight of grains harvested from net plot area was recorded and finally expressed as kg ha⁻¹. Straw yield from net plot area was computed by subtracting the grain yield from the biological yield and later converted into kg ha⁻¹. The harvest index, an index to partitioning of dry matter towards grains was calculated by following formula:

\[
\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100
\]

Results and Discussion

In the present study, soil and foliar application of Zn, Fe, and B exhibited a significant effect on various growth parameters viz., plant population, plant height, number of primary branches, nodulation, and dry matter accumulation (Table 1a) recorded at different stages of crop growth. Plant height increased with the advancement in crop growth. Initially, plant height could not be affected by treatments but at later stage viz. pre-flowering and at harvest it was significantly varied by application of micronutrients in different mode and combinations. Significantly lower plant height at final stage in the control plot as compared to rest of the treatments clearly indicates the importance of micronutrients in plant growth. Plant height measured at vegetative, pre-flowering and at harvesting stage was significantly affected by different micronutrients application. Initially, there was no significant variation in the plant height but as the crop proceeds to its maturity, there was a significant effect of micronutrients on plant height. The plot treated with the foliar application of ZnSO₄ + FeSO₄ + Borax, produced tallest plant with the highest number of primary branches and thereby dry matter accumulation per plant. Plant height with the foliar application of ZnSO₄ + FeSO₄ + Borax (T₉) was significantly higher than the other treatments except T₅ where the same were applied in soil. Similar results in respect to plant height have also been reported by Handiganoor et al., (2017) and Shah et al., (2016).

Initially, the number of primary branches was maximum in T₉ (foliar spray ZnSO₄ + FeSO₄ + Borax). The treatment T₉ was significantly superior to rest of the treatments, having maximum primary branches 18.9 plant⁻¹ while, minimum primary branches 14.3 plant⁻¹ were counted in T₁ (control). Number of primary branches in T₉ (foliar spray ZnSO₄ + FeSO₄ + Borax) were significantly higher over remaining treatments with exception of T₅ and T₇. The number of primary branches in pigeon pea at harvest was found maximum (28.4 plant⁻¹) under the treatment receiving foliar spray of ZnSO₄ + FeSO₄ + Borax which was significantly superior to rest of the treatments except T₅ where same micronutrients were applied in soil. It might be due to crop needed
all three micronutrients. Similar results have been observed by Kumawat et al., (2013).

There was no significant difference with respect to dry matter accumulation at harvest stage but maximum dry matter accumulation (140.8 g) was recorded in the plots where foliar spray of ZnSO₄ + FeSO₄ + Borax were applied (T₉) while minimum (129.1 g) in control (T₁). This might be due to common application of NPK especially of K which is supposed to help in cell elongation and dry matter accumulation (Thamke, 2017). Nitrogen which is also responsible for shoot growth and development increased the dry matter accumulation.

Effect of different treatments on yield attributing characters

The yield attributes viz., number of pods plant⁻¹, number of grains pod⁻¹, pod weight plant⁻¹ and test weight (1000 grains weight in gram), as shown in Table 1c is affected by various treatments of soil and foliar spray of Zn, Fe and B.

Maximum number of grains (4.3 pod⁻¹) statistically at par to T₅, T₆, T₇, T₈, were found in T₉ while, minimum (3.3 grains pod⁻¹) in T₁ (control). The number of grains pod⁻¹ increased by 30.3 % in T₉ over control. The higher pod yield (215.8 g) plant⁻¹ observed with the foliar spray of ZnSO₄ + FeSO₄ + Borax in T₉ treatment, which was statistically at par with T₅, T₆, T₇ and significantly higher than rest of the treatments. The minimum pod yield plant⁻¹ (176.4 g) significantly lower than the remaining treatments was recorded under the control (T₁). At harvest, higher numbers of pods (212.5 plant⁻¹) with the foliar application of ZnSO₄ + FeSO₄ + Borax (T₉) were statistically at par with T₂, T₅, T₆, T₇, T₈ and significantly higher than the rest of treatments, while minimum (178.2 plant⁻¹) in control (T₁). This might be due to positive impact of micronutrients viz. Zn, Fe and B in metabolism and biological activity and its stimulatory effect on growth of pigeon pea. Similar findings have been observed by Talooth et al., (2006), Ali et al., (2007), Shrikantbabu et al., (2012) and Thamke (2017).

Effect of different treatments on yield of pigeon pea

Biological, grains and straw yields (Table 1d) were significantly affected by soil and foliar application of Zn, Fe and B. Maximum biological yield 7.93 t ha⁻¹ recorded in T₉ which was at par to the treatments T₅ and T₇ while minimum in control (T₁). Maximum straw yield 6.47 t ha⁻¹ was found in T₉ (foliar spray ZnSO₄ + FeSO₄ + Borax) while minimum 5.87 t ha⁻¹ in T₁. It is clear from the data that the straw yield differ significantly under the influence of different treatments.

Due to foliar spray ZnSO₄ + FeSO₄ + Borax (T₉) straw yield increased by 10% which was at par to the T₅ and T₇. Numerically maximum harvest index value (18.5%) was observed in T₉ (foliar spray ZnSO₄ + FeSO₄ + Borax), while lowest harvest index (16.4%) was recorded in control (T₄). Maximum grain yield 1.47 t ha⁻¹ obtained by T₉ (foliar spray of ZnSO₄ + FeSO₄ + Borax) was significantly higher than remaining treatments except T₅, T₆, T₇. Minimum grain yield i.e. 1.17 t ha⁻¹ was recorded in the treatment where only NPK was applied (T₁). Combined foliar application of Zn, Fe and B (T₉) significantly improved the grain yield over control which was 25.2% higher over control. Yield increase in these treatments may be the result of inhibition in flower and pod abscission, improvement in morpho-physiological characters (stem girth, early vigour and crop establishment) and enhanced dry matter production Reddy et al., (2007).
Table 1a Effect of mode of micronutrients (Zn, Fe and B) application on growth parameters in pigeon pea

| Treatments                        | Plant height (cm) | Primary branches plant\(^1\) | Dry matter accumulation (g plant\(^1\)) |
|-----------------------------------|-------------------|-------------------------------|---------------------------------------|
| T\(_1\) Control (20:50:40)        | 168.5             | 22.3                          | 129.1                                 |
| T\(_2\) ZnSO\(_4\) @ 25 kg/h     | 181.2             | 24.2                          | 132.3                                 |
| T\(_3\) FeSO\(_4\) @ 40 kg/ha    | 178.6             | 24.1                          | 131.4                                 |
| T\(_4\) Borax @ 10 kg/ha         | 174.4             | 23.5                          | 129.8                                 |
| T\(_5\) ZnSO\(_4\)+ FeSO\(_4\)+ Borax | 195.5          | 26.1                          | 137.4                                 |
| T\(_6\) Foliar spray ZnSO\(_4\)@0.5\% | 188.7            | 24.4                          | 133.9                                 |
| T\(_7\) Foliar spray FeSO\(_4\) @1\% | 190.2             | 24.5                          | 138.2                                 |
| T\(_8\) Foliar spray Borax@0.2\% | 184.7             | 24.2                          | 131.8                                 |
| T\(_9\) Foliar spray ZnSO\(_4\)+ FeSO\(_4\)+ Borax | 199.7          | 28.4                          | 140.8                                 |
| SE m (±)                          | 6.1               | 0.8                           | -                                     |
| C.D (P=0.05)                      | 18.5              | 2.4                           | NS                                   |

Table 1b Effect of mode of micronutrients (Zn, Fe and B) application on effective nodules and their dry weight (at pre-flowering) in pigeon pea

| Treatments                        | Effective nodules plant\(^1\) | Nodules fresh weight (gplant\(^1\)) | Nodules dry weight (mgplant\(^1\)) |
|-----------------------------------|--------------------------------|---------------------------------------|------------------------------------|
| T\(_1\) Control (20:50:40)        | 37.4                           | 135.5                                 | 71.2                               |
| T\(_2\) ZnSO\(_4\) @ 25 kg/h     | 38.6                           | 145.3                                 | 78.4                               |
| T\(_3\) Fe SO\(_4\) @ 40 kg/ha   | 41.7                           | 145.1                                 | 78.3                               |
| T\(_4\) Borax@ 10 kg/ha          | 37.6                           | 136.3                                 | 76.8                               |
| T\(_5\) ZnSO\(_4\)+ FeSO\(_4\)+ Borax | 41.3              | 161.8                                 | 82.8                               |
| T\(_6\) Foliar spray ZnSO\(_4\)@0.5\% | 39.2                  | 156.5                                 | 81.6                               |
| T\(_7\) Foliar spray FeSO\(_4\) @1\% | 40.8                   | 160.6                                 | 81.8                               |
| T\(_8\) Foliar spray Borax@0.2\% | 38.8                           | 152.6                                 | 79.2                               |
| T\(_9\) Foliar spray ZnSO\(_4\)+ FeSO\(_4\)+ Borax | 41.8          | 163.8                                 | 83.4                               |
| SE m (±)                          | -                              | 5.0                                   | -                                  |
| C.D. (P=0.05)                     | NS                             | 15.1                                  | NS                                 |
Table 1c Effect of mode of micronutrients (Zn, Fe and B) application on yield attributes in pigeon pea

| Treatments                                      | Pods per Plant | Grains per pod | Pod weight plant (g) | 1000 grains weight (g) |
|------------------------------------------------|----------------|----------------|----------------------|------------------------|
| T1 Control (20:50:40)                          | 178.2          | 3.3            | 176.4                | 73.6                   |
| T2 ZnSO₄@ 25 kg/h                             | 194.4          | 3.7            | 191.2                | 74.5                   |
| T3 Fe SO₄@ 40 kg/ha                           | 190.9          | 3.5            | 186.7                | 74.2                   |
| T4 Borax@ 10 kg/ha                            | 181.4          | 3.4            | 184.4                | 73.8                   |
| T5 ZnSO₄+ FeSO₄+ Borax                        | 206.0          | 4.2            | 211.3                | 75.6                   |
| T6 foliar spray ZnSO₄@0.5%                    | 199.9          | 4.1            | 198.4                | 74.6                   |
| T7 foliar spray FeSO₄ @1%                     | 202.5          | 4.2            | 206.5                | 74.8                   |
| T8 foliar spray Borax@0.2%                    | 195.7          | 4.0            | 194.6                | 75.3                   |
| T9 foliar spray ZnSO₄+ FeSO₄+ Borax           | 212.5          | 4.3            | 215.8                | 75.8                   |

SE m (±)                                          | 6.5            | 0.2            | 6.5                  | -                      |
C.D. (P=0.05)                                     | 19.7           | 0.5            | 19.8                 | NS                     |

Table 1d Effect of mode of micronutrients (Zn, Fe and B) application on yields (Grains, straw and biological) and harvest index of pigeon pea

| Treatments                                      | Yields (t ha⁻¹) | Harvest index |
|------------------------------------------------|-----------------|---------------|
|                                                 | Grains | Straw | Biological |                     |
| T1 Control (20:50:40)                          | 1.17    | 5.87  | 7.04       | 16.6                 |
| T2 ZnSO₄@ 25 kg/h                             | 1.28    | 6.23  | 7.51       | 17.1                 |
| T3 Fe SO₄@ 40 kg/ha                           | 1.26    | 6.21  | 7.47       | 16.8                 |
| T4 Borax@ 10 kg/ha                            | 1.22    | 6.21  | 7.44       | 16.4                 |
| T5 ZnSO₄+ FeSO₄+ Borax                        | 1.42    | 6.39  | 7.82       | 18.2                 |
| T6 foliar spray ZnSO₄@0.5%                    | 1.36    | 6.35  | 7.70       | 17.6                 |
| T7 foliar spray FeSO₄ @1%                     | 1.38    | 6.38  | 7.76       | 17.8                 |
| T8 foliar spray Borax@0.2%                    | 1.31    | 6.23  | 7.54       | 17.4                 |
| T9 foliar spray ZnSO₄+ FeSO₄+ Borax           | 1.47    | 6.47  | 7.93       | 18.5                 |

SE m (±)                                          | 0.04   | 0.27  | 0.25       | -                     |
C.D. (P=0.05)                                     | 0.13   | 0.49  | 0.71       | NS                   |
The minimum grain biological and straw yield was obtained in the control but as we added the micronutrients, these yields get improved. Zinc is reported to enhance the absorption of native as well as added macro nutrients which might have been attributed to improvement in the yield. Boron’s involvement in hormone synthesis and translocation, carbohydrate metabolism and DNA synthesis probably contributed to additional growth and yield (Ratna Kalyani et al., 1993). Foliar application of iron (T7) showed better results in terms of yield attributes as compare to soil application it might be due to plant utilise iron in reduced form and less usable in oxidised condition in soil. Wankhade et al., (1995) said that application of Fe significantly increased the yield of pigeonpea compared to control. Boron also can play major role in augmenting the yield. Similar findings were also reported by Thamke (2017), Gowda et al., (2015), Khrogamy and Farnia (2009).

In conclusion, the plant height and number of primary branches increased further in later stages by soil and foliar application of micronutrients. There was no significant difference in these two parameters in early stages but as the crop grew, there was a significant change in the height as well as number of primary branches by the soil and foliar application of Zn, Fe and B. Number of pods plant⁻¹, grains pod⁻¹, pod weight plant⁻¹ increased by the application of micronutrients. The number of grains pod⁻¹ increased by 30% in the plot where foliar application of Zn, Fe and B was done. Grain, straw and biological yields get enhanced by the soil and foliar spray of Zn, Fe and B. The highest yields were obtained by T9 followed by T5. Although, soil applied Zn, Fe and B individually gave lower yields but their combined application show the best results. Harvest index remained almost constant with the soil and foliar application of micronutrients although it increased in the micronutrients treated plots with the advancement in crop growth.

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