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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.* T_1 [Control (NPK)], T_2 ($ZnSO_4$ @ 25 kg/h), T_3 (Fe SO_4 @ 40 kg/ha), T_4 (Borax@ 10 kg/ha), T_5 ($ZnSO_4$+ $FeSO_4$+ Borax), T_6 (foliar spray $ZnSO_4$ @ 0.5%), T_7 (foliar spray $FeSO_4$ @1%), T_8 (foliar spray Borax @ 0.2%), T_9 (foliar spray $ZnSO_4$+ $FeSO_4$+ 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 $ZnSO_4$+ $FeSO_4$+ Borax followed by soil application of $ZnSO_4$+

Introduction

Pigeon pea (*Cajanus cajan* L. millsp.*)* belongs to family Fabaceae or Leguminoceae. 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), poisd'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 30^0 N and 35^0 S latitudes. However, major area under pigeon pea in India is lying between 14^0 S and 28^0 N latitudes. After chickpea, pigeon pea is the second most important pulse crop in India, grown in an area of 56.02 lakh hectare 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 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 $29^0 8^1$ NE latitude and $77^0 40^1$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 m^2 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 sample were kept in dryer for 48 hours at 72^0C. Therefore, dry weight of samples was recorded with the help of 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 and 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 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 average. 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 fallowing formula:

$$Harvest\ index = \frac{Economic\ yield}{Biological\ yield} X100$$

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 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 $ZnSO_4$+ $FeSO_4$+ Borax, produced tallest plant with highest number of primary branches and thereby dry matter accumulation per plant. Plant height with the foliar application of $ZnSO_4$+ $FeSO_4$+ Borax (T_9) was significantly higher than the other treatments except T_5 where 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 T_9 (foliar spray $ZnSO_4$+ $FeSO_4$+ Borax). The treatment T_9 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 T_1 (control). Number of primary branches in T_9 (foliar spray $ZnSO_4$+ $FeSO_4$+ Borax) were significantly higher over remaining treatments with exception of T_5 and T_7. The number of primary branches in pigeon pea at harvest was found maximum (28.4 plant^{-1}) under the treatment receiving foliar spray of $ZnSO_4$+ $FeSO_4$+Borax which was significantly superior to rest of the treatments except $T_5$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 $ZnSO_4$+ $FeSO_4$+ Borax were applied (T_9) while minimum (129.1 g) in control (T_1). 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 T_5, T_6, T_7, T_8, were found in T_9 while, minimum (3.3 grains pod^{-1}) in T_1 (control). The number of grains pod^{-1} increased by 30.3 % in T_9 over control. The higher pod yield (215.8 g) plant^{-1} observed with the foliar spray of $ZnSO_4$+ $FeSO_4$+ Borax in T_9 treatment, which was statistically at par with T_5, T_6, $T_7$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 (T_1). At harvest, higher numbers of pods (212.5 plant^{-1}) with the foliar application of $ZnSO_4$+ $FeSO_4$+ Borax (T_9) were statistically at par with T_2, T_5, T_6, T_7, T_8 and significantly higher than the rest of treatments, while minimum (178.2 plant^{-1}) in control (T_1). 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), Shrikanthbabu *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 T_9 which was at par to the treatments T_5 and T_7 while minimum in control (T_1). Maximum straw yield 6.47 t ha^{-1} was found in T_9 (foliar spray $ZnSO_4$+ $FeSO_4$+ Borax) while minimum 5.87 t ha^{-1} in T_1. It is clear from the data that the straw yield differ significantly under the influence of different treatments.

Due to foliar spray $ZnSO_4$+ $FeSO_4$+ Borax (T_9) straw yield increased by 10% which was at par to the T_5 and T_7. Numerically maximum harvest index value (18.5%) was observed in T_9 (foliar spray $ZnSO_4$+ $FeSO_4$+ Borax), while lowest harvest index (16.4%) was recorded in control (T_4). Maximum grain yield 1.47 t ha^{-1} obtained by T_9 (foliar spray of $ZnSO_4$+ $FeSO_4$+ Borax) was significantly higher than remaining treatments except T_5, T_6, T_7. Minimum grain yield i.e. 1.17 t ha^{-1} was recorded in the treatment where only NPK was applied (T_1). Combined foliar application of Zn, Fe and B (T_9) 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_8Foliar 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	Yield attributes			
	Pods per Plant	Grains per pod	Pod weight plant^{-1}(g)	1000 grains weight(g)
T_1 Control (20:50:40)	178.2	3.3	176.4	73.6
T_2 $ZnSO_4$@ 25 kg/h	194.4	3.7	191.2	74.5
T_3 Fe SO_4@ 40 kg/ha	190.9	3.5	186.7	74.2
T_4 Borax@ 10 kg/ha	181.4	3.4	184.4	73.8
T_5 $ZnSO_4$+ $FeSO_4$+ Borax	206.0	4.2	211.3	75.6
T_6 foliar spray $ZnSO_4$@0.5%	199.9	4.1	198.4	74.6
T_7 foliar spray $FeSO_4$ @1%	202.5	4.2	206.5	74.8
T_8 foliar spray Borax@0.2%	195.7	4.0	194.6	75.3
T_9 foliar spray $ZnSO_4$+ $FeSO_4$+ 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	
T_1 Control (20:50:40)	1.17	5.87	7.04	16.6
T_2 $ZnSO_4$@ 25 kg/h	1.28	6.23	7.51	17.1
T_3 Fe SO_4@ 40 kg/ha	1.26	6.21	7.47	16.8
T_4 Borax@ 10 kg/ha	1.22	6.21	7.44	16.4
T_5 $ZnSO_4$+ $FeSO_4$+ Borax	1.42	6.39	7.82	18.2
T_6 foliar spray $ZnSO_4$@0.5%	1.36	6.35	7.70	17.6
T_7 foliar spray $FeSO_4$ @1%	1.38	6.38	7.76	17.8
T_8 foliar spray Borax@0.2%	1.31	6.23	7.54	17.4
T_9 foliar spray $ZnSO_4$+ $FeSO_4$+ 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 (T_7) 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 T_9 followed by T_5. 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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