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Influence of Micronutrient Managment on Growth and Yield Attributes in Pigeonpea [*Cajanus cajan* (L.) *CV. PRG176*] in Kalahandi District of Odisha

H. N. Malik[1], U. Naik[1], U. Sahoo[1], A. Panda[1], A. Phonglosa[2], R. Bhattacharya[3] and F. H. Rahman[3*]

[1]Krishi Vigyan Kendra, Kalahandi, Odisha University of Agriculture and Technology, Kalahandi-766001, Odisha, India.
[2]Odisha University of Agriculture and Technology, Bhubaneswar-751003, Odisha, India.
[3]ICAR-Agricultural Technology Application Research Institute, Kolkota, Bhumi Vihar Complex, Salt lake, Kolkota-700097, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author HNM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors UN and US managed the analyses of the study. Authors AP, AP, RB and FHR corrected the draft and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Pigeon pea (*Cajanus cajan* (L.) is grown worldwide for its protein-rich seed. However, low availability of soil boron adversely affects the seed yield of pigeon pea. The present study was therefore conducted to assess the Influence of micronutrients mainly boron on crop growth and yield of pigeon pea (*Cajanus cajan* (L.) *cv. PRG176.* Field experiment was conducted at farmer's field, Pipalpada and Boria of district Kalahandi of Odisha state. Boron as boric acid at 200, 300 and 400 ppm was given as foliar spray with 100% recommended dose of fertilizer (RDF) with $ZnSO_4$ @ 25 kg/ha and plant height, growth rates and yield attributes were estimated. The results revealed that combined application of 100% RDF, $ZnSO_4$ (25 kg/ha) and Boron (300 ppm) recorded the highest plant height (324.84 cm) at 180 days after sowing (DAS), highest dry matter accumulation

**Corresponding author: E-mail: fhrahmancal@gmail.com;*

(759.30g/m^2) at 180 DAS and best crop growth rate (6.65 g/m^2/day) during 90-180 DAS and highest relative growth rate (0.052 g/m^2/day) during 30-90 DAS. Similarly these combination of treatment resulted in maximum number of branches plant^{-1} (10.30), pods branch^{-1} (19.67) pods plant^{-1} (202.33), seeds pod^{-1} (3.0) and grain yield (1702.64 kg ha-1), gross return (₹102150/ha), net return (₹ 61650/ha) and return per rupee investment (₹ 2.52) in pigeon pea *cv.PRG176.*

Keywords: Micronutrient; yield; net return; pigeon pea; growth; Kalahandi.

1. INTRODUCTION

Pigeon pea, a kharif season crop, commonly known as Red gram or Arhar is the important pulse crop in India. After chickpea it is the second most important pulse crop in the country [1]. India ranks first in area and production in the world with 80% and 67% of world's acreage and production respectively. It is an important multipurpose pulse legume crop in the tropics and subtropics, with several unique features. It can be grown with a temperature ranging from 26^0C to 30^0C in the rainy season (June to October) and 17^0C to 22^0C in post rainy season (November to March). It is easily grown in black cotton soils with a pH range of 7.0-8.5. Pigeon pea is consumed all over the India and constitutes the main constituent of vegetarian diet. Several previous studies refers that India is the primary center of origin of pigeon pea [2-5]. Pulses are the major sources of protein among the vegetarians and it also provides essential amino acids, vitamins and minerals. Pigeon pea contains 22-24% protein, which is almost twice the protein content in wheat and thrice that of rice. Pulses provide important nutritional and health benefits to human. It reduces several noncommunicable diseases like colon cancer and cardiovascular diseases [6].

Pigeon pea is grown over worldwide in an area of 5.41 million hectares with a production of 4.49 million tones and with the productivity of 829.9 kgha^{-1}. Similarly in India, it is grown in area of 3.88 million hectares with the production of 2.80 million tonnes with the productivity of 733.4 kg ha^{-1} [7]. The low productivity of pulse crop is due to poor management and cultivation on agriculturally marginal and sub marginal lands. Hence, it requires earnest care in adoption of desirable production technologies to exploit the yield potential of the pulses and this can be achieved by application of fertilizers, and micro nutrients. Low and imbalanced use of fertilizer and micro nutrients is one of the major reasons for low productivity in pulses.

Zinc deficiency exists in different soils of the world, including India [8,9]. Low availability of soil zinc (Zn) adversely affects plant growth parameters due to reduced enzyme activity influencing the plant metabolism [10-12]. Malnutrition due to Zn deficiency is also a major micro-nutritional problem in the global population [13]. Agronomic bio-fortification practices, like addition of Zn fertilizers, either to soil or foliar, are generally practiced to mitigate soil Zn deficiency and it increases plant growth and yield parameters [14]. Application of Zn to foliar or both soil and foliar were found to be more effective than application to soil only for augmenting Zn uptake by crop seed [15,16]. Moreover, the inadequate availability of zinc (Zn) and boron (B) in the soil may limit the development of crops [17] and also affect forage plants. These minerals are required for the basic processes of plant life. Zinc helps in the synthesis of tryptophan and is required for plant growth, nitrogen metabolism, starch and chlorophyll synthesis and ATPase activity [18]. Like zinc, boron is also an essential micronutrient required for the normal growth and development of plants. It is recognized as one of the most commonly deficient micronutrients in soils worldwide [19]. The deficiency of boron in soils is a major cause of crop yield reduction in China, India, Nepal, and Bangladesh [20]. Boron is essential for maintaining the integrity of cell membrane, cell wall synthesis and lignifications [21]. Thus, the disproportion of these minerals can cause nutritional imbalances that have subsequent effect on dry matter production [22]. Based on recent investigations related to factors limiting pigeon pea yielding physiology as well as grain yield, the present study was undertaken to observe the effect of boron on growth, yield components and economics of pigeon pea *c.v. PRG-176*.

2. MATERIALS AND METHODS

Field experiments on pigeon pea *cv. PRG176* were conducted at Pipalpada (19.7079°N, 83.3652°E) and Boria (19.7079°N, 83.3652°E) of

Kalahandi district of Odisha state during 2019 and 2020. Ten farmers having an average of 0.2 ha of land each were selected for study of the effect of Boron and Zinc on growth, yield and economics of pigeon pea *cv. PRG176*. The mean maximum and minimum temperature registered in the villages during the year was 35.3°C and 16.4°C respectively. Total of 694.8 and 707.4 mm rainfall were received during 2019 and 2020 respectively. The experiment was laid in a completely randomized block design, with five treatments replicated thrice. There were altogether five treatments viz., T1:100% RDF+ Zinc (25kg/ha), T2:100% RDF+ Zinc (25kg/ha) + Boron (200 ppm), T3:100% RDF+ Zinc (25kg/ha) + Boron (300 ppm), T4:100% RDF+ Zinc (25kg/ha) + Boron (400 ppm), T5:100% RDF (control). The pigeon pea seeds were sown by adopting a spacing of 75 X 40 cm. A manurial schedule of 25: 50: 25 kg of N, P_2O_5 and K_2O ha^{-1} was followed. Entire dose of N, P_2O_5 and K_2O were applied basally. The growing crop was supplied with boron (as boric acid) at 200, 300 and 400 ppm concentration as foliar spray. The sprays were given at 30, 60 and 90 days after planting. Control plants were sprayed with solution without boron using Knapsack Sprayer. The spray fluid used per hectare was 500 L ha^{-1}. The Observations on different growth and yield parameters were taken and economic analysis was done by calculating cost of cultivation, gross return, net return and benefit cost ratio (B:C). Final crop yield was recorded and the gross return was calculated on the basis of prevailing market price of the produce. The analyses of variance (ANOVA) method was followed for statistical analyses of the observed experimental data. The significance of different sources of variation was tested by “Error mean square method” following F-test at probability level of 0·05. The test of significance of difference between means of different treatments was done by “t” test at probability level of 0·05.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Analysis of Soil

The soil of the experimental site of Pipalpada and Boria was neutral in reaction (pH 7.13 and 7.26), sandy loam texture with medium organic carbon content (0.62 and 0.46%), medium in nitrogen (N) (326.8 Kg/$ha^{-1}$and 263.2 $Kgha^{-1}$), low in phosphorus (P_2O_5) (36.5 $Kgha^{-1}$ and 45.88 $Kgha^{-1}$) and medium in potassium (K_2O) (29.6 $Kgha^{-1}$ and 31.76 $Kgha^{-1}$) respectively (Table-1). The soil of the Pipalpada and Boria was very low in micronutrient contents Zinc (Zn) (0.45 ppm and 0.48 ppm), Boron (0.26ppm and 0.38ppm) respectively (Table-1). Due to low availability of Zn and Boron, it was observed that Zinc and Boron may be the limiting factor for Arhar yield. Thus the experiment was designed to study the effect of application of Zinc and Boron on the growth and yield of Arhar.

3.2 Growth Attributes

Soil application of $ZnSO_4$ and boron had significant influence on growth attributes of pigeon pea *c.v. PRG176* (viz. plant height, dry matter accumulation and crop growth rate) at different growth stages under study (Table-2). Application of boron (300 ppm) with $ZnSO_4$ @ 25 kg/ha showed highest plant height of pigeon pea *c.v. PRG176* (324.84 cm) at 180 DAS. The cumulative height of main shoot in both control and combination of boron and $ZnSO_4$ treated plants followed typical sigmoid growth pattern (Table-2). Plants treated with 300 ppm boron with $ZnSO_4$ @ 25 kg/ha recorded higher values in height followed by 200 and 400 ppm treated plants indicating 300 ppm foliar application as an optimal requirement. Effect of boron on general growth and development of crop plants has been widely studied [23,24]. Boron's involvement in hormone synthesis and maintaining structural integrity of plasma membrane [25,26] carbohydrate metabolism [27] and DNA synthesis [28] probably contributed to additional growth.

The dry matter accumulation and crop growth rate in pigeon pea *c.v. PRG-176* was initially slow until 30 days after sowing (DAS) but the rate increased subsequently, reaching a maximum on 180 DAS. Plants which received 300 ppm boron recorded highest dry matter accumulation (759.30g/m^2) at 180 DAS and best crop growth rate (6.65 g/m^2/day) during 90-180 DAS and highest relative growth rate (0.052 g/m^2/day) during 30-90 DAS (Table-2). An increasing trend in dry matter accumulation and crop growth rate was found with the age of the crop and plants attained highest dry matter accumulation and crop growth rate at 180 DAS (Table-2). These findings were in conformity with the results reported by previous investigators [7,29]. Application of boron increases photosynthesis in plants [30] and its deficiency in soil retards root elongation, cell division in the root tip, leaf expansion and reduction in photosynthesis [31]. Boron also plays an important role in root growth [32]. These signify the importance of boron in the basic processes of dry matter accumulation.

3.3 Yield Attributes

The pigeon pea *c.v. PRG-176* plant treated with both boron (300 ppm) and $ZnSO_4$ @ 25 kg/ha initiated flowering on the 114th day and 116th day on plants treated with 100 % RDF and $ZnSO_4$ @ 25 kg/ha from the date of sowing (Table-3). The plants treated with only 100% RDF initiated flowering at 119 days and it indicates that days to maturity was not altered much by boron application. Similarly different concentration of boron also has no significant affect on days to flowering. These findings were in accordance with the results reported by previous researchers [7].

Application of boron significantly ($p \leq 0.05$) increased the yield attributes and yield of pigeon pea *cv. PRG-176* (Table-3). The maximum number of branches plant^{-1} (10.30), pods branch^{-1} (19.67) pods plant^{-1} (202.33), seeds pod^{-1} (3.0) and grain yield (1702.64 kg ha-1) were significantly higher with the application of 100% RDF+ $ZnSO_4$ (25 kg/ha) + Boron (300 ppm). The pigeon pea *cv. PRG176* treated with 300 ppm boron exhibited the highest yield attributes in compare to 200 and 400 ppm boron treated plants (Table-3). The better performance of integrated supply of zinc and boron increased the availability and uptake of nutrients that have favored better translocation of photosynthates. These micronutrients are directly involved in the synthesis of protein, chloroplast pigments and electron transfer which lead to increased photosynthetic activity of pigeon pea plant and it naturally accounts for higher number of primary and secondary branches per plant. A similar result of finding was in concomitance with previous investigators [7,33].

In this context it was known that boron is essential for pod and seed formation in pulses. Interaction of B with other nutrients may take place in soils or in plants. Interactions of boron with zinc may lead to the increased availability (synergistic) of those nutrients [34]. Foliar application of boron might have been readily absorbed by plant system that resulted in proper seed filling, which ultimately reflected with higher seed yield. Moreover, boron treatment plays a critical role in reducing the flower and pod drop presumably by preventing abscission layer formation [29]. In addition, temperature as an abiotic factor plays an important role in growth of pulses. At chilling temperature, B uptake, transport and partitioning into growing shoots are strongly impaired [35]. Hence, the above facts imply that boron plays an important role in growth and development of pigeon pea plants.

3.4 Economics

Among the different nutrient management practices in this study, application of 100% RDF+ $ZnSO_4$ (25 kg/ha) + Boron (300 ppm) recorded the highest gross return of Rs. 102150 ha-1 and net return of Rs. 61650 ha-1 with benefit cost ratio of 2.52 (Table-3). The enhanced nutrient availability in balanced manner by integration of major nutrients and micronutrient mixture, foliar spray resulted in improvement of yield attributing characters and yield. This ultimately led to increased gross income and net return. These findings were in concomitance with the previous investigators [7].

Table 1. Soil physical and chemical analysis of the experimental sites

Sl. No.	Properties	Pipalpada	Boria
1.	Depth of soil (cm)	0-30	0-30
2.	Soil texture	Sandy loam	Sandy loam
3.	pH	7.13	7.26
4.	EC (ds m^{-1})	0.13	0.12
5.	Organic matter (%)	0.62	0.46
6.	N (Kg ha^{-1})	326.8	263.2
7.	P2O5 (Kg ha^{-1})	36.5	45.88
8.	K2O (Kg ha^{-1})	29.6	31.76
9.	Zn (ppm)	0.45	0.48
10.	Boron (ppm)	0.26	0.38

Table 2. Effect of micronutrient application on different growth parameters of pigeon pea *cv. PRG176*

Treatment	Plant height (cm)			Dry matter accumulation (g/m^2)			Crop Growth Rate (g/m^2/day)		Relative Growth Rate (g/m^2/day)	
	30 DAS	90 DAS	180 DAS	30 DAS	90 DAS	180 DAS	30-90DAS	90-180DAS	30-90DAS	90-180DAS
T1:100% RDF+ Zinc (25kg/ha)	35.55[a]	219.48[a]	289.50[a]	7.20[a]	79.77[a]	470.63[a]	1.21[a]	4.34[a]	0.04	0.019
T2:100% RDF+ Zinc (25kg/ha) + Boron (200ppm)	34.40[b]	225.97[b]	304.77[b]	7.00[b]	106.57[b]	600.50[b]	1.66[b]	5.49[b]	0.0453	0.019
T3:100% RDF+ Zinc (25kg/ha) + Boron (300ppm)	33.85[c]	239.56[c]	324.84[c]	6.90[c]	161.13[c]	759.30[c]	2.57[c]	6.65[c]	0.052	0.017
T4:100% RDF+ Zinc (25kg/ha) + Boron (400ppm)	36.17[a]	228.31[d]	297.22[d]	7.50[d]	110.97[d]	570.17[d]	1.72[d]	5.10[d]	0.044	0.018
T5:100% RDF	35.84[a]	212.10[e]	257.50[e]	7.33[e]	75.33[c]	407.13[a]	1.13[e]	3.69[e]	0.038	0.018
SEm(±)	0.16	1.52	1.66	0.02	1.42	0.51	0.02	0.02	-	-
$CD_{0.05}$	0.34	3.26	3.55	0.04	3.05	1.10	0.05	0.04	-	-
CV%	0.55%	0.83%	0.69%	0.36%	1.63%	0.11%	1.75%	0.44%	-	-

[a,b,c,d,e] *Values having different superscripts in the same column differ significantly (P<0.05). Results are expressed as mean±s.e.m*

Table 3. Effect of micronutrient application on different yield parameters and economics of pigeon pea *cv. PRG176*

Treatment	No of days for flowering	No of branches	No of pods/ branch	No of pods/ plant	No of seeds/ pod	No of seeds/ plant	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T1:100% RDF+ Zinc (25kg/ha)	116[a]	8.20[a]	15.67[a]	128.37[a]	3.00[a]	385.10[a]	1080.21[a]	30500	64810	34310	2.12
T1:100% RDF+ Zinc (25kg/ha) + Boron (200ppm)	114[b]	9.13[b]	17.67[b]	161.23[b]	3.00[a]	483.70[b]	1356.78[b]	38900	81400	42500	2.09
T1:100% RDF+ Zinc (25kg/ha) + Boron (300ppm)	114[b]	10.30[c]	19.67[c]	202.33[c]	3.00[a]	607.00[c]	1702.64[c]	40500	102150	61650	2.52
T1:100% RDF+ Zinc (25kg/ha) + Boron	114[b]	9.67[d]	17.67[d]	170.83[d]	3.00[a]	512.50[b]	1437.56[b]	41200	86250	45050	2.09

Treatment	No of days for flowering	No of branches	No of pods/ branch	No of pods/ plant	No of seeds/ pod	No of seeds/ plant	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
(400ppm)											
T1:100% RDF	119[c]	7.00[e]	14.67[e]	103.00[e]	2.33[b]	240.33[d]	674.14[d]	28000	40450	12450	1.44
SEm(±)	0.26	0.56	0.45	9.89	0.84	26.58	74.56	-	-	-	-
$CD_{0.05}$	0.55	1.19	0.96	21.20	1.81	57.01	159.92	-	-	-	-
CV%	0.27%	7.69%	3.21%	7.91%	36.03%	7.30%	7.30%	-	-	-	-

[a,b,c,d,e] Values having different superscripts in the same column differ significantly (P<0.05). Results are expressed as mean±s.e.m

4. CONCLUSION

Based on the results of the present study, it is concluded that the combined application of 100% RDF, $ZnSO_4$ (25 kg/ha) and Boron (300 ppm) had highest values for most of the parameters like growth, yield attributes, seed yield and economics of pigeon pea *cv. PRG176*. Hence, this may be considered to be a suitable agro-technique to the pigeon pea farmers for realizing better yield and returns.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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