Assessing the growth and yield metrics of pigeonpea (*Cajanus cajan*) as affected by foliar nutrient management

ABSTRACT

An experiment titled "Study of Foliar Nutrient Management in Pigeonpea (*Cajanus cajan*)" was conducted at the Agriculture Research Station, Badnapur, Maharashtra, under Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during the *kharif* season of July 2018-19. The primary goal was to assess the impact of foliar nutrition on the growth, yield, and economic performance of pigeonpea. The study was designed using a Randomized Block Design (RBD) with ten different treatments and three replications, utilizing the BDN-716 variety of Pigeonpea. The total rainfall received during crop season was 437 mm.The findings indicated that applying RDF combined with a 2% solution of DAP and Multimicronutrient at a rate of 2 ml/litre during 50% flowering resulted in the highest plant height (150 cm), number of branches (14.33), functional leaves (96.67), dry matter accumulation (143.33), pod count (73.67), pod weight per plant (52.67 g), seed yield per plant (38.67 kg/ha), 100-seed weight (14 g), and overall seed yield (1650 kg/ha). It also yielded the highest straw yield (4100 kg/ha), biological yield (5750 kg/ha), harvest index (28.69). This was followed closely by the application of RDF with 2% urea and Multimicronutrient spray at 2 ml/litre.

Keywords:*Borax, foliar nutrient management, multimicronutrient, pigeonpea, urea*

1. INTRODUCTION

Food grain production in India is crucial for maintaining the nation's agricultural sector and ensuring food security for its large population[1]. Pulses, often referred to as food legumes, are ranked second in production and consumption after cereals in India. They are a vital source of dietary protein, energy, minerals, and vitamins. Pulses contribute to 25% of the protein needs for the largely vegetarian population. The protein quality of a vegetarian diet is notably enhanced when pulses and cereals are consumed together [2].This is particularly relevant as dietary patterns shift increasingly towards animal-based foods [3].Pulses are sometimes called "mini fertilizer factories" because they fix atmospheric nitrogen through symbiosis. In developing countries like India, pulses are often dubbed the "poor man's meat" due to their affordability compared to meat.

Pigeonpeaalso referred to as red gram, arhar, or tur [*Cajanus cajan* (L.) Millsp.], is a vital grain legume for the kharif season. It belongs to the Leguminosae family and the sub-family *Papilionaceae*, and it is believed to have originated in Africa.The name "pigeonpea" originated in Barbados, where the seeds were initially used as feed for pigeons[4].It frequently undergoes cross-pollination, with natural out-crossing rates facilitated by insects ranging from 20% to 70%[5]. Despite its low harvest index of 19%, pigeonpea is a valuable source of protein (21-24%) and essential amino acids such as lysine, tyrosine, cysteine, and arginine. It constitutes approximately 11.8% of the total pulse area and 17% of the total pulse production in India. Major producing states include Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, and Andhra Pradesh, which together account for 87% of the country's area and 83.8% of the total production. Bihar leads in productivity with 1702 kg/ha [6].Dry whole seeds and dehulled split seeds (dhal) are utilized in preparing a variety of dishes. In addition to its role as a food crop, pigeonpea is also used for forage, fodder, fuel, and medicinal purposes[7].

In India, pigeonpea is cultivated over 5.4 million hectares, with a production of 4.78 million tonnes and a productivity of 885 kg/ha. In Maharashtra, the crop covers 15.33 lakh hectares, yielding 14.6 lakh tonnes with a productivity of 951 kg/ha for the year 2017-18 [6]. Specifically, in the Marathwada region, pigeonpea is grown on 5.95 lakh hectares, producing 4.47 lakh tonnes with a productivity of 759 kg/ha.In India, the Green Revolution focused heavily on nitrogen fertilizers, with less emphasis on phosphorus and potassium, leading to nutrient imbalances and threats to soil health and crop sustainability. Foliar sprays of macro and micronutrients, such as manganese, zinc, boron, molybdenum, and cobalt, are now crucial for enhancing nutrient efficiency and supporting plant growth.During a cropping season, the plants fix approximately 40 kg/ha of atmospheric nitrogen and contribute valuable organic matter to the soil through fallen leaves, amounting to up to 3.1 t/ha of dry leaf matter[7].

It is primarily grown for its grains, which are processed into dhal, a key protein source for impoverished farmers, providing three times the protein of cereals. Its tender green seeds are used as vegetables, crushed seeds serve as animal feed, green leaves are used as fodder, and the stems have various uses, including fuel, thatching huts, basket making, and fencing, as well as for cultivating lac insects. Additionally, it is often used as a live fence around small farms and is cultivated on mountain slopes to prevent soil erosion. As a secondary crop, pigeonpea is commonly grown on marginal lands, frequently intercropped with other pulses or planted on bunds, and typically receives minimal purchased high-cost inputs.Improving plant nutrition is crucial for enhancing productivity, with fertilizers playing a significant role in boosting crop yields. Given the low yield levels, there is a need to standardize agronomic practices for it to maximize its yield potential. Among various agronomic practices, the foliar application of micronutrients has been identified as a key factor influencing yield.In many pulses, including pigeonpea, flower drop is a critical factor affecting yield and yield-related characteristics. Ensuring the retention of flowers is essential for achieving higher yields.

Among various management practices, fertilization is crucial for optimizing its yields. The crop's low production is often due to its cultivation during the rainy season on marginal and less fertile soils. Insufficient nutrient management is a key factor contributing to low yields. To enhance productivity, it is essential to address the decline in seed treatments with biofertilizers and the use of foliar sprays containing potassium nitrate, DAP, and boron, which help regulate nutrient availability. Additionally, incorporating micronutrients such as copper, zinc, boron, and manganese can significantly boost productivity and improve seed quality.Therefore, this study aimed to systematically gather empirical data on growth and yield of pigeonpeaunder various foliar nutrient management practices.

2. MATERIAL AND METHODS

The field experiment was conducted during the *kharif* season of 2018-2019 at the Agronomy Experimental Farm, Agriculture Research Station, Badnapur, Jalna (Maharashtra), under Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The soil was leveled, well-drained, medium black in color, clayey, fairly deep, and characterized by low nitrogen, medium available phosphorus, high potash, and alkaline reaction. The typical daily maximum temperature ranged from 29.16°C in winter (December) to approximately 41.4°C in summer, while the normal minimum temperature varied from 11.9°C in winter to 24.9°C. The mean relative humidity fluctuated between 30% and 90%.

The experiment utilized a Randomized Block Design (RBD) with ten treatments and three replications, employing the BDN-716 variety. The land was initially ploughed deeply using a tractor with a mouldboard plough and then harrowed twice with a blade harrow to create a fine seedbed. Residues from the previous crop and weeds were collected and burned to clean the field. Before sowing, the seeds were treated with *Rhizobium* and *PSB* at 25 g /kg of seed. Additionally, the seeds were coated with Carbendazim 12% and Mancozeb 63% at 4 g/kg of seed. Sowing was carried out by dibbling, with two seeds placed per hill, spaced 90 cm between rows and 20 cm between plants, at a depth of approximately 5 cm. Seedlings began to emerge 4 days after sowing, with emergence completing within 8 to 10 days.Treatments included: Recommended Dose of Fertilizers (25:50:00 NPK kg/ha), RDF + 2% urea spray, RDF + 2% DAP spray, RDF + 0.5% Borax spray, RDF + 1% urea spray + foliar spray of 0.25% $ZnSO_4$ + 0.25% Borax, RDF + Multimicronutrient spray @ 2 ml/litre, RDF + 2% urea spray + Multimicronutrient spray @ 2 ml/litre, RDF + 2% DAP spray + Multimicronutrient spray @ 2 ml/litre, and RDF + soil application of $ZnSO_4$ @ 15 kg/ha, with a uniform basal application of RDF across all plots.The collected data were statistically analyzed using the analysis of variance (ANOVA) method as outlined by Panse and Sukhatme (1967) [8]. The results of the treatments were summarized in a table of means, which included the standard error (S.E. ±) and critical difference (C.D.) values at the 5% level of significance.

3. RESULTS AND DISCUSSION

The results showed that plant height, number of functional leaves, average number of branches, and total dry matter per plant were significantly impacted by foliar spray treatments. Among the various treatments, RDF + 2% DAP + Multimicronutrient spray @ 2 ml/litre (T_9) achieved the highest values for plant height, number of functional leaves, mean number of branches, and total dry matter at all growth stages. This was followed by RDF + 2% urea spray + Multimicronutrient (T_8). The superior performance of RDF + 2% DAP + Multimicronutrient spray @ 2 ml/litre (T_9) is likely due to enhanced vegetative growth compared to RDF alone (T_1). These observations are consistent with the findings of Muthal (2016) [10] and Shivram and Ahlawat (2000) [11]. This might be due to foliar application of nutrients that increased plant height by promoting nutrient absorption through the leaves. The increased plant height results from elongation of internodes and a more vigorous root system. Additionally, the significant rise in dry matter accumulation is attributed to higher nitrogen levels, which boost chlorophyll content and enhance the root system's ability to absorb solar energy and nutrients. The 2% DAP spray also promotes root and flower growth, while the Multimicronutrient application contributes to overall crop health.The same treatment of RDF + 2% DAP + Multimicronutrient@ 2 ml/litrespray (T_9) achieved the highest values for the number of pods per plant (73.67), pod weight (52.67 g), seed yield per plant (38.67 g), seed yield (1650 kg/ha), straw yield (4100 kg/ha), and biological yield (5750 kg/ha). This treatment was notably superior compared to others. The second-best treatment was RDF + 2% urea spray + Multimicronutrient @ 2 ml/litre (T$_8$). The enhanced yield attributes observed with RDF + 2% DAP + Multimicronutrient spray @ 2 ml/litre (T$_9$) are likely due to improved growth parameters, particularly the number of functional leaves and branches per plant, which contributed to a better source-sink relationship compared to RDF (25:50:00 NPK). These findings align with those reported by Singh et al. (2015), who noted that fertilization with RDF combined with 2% DAP + Multimicronutrient spray @ 2 ml/litre (T$_9$) resulted in significantly higher grain yield. This improvement is attributed to enhanced nutrient supply and reduced losses, facilitating more efficient absorption of nitrogen, phosphorus, and micronutrients during the reproductive stage when nutrient demand peaks due to the crop's indeterminate growth habit.

Table 1. Effect of different nutrient treatments on growth characteristics

Treatment details	**Plant Height (cm)**	**No. of branches plant^{-1}**	**No. of functional leavesplant^{-1}**	**Total dry matter (g)**
T$_1$:RDF (25:50:00)	116.33	9.53	79.66	80
T$_2$:T$_1$+2%urea spray	124.00	10.73	83	96.33
T$_3$:T$_1$+2%DAP spray	129.00	13.23	90.00	111.67
T$_4$:T$_1$+0.5% borax spray	124.00	10.43	84.33	111.00
T$_5$:T$_1$+0.5%ZnSO$_4$ spray	120.00	10.17	83.33	100.67
T$_6$:T$_1$+1%urea+0.25% ZnSO$_4$+0.25%borax	123.33	10.96	87.66	107
T$_7$:T$_1$+Multimicronutrient @2ml/litre	120.00	10.53	85.00	118.33
T$_8$:T$_2$+Multimicronutrient @2ml/litre	146.00	13.33	92.33	140.33
T$_9$:T$_3$+Multimicrontrient @2ml/litre	150.00	14.33	96.67	143.33
T$_{10}$:T$_1$+soil application ofZnSO$_4$@15kg/ha	123.00	9.66	83.33	121.66
SE (±)	5.96	0.54	6.66	12.12
CD (p=5%)	17.70	1.60	NS	36.03

Table 2. Effect of different nutrient treatments on growth rate

Treatment details	**AGRfor plant height(cm**	**AGRfor dry matter (g plant^{-1}**	**RGR for dry matter**

	plant^{-1}day^{-1})	**day)**	**(g g^{-1} day^{-1})**
T_1:RDF (25:50:00)	0.01	0.08	0.0011
T_2:T_1+2%urea spray	0.005	0.08	0.0009
T_3:T_1+2%DAP spray	0.01	0.02	0.0002
T_4:T_1+0.5% borax spray	0.003	0.41	0.0039
T_5:T_1+0.5%$ZnSO_4$ spray	0.01	0.31	0.0032
T_6:T_1+1%urea+0.25% $ZnSO_4$+0.25%borax	0.003	0.33	0.0032
T_7:T_1+Multimicronutrient @2ml/litre	0.003	0.44	0.0039
T_8:T_2+Multimicronutrient @2ml/litre	0.07	0.26	0.0019
T_9:T_3+Multimicrontrient @2ml/litre	0.03	0.11	0.0007
T_{10}:T_1+soil application of$ZnSO_4$@15kg/ha	0.05	0.61	0.0054
SE (±)	0.03	0.26	0.0024
CD (p=5%)	0.01	0.08	0.0011

Table 3. Effect of different nutrient treatments on yield attributing characters

Treatment details	**No of Pods plant^{-1}**	**Weight of pods plant^{-1} (g)**	**Seed yield plant^{-1} (g)**	**No of Seeds pod^{-1}**	**Seed index**
T_1:RDF (25:50:00)	53	37	24.33	3.03	11.9
T_2:T_1+2%urea spray	54	39.66	26.33	3	11
T_3:T_1+2%DAP spray	62.33	45.00	32.00	3.10	13.17
T_4:T_1+0.5% borax spray	61.33	41.00	27.33	3.07	13.00
T_5:T_1+0.5%$ZnSO_4$ spray	55.00	42.33	27.00	3.00	12.00
T_6:T_1+1%urea+0.25% $ZnSO_4$+0.25%borax	59.33	42	28.33	3.06	12.06
T_7:T_1+Multimicronutrient @2ml/litre	58.66	42.66	28.66	3.13	13
T_8:T_2+Multimicronutrient @2ml/litre	69.00	48.00	35.67	3.17	13.50
T_9:T_3+Multimicrontrient @2ml/litre	73.67	52.67	38.67	3.13	14.00

T_{10}: T_1+soil application of $ZnSO_4$@15kg/ha	55.33	40.33	25	3.06	12.33
SE (±)	4.06	2.10	2.54	0.11	0.57
CD (p=5%)	12.05	6.25	7.56	NS	NS

Table 4: Effect of different nutrient treatments on yieldparameters

Treatment details	**Seed yield (kg/ha)**	**Straw yield (kg/ha)**	**Biological yield (kg/ha)**	**Harvest index (%)**
T_1:RDF (25:50:00)	1087	3100	4187	26.21
T_2:T_1+2%urea spray	1200	3133	4333	27.66
T_3:T_1+2%DAP spray	1308	3532	4840	27.59
T_4:T_1+0.5% borax spray	1187	3047	4233	28.09
T_5:T_1+0.5%$ZnSO_4$ spray	1220	3067	4287	26.56
T_6:T_1+1%urea+0.25% $ZnSO_4$+0.25%borax	1210	2990	4200	28.92
T_7:T_1+Multimicronutrient @2ml/litre	1170	3299	4469	26.44
T_8:T_2+Multimicronutrient @2ml/litre	1456	3690	5145	28.35
T_9:T_3+Multimicrontrient @2ml/litre	1650	4100	5750	28.69
T_{10}:T_1+soil application of$ZnSO_4$@15kg/ha	1168	2965	4133	28.35
SE (±)	56.88	233	236	1.61
CD (p=5%)	169	695	703	NS

The reduction in flower drop, leading to improved pod setting and increased seed yield, can be attributed to the treatment. In pulses, pod number is a key determinant of yield, and foliar application of nitrogen through urea, phosphorus through 2% DAP, and additional micronutrients effectively boosted pod numbers in this study. Barik and Rout (1990) [12] also reported that foliar nutrient application during the flowering and pod development stages enhances nutrient absorption and translocation, ensuring a steady nutrient supply during the reproductive phase. The increase in straw yield is closely linked to enhanced vegetative growth, primarily due to greater plant height. The ample nutrient supply at 50% flowering likely facilitated more efficient translocation of photosynthesis from source to sink. The reduction in flower drop associated with the RDF + 2% DAP + Multimicronutrient spray @ 2 ml/litre (T_9) treatment improved flower development and pod numbers per plant. Pod number, being crucial for yield, benefited from the continuous nutrient supply, both basal and as foliar spray, which increased leaf area and dry matter accumulation, resulting in higher straw yield. This improvement is also supported by Mondal et al. (2012) [13], highlighting the role of sustained nutrient uptake throughout the crop growth period. Similar findings were reported by Kalarani(1991) [14],Solaiappan etal. (2002) [15], and Sivaetal. (2017) [16].

4. CONCLUSION

It can be concluded that RDF (25:50:00 NPK kg/ha) in combination with 2% DAP and multimicronutrient@ 2 ml/litrespray has the potential to enhance overall growth, yield attributes and yield of pigeonpea under cultivation.

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