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Optimization of Foliar Nutrition and Nipping for Quality of Pigeonpea [*Cajanus cajan* (L). Millsp.]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted in red sandy clay loam soil at UAS, GKVK, Bengaluru during *kharif* to know the influence of foliar nutrition and nipping on crop growth, seed yield and quality in pigeonpea. The experiment replicated six times in split plot design with treatments of foliar spray of

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water soluble fertilizer (WSF)with three different concentration F_0 (100% RDF), F_1 (75% RDF + 25% WSF (19: 19:19), F_2 (75% RDF + 12.5% WSF (19: 19:19) in combination with nipping (N_1) and no nipping (N_0). The results revealed that seed quality parameters *viz.,*germination (85.75 %) mean seedling length (48.28 cm), mean seedling dry weight (47.33 mg), seedling vigour index-I (4137), seedling vigour index -II (4112), lower electrical conductivity (1.07 mS ppt^{-1}), total dehydrogenase activity (3.30 A_{480nm}) and total soluble protein (23.19%) recorded higher in F_2N_1 (75% RDF + 12.5% WSF (19: 19:19) + nipping) over control (81.42%, 44.59 cm, 41.67 mg $seedling^{-1}$, 3724, 3346, 1.44 mS ppt^{-1}, 2.22 A_{480nm}, 20.22 %,) respectively.

Keywords: Foliar nutrition; nipping; pigeonpea; water soluble fertilizer.

1. INTRODUCTION

Pulses are the wonderful gift of nature. They provide vital protein and vitamins in the diet. Pulse form a cheapest and major source of dietary protein especially for vegetarians who form a major part of our population. The UN general assembly declared 2016 as the 'International Year of Pulses'. This reflects the importance of pulses in global concerns regarding food security, preserving cultural heritage and sustainable development. It provides unprecedented opportunity to raise awareness and to celebrate the role of beans, chickpea, pigeonpea and other pulses in feeding the world. Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a perennial crop native to Africa, belongs to family *Fabaceae*. It is also known as no-eye pea, gungo pea in Jamaica, tropical green pea and arhar in India (Anon.,) [1]. It is one of the protein rich legumes of the semi-arid tropics grown predominantly under rainfed conditions. It is cultivated throughout the tropical and sub-tropical regions of the world, between 30°N and 35°S latitudes. However, major area under pigeonpea in India is lying between 14° and 28° N latitudes. Pigeonpea accounts for about 11.8 % of the total pulse area and 17 % of total pulse production in the country. In India the total area coverage and production of pigeonpea were 38.35 lakh hectares and 29.92 lakh tonnes respectively.

Seed replacement rate (SRR) is a criterion to assess the use of certified and/or quality seed of a crop and gives an indication of area under quality seeds. The SRR in pigeonpea is 50 % lower than recommended in 2014-15. So, it is important to intensify the SRR that helps in enhancing productivity of the crop. Which has been suggested that 40 % SRR would be appropriate for achieving higher productivity in pulses [2]. The treatment foliar spray of water soluble fertilizer in combination nipping can increase the production of quality seeds and can help to provide sufficient quality seeds to the farmer.

Application of foliar nutrients along with soil application has several benefits in supplementing the nutritional requirements to crops. Foliar nutrient spray is designed to exclude the problems like immobilization and fixation of nutrients. Hence, foliar nourishment recognized as an important method of fertilization in modern-day agriculture. This method provides for exploitation of nutrients more efficiently and for correcting deficiencies rapidly. Foliar spray of macronutrients is most important factor in determining the yield [3]. In almost all the pulses, flower drop determines the yield and yield attributing characters. Retention of flowers that are produced by the plant helps realize higher yield than expected.

Nipping of young tender top shoots though traditionally practiced by the farmer but its associated beneficial effects are not scientifically documented. Apical bud nipping is known to alter the source-sink relationship by arresting the vegetative growth and hastening the reproductive phase. It also helps in production of more pod bearing branches with luxuriant foliage thus, enhances the photosynthetic activity, accumulation of more photosynthates, ultimately resulting in better seed quality with higher seed yield [4].

2. MATERIALS AND METHODS

The field experiment was carried out during *kharif* at Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, GKVK, Bengaluru. The experiment consist of six treatment combinations they are as follows F_0N_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF) + No nipping, F_1N_0: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS + No nipping, F_2N_0: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS + No nipping, F_0N_1: Recommended dose of fertilizer 25: 50: 25 kg

NPK ha^{-1} (100 % RDF) + Nipping, F_1N_1: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS + Nipping, F_2N_1: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS + Nipping, laid out in split plot design with six replications. The soil of the experimental site was red sandy loam in texture. The moisture content at field capacity was 14.50 per cent with bulk density of 1.53 g cc^{-1}. The soil was slightly acidic in reaction (pH 6.25) and electrical conductivity was medium (0.18 dS m^{-1}). The organic carbon content is medium (0.42 to 0.48 %). The available nitrogen was medium (228.2 kg ha^{-1}) phosphorus is high (62.5 kg ha^{-1}) and potassium is also high (256.1 kg ha^{-1}).The following seed quality parameters 100 seed weight, Seed moisture (%), Seed Germination (%), Mean seedling length (cm), Mean seedling dry weight per seedling (mg), Seedling Vigour Index-I, Seedling Vigour Index- II, Electrical conductivity (mS ppt^{-1}), Total dehydrogenase activity (TDH) ($A_{480\ nm}$), Total soluble seed protein (%) were recorded and the replicated mean data was subjected to statistical analysis and interpretation of experimental data was done by Fischer's method of "Analysis of variance" (ANOVA). Whenever F-test was significant for comparison amongst the treatments means an appropriate value of critical differences (CD) was worked out. Otherwise against CD values abbreviation NS (Non-Significant) was indicated. All the data were analyzed and the results are presented and discussed at a probability level of 0.05 per cent.

3. RESULTS AND DISCUSSION

3.1 Influence of Foliar Nutrition and Nipping on Seed Quality Parameters of Pigeonpea

100 seed weight, seed moisture and germination: Significant difference was observed with respect to foliar application of water soluble fertilizer on hundred seed weight (Table 1). Significantly higher hundred seed weight was obtained in F_2 12.5 % WSF (F_2: 12.99 g) which is on par with 25 %WSF (F_1: 12.75 g) and lower in control (12.30 g). Significantly higher hundred seed weight was recorded in N_1 (nipping) (12.91 g) compared to control (12.45 g). Interaction effects were significant and higher 100 seed weight was registered in F_2N_1 (13.08 g) and lower in F_0N_0 (11.96 g). The increase in 100 seed weight by foliar spray and nipping might be due to better availability of nutrients like NPK that play a major role for availability of photosynthates to the sink. Nipping diverts the photosynthates to accumulate in sink. These results are in accordance with findings of Zakaria Sawan et al. [5] in cotton and Baloch and Zubair [6] in chickpea and Vijaysingh Thakur et al. [7] in blackgram.

There was a significant difference among the different concentration of water soluble foliar spray with respect to germination. Higher germination was observed in F_2 (84.63 %) followed by F_1 (84.63 %) and least was in F_0 (82.63 %). Seed germination percentage was markedly influenced by nipping. Maximum germination was depicted in nipping (85.03 %), while minimum was in control (82.72 %). Seed germination percentage showed significant differences due to interaction effects of foliar nutrition and nipping. Higher germination was registered in F_2N_1 (85.75 %) and lower was in F_0N_0 (81.42 %).

Seed germination recorded higher values in treatments of foliar nutrition and nipping. This might be due to the production of healthy and bold seeds with more reserve food material as synthesized photosynthates might have translocated to seeds. These findings are in resemblance with Sudeep Kumar et al., [8] in fieldbean.

There was no significant difference among treatments for seed moisture content. Seed moisture content depends upon the physiological maturity of the seed (time of harvesting) and weather conditions at the time of harvesting. Therefore, the foliar nutrition and nipping did not have any significant effect on moisture contents of the seed.

Mean seedling length (cm) and mean seedling dry weight seedling^{-1} (mg): Significant results were obtained for seedling length due to influence of water soluble foliar spray with respect to mean seedling length (Table 1). Higher seedling length was measured in F_2 (47.61 cm) followed by F_1 (46.82 cm) and least was in F_0 (45.34 cm). Seedling length was significantly influenced by nipping. Maximum seedling length was recorded in N_1 (47.34 cm) compared to control (N_0: 45.84 cm). The results revealed significant differences on seedling length due to interaction effect of foliar nutrition and nipping. Higher seedling length was measured in F2N1 (48.28 cm) followed by F1N1(47.65 cm), F2N0

(46.94 cm), F0N1 (46.09 cm), F1N0 (45.99 cm). Whereas, least was in control F0N0 (44.59 cm).

Seedling dry weight differed significantly due to different concentration of water soluble fertilizer spray. F2 (45.33 mg seedling-1) recorded higher seedling dry weight which is on par with F1 (43.33 mg seedling-1), and was lower in F0 (42.67 mg seedling-1). Among nipping the seedling dry weight differed significantly. The higher seedling dry weight (45.06 mg seedling-1) was recorded in nipping compared to control (42.50 mg seedling-1). The interaction of foliar nutrition and nipping on seedling dry weight was found to be significant. Maximum seedling dry weight was recorded in F2N1 (47.33 mg seedling-1), and the minimum was in F0N0 (41.67 mg).

Table 1. Influence of foliar nutrition and nipping on 100 seed weight, seed moisture germination, mean seedling length and mean seedling dry weight in pigeonpea cv. BRG-2

Treatments	100 Seed Weight	Seed Moisture (%)	Germination (%)	Mean Seedling Length (cm)	Mean Seedling Dry Weight Seedling^{-1} (mg)
Main plot (nutrient management)					
F_0	12.30	8.84	82.63	45.34	42.67
F_1	12.75	8.93	84.38	46.82	43.33
F_2	12.99	8.96	84.63	47.61	45.33
S.Em±	**0.06**	**0.03**	**0.44**	**0.51**	**0.59**
CD (p=0.05)	**0.17**	**NS**	**1.29**	**1.51**	**1.73**
Sub plot (nipping)					
N_0	12.45	8.87	82.72	45.84	42.50
N_1	12.91	8.95	85.03	47.34	45.06
S.Em±	**0.05**	**0.03**	**0.47**	**0.36**	**0.52**
CD (p=0.05)	**0.19**	**NS**	**1.70**	**1.322**	**1.87**
Interaction					
F_0N_0	11.96	8.83	81.42	44.59	41.67
F_1N_0	12.51	8.83	83.25	45.99	42.50
F_2N_0	12.89	8.93	83.50	46.94	43.33
F_0N_1	12.65	8.85	83.83	46.09	43.67
F_1N_1	13.00	9.03	85.50	47.65	44.17
F_2N_1	13.08	8.98	85.75	48.28	47.33
Different levels of F means at the same or different levels of N					
S.Em±	**0.08**	**0.05**	**0.62**	**0.72**	**0.83**
CD (p=0.05)	**0.24**		**1.83**	**2.14**	**2.45**
Different levels of F means at the different levels of N					
S.Em±	**0.09**	**0.05**	**0.69**	**0.69**	**0.85**
CD (p=0.05)	**0.28**	**NS**	**2.25**	**2.18**	**2.73**
CV (%)	**1.60**	**1.33**	**2.36**	**3.81**	**4.65**

Main plot treatment (nutrient management)

F_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF).

F_1: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

F_2: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75% RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

Sub plot treatments (nipping)

N_0: No nipping

N_1: Nipping at 45-60 DAS

The better development of seed owing to greater accumulation of storage reserves, which in turn might have utilized for germination and seedling growth resulted in maximum total seedling length and seedling dry weight. These results are in resemblance with [8] in fieldbean. Bagli et al. [9] in sunhemp. Similar increase in total seedling length with apical bud nipping and foliar spray of cycocel was earlier revealed by Gopal Singh and Rama Rao [10] in sunflower. Narayanaswamy and Channarayappa [11] in groundnut.

Seedling vigour index-I (SVI-I) and Seedling vigour index-II (SVI-II): The influence of different concentration of water soluble fertilizer sprays on seedling vigour index-I was differed significantly (Table 2). Higher seedling vigour index-I was documented in F_2 (4000) followed by F_1 (3937) while, least was in F_0 (3795). Seedling vigour index-I showed significant differences due to influence of nipping. Maximum seedling vigour index-I was catalogued in N_1 (4016) and minimum in N_0 (3805). Significant differences were observed for seedling vigour index-II due to interaction effect of foliar nutrition and nipping. F_2N_1 (4112) recorded higher seedling vigour index-II and least was in F_0N_0 (3346). The increase in seedling vigour index I and II was due

Table 2. Influence of foliar nutrition and nipping on SVI-I, SVI-II, Electrical Conductivity, Total dehydrogenase activity and total soluble seed protein content in pigeonpea cv. BRG-2

Treatments	SVI-I	SVI-II	Electrical Conductivity (mS ppt^{-1})	Total dehydrogenase activity ($A_{480\ nm}$)	Total Soluble Seed Protein content (%)
Main plot (nutrient management)					
F_0	3795	3512	1.27	2.66	21.22
F_1	3937	3694	1.10	2.92	21.39
F_2	4000	3785	1.07	3.10	22.61
S.Em±	**44.35**	**50.26**	**0.02**	**0.03**	**0.29**
CD (p=0.05)	**130.8**	**148.3**	**0.05**	**0.10**	**0.85**
Sub plot (nipping)					
N_0	3805	3441	1.21	2.58	21.28
N_1	4016	3887	1.08	3.21	22.20
S.Em±	**40.08**	**34.08**	**0.03**	**0.03**	**0.09**
CD (p=0.05)	**145.7**	**123.9**	**0.09**	**0.11**	**0.33**
Interaction					
F_0N_0	3724	3346	1.44	2.22	20.72
F_1N_0	3829	3519	1.11	2.62	21.07
F_2N_0	3863	3458	1.08	2.89	22.04
F_0N_1	3865	3678	1.10	3.10	21.73
F_1N_1	4045	3869	1.09	3.22	21.70
F_2N_1	4137	4112	1.07	3.30	23.19
S.Em±	**62.72**	**71.07**	**0.03**	**0.05**	**0.41**
CD (p=0.05)	**185.02**	**209.6**	**0.08**	**0.14**	**1.20**
S.Em±	**65.03**	**67.3**	**0.04**	**0.05**	**3.44**
CD (p=0.05)	**208.7**	**210.3**	**0.12**	**0.16**	**1.03**
CV (%)	**4.35**	**4.75**	**4.98**	**4.04**	**4.58**

Main plot treatment (nutrient management)
F_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF).
F_1: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.
F_2: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75% RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

Sub plot treatments (nipping)
N_0: No nipping
N_1: Nipping at 45-60 DAS

to higher seed germination per cent, longer length of the root and shoot and seedlings dry weight [8]. Enhanced translocation of assimilates/photosynthates towards the seeds, as nipping treatment and foliar spray of water soluble fertilizer are known to boost source and sink relationships, resulting in improved seed germination performance, growth, and dry weight of seedlings Topani and Kulkarni [12] in cowpea and Upadhyay, [13] in chickpea. Similar benefits were also reported in pigeonpea by Deshpande [14] and in black gram by Lakshmamma and Rao [15] with foliar spray of growth regulators by Fageria [16], Sanjay in soybean [17].

Electrical conductivity of seed leachate (mS ppt^{-1}), Total dehydrogenase activity (A_{480nm}) and Total soluble seed protein (%): Statistically significant difference found for the electrical conductivity of seed leachate among the treatments of foliar spray of water soluble fertilizer (Table 2). Higher electrical conductivity found in control F_0 (1.27 mS ppt^{-1}) and lower in F_2 (1.07 mS ppt^{-1}). Significant difference was found for the electrical conductivity of seed leachate among the treatments of nipping. Higher electrical conductivity found in no nipping (1.21 mS ppt^{-1}) and lower in N_1 (1.08 mS ppt^{-1}). Interaction effects were found to be significant for the electrical conductivity of seed leachate among the treatments of foliar spray of water soluble fertilizer. Higher electrical conductivity found in control (1.44 mS ppt^{-1}) and lower in F_2 (1.07 mS ppt^{-1}). There was significant difference for TDH activity of seeds among treatments of water soluble fertilizer spray. Higher TDH was found in F_2 (3.10) and lower in control F_0 (2.66). Significant difference was noticed for the TDH activity among the treatments of nipping. Higher electrical conductivity found in nipping N_1 (3.21) and lower in N_0 no nipping (2.58). Interaction effects were found to be significant for TDH activity. Higher TDH activity was found in F_2N_1 (3.30) and lower in control (2.22).

The higher seed quality parameters noticed with nipping at proper stage and foliar nutrition may be due to increased photosynthetic area leading to higher photosynthetic rate, better assimilation and accumulation of more photosynthates that might resulted in better seed development as evident with higher test weight. Similar increase in germination, lesser electric conductivity of seed leachate, higher TDH. Was earlier reported by Venkata Reddy et al*.* [18] and Sajjan et al*.* [19] in okra, Iyyannagouda [20] in coriander and Sudarshan [21] in fenugreek.

The protein content of seeds differed significantly among different foliar spray. Higher protein content was recorded in F_2 (22.6%) followed by F_1 (21.4%) and lowest protein content was recorded in F_0 (21.2%). The protein content of seeds differed significantly among nipping. Higher protein content was recorded in N_1 (22.2%) and lower protein content was recorded in N_0 (21.3%). The protein content of seeds in interaction effect differed significantly. Highest protein content was recorded in F_2N_1 (23.19 %) and lowest protein content was recorded in F_0N_0 (20.7 %).

The higher nitrogen supply through foliar application at different crop growth stages resulted in enhancement of protein content of seeds, suggesting that hydrocarbons synthesized during photosynthetic process are diverted to form more proteins and nipping also helps to divert photosynthates to the sink and might increased the protein content of the seeds. These results are parallel to Sudeep Kumaret al*.* [8] in fieldbean, Venkata Reddy et al*.* [18] and Sajjan et al*.* [19] in okra.

4. CONCLUSION

The present experimental findings, it can be concluded that adopting of foliar application of water soluble fertilizer (12.5 %) at 45 and 75 DAS along with nipping (F_2N_1) is found to be the best for seed quality parameters. The higher seed quality parameters noticed with nipping at 45 and 75 DAS and foliar nutrition may be due to increased photosynthetic area leading to higher photosynthetic rate, better assimilation and accumulation of more photosynthates that might resulted in better seed development as evident with higher 100 seed weight, seed moisture, germination,mean seedling length, mean seedling dry weight, seedling vigour index-I, seedling vigour index-II, electrical conductivity, total dehydrogenase activity and total soluble seed protein content in pigeonpea cv. BRG-2

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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