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Effect of Foliar Application of Calcium Nitrate, Boron and on Growth, Yield and Economics of Transplanted Pigeonpea

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A B S T R A C T

Pulses are an important source of high quality protein complementing cereal proteins for pre-dominantly substantial vegetarian population of the country. Pigeonpea (*Cajanus cajan* (L.) Mill sp.) is the second most important pulse crop of India after chickpea and is grown for it's grain as dhal and green seed as a vegetable. A field experiment was conducted at College of Agriculture, Vishweshwaraiah Canal Farm, Mandya during *kharif* 2017 to study the effect of foliar application of calcium nitrate, boron and humic acid on growth and yield of transplanted pigeonpea. The design followed is randomized complete block design with three replications. Significantly higher grain and stover yield (2093 and 7428 kg ha^{-1}) was recorded for the treatment with foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) and foliar spray of 0.50% borax at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{11}) recorded the higher B:C ratio (1.82). Similar results were found in growth parameters like plant height (307.33 cm), no. of primary branches per plant (28.67), no. of secondary branches per plant (40.33), leaf area (5110.33 cm^2/plant) and total dry matter production per plant (436.67 g) at harvest.

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is the second most important pulse crop of India after chickpea and is grown for it's grain as dhal and green seed as a vegetable. In India, pigeonpea is grown in an area of 3.85 m ha with a production and productivity of 2.81 m t and 729 kg ha^{-1} respectively and in Karnataka, it is grown in an area of 0.73 m ha with a production and productivity of 0.47 m t and 651 kg ha^{-1} respectively (Anon. 2015). Pigeonpea is the medium to long duration crop and cannot fit in double cropping system of command areas. Hence, transplanted pigeonpea is the alternate option for optimum utilization of land and water resources. The transplanting of pigeonpea seedlings has been shown to increase grain yield by 69.5 per cent than direct sowing of pigeonpea. One of the technologies that supported the increase in production of crops is foliar fertilization of macronutrients and micronutrients. It helps in rapid absorption of nutrients, serving as a complement to soil fertilization. Generally nutrients are quickly available to the plants by foliar application than the soil application (Phillips, 2004).

Calcium affects the several important physiological processes in plants like ion transport, translocation of carbohydrates, proteins and their storage during seed formation and other enzymatic activities. Calcium has been reported to inhibit Na^+ uptake and thereby reduce its adverse effect on seed germination (Nayyar, 2003) as well as increase plant growth (Munns, 2002). Calcium is an immobile element in plant and therefore application of calcium is more crucial for enhanced productivity. Foliar application of calcium is most effective when applied to buds and flowers as it can be readily absorbed and utilized by the plants. Calcium nitrate is highly soluble in nature and its high solubility makes it popular for immediate supply of available source of nitrate and calcium directly to soil through irrigation water or with foliar applications.

Boron (B) is an essential trace element whose deficiency affects the yield and nutrient uptake of different crops, especially in legumes. Boron has a great influence on plant growth and development. Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates (Bose and Tripathi, 1996). Boron also plays an important role in flowering and fruit formation (Nonnecke, 1989). Its deficiency affects translocation of sugar, starch, nitrogen and phosphorus, synthesis of amino acids and proteins (Stanley *et al.,* 1995). Boron is an essential micronutrient for plants, but at the same time, its range between deficiency and toxicity is narrower than that of any other element.

Among micronutrients, B deficiency is wide spread throughout India. The deficiency is common in soils with alkaline reaction, coarse (sandy) texture, low organic matter and low moisture. Other major factors that may cause shortfall in B supply for reproductive development are poor translocation of B from leaves and other mature tissues to the floral parts and poor access of the pollen grains and the embryo sacs to the vascular supply. In such situation providing B by means of foliar application would be advantageous (Pandey and Gupta, 2013).

Humic acid is the most complex form of organic material and it is a ready source of carbon and nitrogen and known as the black gold of agriculture and is increasingly becoming popular for use in agriculture. Humic acid is the major extractable component of soil humic substances having dark brown to black in colour. Foliar application of humic acid in leguminous plants has remarkable effects on growth of plant by increasing leaf area index which in turn increases photosynthetic activity (Ghorbani *et al.,* 2010). Humic acid stimulates plant growth by the assimilation of major and minor elements, enzyme activation or inhibition, changes in membrane permeability and protein synthesis (Ulukan, 2008). Humic acid is also known to increase the plant growth through chelating different nutrients resulting in increase in production and quality of agricultural products through production of hormonal compounds (Albayrak and Camas, 2005).

Material and Methods

Field experiment was conducted at College of Agriculture, Vishweshwaraiah Canal Farm, Mandya during *kharif* 2017. It falls under the region III and agro climatic zone VI (Southern dry zone) of Karnataka. Geographically the experimental site was located at 12^o 34.31' North latitude and 76^o 49.8' East longitude at

697 meter above mean sea level. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 13 treatments replicated thrice. Treatments included are T_1 = Control (No spray), T_2 = Foliar spray of 1.0% Calcium nitrate at flower initiation, T_3 = Foliar spray of 2.0% Calcium nitrate at flower initiation, T_4 = Foliar spray of 0.25% borax at flower initiation, T_5 = Foliar spray of 0.50% borax at flower initiation, T_6 = Foliar spray of humic acid 4 ml L^{-1} at flower initiation, T_7 = Foliar spray of humic acid 6 ml L^{-1} at flower initiation, T_8 = Foliar sprays of 1.0% Calcium nitrate each at flower initiation and 15 days after flower initiation, T_9 = Foliar sprays of 2.0% Calcium nitrate each at flower initiation and 15 days after flower initiation, T_{10}= Foliar sprays of 0.25% borax each at flower initiation and 15 days after flower initiation, T_{11} = Foliar sprays of 0.50% borax each at flower initiation and 15 days after flower initiation, T_{12} = Foliar sprays of humic acid 4 ml L^{-1} each at flower initiation and 15 days after flower initiation and T_{13} = Foliar sprays of humic acid 6 ml L^{-1} each at flower initiation and 15 days after flower initiation [Note : Recommended dose of fertilizer and FYM (as per University of Agricultural Sciences, Bengaluru, package of practice) are same to all the treatments. Commercial grade 12% Humic acid was used].

Results and Discussion

Growth parameters

Plant height

The data on plant height (cm) of transplanted pigeonpea as influenced by foliar application of calcium nitrate, borax and humic acid at different growth stages.

Significantly higher plant height (307.33 cm) were recorded for the treatment with foliar spray of humic acid 6 ml L^{-1} at FI and 15 days after flowering initiation along with RDF and FYM (T_{13}) at harvest which was on par with the treatment T_9 (304 cm) foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM. Significantly lower plant height (268.67 cm) were recorded in control (T_1) with RDF and FYM at harvest.

Number of primary branches per plant

The data presented in the Table 1 indicates influence of foliar application of calcium nitrate, borax and humic acid on number of primary branches per plant of transplanted pigeonpea at harvest.

Foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) recorded significantly higher number of primary branches per plant (28.67) at harvest, which was on par with the treatment T_9 (28.5) foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM. Significantly lower number of primary branches per plant (20.8) at harvest were recorded in control (T_1).

Number of secondary branches per plant

The data on number of secondary branches per plant of transplanted pigeonpea as influenced by foliar application of calcium nitrate, borax and humic acid at harvest presented in Table 1.

Treatment T_{13} (foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM) recorded significantly higher number of secondary branches per plant (40.33) at harvest, which was on par with the treatment T_9 (37.33) foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM. Control T_1 recorded significantly lower number of secondary branches per plant (26.0) at harvest.

Leaf area per plant (cm^2)

The data presented in the Table 1 indicates that there was significant difference in leaf area per plant at harvest.

Significantly higher leaf area per plant (5110.33 cm^2) was recorded for the treatment with foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after FI along with RDF and FYM (T_{13}) at harvest, which was on par with the treatment T_9 (5007.33 cm^2) foliar spray of 2.0% $Ca(NO_3)_2$ at flowering initiation and 15 days after flowering initiation along with RDF and FYM. Significantly lower leaf area per plant (3999.00 cm^2) was recorded in control (T_1) at harvest.

Total dry matter production per plant (g)

The data presented in the Table 1 indicates that there was significant difference was observed in total dry matter production per plant at harvest.

Foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) recorded significantly higher total dry matter production per plant (436.67 g) at harvest, which was on par with the treatment T_9 (434.67 g) foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM. Significantly lower total dry matter production per plant (345.67 g) was recorded in control (T_1) at harvest.

The growth parameters of transplanted pigeonpea *viz*., plant height, number of primary branches per plant, number of secondary branches per plant**,** leaf area and total dry matter production per plant varied significantly due to foliar application of calcium nitrate, borax and humic acid. The highest plant height (307.33 cm), number of primary branches per plant (28.67), number of secondary branches per plant (40.33)**,** leaf area (5110.33 cm^2 $plant^{-1}$) and total dry matter production per plant (436.67 g) at harvest was recorded in treatment T_{13} (foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM). The results were in line with the findings of Meena *et al.,* (2017) who have reported that foliar application of humic acid at 60-90 DAS, at the time of flowering and pod development stage significantly increased the growth parameters of pigeonpea. This may be attributed to the remarkable effects of foliar application of humic acid on growth of leguminous plants which increases the leaf area index and photosynthetic activity (Ghorbani *et al.*, 2010).

The growth parameters of treatment T_9 (foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM) were on par with the treatment $T_{13.}$ The improvement in the growth parameters on foliar application of $Ca(NO_3)_2$ is probably due to high production of photosynthates leading to increased availability, absorption and translocation of nutrients (Raj and Mallick, 2017). The similar findings of significant increase in growth due to foliar application of $Ca(NO_3)_2$ was also reported by Deotale *et al.,* (2015) and Sarkar and Pal (2006) in green gram.

Yield parameters

Pod length (cm)

The data on pod length (cm) as influenced by foliar application of calcium nitrate, borax and humic acid is presented in Table 2.

Significantly higher pod length (7.23 cm) was recorded for the treatment with foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) over the control (6.07 cm). However, it was found to be on par with the treatment T_9 (7.13 cm) foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM, T_{11} (7.03 cm) foliar spray of 0.50% borax at flower initiation and 15 days after flower initiation along with RDF and FYM, T_8 (6.98 cm) foliar spray of 1.0% $Ca(NO_3)_2$ at flower initiation and 15 days after FI along with RDF and FYM, T_3 (6.95 cm) foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation along with RDF and FYM and T_7 (6.9 cm) foliar spray of humic acid 6 ml L^{-1} at flower initiation along with RDF and FYM.

Number of pods per plant

The data presented in the Table 2 indicates influence of foliar application of calcium nitrate, borax and humic acid on number of pods per plant.

Foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) recorded significantly higher number of pods per plant (190.33). Significantly lower number of pods per plant (148.33) was recorded in Control (T_1).

Number of seeds per pod

The data on number of seeds per pod as influenced by foliar application of calcium nitrate, borax and humic acid is presented in Table 2.

Treatment T_{13} (foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM) recorded significantly higher number of seeds per pod (5.57) over T_1, T_2, T_3, T_4, T_5 and T_6. However, which was on par with the treatment T_{11} (5.30) foliar spray of 0.50 % borax at flower initiation and 15 days after flower initiation along with RDF and FYM, treatment T_9 (5.27) foliar spray of 2% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM, treatment T_{12} (5.27) foliar spray of humic acid 4 ml L^{-1} at FI and 15 days after flower initiation along with RDF and FYM, treatment T_8 (5.23) foliar spray of 1.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM, treatment T_{10} (5.22) foliar spray of 0.25% borax at FI and 15 days after FI along with RDF and FYM and treatment T_7 (5.22) foliar spray of humic acid 6 ml L^{-1} at flower initiation along with RDF and FYM. Control treatment T_1 (RDF and FYM) recorded significantly lower number of seeds per pod (4.67).

Pod weight per plant (g)

The data presented in the Table 2 indicates influence of foliar application of calcium nitrate, borax and humic acid on pod weight per plant.

Significantly higher pod weight per plant (143 g) was recorded for the treatment with foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}), followed by the treatment T_{11} foliar spray of 0.50% borax at flower initiation and 15 days after flower initiation along with RDF and FYM (136.33 g). Significantly lower pod weight per plant (106 g) was recorded in control (T_1).

Table.1 Effect of foliar application of calcium nitrate, borax and humic acid on growth parameters of transplanted pigeon pea at harvest.

Treatments		Plant height (cm)	Number of Primary branches / plant	Number of Secondary branches / plant	leaf area per plant (cm^2)	Total dry matter production (g)
T_1	Control (No spray)	268.67	20.80	26.00	3999.00	345.67
T_2	FS of 1.0% $Ca(NO_3)_2$ at FI	283.67	23.00	29.67	4262.67	368.00
T_3	FS of 2.0% $Ca(NO_3)_2$ at FI	294.00	25.83	33.00	4666.67	404.52
T_4	FS of 0.25% borax at FI	279.33	22.83	29.00	4189.67	366.61
T_5	FS of 0.50% borax at FI	286.00	24.17	31.00	4516.67	398.85
T_6	FS of HA 4 ml L^{-1} at FI	284.33	23.33	30.17	4480.00	390.00
T_7	FS of HA 6 ml L^{-1} at FI	293.67	25.50	32.83	4655.00	403.00
T_8	FS of 1.0% $Ca(NO_3)_2$ at FI and 15 days after FI	294.33	26.00	33.50	4674.00	409.67
T_9	FS of 2.0% $Ca(NO_3)_2$ at FI and 15 days after FI	304.00	28.50	37.33	5007.33	434.67
T_{10}	FS of 0.25% borax at FI and 15 days after FI	288.00	25.00	32.67	4625.00	401.29
T_{11}	FS of 0.50% borax at FI and 15 days after FI	295.33	26.17	34.00	4746.33	417.00
T_{12}	FS of HA 4 ml L^{-1} at FI and 15 days after FI	294.67	26.17	33.83	4700.33	412.41
T_{13}	FS of HA 6 ml L^{-1} at FI and 15 days after FI	307.33	28.67	40.33	5110.33	436.67
S.Em ±		**2.92**	**0.61**	**0.90**	**42.83**	**5.58**
CD @ 5%		**8.53**	**1.79**	**2.63**	**125.03**	**16.3**

FS : Foliar spray FI : Flower initiation HA : Humic acid

Table.2 Effect of foliar application of calcium nitrate, borax and humic acid on yield and yield parameters of transplanted pigeon pea at harvest.

Treatments		Yield parameters					Yield		
		Pod length (cm)	No. of pods / plant	No of seeds / pod	Pod weight / plant (g)	100 seed weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
T_1	Control (No spray)	6.07	148.33	4.67	106.00	10.60	1540.00	6381.00	0.195
T_2	FS of 1.0% $Ca(NO_3)_2$ at FI	6.78	155.67	4.93	113.33	11.02	1670.00	6749.00	0.198
T_3	FS of 2.0% $Ca(NO_3)_2$ at FI	6.95	163.00	5.15	120.67	11.38	1703.00	6966.00	0.197
T_4	FS of 0.25% borax at FI	6.41	156.67	4.93	114.00	11.22	1673.00	6663.00	0.201
T_5	FS of 0.50% borax at FI	6.52	163.00	5.13	120.67	11.57	1700.00	6821.00	0.200
T_6	FS of HA 4 ml L^{-1} at FI	6.47	158.33	5.10	115.33	11.35	1693.00	6705.00	0.202
T_7	FS of HA 6 ml L^{-1} at FI	6.90	164.67	5.22	121.67	11.59	1740.00	6900.00	0.201
T_8	FS of 1.0% $Ca(NO_3)_2$ at FI and 15 days after FI.	6.98	165.33	5.23	122.00	11.63	1766.00	7066.00	0.200
T_9	FS of 2.0% $Ca(NO_3)_2$ at FI and 15 days after FI.	7.13	174.33	5.27	129.67	11.93	1836.00	7350.00	0.199
T_{10}	FS of 0.25% borax at FI and 15 days after FI.	6.56	164.67	5.22	121.00	11.58	1716.00	6883.00	0.200
T_{11}	FS of 0.50% borax at FI and 15 days after FI.	7.03	181.33	5.30	136.33	11.97	1956.00	7153.00	0.215
T_{12}	FS of HA 4 ml L^{-1} at FI and 15 days after FI.	6.60	167.33	5.27	123.33	11.86	1800.00	7126.00	0.202
T_{13}	FS of HA 6 ml L^{-1} at FI and 15 days after FI.	7.23	190.33	5.57	143.00	12.04	2093.00	7428.00	0.220
S.Em ±		**0.13**	**2.37**	**0.12**	**2.14**	**0.11**	**44.12**	**92.73**	**0.006**
CD @ 5%		**0.37**	**6.93**	**0.35**	**6.26**	**0.34**	**128.77**	**270.66**	**NS**

FS : Foliar spray FI : Flower initiation HA : Humic acid

Table.3 Economics of foliar application of calcium nitrate, borax and humic acid in transplanted pigeon pea.

Treatments		Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs.ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1	Control (No spray)	42166.00	61746.00	19579.00	1.46
T_2	FS of 1.0% $Ca(NO_3)_2$ at FI	43241.00	66834.00	23593.00	1.55
T_3	FS of 2.0% $Ca(NO_3)_2$ at FI	43916.00	68210.00	24293.00	1.55
T_4	FS of 0.25% borax at FI	42573.00	66918.00	24345.00	1.57
T_5	FS of 0.50% borax at FI	42580.00	68010.00	25430.00	1.60
T_6	FS of HA 4 ml L^{-1} at FI	44006.00	67699.00	23693.00	1.54
T_7	FS of HA 6 ml L^{-1} at FI	44726.00	69570.00	24843.00	1.56
T_8	FS of 1.0% $Ca(NO_3)_2$ at FI and 15 days after FI.	44116.00	70666.00	26550.00	1.60
T_9	FS of 2.0% $Ca(NO_3)_2$ at FI and 15 days after FI.	45466.00	73088.00	27622.00	1.61
T_{10}	FS of 0.25% borax at FI and 15 days after FI.	42780.00	68675.00	25894.00	1.61
T_{11}	FS of 0.50% borax at FI and 15 days after FI.	42793.00	77930.00	35136.00	1.82
T_{12}	FS of HA 4 ml L^{-1} at FI and 15 days after FI.	45646.00	71963.00	26316.00	1.58
T_{13}	FS of HA 6 ml L^{-1} at FI and 15 days after FI.	47086.00	83260.00	36174.00	1.77

FS : Foliar spray FI : Flower initiation HA : Humic acid

100 seed weight (g)

The data presented in the Table 2 indicates influence of foliar application of calcium nitrate, borax and humic acid on 100 seed weight of transplanted pigeonpea seed.

Foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) recorded significantly higher 100 seed weight (12.04 g), which was on par with the treatment T_{11} foliar spray of 0.50% borax at flower initiation and 15 days after FI along with RDF and FYM (11.97 g), treatment T_9 foliar spray of 2.0% $Ca(NO_3)_2$ at flower initiation and 15 days after flower initiation along with RDF and FYM (11.93 g) and with treatment T_{12} foliar spray of humic acid 4 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (11.86 g). Significantly lower 100 seed weight (10.6 g) was recorded in control.

Yield

Grain yield (kg ha^{-1})

The data on grain yield (kg ha^{-1}) as influenced by foliar application of calcium nitrate, borax and humic acid is presented in Table 2.

Significantly higher grain yield (2093.00 kg ha^{-1}) was recorded for the treatment with foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}), followed by the treatment T_{11} (1956.00 kg ha^{-1}) foliar spray of 0.50% borax at flower initiation and 15 days after flower initiation along with RDF and FYM. Significantly lower grain yield (1540.00 kg ha^{-1}) was recorded in control (T_1) with RDF and FYM, followed by the treatment (1670.00 kg ha^{-1}) with foliar spray of 1.0% $Ca(NO_3)_2$ at flower initiation along with RDF and FYM.

Stover yield (kg ha^{-1})

The data presented in the Table 2 indicates influence of foliar application of calcium nitrate, borax and humic acid on stover yield (Kg ha^{-1}).

Foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) recorded significantly higher stover yield (7428.00 kg ha^{-1}), which was on par with T_9 (7350.00 kg ha^{-1}) foliar spray of 2.0% $Ca(NO_3)_2$ at FI and 15 days after flower initiation along with RDF and FYM, followed by T_{11}(7153.00 kg ha^{-1}) foliar spray of 0.50% borax at flower initiation and 15 days after flower initiation along with RDF and FYM. Control (T_1) with RDF and FYM recorded significantly lower stover yield (6381.00 kg ha^{-1}), followed by T_4 (6663.33 kg ha^{-1}) foliar spray of 0.25% borax at FI along with RDF and FYM.

Harvest index

The data on harvest index as influenced by foliar application of calcium nitrate, borax and humic acid is presented in Table 2.

Harvest index did not differ significantly among the treatments. However, numerically higher harvest index (0.22) was recorded in Treatment T_{13} (foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM). Control treatment T_1 (RDF and FYM) recorded lowest harvest index (0.195).

The foliar application of calcium nitrate, borax and humic acid significantly enhanced the grain and stover yield of transplanted pigeonpea. The present study indicated higher grain and stover yield of transplanted pigeonpea (2093.00 and 7428.00 kg ha^{-1} respectively) due to the foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}). The stover yield of T_{13} treatment was on par with treatment T_9 (7350.0 kg ha^{-1}). Application of humic acid significantly increased the growth and yield parameters, this may be attributed to better nutrient translocation which in turn lead to better cell division, cell elongation and also increased the chlorophyll content thus increased the photosynthetic activity, growth and yield as confirmed by Thakur *et al.,* (2013).

In the present investigation the higher yield due to foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) is probably due to humic acid delayed the senescence of leaves thus resulting in the increased the leaf area per plant (5110.33 cm^2) which in turn lead to better photosynthesis and translocation of photosynthates to the reproductive parts. It also reduced the flower drop as evidenced by increased number of pods per plant (190.33) and higher number of seeds per plant (5.57). Humic acid also increased the assimilation of photosynthates which is supported by increased 100 seed weight (12.04 g) and pod weight per plant (143 g). Thus the combined effect of all above mentioned parameters resulted in the highest yield due to foliar application of humic acid when compared to other treatments. Similar findings were also reported by Elayaraja *et al.,*

(2011) in bendhi, Ananthi *et al.,* (2012) in greengram and Gad El-Hak *et al.,* (2012) in peas.

Economics

The data on cost of cultivation, gross returns, net returns and B: C ratio as influenced by foliar application of calcium nitrate, borax and humic acid is presented table 3.

Cost of cultivation

Cost of cultivation of transplanted pigeonpea varied due to foliar application of calcium nitrate, borax and humic acid. Foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) recorded the higher cost of cultivation (Rs. 47086.00 ha^{-1}), followed by the treatment T_{12} (Rs. 45646.00 ha^{-1}) foliar spray of humic acid 4 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM and the lower cost of cultivation (Rs. 42166.00 ha^{-1}) was recorded in control.

Gross returns

Among different treatments foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{13}) recorded the higher gross returns (Rs. 83260.00 ha^{-1}) and the control treatment recorded the lower gross returns (Rs. 61745.0 ha^{-1}).

Net returns

Net returns were lowest (Rs. 19579.00 ha^{-1}) in the control treatment whereas the highest (Rs. 36174.00 ha^{-1}) net returns was noticed in foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM.

B:C ratio

Different foliar application treatments influenced the B:C ratio, foliar spray of 0.50% borax at flower initiation and 15 days after flower initiation along with RDF and FYM (T_{11}) recorded the higher B:C ratio (1.82), followed by the treatment T_{13} foliar spray of humic acid 6 ml L^{-1} at flower initiation and 15 days after flower initiation along with RDF and FYM (1.77). The lower B:C ratio was obtained in control (1.46).

The economic analysis revealed that, The higher B:C ratio (1.82) was obtained in foliar spray of 0.50% borax at flower initiation and 15 days after flower initiation along with RDF and FYM. The lower B:C ratio was obtained in control (1.46). Highest B:C ratio in T_{11} is due to lower cost of borax as compared to humic acid.

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