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Effect of foliar nutrition on yield, quality and economics of pigeonpea [*Cajanus cajan* (L.) Mill sp.]

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Abstract

Pigeonpea is the most important rainfed pulse crop of Karnataka. Yield of pigeonpea is decreasing due to flower drop and poor pod setting under vulnerable climatic situation. Field experiment was conducted to the study growth and yield of pigeonpea as influenced by nutrients and plant growth regulators. The experiment consisted of foliar application of two types of nutrients (19:19:19 and Pulse magic), two growth promoters (NAA, and N - Triacontanol) and their combinations at flowering and pod formation stages. The growth and yield attributes were varied significantly and RDF + foliar application of 1% pulse magic at flowering and pod formation stage recorded higher plant height (144.6 cm), number of branches (16.8 plant^{-1}), leaf area (3218 cm^2 plant^{-1}), total dry matter accumulation (135.5 g plant^{-1}), absolute growth rate (0.812 g plant^{-1} day^{-1}), crop growth rate (5.19 g m^{-2} day^{-1}) and relative growth rate (0.010 g g^{-1} day^{-1}) as compared to control (122.2 cm, 12.9, 2421 cm^2 plant^{-1}, 89.4 g plant^{-1}, 0.633 g plant^{-1} day^{-1}, 4.24 g m^{-2} day^{-1} and 0.007 g g^{-1} day^{-1}, respectively) at harvest. Higher seed yield (1590 kg ha^{-1}), stalk yield (4308 kg ha^{-1}) and harvest index (0.26) recorded with the application of RDF + foliar application of 1% pulse magic at flowering and pod formation stage and lower seed yield, stalk yield and harvest index (1104 kg ha^{-1}, 3416 kg ha^{-1} and 0.23, respectively) was recorded with control treatment.

Keywords: Pigeonpea, pulse magic, NAA, N-Triacontanol, 19:19:19

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.], also referred as redgram holds the distinction of being the fifth most notable legume crop on a global scale. It stands as a significant member of the pulse family, securing the second position in India's agricultural landscape after chickpea, both in terms of area and production. A staggering 90 percent of the world's pigeonpea output is attributed to India, solidifying its virtual monopoly in the production of this crop. In India, Pigeonpea occupies 90 percent of area and 85 percent of pulse production. It is grown in an area of 47.17 lakh hectares, producing 41.37 lakh tons annually with the productivity of 877 kg ha^{-1} (Anon., 2022) [2]. Karnataka occupies second place next to Maharashtra in production (11.74 lakh tons) with a productivity of 737 kg ha^{-1} which is nearer to the national average of 877 kg ha^{-1} (Anon., 2022) [2].

Pulses are the major protein source in the vegetarian diet. Furthermore, in recent years consumption of pulses has noticeably increased as they are considered healthy foods. Thus, the food legumes ensure nutritional security to the poor masses of the country which still encounter protein malnutrition. Pigeonpea is a rich source of protein, calcium, manganese, crude fiber, trace elements and minerals (Saxena *et al.*, 2010) [8]. It is the economical and easily accessible source of protein to bulk of the population. Compared to animal source of protein which is costly, heavy on environment and not relished by all. Additionally, pigeonpea functions as a soil ameliorant, improving the soil's fertility through leaf litter and biological nitrogen fixation (Udhaya *et al*., 2015) [15]. The dried split seeds as dal and fresh pods are used by humans, leaves and husk is used as feed for animals and stem portion used for vermicomposting and also fuel.

Pigeonpea yield is low for a number of reasons, but one of the major causes is the high level of flower abscission (70–96%) as well as the lack of nutrients from flowering onwards to maintain photo synthetically active green leaves, which results in a significantly lower realisation of sink potential (Tekale *et al*., 2009) [13].

Further, as the photosynthates from leaves moves to sink, the leaves turn weak and fall down reducing the photosynthate production when it is required most. Its impact is seen directly on crop yield.

In the pursuit of elevating pigeonpea productivity, a range of approaches have been considered. Prominent among these strategies is the application of foliar nutrients and growth promoters, which have demonstrated their potential to play pivotal roles. The prominent effect of foliar application of nutrients and growth regulator at pre-flowering and pod development stage was on supplying the nutrient for sink development and reduction in flower shed/drop percentage (Sumathi *et al.*, 2018) [12]. Application of nutrients through foliar sprays in addition to soil application, there are many benefits to augmenting crop dietary demands. It is intended to correct the natural deficiencies quickly and remove issues such as fixation of nutrients and immobilization in soil. Therefore, foliar nutrition is identified as an important fertilization strategy in present agriculture (Chaurasia *et al.*, 2005) [3]. The present experiment was conducted to study the influence of foliar application of nutrients (Macro and micro), growth regulators on yield, quality and economics of pigeonpea

Materials and Methods

The field experiment was conducted during *Kharif* 2022 at 'K' Block, Zonal Agricultural Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru. The experimental site belongs to Eastern Dry Zone (Zone-V) of Karnataka and located between 12º 51' N Latitude and 77º 35' E Longitude at an altitude of 930 m above mean sea level (MSL). The soil of the experiment site is red sandy loam (Soil pH 6.08; EC 0.19 dSm^{-1}). The available soil nitrogen, phosphorus and potassium were 280.2, 26.1 and 257.5 kg ha^{-1}, respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with 8 treatments. The treatments *viz.*, foliar application of 0.5% pulse magic at flowering stage (T_1), foliar application of 0.5% pulse magic at flowering and pod formation stage (T_2), foliar application of 1% pulse magic at flowering stage (T_3), foliar application of 1% pulse magic at flowering and pod stage (T_4), foliar application of 2% water soluble fertilizer (19:19:19) + 0.05% NAA at flowering stage (T_5), foliar application of 2% water soluble fertilizer (19:19:19) + 0.05% NAA at flowering and pod formation stage (T_6), foliar application of 2% water soluble fertilizer (19:19:19) + 200 ppm N- Triacontanol at flowering stage (T_7) and Control (T_8) with 3 replications using BRG-5 variety with spacing of 90×15 cm. The recommended dose of fertilizer (NPK 25:50:25 kg ha^{-1}) is common for all the treatments.

Pulse magic is a product developed and released by UAS, Raichur for increasing the yield of pulse crops. It contains 10 percent nitrogen, 40 percent phosphorous, 3 percent micronutrients and 20 ppm plant growth regulator. The two sprays were taken up at 2 stages *viz.*, flowering and pod formation stage. Five plants were tagged at random in net plot area for recording growth and yield. Soil sample were collected from each plot from a depth of 15 cm, similarly plant sample from each treatment collected, processed and analyzed for nutrient status to know the available nutrient status and plant uptake.

Results and Discussion

Yield attributes of pigeonpea

The data related to yield attributes *viz.*, pod length, number of pods per plant, number of seeds per pod, pod yield per plant (g), seed yield per plant (g), stalk yield (g $plant^{-1}$), shelling percentage (%), seed index (g) and harvest index of pigeonpea as influenced by foliar nutrition are presented in Table 1. Application of RDF + foliar application of 1% pulse magic at flowering and pod formation stage (T_4) resulted in significantly higher pod length (8.1 cm), number of pods (105.2 $plant^{-1}$), number of seeds (5.6 pod^{-1}), pod yield (48.5 g $plant^{-1}$), seed yield (35.1 g $plant^{-1}$), stalk yield (114.1 g $plant^{-1}$) and seed index (16.8 g) and it was on par with T_3 and T_2, whereas lower pod length, number of pods per plant, number of seeds per pod, pod yield per plant, stalk yield per plant and seed index (6.2, 69.5, 4.1, 33.2, 22.5, 63.1 and 14.0, respectively) were recorded with application of RDF only (T_8). Foliar nutrition did not show significant difference in shelling percentage of pigeonpea. However, among the treatments, numerically higher shelling percentage recorded in T_4 (72.4%).

Table 1: Yield attributes of pigeonpea as influenced by foliar nutrition

Treatments	Pod length (cm)	No of pods $plant^{-1}$	No of seeds pod^{-1}	Pod yield (g $plant^{-1}$)	Seed yield (g $plant^{-1}$)	Stalk yield (g $plant^{-1}$)	Shelling percentage (%)	Seed index (g)
T_1: RDF + FA of 0.5% pulse magic @ flowering stage	7.1	80.5	5.0	38.3	26.6	76.6	69.5	15.1
T_2: RDF + FA of 0.5% pulse magic @ flowering and pod formation stage	7.5	88.3	5.2	41.6	29.5	93.0	70.6	15.4
T_3: RDF + FA of 1% pulse magic @ flowering stage	7.7	91.8	5.3	42.8	31.2	97.2	71.9	15.6
T_4: RDF + FA of 1% pulse magic @ flowering and pod formation stage	8.1	105.2	5.6	48.5	35.1	114.1	72.4	16.8
T_5: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering stage	6.4	74.7	4.3	36.4	24.9	69.0	68.4	14.8
T_6: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering and pod formation stage	7.4	86.8	5.0	41.5	28.9	86.0	69.6	15.0
T_7: RDF + FA of 2% WSF (19:19:19) + 200 ppm N-Triacontanol @ flowering stage	6.5	77.5	4.8	37.1	26.1	71.6	70.4	14.9
T_8: RDF (Control)	6.2	69.5	4.1	33.2	22.5	63.1	67.8	14.0
S.Em. ±	0.2	2.9	0.1	1.3	0.9	2.9	2.3	0.5
CD at 5%	0.7	8.8	0.5	4.1	2.9	9.0	-	1.5

Significant increase in yield attributes of pigeonpea due to foliage applied macro and micro nutrients at critical stages of crop were effectively absorbed and translocated to the developing pods which has also helped in better filling of seeds in pod. Foliar application of growth regulators at flowering and 15 days after first spray have helped for reducing flower drop and contributed more for reproductive parts resulting in increased number of pods per plant in pigeonpea (Raju *et al.*, 2016) [6]. Large sized pods mean higher pod length was observed in pulse magic foliar spray and it might be due to the application of nutrients at reproductive stage that helped in more translocation of photosynthates to the developing pods. Further increased pod size accommodated more number of seeds which were bold sized or seen by increased number of seeds per pod and test weight (Thakur *et al.*, 2017) [14]. The cumulative and conjunctive application of nutrients, the crop might have enjoyed with sufficient nutrient availability for a longer period of time and the nutrient uptake there by allowing the plant to perpetuate with all the yield components and yield. This result was in conformity with the findings of Mishra *et al.* (2012) [5] in chickpea and Subbarami *et al.* (2011) [10] in pigeonpea.

Seed yield, stalk yield, harvest index and crude protein yield of pigeonpea

The data pertaining to seed yield, stalk yield, harvest index and crude protein yield as influenced by foliar nutrition are presented in Table 2. Significantly higher seed yield (1590 kg ha^{-1}), stalk yield (4308 kg ha^{-1}) and crude protein (335.5 kg ha^{-1}) were recorded with foliar application of 1% pulse magic at flowering and pod formation stage (T_4), followed by foliar application of 1% pulse magic at flowering stage (1438 and 4060 kg ha^{-1}, respectively). The application of foliar nutrition on pigeonpea harvest index was found non-significant. A slight increase in harvest index was observed in foliar nutrition applied treatments. Considerably higher harvest index (0.26) was observed in T_4. Foliar nutrition during critical stages of crop growth enhanced photosynthetic activity and higher uptake of nutrients and there by increased plant dry matter production in the pod setting phase which might have improved the pod development and number of pods per plant and finally contributed for higher productivity. These results are in confirmation with the results of Jayarani *et al.* (2004) [4] in pigeonpea, Verma *et al.* (2009) [17] in chickpea and Amany (2007) in mung bean. Increased protein yield of pigeonpea may also because of the fact that involvement of nitrogen as well as micronutrients supplied by pulse magic which takes part in nitrate conversion to ammonia in plants, zinc sulphate also activates indole acetic acid which makes amino acid to protein. Similar results were observed with earlier findings of Setty *et al.* (1992) [9] in chickpea and Yadav and Choudhary (2012) [18] in cowpea.

Table 2: Influence of foliar nutrition on seed yield, stalk yield, crude protein yield and harvest index of pigeonpea

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index	Crude protein yield (kg ha^{-1})
T_1: RDF + FA of 0.5% pulse magic @ flowering stage	1286	3810	0.24	258.5
T_2: RDF + FA of 0.5% pulse magic @ flowering and pod formation stage	1411	3984	0.25	287.8
T_3: RDF + FA of 1% pulse magic @ flowering stage	1438	4060	0.25	296.2
T_4: RDF + FA of 1% pulse magic @ flowering and pod formation stage	1590	4308	0.26	335.5
T_5: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering stage	1226	3541	0.25	246.4
T_6: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering and pod formation stage	1351	3876	0.25	277.0
T_7: RDF + FA of 2% WSF (19:19:19) + 200 ppm N-Triacontanol @ flowering stage	1274	3591	0.25	259.9
T_8: RDF (Control)	1104	3416	0.23	218.6
S.Em. ±	45.4	93.93	0.01	9.3
CD at 5%	137.7	284.91	-	28.4

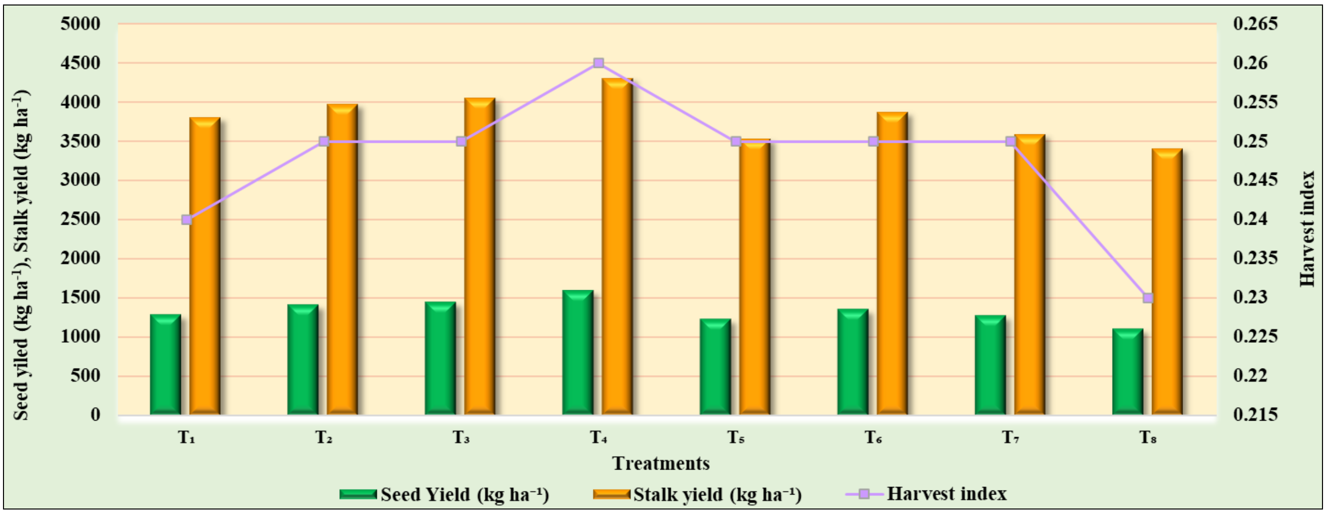

Fig 1: Influence of foliar nutrition on seed yield (kg ha^{-1}), stalk yield (kg ha^{-1}) and harvest index at harvest of pigeonpea

Available soil nutrient status

Table 3: Available N, P_2O_5 and K_2O in soil after harvest of the pigeonpea as influenced by pigeonpea

Treatments	4 Available N (kg ha^{-1})	4 Available P_2O_5 (kg ha^{-1})	4 Available K_2O 5 (kg ha^{-1})
T_1: RDF + FA of 0.5% pulse magic @ flowering stage	234.6	25.7	207.1
T_2: RDF + FA of 0.5% pulse magic @ flowering and pod formation stage	230.3	24.1	198.6
T_3: RDF + FA of 1% pulse magic @ flowering stage	224.5	23.4	192.5
T_4: RDF + FA of 1% pulse magic @ flowering and pod formation stage	221.9	22.1	188.2
T_5: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering stage	244.2	28.8	210.6
T_6: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering and pod formation stage	231.0	25.9	202.0
T_7: RDF + FA of 2% WSF (19:19:19) + 200 ppm N-Triacontanol @ flowering stage	236.6	28.1	208.3
T_8: RDF (Control)	254.9	32.5	212.9
S.Em.±	6.3	0.8	5.1
CD at 5%	19.3	2.4	15.6

Available nutrients in soil at harvest of the pigeonpea as influenced by foliar nutrition is presented in Table 3. Available nutrients in the soil was significantly affected due to the foliar nutrition. Higher available nitrogen (254.9 kg ha^{-1}), phosphorous (32.5 kg ha^{-1}) and potassium (212.9 kg ha^{-1}) were recorded with the treatment RDF (T_8). However, lower soil available nitrogen, phosphorous and potassium (221.9, 22.1 and 188.2 kg ha^{-1}, respectively) were observed with the application of RDF + foliar application of 1% pulse magic at flowering and pod formation stage (T_4). This was mainly due to lower nutrient absorption by pigeonpea in case of application of RDF only. Availability of nutrients in soil after harvest of pigeonpea was lower in the foliar application pulse magic as well as water soluble fertilizer compared to the soil application of fertilizers. The lesser quantity of soil available nutrients was due to more extraction of nutrients by pigeonpea crop (Sujatha, 2001) [11].

Nutrient uptake by the pigeonpea

Table 4: Influence of foliar nutrition on uptake of total nitrogen, phosphorous and potassium by pigeonpea

Treatments	Nutrient uptake (kg ha^{-1})		
	N	P	K
T_1: RDF + FA of 0.5% pulse magic @ flowering stage	98.5	17.0	83.0
T_2: RDF + FA of 0.5% pulse magic @ flowering and pod formation stage	109.1	19.0	86.5
T_3: RDF + FA of 1% pulse magic @ flowering stage	111.5	19.2	93.6
T_4: RDF + FA of 1% pulse magic @ flowering and pod formation stage	123.0	21.6	96.2
T_5: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering stage	91.9	14.3	80.2
T_6: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering and pod formation stage	107.6	18.2	89.0
T_7: RDF + FA of 2% WSF (19:19:19) + 200 ppm N-Triacontanol @ flowering stage	94.3	16.1	81.6
T_8: RDF (Control)	80.2	12.2	78.7
S.Em.±	3.4	0.5	2.8
CD at 5%	10.5	1.8	8.7

Total nutrient uptake (kg ha^{-1}) by the pigeonpea as influenced by different foliar nutrition is presented in Table 4. Nutrient uptake by the pigeonpea has shown significant difference due to foliar nutrition. Significantly higher nitrogen (123.0 kg ha^{-1}), phosphorous (21.6 kg ha^{-1}) and potassium (96.2 kg ha^{-1}) uptake was observed with the application of RDF + foliar application of 1% pulse magic at flowering and pod formation stage (T_4). Lower uptake of nitrogen, phosphorous and potassium (80.2, 12.2 and 78.7 kg ha^{-1}, respectively) was recorded with treatment control (T_8). Foliar application of pulse magic increased nitrogen uptake might be due to increased availability of nitrogen to the crop and higher biomass production and minimized the loss of chlorophyll and leaf nitrogen causing increased photosynthesis and increase nitrogen supply during flowering and pod filling stages of pigeonpea (Sathyamoorthi *et al.*, 2007) [7]. The increase in uptake of phosphorous and potassium has been attributed to the foliar spray of micro and macro nutrients and growth hormone, which increase the uptake of nutrients from soil and also increases metabolic activity in the plant cell. The results were in conjugation with Venkatesh and Basu (2011) in chickpea, urd bean and Mondal *et al.* (2011) in mung bean.

Economics of pigeonpea

Table 5: Cost of cultivation, Gross returns, Net returns and Benefit cost ratio of pigeonpea as influenced by foliar nutrition

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1: RDF + FA of 0.5% pulse magic @ flowering stage	37650	79610	41960	2.11
T_2: RDF + FA of 0.5% pulse magic @ flowering and pod formation stage	38448	85368	46920	2.21
T_3: RDF + FA of 1% pulse magic @ flowering stage	38278	87788	49510	2.29
T_4: RDF + FA of 1% pulse magic @ flowering and pod formation stage	39578	92148	52570	2.33
T_5: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering stage	38118	74109	35991	1.93
T_6: RDF + FA of 2% WSF (19:19:19) + 0.05% NAA @ flowering and pod formation stage	39258	81660	42402	2.12
T_7: RDF + FA of 2% WSF (19:19:19) + 200 ppm N-Triacontanol @flowering stage	38140	78079	39939	2.05
T_8: RDF (Control)	36918	36918	27322	1.74

Effect of foliar nutrition on economics of pigeonpea is described in Table 5 and Figure 1. Maximum cost of cultivation (Rs. 39578 ha^{-1}), gross returns (Rs. 92148 ha^{-1}), net returns (Rs. 52570 ha^{-1}) and B:C ratio (2.33) were recorded with the application of RDF + foliar application of 1% pulse magic at flowering and pod formation stage (T_4), whereas lower cost of cultivation, gross returns, net returns (Rs. 36918, Rs. 36918 and Rs. 27322 ha^{-1}, respectively) and B:C ratio (1.74) were recorded with treatment control (T_8). Though the soil application of fertilizers was economical, but they undergo various losses in soil and limited availability of nutrients was reflected in yield levels compared to foliar application. The gross returns and net returns of pigeonpea was higher due to more seed yield obtained because of foliar nutrition which enhanced greater availability of essential nutrients to plant, better translocation of photosynthates lead to higher stalk and grain yield.

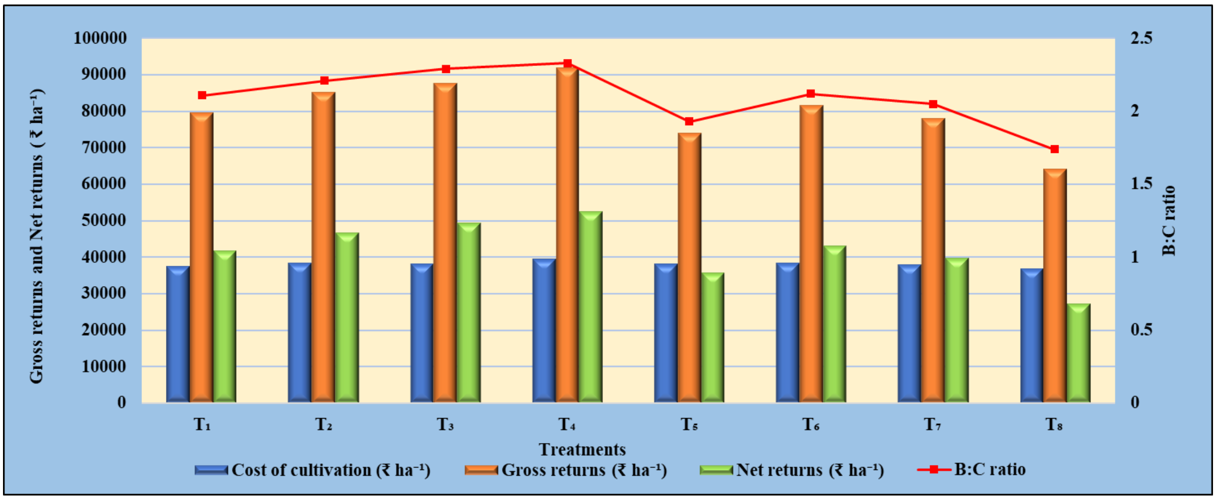

Fig 2: Influence of foliar nutrition on economics of pigeonpea cultivation

Conclusion

The present study was carried out to understand the influence of foliar nutrition on yield, quality, nutrient uptake and economics of pigeonpea. From this study, it is concluded that among the different treatments, foliar application of 1 percent pulse magic both at flowering and pod formation stage shows significantly higher seed yield, stalk yield, protein yield, nutrient uptake, net returns and BC ratio over the other treatments.

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