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Influence of distinct nutrient sources on growth, yield attributes, and yield of field bean (*Dolichos lablab* L.)

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Abstract
A field experiment was conducted during the summer of 2024 at the Agriculture Research Station, Nelamakanahalli, Chikkaballapur, Karnataka, India, to study the "Influence of distinct nutrient sources on growth, yield attributes, and yield of field bean (*Dolichos lablab* L.)". The experiment comprised eleven treatments laid out in a Randomized Complete Block Design with three replications. The objective was to assess the impact of various nutrient sources on the growth, yield attributes, and overall yield of field bean. The results revealed that the application of a 100% recommended dose of fertilizers combined with two sprays of nano-fertilizer at 30 and 45 days after sowing significantly enhanced plant height (71.03 cm), yield attributes *viz.*, number of pods per plant (23.91), pod length (5.23 cm), number of seeds per pod (3.95), and test weight (18.12 g). This treatment also achieved a higher seed yield (1139 kg ha^{-1}) and haulm yield (2114 kg ha^{-1}), outperforming all other nutrient sources and the absolute control. Conversely, the absolute control recorded the lower values for all measured parameters. In conclusion, the study demonstrates that applying 100% RDF combined with two nano-fertilizer sprays at 30 and 45 DAS is highly effective in enhancing the growth, yield attributes, and yield of field bean. This approach is best practice for maximizing productivity in field bean cultivation.

Keywords: Field bean, growth, nano-fertilizer, nutrient management, yield attributes, yield

Introduction
Field bean (*Dolichos lablab* L.), commonly known as lablab beans or hyacinth beans, is a significant leguminous crop that plays an essential role in global agriculture (Naeem *et al.*, 2020) [15]. These beans are highly valued for their rich nutritional profile, providing a substantial amount of protein, dietary fiber, and vital vitamins and minerals (Hayat *et al.*, 2014) [5]. Consequently, they contribute meaningfully to food security and nutritional needs, particularly in developing countries where protein sources may be limited. Furthermore, field beans are not only consumed directly as food but also serve as crucial livestock feed, thereby supporting the agricultural economy (Kebede, 2020) [12]. In addition to their nutritional importance, field beans play a pivotal role in enhancing soil fertility through the process of nitrogen fixation. This unique capability enables them to convert atmospheric nitrogen into a form usable by plants, enriching the soil for subsequent crops. This dual benefit provides food for humans and livestock while simultaneously improving soil health (Huang, 2024) [7].

The growth and yield of field beans are significantly influenced by various nutrient sources, which can be broadly categorized into organic and inorganic fertilizers. Effective nutrient management is a cornerstone of sustainable agriculture (Amanullah *et al.*, 2023) [1], particularly for legumes like field beans, which have specific nutritional requirements. The balance and interaction among key macronutrients, micronutrients, and other beneficial compounds are essential for maximizing growth and yield (Malvi, 2011) [14]. Moreover, the timing and method of nutrient application can significantly impact the growth dynamics of field beans. Agronomic practices can interact with environmental conditions to affect plant performance. Additionally, the choice of nutrient sources can have broader implications for soil health and sustainability (Powlson *et al.*, 2011) [16].

Organic amendments such as farmyard manure (FYM), panchagavya, and humic acid not only supply essential nutrients but also enhance soil structure and increase microbial activity. Improved soil health, characterized by better aeration, water retention, and nutrient cycling, is crucial for maintaining productivity over time. Recent advancements in nano-fertilizers further improve nutrient use efficiency, demonstrating the potential for integrating innovative practices into traditional farming methods (Iqbal *et al.*, 2019) [8]. Therefore, adopting a holistic approach to nutrient management that incorporates both organic and inorganic sources is vital for ensuring long-term agricultural sustainability and productivity while minimizing environmental impacts (Wu and Ma, 2018) [20]. This study aims to provide valuable insights into the effects of diverse nutrient management practices on the growth, yield attributes, and yield of field beans, ultimately contributing to the optimization of agricultural practices and the sustainability of farming systems.

Materials and Methods

The field experiment was conducted at the Agriculture Research Station, Nelamakanahalli, Chikkaballapur, during the summer of 2024. The site is situated in the Eastern Dry Zone (Zone-V) of Karnataka, located at an altitude of 930 m above mean sea level, with geographical coordinates of 13°37' N latitude and 77°82' E longitude. During the cropping period from January to April 2024, the area received a total rainfall of 269.6 mm, which was significantly lower than the normal by 560 mm. The soil at the experimental site was classified as red sandy loam under the *Alfisols* order. Before treatment imposition, composite soil samples were collected from a depth of 0 to 15 cm for analysis. The soil's physical and chemical properties indicated a pH of 6.32, electrical conductivity of 0.23 dS m^{-1}, 0.43 percent organic carbon, and available nutrient levels of 236.6 kg ha^{-1} nitrogen, 41.39 kg ha^{-1} phosphorus, and 224.5 kg ha^{-1} potassium. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. A total of eleven treatments were applied to field bean variety HA-5. The treatments included various combinations of recommended fertilizer doses and foliar sprays of nano fertilizer, pulse magic, panchagavya, and humic acid, along with absolute control. The plots measured 4.5 m x 3.0 m (gross size) and 3.6 m x 2.7 m (net size), with a spacing of 45 cm x 15 cm for planting. Fertilizer applications were based on the recommended dose of 25:50:25 kg NPK ha^{-1}, with adjustments according to the treatment groups. Foliar nutrition was administered at 30 and 45 days after sowing (DAS).

Seeds of the HA-5 variety were sown on 21st January 2024, with one to two seeds placed per hill in furrows opened at the specified spacing. Manual thinning was performed to maintain optimal plant density by removing excess seedlings, and gap filling was conducted by dibbling seeds into larger gaps. Hand weeding was carried out at 30 DAS to keep the plots free from weeds. To protect the seedlings from diseases and pests, fungicide carbendazim was applied at 2 g L^{-1} at the seedling stage, followed by sprays of Chlorantraniliprole and Chlorpyrifos at 65 and 85 DAS, respectively. The harvesting of the field beans occurred on 30th April when the pods had matured and turned golden yellow colour.

Biometric observations

Observation on the plant height of field bean was recorded at 30 and 60 days after sowing (DAS) and at harvest. Plant height was measured from the base to the tip of the plant, with the average height calculated from five randomly selected plants and expressed in centimeters. For yield parameters, five tagged plants from the net plot area were harvested at physiological maturity to record various yield components and seed yield. The number of pods per plant was determined by counting and averaging the number of pods from the five tagged plants. Pod length was assessed by measuring the lengths of five pods, with the mean expressed in centimeters. The number of seeds per pod was calculated by counting seeds from ten representative pods and dividing this total by the number of pods to obtain the average. Test weight was determined by counting and weighing 100 seeds from the samples collected from each net plot and expressed in grams. Seed yield was calculated by threshing and cleaning the pods from each net plot, with the resulting seed weight converted to kg ha^{-1}. Additionally, haulm yield was obtained by drying and weighing the plants from the net plot after threshing, also expressed as kg ha^{-1}. The harvest index (HI) was calculated by dividing the economic yield by the biological yield to assess the efficiency of the crop in converting biomass into harvestable yield.

Results and Discussion

Plant height

The data on plant height at 30, 60 DAS, and harvest of field bean as influenced by application of different sources of nutrients are presented in Table 1 and Fig 1. Initially, at 30 DAS there was a significant difference in plant height among the treatments. Basal dose application of 100% RDF treatments showed significantly higher plant height compared to 75% RDF and 50% RDF and lower plant height was recorded in absolute control. At 60 DAS, plant height was significantly influenced by foliar application of different sources of nutrients. Application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS recorded significantly higher plant height (50.21 cm) which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (47.75 cm). Whereas, lower plant height was recorded in absolute control (35.98 cm). At the time of harvest, application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS recorded significantly higher plant height (71.03 cm) which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (69.97 cm). Whereas, lower plant height was recorded in absolute control (50.85 cm). The increase in plant height after 30, 60 DAS, and at harvest might be due to sufficient availability of basal dose of fertilizers along with foliar application nano fertilizer at later stages (Janmohammadi *et al.*, 2016) [10]. The combination of Nano DAP, Nano-K, and Nano-Zn significantly boosts plant height due to their higher permeability and rapid absorption through plant leaves. This enhanced nutrient uptake promotes root development with Nano DAP supplying essential nitrogen and phosphorus, while Nano-K provides potassium for water regulation and enzyme activation. While, Nano-Zinc supports enzymatic reactions and hormone regulation (Kaur *et al.*, 2024) [11]. Together, these nano fertilizers improve photosynthetic efficiency and increase chlorophyll content, leading to greater energy production. This targeted foliar application ensures timely nutrient delivery, stimulating meristematic tissue activity and enhancing auxin production, which drives cell division and expansion for vigorous growth.

Table 1: Plant height of field bean at different growth stages as influenced by the application of different sources of nutrients

	Treatment	Plant Height (Cm)		
		30 DAS	60 DAS	At harvest
T_1	100% RDF	19.05	44.21	65.16
T_2	100% RDF + 2 Sprays of nano fertilizer	19.53	50.21	71.03
T_3	100% RDF + 2 Sprays of pulse magic @ 1%	19.24	47.75	69.97
T_4	75% RDF + 2 Sprays of nano fertilizer	17.23	44.12	64.73
T_5	75% RDF + 2 Sprays of pulse magic @ 1%	16.01	43.39	62.04
T_6	50% RDF + 2 Sprays of nano fertilizer	15.82	42.79	61.49
T_7	50% RDF + 2 Sprays of pulse magic @ 1%	15.23	41.53	61.26
T_8	100% RDF + 2 sprays of panchagavya @ 3%	19.10	44.78	66.85
T_9	100% RDF + 2 sprays of humic acid @ 0.1%	19.08	44.19	63.95
T_{10}	FYM @ 7.5 t ha^{-1} + 2 Sprays of nano fertilizer	14.95	40.95	60.23
T_{11}	Absolute control	13.43	35.98	50.85
	F-test	*	*	*
	S.E.M. ±	0.73	1.78	1.30
	CD @ 5%	2.14	5.23	3.81

Note: RDF – 25:50:25 kg NPK ha^{-1}, Foliar spray done at 30 and 45 DAS, Nano fertilizer (Nano DAP @ 4 ml L^{-1} + Nano-K @ 4 ml L^{-1} + Nano-Zn @ 2 ml L^{-1}), '*' indicates significant at 5% C.D. value

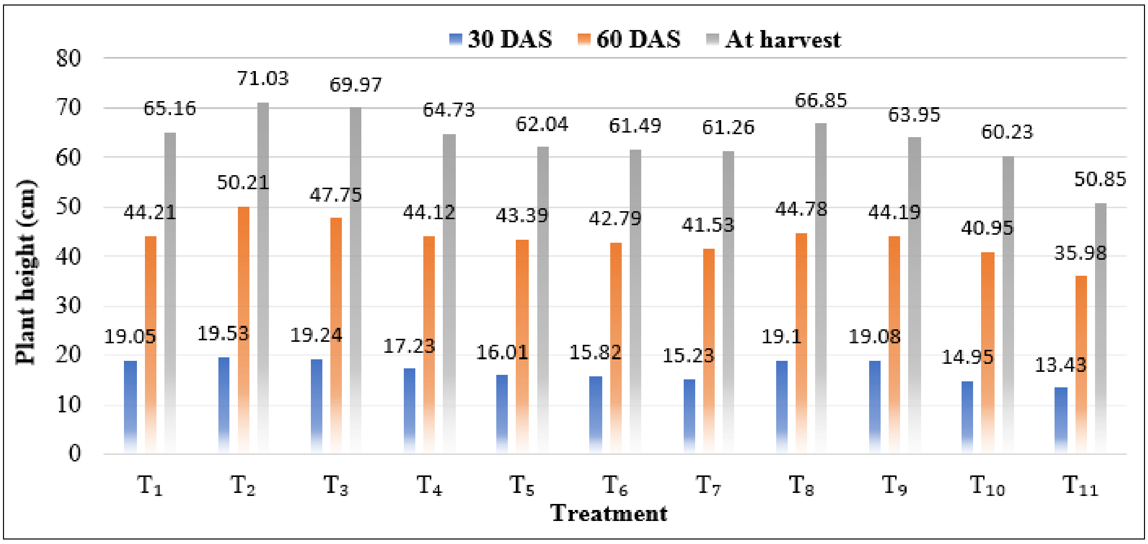

Fig 1: Plant height of field bean at different growth stages as influenced by the application of different sources of nutrients

Yield attributes and Yield

The data on yield attributes of field bean *viz*., number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, test weight, seed yield, haulm yield, and harvest index were influenced by different sources of nutrients are presented in Tables 2 and 3, and Fig. 2 and 3.

Number of pods per plant

At the time of harvest, a significantly higher number of pods $plant^{-1}$ (23.91) were observed under the application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (22.40) on other hand, a significantly lower number of pods $plant^{-1}$ (19.2) were observed with absolute control (13.72). The increase in number of pods might be due to basal application of 100% RDF which supports the crop to good establishment and development up to the grand vegetative growth period (Singh *et al*., 2014) [18] and subsequent application of foliar nutrition of nano fertilizers at 30 and 45 DAS and thereafter, the nano DAP, nano-K and nano-Zinc supplied to the crop in a balanced way and these nano sized particles have the massive surface area and possess smart delivery system *i.e*., controlled release pattern of nutrients making the leaf surface more vulnerable to spraying the fertilizer and then absorbing the element more by the leaves thereby providing sufficient nutrition to the crop at flowering and pod setting stages of the crop (Solanki *et al*., 2015) [19], increasing the speed of transport of photosynthates from their source to the sink in the plant during the reproductive phase and this was reflected in the increase in the number of pods $plant^{-1}$.

Pod length

Significantly, higher pod length (5.23 cm) was observed with the application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (5.08 cm). Whereas lower pod length (3.54 cm) was recorded in absolute control. The increase in a trait of pod length with nano DAP, nano-K and nano-Zinc may be due to the increase in leaf area and chlorophyll content in the leaves followed by an increase in the division and elongation of their cells, which was reflected in increasing the length of the pod (Mahmoud, 2023) [13].

Number of seeds per pod

The effect of different sources of nutrients on the number of seeds per pod was found significant. A higher number of seeds pod^{-1} (3.95) were recorded with the application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (3.77). Whereas, a lower number of seeds pod^{-1} (2.85) was observed with the absolute control. This might be due to the positive effect of nitrogen in increasing the percentage of pod fertilization reflected positively in increasing the number of seeds per pod (Goudsmit *et al.*, 2023) [4]. The role of nano fertilizers in increasing vegetative growth, providing adequate nutrients, which contributes to increasing the amount of interception of light, thus increasing photosynthesis, then increase the amount of photosynthesis (Faridvand *et al.*, 2021) [3], which plants benefit from in forming their other parts, contributes to the lack of competition and abortion, which led to an increase in the number of seeds per pod.

Test weight

The test weight results were non-significant among the treatments. However, numerically higher test weight (18.12 g) was found with the application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS followed by 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (18.08 g). However, a lower test weight (16.89 g) was recorded with absolute control.

Seed yield

The seed yield (kg plot^{-1}) of field bean was affected significantly due to different sources of nutrients. The higher seed yield (1.107 kg plot^{-1}) was noticed with the application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (1.036 kg plot^{-1}) and significantly lower seed yield (0.319 kg plot^{-1}) was noticed with the absolute control. Further, on a hectare basis, the seed yield of field bean affected significantly due to different sources of nutrients. The higher seed yield (1139 kg ha^{-1}) was noticed with application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (1067 kg ha^{-1}) and significantly lower seed yield (403.7 kg ha^{-1}) was noticed with the absolute control. Higher seed yield in 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS of plants is mainly attributable due to the synergistic effect of conventional soil applied urea and foliar applied nano fertilizers which enhanced the uptake of nutrients. Foliar treatment is more effective as it comes into direct touch with the leaves and is taken up by the target organs, resulting in a more targeted and immediate response (Hoang *et al.*, 2022) [6]. Nano fertilizers are more reactive and may pierce the cuticle, allowing for regulated release and delivery, and nitrogen being a component of many amino acids is believed to help in cell division and expansion strengths sink capacity and acquire more photosynthates. As pulse crops are highly prone to greater extent of flower drop, a foliar supplement of nutrition resolves the problem of flower shedding thus enhancing the pod conversion ratio and seed set percent (Saitheja *et al.*, 2022) [17]. Besides controlling flower drop, it also augments the source-sink relationship as nitrogen imparts green colour to the plants thereby extending the retention of the photo-assimilatory surface until the crop attains its physiological maturity. The higher leaf area and prolonged senescence of leaves increased the dry matter production and translocation of photosynthates from source to sink, better source to sink relationship resulted in the production of a higher value of sink those are the number of pods per plant, and number of seed per pod, length of pods (cm) and test weight (g) resulted in higher seed yield in the treatment (Iqbal *et al.*, 2012) [8].

Haulm yield

The haulm yield results significantly differed with the application of 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS (2114 kg ha^{-1}) which was on par with 100% RDF + 2 sprays of pulse magic @ 1% at 30 and 45 DAS (2046 kg ha^{-1}) and significantly lower haulm yield (996.8 kg ha^{-1}) was recorded with the absolute control. The addition of nitrogen has a greater role in increasing the vegetative growth of the plant thus, the activity of photosynthesis increases resulting in greater accumulation of dry matter in the seed (Dordas and Sioulas, 2009) [2] and phosphorus helps in prolonging the period of full seed development and delaying senescence of leaves. Nanoscale nutrients supply has greater importance than conventional fertilizers because of its smaller size which enhanced the surface area and improved the absorption which resulted in increased haulm yield in the plants.

Harvest index

Harvest index is the ratio of economic yield to the biological yield which represents the portion of total dry matter accumulated in the plants converted as economic part. The influence of nano DAP, nano-K, and nano-Zn on the field bean harvest index has been found non-significant. However, numerically higher harvest index (0.35) was observed in treatment applied with 100% RDF + 2 sprays of nano fertilizer at 30 and 45 DAS.

Table 2: Number of pods per plant, pod length, number of seeds per pod and, test weight of field bean as influenced by the application of different sources of nutrients

	Treatment	Number of pods plant^{-1}	Pod Length (Cm)	Number of seeds pod^{-1}	Test Weight (G)
T_1	100% RDF	21.05	4.52	3.35	17.85
T_2	100% RDF + 2 Sprays of nano fertilizer	23.91	5.23	3.95	18.12
T_3	100% RDF + 2 Sprays of pulse magic @ 1%	22.40	5.08	3.77	18.08
T_4	75% RDF + 2 Sprays of nano fertilizer	20.51	4.46	3.32	17.58
T_5	75% RDF + 2 Sprays of pulse magic @ 1%	20.28	4.42	3.25	17.49
T_6	50% RDF + 2 Sprays of nano fertilizer	19.67	4.37	3.18	17.42
T_7	50% RDF + 2 Sprays of pulse magic @ 1%	19.21	4.35	3.12	17.39
T_8	100% RDF + 2 sprays of panchagavya @ 3%	21.38	4.65	3.53	17.96
T_9	100% RDF + 2 sprays of humic acid @ 0.1%	21.06	4.56	3.40	17.79
T_{10}	FYM @ 7.5 t ha^{-1} + 2 Sprays of nano fertilizer	18.57	3.92	3.01	17.21
T_{11}	Absolute control	13.72	3.54	2.85	16.89
	F-test	*	*	*	NS
	S.E.M. ±	0.77	0.19	0.14	0.74
	CD @ 5 %	2.27	0.55	0.41	-

Note: RDF – 25:50:25 kg NPK ha^{-1}, Foliar spray done at 30 and 45 DAS, Nano fertilizer (Nano DAP @ 4 ml L^{-1} + Nano-K @ 4 ml L^{-1} + Nano-Zn @ 2 ml L^{-1}), '*' indicates significant at 5% C.D. value

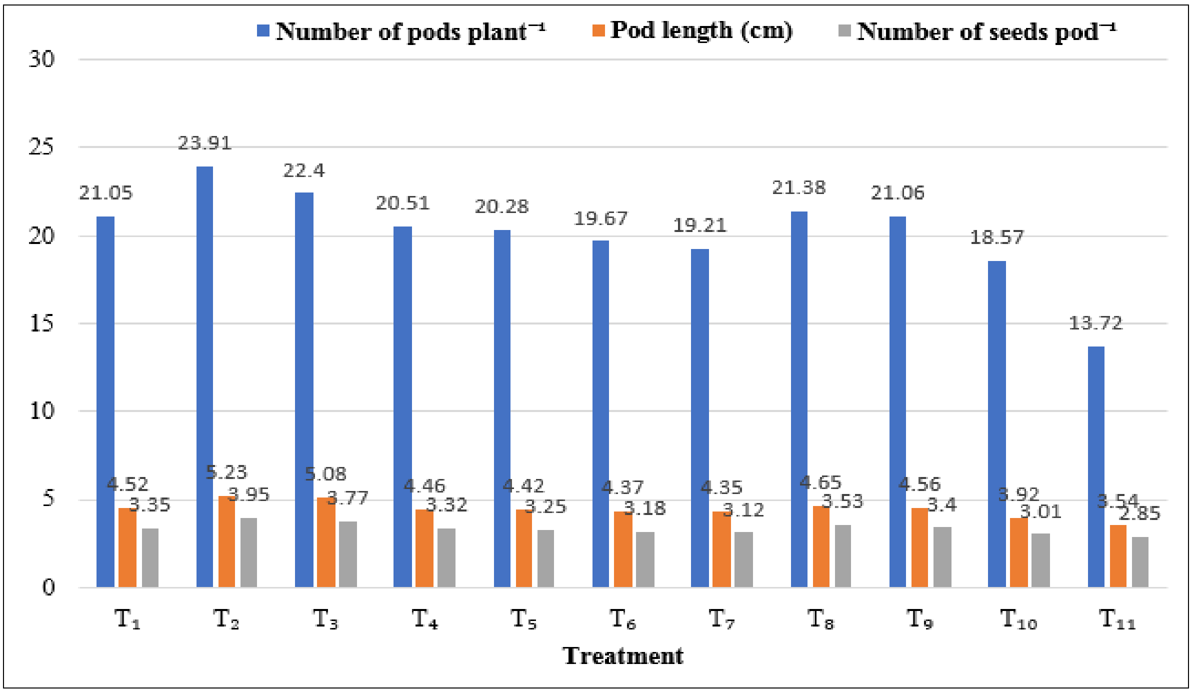

Fig 2: Number of pods per plant, pod length, number of seeds per pod and, test weight of field bean as influenced by the application of different sources of nutrients

Table 3: Seed yield, Haulm yield and, Harvest index of field bean as influenced by the application of different sources of nutrients

	Treatment	Seed Yield (Kg Plot^{-1})	Seed Yield (Kg Ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index
T_1	100% RDF	0.898	924.0	1904	0.33
T_2	100% RDF + 2 Sprays of nano fertilizer	1.107	1139	2114	0.35
T_3	100% RDF + 2 Sprays of pulse magic @ 1%	1.036	1067	2046	0.34
T_4	75% RDF + 2 Sprays of nano fertilizer	0.856	881.5	1873	0.32
T_5	75% RDF + 2 Sprays of pulse magic @ 1%	0.833	857.9	1823	0.32
T_6	50% RDF + 2 Sprays of nano fertilizer	0.766	798.4	1777	0.31
T_7	50% RDF + 2 Sprays of pulse magic @ 1%	0.756	778.4	1733	0.31
T_8	100% RDF + 2 sprays of panchagavya @ 3%	0.962	990.3	1951	0.33
T_9	100% RDF + 2 sprays of humic acid @ 0.1%	0.912	945.8	1908	0.33
T_{10}	FYM @ 7.5 t ha^{-1} + 2 Sprays of nano fertilizer	0.729	750.3	1751	0.30
T_{11}	Absolute control	0.319	403.7	996.8	0.29
	F-test	*	*	*	NS
	S.E.M. ±	0.04	36.85	54.57	0.013
	CD @ 5 %	0.10	108.08	160.08	-

Note: RDF – 25:50:25 kg NPK ha^{-1}, Foliar spray done at 30 and 45 DAS, Nano fertilizer (Nano DAP @ 4 ml L^{-1} + Nano-K @ 4 ml L^{-1} + Nano-Zn @ 2 ml L^{-1}), '*' indicates significant at 5% C.D. value

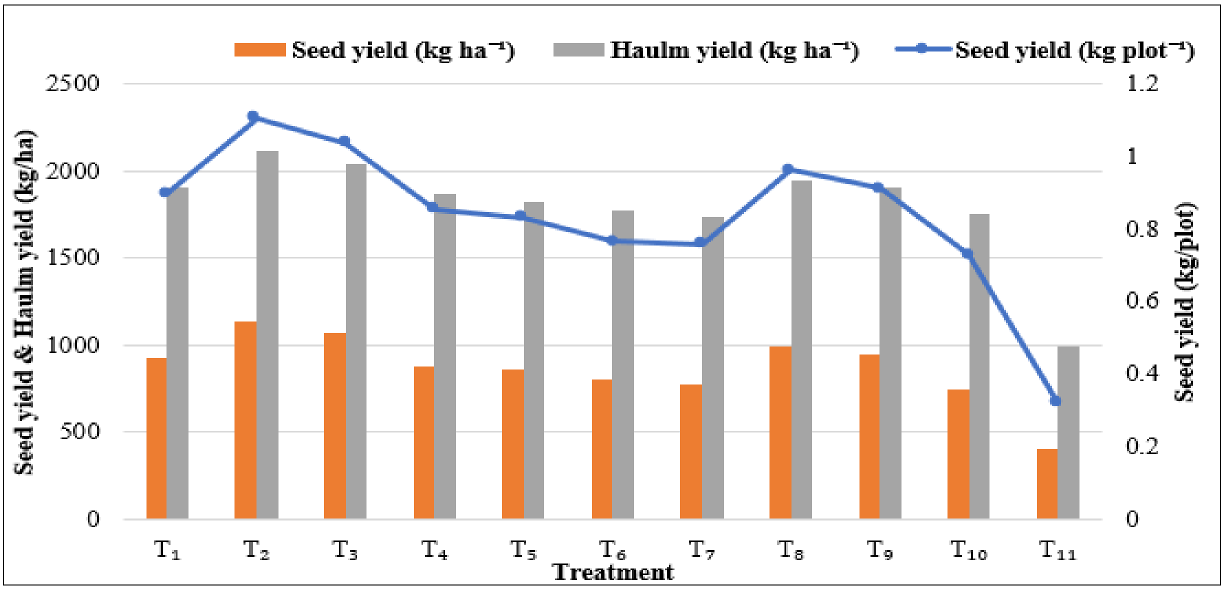

Fig 3: Seed yield, Haulm yield and, Harvest index of field bean as influenced by the application of different sources of nutrients

Conclusion

From this study, it can be concluded that application of 100% Recommended Dose of Fertilizers combined with two foliar sprays of nano fertilizer at 30 and 45 days after sowing significantly enhances both growth parameters and yield attributes. This treatment notably improves plant growth, resulting in a higher number of pods per plant, increased pod length, a greater number of seeds per pod, and improved test weight. Consequently, these improvements lead to an increase in seed yield, haulm yield, and harvest index. Therefore, integrating 100% RDF with timely nano fertilizer applications is a promising approach for optimizing crop productivity and achieving sustainable agricultural gains.

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