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INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON THE GROWTH DYNAMICS OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.)

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ABSTRACT

A field experiment was conducted during Rabi season 2023-24 and 2024-25 at Agricultural Research Farm of NRM block, BUAT, Banda, Uttar Pradesh, India. Thirteen treatments- where T_1 control (100% RDF), T_2 (100% RDF +V_1 @ 2-tons/ha), T_3 (100% RDF + V_2 @ 2-tons/ha), T_4 (100% RDF + V_3 @ 2 ton/h), T_5 (100% RDF + V_4 @ 2-tons/ha) , T_6 (75%% RDF+ V_1 @ 2-tons/ha), T_7 (75% RDF + V_2 @ 2-tons/ha) and T_8 (75% RDF + V_3 @ 2-tons/ha), T_9 (75% RDF + V_4 @ 2-tons/ha), T_{10} (50% RDF + V_1 @ 2-tons/ha), T_{11} (50% RDF + V_2 @ 2-tons/ha), T_{12} (50% RDF + V_3 @ 2-tons/ha), T_{13} (50% RDF + V_4 @ 2-tons/ha), where V_1, V_2, V_3, V_4 is vermicompost which is prepared through cow dung, Paddy Straw, Moong Straw and Carton respectively. were tested in three replications with Randomized Block Design. The highest plant height (cm) at 30 DAS, 60 DAS, 90 DAS and at harvest, No. of branches at 30 DAS, Dry matter accumulation, were result found that significantly better growth attributes with combined application of T_4 (100% RDF + V_3 @ 2 t/ha^{-1}) over rest of the treatments.
***Keywords*: Mustard, Plant Height, Straw, Vermicompost.

Introduction

India stands as one of the leading global producers of rapeseed and mustard, contributing the highest share to the world's total production of these crops. Mustard, a predominant Rabi season crop in India, is typically cultivated between October–November and harvested during February–March. Despite their rich energy content, oilseed crops are generally grown under suboptimal nutrient and energy conditions, resulting in reduced yield potential.

Mustard is believed to have originated in Central Asia, with secondary centres of diversity located in Central and Western China, Eastern India, Burma, and regions extending through Iran to the Near East. It has been cultivated for centuries across various parts of Eurasia. In India, rapeseed–mustard crops collectively span an area of approximately 6.23 million hectares, producing around 9.34 million tonnes with an average productivity of 1,499 kg ha^{-1}. The major mustard-producing states include Rajasthan, Uttar Pradesh, and Haryana. Notably, Rajasthan and Uttar Pradesh account for nearly 50% of the nation's total mustard output. In Uttar Pradesh alone, rapeseed–mustard is extensively cultivated over an area of 0.56 million hectares, yielding 0.699 million tonnes with a productivity of 1,248 kg ha^{-1} (GOI.2020-21).

Continuous use of inorganic fertilizers alone on the soil physico-chemical properties and environment besides their higher cost affects the health of soil. In coming decades, a major issue in designing sustainable agriculture system will be soil organic matter management and the balanced use of organic and inorganic fertilizers which will check the plant nutrient depletion as well as maintain the soil health and ultimately improves the productivity of mustard crop (Bisht *et al.,* 2018).

INM improves the soil health and availability of nutrients which are responsible for better plant growth and development, hence yield of crop increases (Prasad *et al*., 1991). Integration of chemical and organic sources and their efficient management have shown promising results not only in sustaining the productivity but also in maintaining the soil health (Pal and Pathak, 2016). Nitrogen is the most important nutrient, and being a constituent of protoplasm and protein, it is involved in several metabolic processes that strongly influence growth, productivity and quality of crops (Kumar *et al*., 2000). Nitrogen is known to activate most of the metabolic activities and transformation of energy (Patel *et al*., 2022).

Vermicompost is recognized as a nutrient-rich organic amendment, containing approximately 1.25% nitrogen (N), 0.30% phosphorus (P), 0.70% potassium (K), 0.01% copper (Cu), 0.18% iron (Fe), and 0.005% zinc (Zn) (Sinha *et al.,* 2009). Beyond its nutritional value, vermicompost contributes significantly to the improvement of soil physical and biological properties. It enhances soil aeration, minimizes erosion, reduces water evaporation losses, accelerates humification processes, and stimulates microbial activity. Additionally, it aids in the deodorization of unpleasant odors, eradication of soil-borne pathogens, and detoxification of pollutants thereby fostering a more sustainable and resilient soil environment.

Farmyard manure (FYM), through biological decomposition, provides essential macronutrients including nitrogen, phosphorus, and potassium in plant-available forms. Alongside these primary nutrients, sulphur plays a critical role as a secondary nutrient necessary for optimal plant growth and physiological function. Sulphur is particularly vital for mustard crops due to their high requirement for sulphur-containing amino acids such as methionine and cystine. Adequate sulphur supplementation has been associated with substantial improvements in plant growth and yield, as well as enhanced oil content in mustard cultivars (Singh *et al.*, 2014).

Nutrient management plays a critical role in influencing the agronomic performance of Indian mustard (*Brassica juncea* L.). Exclusive reliance on chemical fertilizers to meet crop nutrient demands has been associated with declining soil fertility and unsustainable yield trends. In contrast, the integration of organic manures and bio-fertilizers offers a more ecologically sound approach to nutrient management, promoting soil health and sustaining crop productivity (Swaminathan., 1976).

Material and Methods

This experiment was conducted during Rabi season, 2023-24 and 2024-25 at agriculture research farm, NRM block, CoA, BUAT, Banda, Uttar Pradesh, India. In this experimental study, nutrient inputs were administered both chemically and organically in accordance with the designated treatment protocol. Chemical fertilizers included urea, diammonium phosphate, single superphosphate, and muriate of potash, while organic amendments consisted through vermicompost (VC) which is prepared by different type of Raw material (Cow Dung V_1, Paddy straw V_2, Moong Straw V_3 and Carton V_4). These inputs were thoroughly incorporated into the soil prior to sowing.

The field experiment was structured using a Randomized Block Design (RBD) with three replications and 13 distinct treatment combinations as follows: T_1 control (100% RDF), T_2 (100% RDF +V_1 @ 2-tons/ha), T_3 (100% RDF + V_2 @ 2-tons/ha), T_4 (100% RDF + V_3 @ 2 ton/h), T_5 (100% RDF + V_4 @ 2-tons/ha) , T_6 (75%% RDF+ V_1 @ 2-tons/ha), T_7 (75% RDF + V_2 @ 2-tons/ha) and T_8 (75% RDF + V_3 @ 2-tons/ha), T_9 (75% RDF + V_4 @ 2-tons/ha), T_{10} (50% RDF + V_1 @ 2-tons/ha), T_{11} (50% RDF + V_2 @ 2-tons/ha), T_{12} (50% RDF + V_3 @ 2-tons/ha), T_{13} (50% RDF + V_4 @ 2-tons/ha).

Phosphorus and potassium fertilizers were applied as basal doses through the broadcasting method. Nitrogen was applied in two phases: half as a basal dose at sowing and the remaining half in two split applications first at 30 days after sowing and second at the flowering stage. The organic manures (VC) were incorporated into the soil 15 days prior to sowing according to the treatment requirements. Throughout the study, various agronomic parameters related to crop growth and development were systematically recorded during various intervals and analysed first, second and average data also.

Plant height (cm)

plant height was recorded for five pre-selected (tagged) plants in each experimental plot during 2023-24 and 2024-25. Measurements were taken at 30, 60, 90 DAS and at harvest, using a meter scale, extending from the soil surface at the base of the plant to the apex of the main stem. This approach ensured consistency in data collection and accurate representation of final plant stature across treatments.

Number of branches plant^{-1}

Number of branches per plant were collected from the same five previously tagged plants at 60 and 90 DAS in each experimental plot. These observations were systematically recorded, and the average number of branches for each category was computed to ensure a representative assessment of branching pattern across treatments. This metric serves as a key indicator of morphological development and contributes to evaluating the influence of integrated nutrient management practices on the growth architecture of mustard (*Brassica juncea* L.)

Dry matter accumulation (g)

In each treatment plot, five plants were randomly selected from the inner border rows excluding the outermost row for destructive sampling at four growth stages: 30, 60, 90 days after sowing (DAS), and at harvest. The collected plant samples were initially subjected to shade drying to minimize moisture content while preserving tissue integrity. Subsequently, they were dried in a hot air oven maintained at 60°C until a constant dry weight was achieved. The final biomass was recorded and extrapolated to a per hectare basis, expressed as kilograms per hectare (kg ha^{-1}), to facilitate quantitative assessment of above-ground dry matter accumulation under different nutrient management treatments.

Results and Discussion

The maximum plant height at 30,60, 90 DAS and at harvest is of Indian mustard (*Brassica juncea* L.). Data presented in Table.1, was consistently recorded under treatment T_4 (100% RDF + V_3 @ 2 t ha^{-1}) and lowest data was found in T_1(Control) during 2023-24, 2024-25 and average data also. across all observed average data of both year, growth stages namely, 30 DAS, 60 DAS, 90 DAS, and at harvest. during measuring the plant, the manximum data was found in T_4 and which is 30.61cm, 106.17cm, 177.17 cm, and 211.90 cm, respectively. This was closely followed by treatment T_8, with recorded heights of 27.43 cm, 102.32 cm, 173.54 cm, and 186.56 cm, in average data of both the years at corresponding stages. Conversely, the minimum plant height was observed in the control treatment (T_1), with respective values of 26.19 cm, 90.95 cm, 148.38 cm, and 175.07 cm. Notably, a marginal increase in plant height was observed between 60-90 DAS and harvest across all treatments, suggesting a tapering growth phase during the latter part of the crop cycle.

The data presented in Table.3, illustrates the number of primary branches per plant recorded at 60 and 90 days after sowing (DAS). The treatment designated as T4, comprising 100% Recommended Dose of Fertilizers (RDF) supplemented with vermicompost (V_3) at a rate of 2 t/ha, resulted in the highest number of primary branches per plant at all observed intervals 8.69 at 60 DAS, 15.87 at 90 DAS. In contrast, the control treatment (T_1), which have received RDF100% nutrient supplementation, recorded the lowest number of branches 7.54 at 60 DAS, and 11.45 at 90 DAS.

Dry matter accumulation in mustard as influenced by integrated nutrient management. The data presented in Table.2, indicates that dry matter accumulation in mustard was significantly affected by integrated nutrient management practices except 30 DAS. across all developmental stages, from 30 days after sowing (DAS) through to harvest. A progressive increase in dry matter was observed as the crop advanced in growth, reaching its peak at harvest. among the treatments, the highest dry matter accumulation was recorded under T_4, which involved the application of 100% Recommended Dose of Fertilizers (RDF) supplemented with vermicompost (V_3) at 2 t/ha. The recorded highest values were 2.95 g/plant at 30 DAS, 16.58 g/plant at 60 DAS, 45.66 g/plant at 90 DAS, and 95.28 g/plant at harvest. In contrast, the lowest accumulation was noted in the control treatment (T_1), with values of 2.35 g/plant at 30 DAS, 10.79 g/plant at 60 DAS, 37.84 g/plant at 90 DAS, and 84.55 g/plant at harvest.

Previous findings by Mukherjee (2016) corroborate the positive influence of organic amendments, reporting enhanced plant height and leaf area in mustard following FYM application at 30 t/ha during the first year and 20 t/ha in the second year. Similarly, Brar *et al.,* (2016) observed that the application of 100% RDF in conjunction with Azotobacter and phosphate-solubilizing bacteria (PSB) inoculation significantly improved plant height and increased the number of both primary and secondary branches in brown sarson. Effect of nutrient management Strategies on Growth Parameters in Mustard Findings from the 2017 study revealed that the application of farmyard manure (FYM) at 5 t/ha in combination with 100% recommended dose of fertilizers (RDF) resulted in a greater number of primary and secondary branches per mustard plant compared to treatments involving FYM at 5 t/ha combined with either 50% RDF plus biofertilizer or 75% RDF plus biofertilizer. These observations highlight the superior efficacy of integrating full doses of chemical fertilizers with organic inputs. Consistent outcomes were reported by Hadiyal *et al.* (2017), who found that seed inoculation with *Azotobacter* spp. and phosphate-solubilizing bacteria (PSB) at the rate of 10 ml/kg of seed significantly enhanced growth parameters, particularly the number of primary and secondary branches per plant. Similarly, Diwakar *et al.* (2021) demonstrated that the application of 75% of the recommended dose of NPK fertilizers along with 25% FYM, 40 kg of elemental sulfur (S), and mulching at

10 t/ha resulted in the highest recorded values for number of branches per plant, dry matter accumulation per plant, and plant height at 60 DAS and at harvest.

Table 1 : Effect of different treatments of vermicompost on plant height of mustard crop at different days intervals.

T. Symbol	Treatment details	Plant height (cm.)											
		30DAS			60 DAS			90 DAS			Harvest stage		
		2023-24	2024-25	Average data	2023-24	2024-25	Average data	2023-24	2024-25	Average data	2023-24	2024-25	Average data
T1	100% RDF (80 Kg N, 40 Kg P_2O_5, 40 Kg K_2O, 20 Kg S)	25.51	26.87	26.19	90.65	91.25	90.95	147.96	148.80	148.38	174.55	175.60	175.07
T2	100 % RDF (N:P:K:S) + (V_1) @ 2 tonne ha $^{-1}$	27.03	28.39	27.71	100.50	101.85	101.17	171.70	172.48	172.09	202.73	199.75	201.24
T3	100 % RDF (N:P:K:S) + (V_2) @2 tonne ha $^{-1}$	26.26	27.61	26.93	98.52	99.907	99.21	167.60	169.02	168.31	186.25	186.05	186.15
T4	100 % RDF (N:P:K:S) + (V_3) @2 tonne ha $^{-1}$	29.94	31.29	30.61	105.46	106.87	106.17	177.93	177.71	177.82	212.26	211.61	211.9
T5	100 % RDF (N:P:K:S) +(V_4) @2 tonne ha^{-1}	27.03	28.38	27.70	98.21	97.64	97.92	166.60	167.05	166.82	182.73	184.65	183.69
T6	75 % RDF (N:P:K:S) +(V_1) @2 tonne ha^{-1}	26.44	27.79	27.11	96.00	97.59	96.79	171.00	166.96	168.98	179.84	181.43	180.63
T7	75 % RDF (N:P:K:S) +(V_2) @2 tonne ha^{-1}	26.32	27.68	27.00	95.96	96.73	96.34	169.22	166.56	167.89	178.27	179.75	179.01
T8	75 % RDF (N:P:K:S) + (V_3) @2 tonne ha^{-1}	27.43	28.79	28.11	101.84	102.81	102.32	174.47	172.62	173.54	186.73	186.40	186.56
T9	75 % RDF (N:P:K:S) +(V_4) @2 tonne ha^{-1}	26.08	27.44	26.76	94.88	95.34	95.11	164.22	164.35	164.29	177.60	177.18	177.39
T10	50 % RDF (N:P:K:S) +(V_1) @ 2 tonne ha^{-1}	25.78	27.13	26.45	93.95	95.97	94.96	166.73	163.87	165.30	176.12	174.45	175.28
T11	50 % RDF (N:P:K:S) +(V_2) @ 2 tonne ha^{-1}	25.65	27.00	26.32	94.09	94.78	94.44	164.73	163.32	164.02	175.93	173.60	174.77
T12	50 % RDF (N:P:K:S) +(V_3) @ 2 tonne ha^{-1}	25.84	27.20	26.52	95.66	99.16	97.41	169.41	168.70	169.06	181.43	180.82	181.13
T13	50 % RDF (N:P:K:S) +(V_4) @ 2 tonne ha^{-1}	25.67	27.03	26.35	93.16	95.26	94.21	162.26	163.01	162.64	175.56	176.62	176.09
	SEm$\pm$	0.94	0.81	0.86	1.89	1.77	1.25	2.12	2.91	1.60	2.20	2.17	2.09
	CD (0.05)	NS	NS	NS	5.51	5.16	3.65	6.20	8.50	4.67	6.42	6.34	5.86

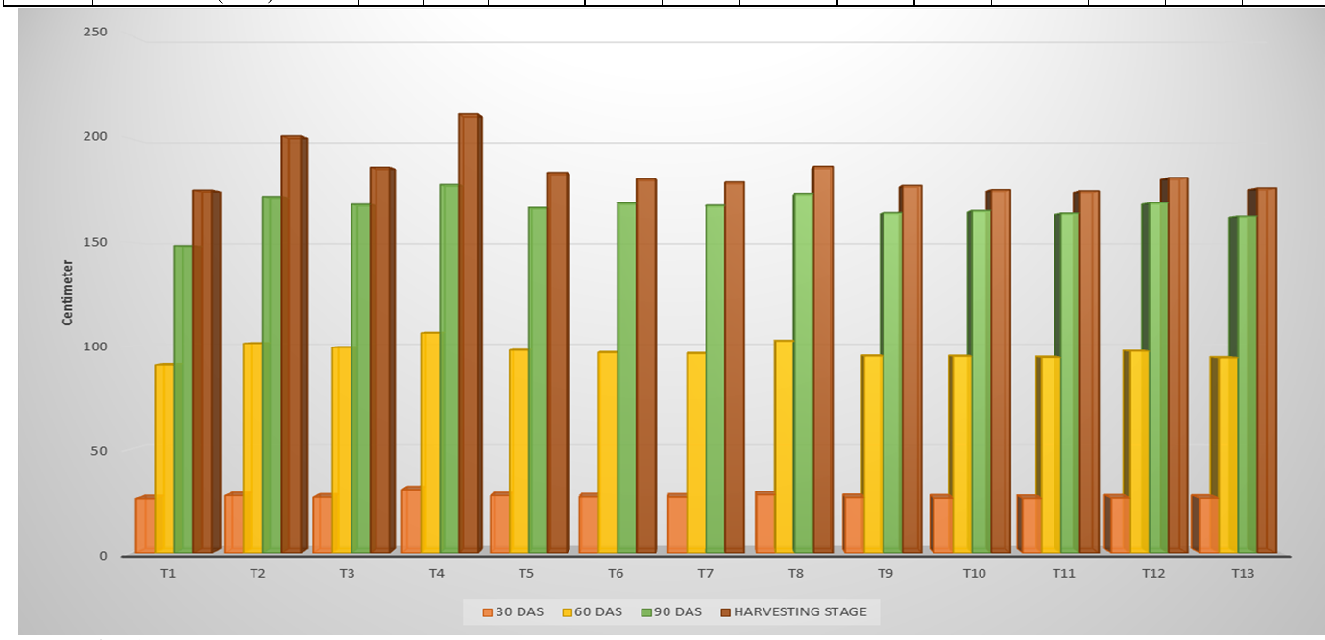

Fig. 1 : Effect of different treatments of vermicompost on plant height of mustard crop at different days intervals.

Table 2 : Effect of different treatments of vermicompost on Dry matter accumulation at different days intervals.

T. Symbol	Treatment details	Dry Matter /plant (g.)											
		30DAS			60 DAS			90 DAS			Harvest stage		
		2023-24	2024-25	Average pool	2023-24	2024-25	Average pool	2023-24	2024-25	Average pool	2023-24	2024-25	Average pool
T1	100% RDF (80 Kg N, 40 Kg P_2O_5, 40 Kg K_2O, 20 Kg S)	2.35	2.36	2.35	9.99	11.60	10.79	37.51	38.17	37.84	84.05	85.06	84.55
T2	100 % RDF (N:P:K:S) + (V_1) @ 2 tonne ha^{-1}	2.44	2.49	2.47	13.06	14.66	13.86	43.13	44.01	43.57	91.28	92.84	92.06
T3	100 % RDF (N:P:K:S) + (V_2) @2 tonne ha^{-1}	2.41	2.45	2.43	12.06	13.66	12.86	41.90	43.86	42.88	89.60	91.30	90.45
T4	100 % RDF (N:P:K:S) + (V_3) @2 tonne ha^{-1}	2.92	2.99	2.95	15.78	17.39	16.58	45.18	46.14	45.66	94.68	95.87	95.28
T5	100 % RDF (N:P:K:S) +(V_4) @2 tonne ha^{-1}	2.39	2.44	2.42	11.97	13.57	12.77	40.79	42.24	41.52	88.34	89.53	88.94
T6	75 % RDF (N:P:K:S) +(V_1) @2 tonne ha^{-1}	2.37	2.42	2.40	11.75	13.35	12.55	39.15	40.51	39.83	89.09	89.51	89.30
T7	75 % RDF (N:P:K:S) +(V_2) @2 tonne ha^{-1}	2.36	2.41	2.38	10.86	12.46	11.66	38.99	39.15	39.07	87.96	89.12	88.54
T8	75 % RDF (N:P:K:S) + (V_3) @2 tonne ha^{-1}	2.40	2.56	2.48	12.18	13.79	12.99	40.58	41.73	41.15	91.00	91.96	91.48
T9	75 % RDF (N:P:K:S) +(V_4) @2 tonne ha^{-1}	2.37	2.40	2.38	10.81	12.41	11.61	38.31	39.33	38.82	86.93	87.31	87.12
T10	50 % RDF (N:P:K:S) +(V_1) @ 2 tonne ha^{-1}	2.36	2.42	2.39	11.20	12.81	12.01	37.85	40.28	39.07	88.78	88.98	88.88
T11	50 % RDF (N:P:K:S) +(V_2) @ 2 tonne ha^{-1}	2.36	2.39	2.38	10.79	12.39	11.59	37.84	39.44	38.64	87.42	87.65	87.53
T12	50 % RDF (N:P:K:S) +(V_3) @ 2 tonne ha^{-1}	2.38	2.44	2.41	13.56	15.16	14.36	40.51	40.97	40.74	90.46	91.06	90.76
T13	50 % RDF (N:P:K:S) +(V_4) @ 2 tonne ha^{-1}	2.35	2.36	2.35	10.57	12.18	11.37	37.59	37.59	37.59	85.60	86.26	85.93
	SEm±	0.12	0.11	0.11	0.47	0.47	0.46	1.19	0.96	0.87	1.60	1.68	1.26
	CD (0.05)	NS	NS	NS	1.36	1.38	1.35	3.49	2.79	2.55	4.67	4.91	3.68

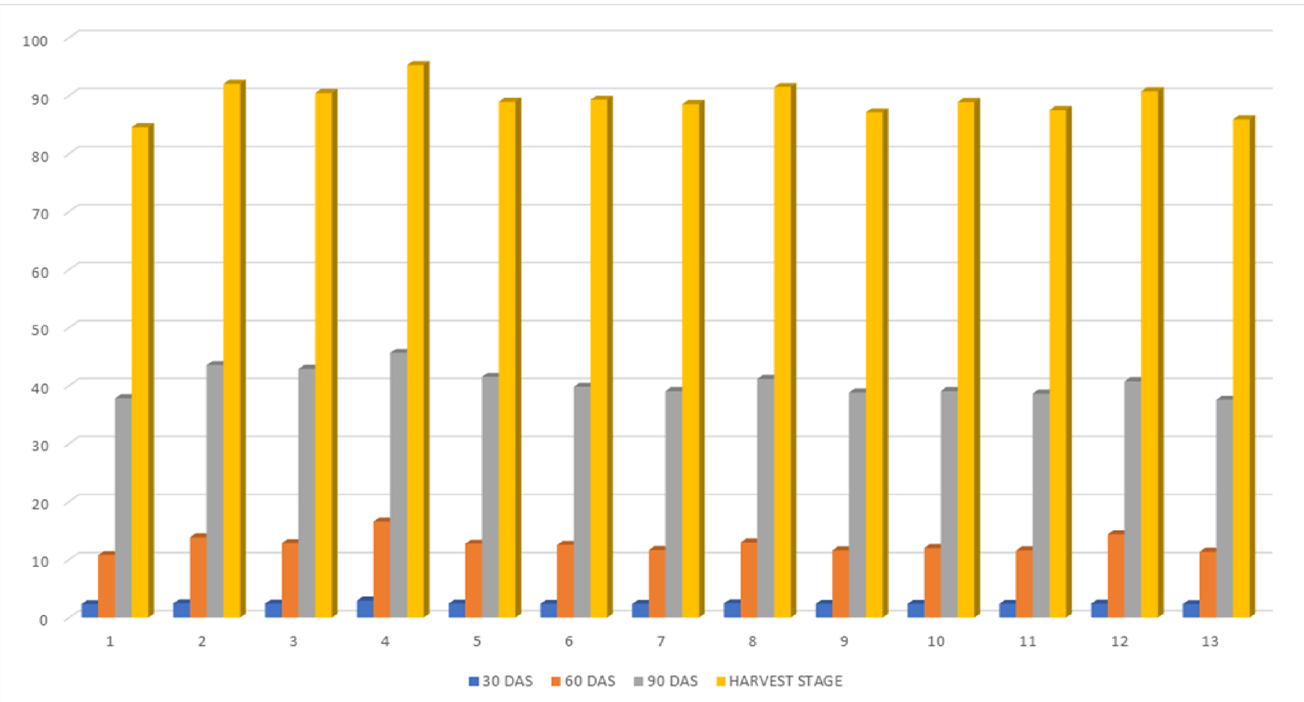

Fig. 2 : Effect of different treatments of vermicompost on Dry matter accumulation at different days intervals.

Table 3 : Effect of different treatments of vermicompost on plant population and days to 50% flowering.

T. Symbol	Treatment details	Plant population/M^2		
		2023-24	**2024-25**	**Pool data**
T1	100% RDF (80 Kg N, 40 Kg P_2O_5, 40 Kg K_2O, 20 Kg S)	22.33	25.33	23.83
T2	100 % RDF (N:P:K:S) + (V_1) @ 2 tonne ha $^{-1}$	25.33	28.66	27.00
T3	100 % RDF (N:P:K:S) + (V_2) @2 tonne ha $^{-1}$	24.66	28.00	26.33
T4	100 % RDF (N:P:K:S) + (V_3) @2 tonne ha $^{-1}$	26.33	31.33	28.83
T5	100 % RDF (N:P:K:S) +(V_4) @2 tonne ha^{-1}	23.66	27.66	25.66
T6	75 % RDF (N:P:K:S) +(V_1) @2 tonne ha^{-1}	24.00	27.33	25.66
T7	75 % RDF (N:P:K:S) +(V_2) @2 tonne ha^{-1}	23.33	26.33	24.83
T8	75 % RDF (N:P:K:S) + (V_3) @2 tonne ha^{-1}	25.00	29.66	27.33
T9	75 % RDF (N:P:K:S) +(V_4) @2 tonne ha^{-1}	23.00	27.3	25.16
T10	50 % RDF (N:P:K:S) +(V_1) @ 2 tonne ha^{-1}	24.00	27.66	25.83
T11	50 % RDF (N:P:K:S) +(V_2) @ 2 tonne ha^{-1}	23.33	27.33	25.33
T12	50 % RDF (N:P:K:S) +(V_3) @ 2 tonne ha^{-1}	24.00	28.33	26.16
T13	50 % RDF (N:P:K:S) +(V_4) @ 2 tonne ha^{-1}	22.66	26.33	24.50
	SEm$\pm$	0.87	1.09	0.91
	CD (0.05)	NS	NS	NS

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