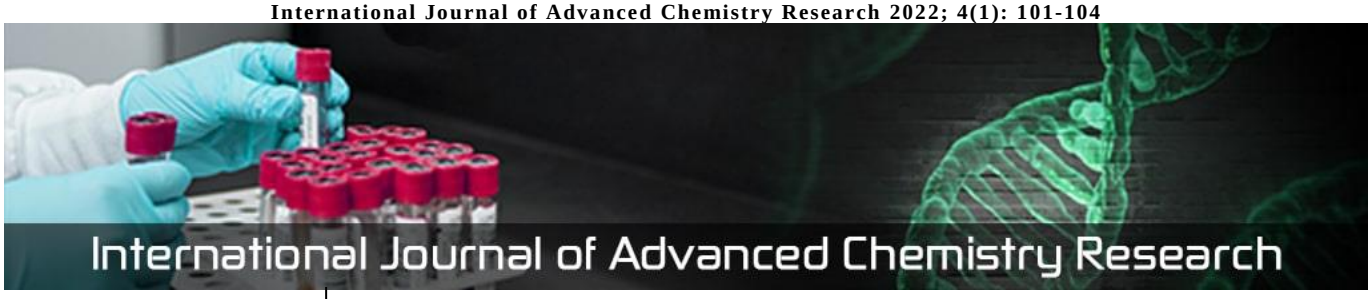

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To study the effects of integrated nutrient management on the growth and yield of Radish (*Raphanus sativus* L.)

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Abstract
The present investigation entitled "To study the effect of integrated nutrient management on growth and yield of Radish (*Raphanus sativus* L.)" planned to be carried out at Horticulture Research cum Instructional farm, BTC College of Agriculture and Research Bilaspur (C.G.) during *Rabi* season of 2021-22. The experiment was laid out in Randomized Block Design (RBD) with three replications and ten treatments comprises of 100% RDF (T_1), 75% RDF + FYM@ 2.5 t ha^{-1} (T_2), 75% RDF + Vermicompost @ 1 t ha^{-1} (T_3), 50% RDF + FYM@ 5 t ha^{-1} (T4), 50% RDF + Vermicompost @2.5 t ha^{-1} (T_5), 75% RDF + FYM@ 2.5 t ha^{-1}+ Consortia (T_6), 75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia (T_7), 50% RDF + FYM@ 5 t ha^{-1} + Consortia (T_8), 50% RDF + Vermicompost @ 2.5 t ha^{-1} + Consortia (T_9), Control plot (T10). The periodical observation on growth, yield attributes were recorded on 30, 45 DAS and at harvest. On the basis of observations it is concluded that T1 (100% RDF) has significant influence and was found superior for almost all the traits under study and it was followed by T_7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia). The maximum values of plant height (38.67 cm, 43.82 cm, 42.7 cm), number of leaves (8.63, 12.1, 10.35), leaf length (16.09cm, 20.15 cm, 23.12 cm), shoot length (27.44 cm, 9.53cm, 9.03 cm), length of roots (20.61 cm), root girth (12.36 cm), fresh weight (178.49 gm), yield of roots (177.55 q ha^{-1}), B:C ratio (3.98) were recorded in T1 (100% RDF) followed by T7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia), thus can also be suggested for better soil health and environment condition as alternative for chemical fertilizer.

Keywords: Radish (Raphanus sativus L.), integrated nutrient management, Randomized Block Design (RBD)

Introduction
Radish (*Raphanus sativus L.)* is a popular root vegetable grown in both tropical and temperate regions belongs to the family of Cruciferae and is a native of Europe and Asia. Radish is grown for its young tender and fusiform tuberous root which is consumed either raw (salad) or cooked (vegetable).The edible part of radish is modified root that develops from primary roots as well as hypocotyls both. Radish is a good source of minerals like calcium, potassium and phosphorous and vitamin A, vitamin C and due to its medicinal properties it is prescribed for patients suffering from piles, chronic diarrhea, liver troubles and jaundice. Radish is a cool season vegetable crop but the varieties of Asiatic type can also tolerate high temperature than the European varieties. The leaves of radish is a good source for extraction of protein in a commercial basis. The characteristic pungent flavour of radish is due to the presence of volatile isothiocyanate.

Integrated Nutrient Management (INM) is defined as the use of inorganic, organic and biological nutrient sources in optimum condition to achieve and sustain optimum yield without harming the soil ecosystem and environment. Optimum nutrition should be provided through organic, inorganic, and bio-fertilizer sources for smooth and better production (Sandeep *et al.*, 2014) [9]. INM helps to obtain agronomically feasible, economically viable, environmentally sound and sustainable high crop yields (Kafle *et al*., 2019) [10]. Organic nutrition for vegetable is important as they also provide human health security. It is gaining movement in India due to the individual as well as group efforts to conserve environments and avoid contamination from the use of chemical fertilizer and pesticides

Farmyard manure being a bulky organic manure releases the soil compaction and improves the soil aeration in addition to the supply of the essential plant nutrients and organic matter, thereby increasing the soil microbial establishment along with the accumulation of excess

Humas content in the soil. Vermi compost provides almost vital macronutrients (N, P_2O_5, K_2O, Ca, and Mg) and also micronutrients (Fe, Mn, Zn and Cu). The chemical analysis of Vermi compost reveals that the N, P_2O_5, K_2O, content was 0.8, 1.1, 0.5, respectively (Giraddi *et al.*, 1993) [11]. Bio fertilizers are the natural fertilizer that may be used to supplement or replace chemical fertilizer in sustainable agriculture (Ebrahimpour *et al*., 2011) [12]. Consortia is a liquid bio fertilizer containing free living nitrogen fixing Azotobacter, Potash mobilizing bacteria (KMB), Phosphorus solubilize bacteria (PSB). Moreover this approach is economically cheap, technically sound, practically feasible and is capable of maintaining the sustainability in production.

Materials and methods

The experiment was carried out at Horticulture Research and Instructional farm, Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur. The experiment was laid out in Randomized Block Design (RBD) with three replications and ten treatments that are 100% RDF 60:50:80 kg NPK ha^{-1}) (T_1), 75% RDF + FYM@ 2.5 t ha^{-1} (T2), 75% RDF + Vermicompost @ 1 t ha^{-1} (T_3), 50% RDF + FYM@ 5 t ha^{-1} (T_4), 50% RDF + Vermicompost @ 2.5 t ha^{-1} (T_5), 75% RDF + FYM@ 2.5 t ha^{-1}+ Consortia (T_6), 75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia (T_7), 50% RDF + FYM@ 5 t ha^{-1} + Consortia (T_8), 50% RDF + Vermicompost @2.5 t ha^{-1} + Consortia (T_9), Control plot (T_{10}). The area of each plot was 11.7 m^2 (3m X 3.9m). The sowing was done in 19th October, 2021 with the spacing of 30 cm X 10 cm. The chemical fertilizer were used in the form of Urea, SSP, MOP. Full dose of P and K and half dose of N is applied as a basal dose and the remaining half dose was applied at 20 DAS. Organic manure: FYM and vermicompost treated with consortia (biofertlizer) a week ago kept in shade and applied into the soil 15 days prior to sowing. First irrigation was given soon after sowing, thereafter at 10 to 15 days interval. Thinning and weeding were done at 15 days of sowing in order to maintain the plant population as per spacing. The observation were recorded i.e. (Growth attribute): plant height (cm), length of leaves (cm), No. of leaves at 30, 45 DAS and at harvest; (yield attribute): length of roots (cm), Root girth (cm), Root yield (q ha^{-1}) at harvest. Five plants were tagged randomly in each plot and these were measured with measuring scale, varnier caliper. The data on growth and yield were statistically analysed. 'F' test was done to find out significant at $p < 0.05$ level, S.E.M and C.D are calculated.

Results and discussion

Effect of integrated nutrient management on growth attributes

The plant height increases from 27.86 cm to 38.67 cm in 30 DAS, 30.09 cm to 43.82 cm in 45 DAS and 29.35 cm to 42.7 cm at harvest. The maximum plant height was observed in treatment T_1 (100% RDF [60:50:80 kg NPK ha^{-1}]) at 30, 45 DAS and at harvest (38.67 cm, 43.82 cm, 42.7 cm)which was followed by T_7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia) showing 38.52cm,42.78cm, 41.89 cm at 30,45 DAS and at harvest. The minimum plant height was observed in T_{10} (Control plot) at 30, 45 DAS and at harvest (27.86 cm, 30.09 cm, 29.35 cm). Similar findings had also been observed earlier by Basnet *et al.* (2021) [13] and Khalid *et al*. (2015) [5]. The number of leaves increases from 7.07 to 8.63 in 30 DAS, 8.8 to 12.1 in 45 DAS and 7.07 to 10.35 at harvest. The maximum number of leaves was observed in treatment T_1 (100% RDF [60:50:80 kg NPK ha^{-1}]) at 30, 45 DAS and at harvest (8.63, 12.1, 10.35) which was followed by T7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia) showing 8.07, 11.13, 9.73 at 30, 45 DAS and at harvest. The minimum number of leaves was observed in T_{10} (Control plot) at 30, 45 DAS and at harvest (7.07, 8.8, 7.07). This outcome is in close association with the findings of P. Jaishankar (2014) [14], Kumar *et al*. (2018) [15] and Sahu *et al* (2016) [16]. The leaf length increases from 12.01 cm to 16.09 cm in 30 DAS, 13.43 cm to 20.15 cm in 45 DAS and 15.05 cm to 23.12 cm at harvest. The maximum leaf length was observed in treatment T_1 (100% RDF [60:50:80 kg NPK ha^{-1}]) at 30, 45 DAS and at harvest (16.09 cm, 20.15 cm, 23.12 cm)which was followed by T7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia) showing (15.74cm, 19.27 cm, 22.37 cm)at 30,45 DAS and at harvest respectively. The minimum leaf length was observed in T10 (Control plot) at 30, 45 DAS and at harvest (12.01 cm, 13.43 cm, 15.05 cm). Similar findings had also been observed earlier by Dash *et al.* (2017) [17].

Effect of integrated nutrient management on yield attributes.

The lengths of roots shows a range from 15.25 cm to 20.61 cm at harvest. The maximum root length was observed in the treatment T_1 (100% RDF (60:50:80 kg NPK ha^{-1}) at harvest giving the result of 20.61 cm which if followed by T_7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia) at harvest showing (19.84 cm). The minimum root length was observed I the treatment T_{10} (Control plot) with 15.25 cm. Similar results were observed from the findings of Sharma *et al.* (2012) [18] and Dulal *et al.* (2020) [19]. The root girth of radish shows a range from 8.48 cm to 12.36 cm at harvest. The maximum root length was observed in the treatment T_1 (100% RDF (60:50:80 kg NPK ha^{-1}) at harvest giving the result of 12.36 cm which if followed by T_7 (75% RDF + Vermicompost @ 1 t ha^{-1} +Consortia) at harvest showing (12 cm). The minimum root girth was observed in the treatment T_{10} (Control plot) with 8.48 cm. Similar results are obtained from the findings of Politud *et al.* (2014) and Jaishankar (2018) [1]. The yield of root (q ha^{-1}) of radish shows a range from 47.29 q ha^{-1} to 177.55 q ha^{-1} at harvest. The maximum yield of root (q ha^{-1}) was observed in the treatment T1 (100% RDF (60:50:80 kg NPK ha^{-1}) at harvest giving the result of 177.55 q ha^{-1} which if followed by T_7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia) at harvest showing (171.34 q ha^{-1}). The minimum yield of root (q ha^{-1}) was observed in the treatment T_{10} (Control plot) with 47.29 q ha^{-1}. The outcomes are in close association with the findings of the Noor *et al.* (2007) [3] and Khan (2010) [2].

Table 1.1: Effect of integrated nutrient management on the growth attributes, plant height (cm)

	Treatment	30 Das	45 Das	AT Harvest
T_1	100% RDF(60:50:80 kg NPK ha^{-1})	38.67	43.82	42.7
T_2	75% RDF + FYM@ 2.5 t ha^{-1}	33.66	37.54	37.38
T_3	75% RDF + Vermicompost @ 1 t ha^{-1}	35.57	37.63	37.19
T_4	50% RDF + FYM@ 5 t ha^{-1}	29.26	30.97	32.71
T_5	50% RDF + Vermicompost @2.5 t ha^{-1}	32.03	34.71	34.18
T_6	75% RDF + FYM@ 2.5 t ha^{-1}+ Consortia	36.92	39.96	39.95
T_7	75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia	38.52	42.78	41.89
T_8	50% RDF + FYM@ 5 t ha^{-1} + Consortia	36.37	38.88	38.11
T_9	50% RDF + Vermicompost @2.5 t ha^{-1} + Consortia	36.63	39.76	38.64
T_{10}	Control plot	27.86	30.09	29.35
	Mean	34.55	37.61	37.21
	S.E.M	1.9	2.01	1.95
	CD (p = 0.05)	5.64	5.96	5.79

Table 1.2: Effect of integrated nutrient management on the growth attributes; No. of leaves

	Treatment	30 Das	45 Das	AT Harvest
T_1	100% RDF(60:50:80 kg NPK ha^{-1})	8.63	12.1	10.35
T_2	75% RDF + FYM@ 2.5 t ha^{-1}	7.67	9.4	8.27
T_3	75% RDF + Vermicompost @ 1 t ha^{-1}	7.7	10.4	8.87
T_4	50% RDF + FYM@ 5 t ha^{-1}	7.4	9.07	8
T_5	50% RDF + Vermicompost @2.5 t ha^{-1}	7.47	9.67	8.2
T_6	75% RDF + FYM@ 2.5 t ha^{-1}+ Consortia	7.87	10.67	9.27
T_7	75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia	8.07	11.13	9.73
T_8	50% RDF + FYM@ 5 t ha^{-1} + Consortia	7.73	10.4	9
T_9	50% RDF + Vermicompost @2.5 t ha^{-1} + Consortia	7.77	10.47	9.2
T_{10}	Control plot	7.07	8.8	7.07
	Mean	7.74	12.1	8.8
	S.E.M	0.41	0.59	0.49
	CD (p = 0.05)	1.23	1.76	1.46

Table 1.3: Effect of integrated nutrient management on the growth attributes; leaf length (cm)

	Treatment	30 DAS	45 Das	AT Harvest
T_1	100% RDF(60:50:80 kg NPK ha^{-1})	16.09	20.15	23.12
T_2	75% RDF + FYM@ 2.5 t ha^{-1}	14.36	16.09	17.96
T_3	75% RDF + Vermicompost @ 1 t ha^{-1}	14.24	16.52	18.63
T_4	50% RDF + FYM@ 5 t ha^{-1}	12.26	15.12	14.88
T_5	50% RDF + Vermicompost @2.5 t ha^{-1}	12.17	14.61	17.1
T_6	75% RDF + FYM@ 2.5 t ha^{-1}+ Consortia	15.43	18.44	20.57
T_7	75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia	15.74	19.27	22.37
T_8	50% RDF + FYM@ 5 t ha^{-1} + Consortia	14.45	16.65	18.89
T_9	50% RDF + Vermicompost @2.5 t ha^{-1} + Consortia	15.11	17.01	18.62
T_{10}	Control plot	12.01	13.43	15.05
	Mean	14.19	16.73	18.72
	S.E.M	0.75	0.93	1.01
	CD (p = 0.05)	2.22	2.76	3

Table 1.3: Effect of integrated nutrient management on the yield attributes

	Treatment	Root Length (cm)	Root Girth (cm)	Yield (q ha^{-1})
T_1	100% RDF(60:50:80 kg NPK ha^{-1})	20.61	12.36	177.55
T_2	75% RDF + FYM@ 2.5 t ha^{-1}	17.53	10.93	130.44
T_3	75% RDF + Vermicompost @ 1 t ha^{-1}	18.26	11.32	157.27
T_4	50% RDF + FYM@ 5 t ha^{-1}	16.58	10.53	76.84
T_5	50% RDF + Vermicompost @2.5 t ha^{-1}	16.9	10.78	93.96
T_6	75% RDF + FYM@ 2.5 t ha^{-1}+ Consortia	19.38	11.73	168.38
T_7	75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia	19.84	12.0	171.34
T_8	50% RDF + FYM@ 5 t ha^{-1} + Consortia	18.59	11.19	162.16
T_9	50% RDF + Vermicompost @2.5 t ha^{-1} + Consortia	19.41	11.55	162.31
T_{10}	Control plot	15.25	8.48	47.29
	Mean	18.23566	11.12733	134.75
	S.E.M	0.97	0.59	8.31
	CD (p = 0.05)	2.87	1.75	24.68

Conclusion

As per the investigation the obtained observation and results, the following conclusion could be drawn which may be required for the recommendation for the cultivation of radish (*Raphanus sativus* L.) in Chhattisgarh plains. According to the obtained results of the growth attributes *viz* plant height (cm), number of leaves, leaf length (cm) was observed superior with T1 (100% RDF (60:50:80 kg NPK ha^{-1}) which was closely followed by T7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia). This integrated nutrient management also had the significant effect on yield attributes *viz* length of roots (cm), roots girth (cm) and yield q ha^{-1} with T1 (100% RDF (60:50:80 kg NPK ha^{-1}) resulted maximum observation followed by T_7 (75% RDF + Vermicompost @ 1 t ha^{-1} + Consortia). The minimum observation was recorded in T_{10} (Control plot) in both growth and yield attributes.

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