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Effect of integrated nutrient management on yield and chemical properties of kodo millet (*Paspalum scrobiculatum* L.) under direct seeded method

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Abstract
A field experiment was conducted during *kharif* season 2023 to study the Effect of integrated nutrient management on kodo millet (*Paspalum scrobiculatum* L.) under direct seeded method. The treatments consisted of the treatments comprised of T_1: Control, T_2: 100% RDN, T_3: 75% RDN + 25% N through Vermicompost, T_4: 75% RDN + Consortia, T_5: 75% RDN + 25% N through Vermicompost + Consortia, T_6: 50% RDN + 50% N through Vermicompost, T_7: 50% RDN + 50% N through Vermicompost, T_8: 100% N through Vermicompost, T_9: 50% RDN + Consortia, T_{10}: 50% N through Vermicompost. The experiment was laid down in a randomized block design, replicated thrice with ten treatments of different combinations of inorganic fertilizers, vermicompost and biofertilizers. A study was undertaken to describe the soil resources of the investigation field. The residual effect of integrated nutrient management on soil chemical properties like the available nitrogen, phosphorus and potassium were significantly higher with application of 75% RDN + 25% N through Vermicompost + Consortia was proved to be the most promising integrated nutrient management practice. The similar results were obtained under yield and yield attributing parameter.

Keywords: INM, kodo millet, vermicompost, consortia

Introduction
Kodo millet is so resistant to drought, it can be cultivated in regions with inconsistent and little rainfall. Among the small millets, kodo millet is one of the hardiest crops. A group of cereal plants with little seeds are called mini millets. Due to their widespread use, these crops are now grown as a part of dry land agriculture in the tropics and subtropics. While little millets don't produce much food, they are vital to the ecosystems in which they are found as staple foods (Prabudoss *et al.*, 2014) [9].

Nitrogen, phosphorus and potassium elements are the most essential plant nutrients that plants require in considerable amounts for growth and development because of its crucial role in nearly all of their metabolic processes and the unavailability of nitrogen significant losses it experiences in soil-plant systems. (Ladha *et al.*, 2003) [5].

Azospirillum bacteria are free-living nitrogen (N_2)-fixing rhizobacteria that grow close to the plant roots. It has the ability to enhance plant development and yield for different agronomic crops under a variety of environmental and soil conditions. (Okon and Vanderleyden 1997) [7].

Integration of chemical fertilizers with organic manures and biofertilizers has been proved quite promising in addition to in sustaining soil health and productivity but also in stabilizing crop yield when compared to the utilization of each component separately (Hemlata *et al*, 2021) [4].

Materials and Methods
A field experiment was conducted during *kharif* season, 2023 at BTC college of agriculture and research station Bilaspur (C.G.), on sandy clay loam soil with pH 6.7 having low organic carbon content (0.47%), low in available nitrogen (219.56 kg ha^{-1}), low in available P_2O_5 (11.27 kg ha^{-1}) and available K_2O (290.47 kg ha^{-1}). The experiment was laid out in randomized block design with ten treatments and replicated thrice. The treatments comprised of T_1: Control, T_2: 100% n

RDN, T_3: 75% RDN + 25% N through Vermicompost, T_4: 75% RDN + Consortia, T_5: 75% RDN + 25% N through Vermicompost + Consortia, T_6: 50% RDN + 50% N through Vermicompost, T_7: 50% RDN + 50% N through Vermicompost, T_8: 100% N through Vermicompost, T_9: 50% RDN + Consortia, T_{10}: 50% N through Vermicompost. The seed rate is 10kg ha^{-1} and spacing is 30x10 cm.

Results and Discussion

Table 1: Effect of Integrated nutrient management on yield and yield attributing character of kodo millet

Treatment details		Panicle length (cm)	Number of racemes (Plant^{-1})	Weight of grains (Racemes^{-1})	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1	Control	6.70	4.28	5.26	6.55	11.36	24.87
T_2	100% RDN	8.90	6.41	6.96	9.94	22.39	49.03
T_3	75% RDN + 25% N through Vermicompost	8.33	5.44	6.37	6.74	18.08	39.59
T_4	75% RDN + Consortia	8.55	5.45	6.93	6.83	21.81	46.16
T_5	75% RDN + 25% N through Vermicompost + Consortia	9.79	6.57	7.23	6.97	23.32	51.07
T_6	50% RDN + 50% N through Vermicompost	8.13	4.43	6.44	6.71	16.54	36.22
T_7	50% RDN + 50% N through Vermicompost + Consortia	9.93	5.58	6.86	6.80	19.44	42.57
T_8	100% N through Vermicompost	7.06	4.37	5.87	6.63	13.52	29.60
T_9	50% RDN + Consortia	8.30	5.47	6.50	6.72	17.28	37.84
T_{10}	50% N through Vermicompost + Consortia.	4.46	4.46	6.32	6.65	15.53	34.01
S.Em (±)		0.41	0.41	0.37	0.04	1.27	2.07
CD (5%)		1.46	1.22	1.07	NS	3.81	6.15

Yield attribute

All the yield attribute *viz*. Panicle length, Number of racemes, weight of grain, Test weight was analyzed and presented on table 1 found that higher panicle length 9.79 cm was recorded with T_5(75% RDN + 25% N through Vermicompost + Consortia), which was at par with treatment T_2 (100% RDN), T_3 (75% RDN + 25% N through Vermicompost), T_4 (75% RDN + Consortia) and T_7 (50% RDN + 50% N through Vermicompost + Consortia), while significant over rest of the treatments during the course of investigation. However, lowest panicle length (6.70) was recorded under the treatment T_1 (Control). Higher number of racemes6.57 plant^{-1}was recorded with T_5(75% RDN + 25% N through Vermicompost + Consortia), which was at par with treatment T_2 (100% RDN), T_3 (75% RDN + 25% N through Vermicompost), T_4 (75% RDN + Consortia), T_7 (50% RDN + 50% N through Vermicompost + Consortia) and T_9(50% RDN + Consortia) while significant over rest of the treatments during the course of investigation. However, lowest number of racemes 4.28 plant^{-1} was recorded under the treatment T_1 (Control).Higher weight of grains 7.23 racemes^{-1}was recorded with T_5(75% RDN + 25% N through Vermicompost + Consortia), which was at par with treatment T_2 (100% RDN), T_3 (75% RDN + 25% N through Vermicompost), T_4 (75% RDN + Consortia), T_6 (50% RDN + 50% N through Vermicompost), T_7 (50% RDN + 50% N through Vermicompost + Consortia) and T_9(50% RDN + Consortia) while significant over rest of the treatments during the course of investigation. However, lowest weight of grains 5.26 racemes^{-1} was recorded under the treatment T_1 (Control). Test weight was not affected significantly by different treatments.

Kodo millet yield

The data presented in Table no. 1 revealed that the higher grain yield 23.52q ha^{-1} was recorded with treatment T_5 (75% RDN + 25% N through Vermicompost + Consortia) which was at par with T_2 (100%RDN) and T_4(75% RDN + Consortia), while significant over rest of the treatments during the course of investigation. However, lowest grain yield 11.36 q ha^{-1} was recorded under the treatment T_1 (Control). Data revealed that the higher grain yield 51.07 q ha^{-1} was recorded with treatment T_5 (75% RDN + 25% N through Vermicompost + Consortia) which was at par with T_2 (100%RDN) and T_4(75% RDN + Consortia), while significant over rest of the treatments during the course of investigation. However, lowest grain yield 24.87 q ha^{-1} was recorded under the treatment T_1 (Control). Sufficient availability of organic, inorganic and biofertilizers within the plant system promote the plant height and number of tillers m^{-1} row length which resulted in the form of higher straw yield gained in treatment T_5 (75% RDN + 25% N through Vermicompost + Consortia), T_2 (100% RDN) and T_4 (75% RDN + Consortia).

Table: 2: Effect of Integrated nutrient management on Available N, P_2O_5 and K2O (Kg ha^{-1}) in soil after harvest of Kodo millet

Treatment Details		N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
T_1	Control	190.01	8.62	252.33
T_2	100% RDN	233.12	15.80	298.49
T_3	75% RDN + 25% N through Vermicompost	224.00	16.76	294.16
T_4	75% RDN + Consortia	230.34	16.62	303.00
T_5	75% RDN + 25% N through Vermicompost + Consortia	237.23	17.44	307.52
T_6	50% RDN + 50% N through Vermicompost	216.45	15.61	290.30
T_7	50% RDN + 50% N through Vermicompost + Consortia	227.43	16.40	296.92
T_8	100% N through Vermicompost	210.86	13.62	271.52
T_9	50% RDN + Consortia	225.54	16.74	295.44
T_{10}	50% N through Vermicompost + consortia.	219.98	17.43	272.33
S.Em (±)		8.54	0.88	10.03
CD (5%)		25.59	2.65	30.04

Residual effect
The data presented in table no. 2 revealed that available N, P_2O_5 and K_2O kg ha-1 in soil after harvesting of kodo millet was significantly influenced by different treatments. The application T_5 (75% RDN + 25% N through Vermicompost + Consortia) illustrated significantly higher available N (237.23 kg ha-1), P_2O_5(17.44 kg ha-1) and K_2O (307.52 kg ha-1) which were at par with T_2 (100% RDN) and treatment T_4(75% RDN + Consortia) whereas significantly over with T_7(50% RDN + 50% N through Vermicompost + Consortia), T_3(75% RDN + 25% N through Vermicompost) and T_9(50% RDN + Consortia). Also lower was recorded in T_1 (Control).

Table: 3: Effect of Integrated nutrient management on Physical Properties of Experimental Field after harvest of kodo millet

Treatment Details		Physical properties		
		pH	EC (dSm^{-1})	OC (%)
T_1	Control	6.68	0.22	0.43
T_2	100% RDN	6.73	0.22	0.44
T_3	75% RDN + 25% N through Vermicompost	6.72	0.23	0.46
T_4	75% RDN + Consortia	6.72	0.22	0.44
T_5	75% RDN + 25% N through Vermicompost + Consortia	6.73	0.23	0.47
T_6	50% RDN + 50% N through Vermicompost	6.70	0.23	0.45
T_7	50% RDN + 50% N through Vermicompost + Consortia	6.72	0.21	0.45
T_8	100% N through Vermicompost	6.69	0.21	0.46
T_9	50% RDN + Consortia	6.70	0.20	0.44
T_{10}	50% N through Vermicompost + Consortia.	6.70	0.21	0.45
S.Em (±)		0.38	0.01	0.02
CD (5%)		NS	NS	NS

Chemical properties
The data pertaining to pH, EC and OC of soil after harvesting of kodo millet are presented in Table 3. pH, EC and OC (%) were significantly not affected by any treatment. The high content was found in T_5 (75% RDN + 25% N through Vermicompost + Consortia) treatment where both organic and inorganic source of nutrients were applied.

Conclusion
In conclusion, the present investigation reported that higher yield, yield attributing and residual effect of kodo millet could be realized with T_5 (75% RDN + 25% N through Vermicompost + Consortia). Among the different combination of integrated nutrient management, application of T_2(100% RDN) and T_4(75% RDN + Consortia) was proved to be the most promising and feasible viable nutrient management practice for higher yield attribute and yield of kodo millet.

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