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Effect of inputs integration on yield, uptake and economics of Kodo Millet (*Paspalum scrobiculatum* L.)

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ABSTRACT

Kodo millet provides staple food with cheap protein, minerals and vitamins to poor, marginal, tribal and backward people of Madhya Pradesh. This crop is responsive to the adverse climatic and poor soil conditions. The present investigation was carried out to improve kodo yield through different inputs and their integration to reduce the input cost. Due to very poor soil nature, a single source of any input was not found encouraging. Inorganic fertilizers (T2-100% NPK) gave promise grain yield (1435 kg/ha) over control (620 kg/ha) but it is realized that they are beyond the purchasing power of these resource poor farmers. *Azotobacter* + PSB (T4) was better in grain yield (695 kg/ha) as compared to *Azospirillum* +PSB (T7-665 kg/ha). While FYM alone (T12) gave grain yield 815 kg/ha. Integration of all the inputs 50% NP +100% K+ *Azotobacter* + PSB+ FYM proved best and increased the kodo yield (T10-1585 kg/ha) significantly. All treated plots had higher indices of profitability than control. The profitability was maximum 1.90 under T10 (50%NP +100% K+ *Azotobacter* + PSB+ FYM).

Keywords: Integrated plant nutrient, yield, uptake, economics, kodo

Today millet ranks as the sixth most important grain in the world, sustains one third of the world's population and is a significant part of diet in Africa, India, Northern Chaina, Japan, Manchuria and various area of the former Soviet Union and Egypt (Sahu, 2010). The importance lies in the ecological niche they occupy where no other food crops can be profitably grown. These crops with much longer history of cultivation than major food grains were rated highly in the past, playing an important role in our traditional food culture and farming systems (Gowda and Seetharam, 2007).

Kodo millet (*Paspalum scrobiculatum* L.) is a small grain crop in India, called by different names (Hindi: *Kodra*, Tamil: *Varagu*, Telugu: *Arikelu*, Karrda: *Harka*). It is provide staple food with cheap protein, minerals and vitamins to poor, marginal, tribal and backward people of Madhya Pradesh. Dindori district ranks second after Baster among the small millets growing district of the state Madhya Pradesh. (Anonymous, 2002).

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The crop is generally grown in fertility-depleted soils. The average fertilizer consumption of Dindori district is negligible, 3.1 kg/ha in *kharif* and 0.9 kg/ha in *rabi* with the annual average of 2.4 kg/ha. The productivity of kodo millet is very low on account of inadequate and imbalanced use of fertilizers, use of indigenous cultivars, non-addition of organic manures as well as biofertilizers by farmers (Dubey, 1991 and Ramesh *et al*., 2006). Synthetic fertilizers are becoming costlier gradually and these resource poor tribal farmers are unable to afford them. Therefore, these resource poor farmers' communities demand a special attention for low-cost input sustainable technology. Keeping in view the above facts, the present study was undertaken.

Materials and Methods

Field experiments were conducted on kodo millet cv. JK 41 at Regional Agricultural Research Station, Dindori, Madhaya Pradesh, India during kharif season. However, laboratory work was carried out at Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur (MP), India.

The soil was slightly acidic in pH (6.3 pH), normal in EC (0.12 dSm^{-1}) and poor in organic carbon content (0.38%) and low in available nitrogen (205 kg/ha) and phosphorus (8.2 kg/ha). However, the content of available potassium (265 kg/ha) was medium. Twelve treatments comprised as absolute control (T1), 100% recommended NPK (T2), 50% recommended NP + 100% recommended K (T3), *Azotobacter* + PSB (T4), T2+ *Azotobacter* + PSB (T5), T3+ *Azotobacter* + PSB (T6), *Azospirillum* + PSB (T7), T2+ *Azospirillum* + PSB (T8), T3+ *Azospirillum* + PSB (T9), T6+5 t FYM/ ha (T10), T9+5 t FYM/ ha (T11) and 5 t FYM/ ha (T12) were tested in randomized block design with four replications. As per recommended dose of the fertilizer (40:20:10 NPK), nitrogen was applied as urea, phosphorus as SSP and potash as muriate of potash. Plot wise required quantities of fertilizers as per treatment and experiment plan were applied in furrows. Then these synthetic fertilizers were mixed in furrows soil with the help of a wooden stick to avoid direct contact with the applied biofertilizers. Only 50% N and 100% P & K was applied as basal dose. While remaining 50% N was top dressed after one month of sowing. Seed were inoculated with Azotobacter and Azospirillum @ 3g/kg seed and PSB was applied @ 3 kg PSB with 150 kg FYM/ ha before sowing. Plant samples at maturity stage were taken from each plot for chemical determination of N, P and K contents in grain and straw of kodo. Nutrient status of the post-harvest soil was determined treatment-wise by the standard chemical procedure.

Results and Discussion

Grain and straw yield

On considering the mean value of two years grain yield of kodo it was observed that treatment T10 (50%NP +100% K+ *Azotobacter* + PSB+ FYM) gave highest grain yield (1585 kg/ha) followed by T11,T8, T5, T2, T6, T9, T3 and T12 (table 1). It is due to integration of all inputs. The treatments T4 and T7 (inoculation of biofertilizers alone) failed to increase the grain yield significantly over control and were at par to each other due to insufficient nutrient supply for crop growth. While remaining treatments were statistically superior over control. Similar results were reported by Ponnuswamy *et al.* 2002; Dwivedi and Rawat, 2009.

Straw yield of kodo was significantly varied due to different treatments during both year. Straw yield was relatively high during second year than the first year under all treatments because of more favorable climatic conditions. In case of straw yield of kodo, it was found that treatment T10 (50%NP +100% K+ *Azotobacter* + PSB+ FYM) gave highest straw yield (2450 kg/ha) followed by T11, T5, T8, T2, T6, T9, T3 and T12 (Table 1). The treatments T4 and T7 (inoculation of biofertilizers alone) failed to increase the straw yield significantly over control.

Thus, it could be stated that all treated plots produced higher straw yield than control mainly due to improvement in the vegetative growth parameters and finally yield attributes of crop plants. Singh (2004) and Varalakshmi *et al.* (2005) also reported the related finding.

Table 1: Yield, nutrient uptake and economics of kodo crop

Treatment	Grain (kg/ha)				Straw (kg/ha)				Gross monetary return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net monetary return (₹ ha^{-1})	Benefit: Cost ratio
	Yield	Uptake			Yield	Uptake						
		N	P	K		N	P	K				
T_1- Control	620	5.90	0.64	0.59	900	2.63	0.41	10.98	2570	2350	220	1.09
T_2 – 100% NPK	1435	24.69	2.66	2.55	2034	10.89	1.54	34.37	5943	3190	2753	1.86
T_3 – 50% NP + 100% K	1125	13.06	1.83	1.73	1395	5.83	0.86	21.50	4540	2803	1837	1.65
T_4 – Azt + PSB	695	7.20	0.84	0.73	1063	3.64	0.53	14.40	2886	2510	376	1.14
T_5 – T_2 + Azt + PSB	1545	27.12	2.92	2.90	2223	12.23	1.76	38.56	6393	3350	3043	1.90
T_6 – T_3 + Azt + PSB	1200	14.70	2.07	1.95	1580	6.95	1.01	25.44	4958	2963	1995	1.67
T_7 – Asp + PSB	665	6.62	0.80	0.71	1015	3.45	0.50	13.45	2762	2510	252	1.10
T_8 – T_2 + Asp + PSB	1515	26.14	2.83	2.80	2164	11.58	1.69	36.35	6276	3350	2926	1.87
T_9 – T_3 + Asp + PSB	1165	14.10	2.00	1.84	1490	6.48	0.92	23.39	4809	2963	1846	1.62
T_{10} – T_6 + FYM	1585	28.14	3.09	3.03	2450	13.73	1.96	42.14	6585	3463	3122	1.90
T_{11} – T_9 + FYM	1545	27.07	3.00	2.91	2340	12.57	1.85	40.29	6417	3463	2954	1.85
T_{12} – FYM	815	8.48	0.99	0.93	1205	4.14	0.62	16.70	3382	2850	532	1.18
Mean	1159.17	16.93	1.97	1.89	1654.63	7.84	1.14	26.46				
SEm±	106.22	1.82	0.21	0.20	155.78	0.84	0.12	3.10				
CD (0.05%)	208.19	3.56	0.42	0.40	305.32	1.65	0.24	6.07				

Azt. = Azotobacter; Asp. = Azospirillum, PSB = Phosphate solubilizing bacteria and FYM=Farm Yard Manure

Nutrients uptake by kodo crop

The data presented in Table 1 revealed that the maximum values of N,P and K uptake by kodo grain were 28.14, 3.09 and 3.03 kg ha^{-1} in T_{10} (50% NP + 100% K + *Azotobacter* + PSB + FYM) which was significantly superior over control (T_1 – 5.90, 0.64 and 0.59 kg ha^{-1}). The increasing rates of fertilizers increased the uptake by crop in grain, which could be due to increased nutrient supply to crop (Rao *et al*., 1986; Mishra *et al*., 1995). In case of uptake by kodo straw the maximum values of N,P and K were 13.73, 1.96 and 42.14 kg ha^{-1} in T_{10} (50% NP + 100% K + *Azotobacter* + PSB + FYM) which was significantly superior over control (T_1 – 2.63, 0.41 and 10.98 kg ha^{-1}). The increasing rates of fertilizers increased the uptake by crop in straw, which could be due to increased nutrient supply to crop (Varalakshmi *et al*., 2005 and Parihar *et al*., 2010).

The application of 5 t FYM ha^{-1} integrated with 50% NP + 100% K dose and biofertilizers recorded significantly higher values of nitrogen, phosphorus and potassium uptake. The increased uptake may be attributed to solubility action of organic acids produced during degradation of FYM resulting in more release of N, P, K and also to contribution by this manure. Further, it was also found that when FYM and biofertilizers were used alone (T_{12}, T_4 and T_7), it had resulted in a non significant increase in nutrient uptake over control but when they were used with 50% NP + 100% K dose, they exerted their beneficial effect through better nutrition of the crop. As it is stated these soils are skeletal soils with very poor nutrient status, so the only added and effective source of nutrients can play a positive role towards nutrients uptake and yield of crops.

Economic viability of the treatments

Economic analysis of the treatments is most important from the point of view for the practical value of the treatments. Most of the farmers are unable to afford costly agro–inputs to grow kodo crop. Mean while, the use of energy rich and no renewable agro-inputs is posing several problems for soil health and environmental quality on long run basis. Therefore, the

Table 2: Chemical and biological properties of soil after harvesting of kodo crop

Treatment	pH	EC (dSm^{-1})	OC (%)	Nitrogen (kg/ha)				P (kg/ ha)	K (kg/ ha)	Microbial Population		
				NH_4-N	NO_3-N	Av-N	Total –N			Azt (x10^3 g^{-1})	Asp (x10^3 g^{-1})	TBC (x10^6 g^{-1})
Initial	6.28	0.11	0.38	18.93	21.78	205.00	365	8.15	255	11.77	7.31	7.92
T_1- Control	6.28	0.11	0.37	18.79	19.99	187.50	348	7.80	238	11.58	6.85	7.59
T_2 – 100% NPK	6.35	0.12	0.43	22.85	26.49	245.00	535	11.13	310	28.42	14.31	15.89
T_3 – 50% NP + 100% K	6.30	0.11	0.39	20.94	23.18	220.50	425	9.13	285	17.40	10.77	10.76
T_4 – Azt + PSB	6.29	0.10	0.38	19.54	20.94	211.50	373	8.38	265	17.10	6.89	8.66
T_5 – T_2 + Azt + PSB	6.36	0.12	0.44	23.74	27.44	257.50	548	12.15	318	33.62	12.70	17.12
T_6 – T_3 + Azt + PSB	6.30	0.11	0.39	21.34	24.75	227.50	473	9.65	295	23.04	9.65	11.38
T_7 – Asp + PSB	6.28	0.10	0.38	19.38	20.72	207.50	368	8.33	260	10.53	8.20	8.46
T_8 – T_2 + Asp + PSB	6.36	0.12	0.43	23.52	26.99	252.50	543	11.45	310	23.39	16.08	16.82
T_9 – T_3 + Asp + PSB	6.30	0.11	0.39	21.15	24.30	226.00	460	9.38	295	18.28	13.42	11.56
T_{10} – T_6 + FYM	6.33	0.12	0.48	23.97	27.55	267.50	555	12.48	325	39.40	11.25	21.11
T_{11} – T_9 + FYM	6.33	0.12	0.47	23.65	27.22	264.00	550	12.35	320	29.09	26.56	21.73
T_{12} – FYM	6.27	0.10	0.46	20.05	22.18	215.00	385	8.90	261	24.99	17.44	24.54
Mean	6.31	0.11	0.42	21.58	24.31	231.83	463.33	10.09	290.08	22.82	12.84	14.63
SEm±	0.46	0.01	0.04	1.55	1.99	19.99	41.08	0.88	25.47	2.07	1.13	1.30
CD (0.05%)	0.90	0.02	0.08	3.04	3.90	39.19	80.52	1.72	49.93	4.07	2.22	2.55

Azt. = Azotobacter; Asp. = Azospirillum, PSB = Phosphate solubilizing bacteria and FYM=Farm Yard Manure

present investigation was aimed to curtail or minimize the use of chemical fertilizers which are not only costly but they are non-renewable nature of energy. For this purpose the FYM and different biofertilizers were used for sustainable productivity of kodo which is normally grown as low fertilizer needing crop particularly in hilly lands dominated by the tribal farmers.

The NMR was maximum in 50% NP + 100% K + bacterial inoculates + FYM (3122 ha^{-1}) followed by 100% NPK + bacterial inoculation (3043, 2926 ha^{-1}) and 100% NPK through chemical fertilizers (2753 ha^{-1}) in kodo crop respectively (Table 1). The NMR was minimum after that control in FYM alone (532 ₹ ha^{-1}) but it was found more profitable than bacterial inoculation only (376, 252 ₹ ha^{-1}) in kodo crops, respectively. Similar finding were also reported by Dubey and Agrawal 2007 and Dwivedi *et al.* 2015.

Profitability refers the monetary gain over each rupee of investment under a particular treatment. All treated plots had higher indices of profitability than control. The profitability was maximum 1.90 under T10 (50%NP +100% K+ *Azotobacter* + PSB+ FYM). Profitability of T8 was 1.87 next to maximum, closely followed by T2, T11 and T6 (1.86, 1.85 and 1.67). Application of 50% NP + 100% K through chemical fertilizers with or without biofertilizers had the cost benefit ratio 1.65 and 1.62 (T3, and T9) which were quite low than 100% NPK with or without biofertilizer.

The profitability due to application of biofertilizer and FYM alone were 1.14, 1.10 and 1.18 (T4, T7 and T12) which were slightly higher than control (Table 1). The increase in yield over control was marginal under these treatments; hence the profitability also did not increase much. The benefit to cast ratio of the use of various inputs was very attractive and justified the recommendation to include integrated plant nutrient management strategies for improving the yield of kodo grown by tribal and ensure their livelihood security. Similar finding were also reported by Ganeshe *et al.* (1998) and Kumar *et al.* (2005).

Chemical properties of soil

Soil organic carbon was significantly improved in the treatments where FYM was incorporated. Application of inorganic fertilizers had resulted in increasing available nitrogen and phosphorus status in the soil over initial status (Table 2). Use of 50% NP and 100% K along with FYM and biofertilizers had attained the same status as that of 100% NPK. Similar finding were also reported by Dubey and Agrawal (2007). When the requirement of a particular nutrient is more, naturally the removal from the soil will be more which is reflected from its lower content in the soil (Kanwar and Reddy, 2003). While soil potassium showed the same behavior as available nitrogen and phosphorus.

Performance of FYM was slightly better as compared to biofertilizers. Application of 50% NP + 100% K, biofertilizers and FYM significantly enhance the content of mineral and total nitrogen over control while other treatments remained non significant. The more availability of mineral nitrogen in soil is responsible for more nitrogen uptake by plants. The presence of mineral nitrogen in the soil may be due to either mineralization of organic form of nitrogen like protein, amino acid to inorganic form of nitrogen like NH_4^+ and NO_3^- or it appears in soil by the application of straight chemical nitrogen fertilizer like urea, DAP (Bear, 1967).

Biological properties of soil

The data presented in Table 2 revealed that after harvest of kodo crop, population of *Azotobacter*, *Azospirillum* and total bacteria was increased significantly with increasing level of fertilizers. It may be due to better rhizosphere and lizosphere effect (Tilak, 1993).

Further it was also found that integration of inorganic fertilizers with FYM and biofertilizer enhanced microbial activities in the rhizosphere. Integration of all sources of nutrient directly influences the population by providing a wide range of micro nutrients and essential growth promoting substances as well as a favorable physical environment. Similar results were also reported by Jain *et al*. 2003, Dwivedi and Dwivedi 2015.

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