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Integrated nutrient management on growth, yield and economics of kodo millet *(Paspalum scrobiculatum* L.)

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ABSTRACT

A field experiment was carried out during kharif season 2016 and 2017 at the farmer's field in village Gudhar, Rewa (M.P.) to study the effect of integrated nutrient management on growth, yield and economics of kodo millet (Paspalum scrobiculatum L.). Sixteen treatments were evaluated in randomized block design with three replications. The results revealed that the application of 100% NPK fertilizers (40 kg N, 20 kg P_2O_5 and 10 kg K_2O ha^{-1}) proved the most beneficial for growing kodo millet var. JK-13 under rainfed condition of Kymore plateau of Madhya Pradesh. Application of 100% NPK fertilizer gave maximum panicles (6.56/plant), grains count (237.5/panicle), panicle length (14.86 cm), grains weight (1.24 g/panicle) and test weight (6.36 g), grain yield of 27.55 q ha^{-1} and net income of Rs.60098 ha^{-1} with 5.46 B:C ratio. Amongst the integrated nutrient management (INM) packages, application of 100% N by 80 q ha^{-1} vermicompost along with 66.6 kg ha^{-1} rock phosphate performed the best giving higher attributes and yield of 25.35 q ha^{-1} with net income of Rs.51950 ha^{-1} and 4.47 B:C ratio. The second best INM package (50% N by FYM + green manuring +33.3 kg rock phosphate ha^{-1}) gave 23.74 q ha^{-1} yield and Rs.46706 ha^{-1} net income. Both these packages may be followed to achieve sustainable productivity of kodo-millet. The lower values of all the para meters were recorded under control.

Key words: Integrated nutrient management, kodo-millet, yield

INTRODUCTION

The long-term use of chemical fertilizers is known to degrade physico-chemical and biological properties of soil i.e. soil environment and soil health. The nutrient requirement of crops cannot, however, be met through fertilizers alone. Besides, the escalating prices of fertilizers and there inadequacy calls for integration of nutrient sources for meeting the nutrient demand of crops. The estimated nutrient potential of organic wastes in the country is about 19.11 million tonnes. Organic wastes can be transformed into usable manures with high nutritive value (Sharanappa, 2002). In fact, the balanced fertilization from different sources is referred as the integrated nutrient management. Organic manures such as vermicompost, poultry manure, FYM (cattle manure), composts etc. are important components of integrated nutrient management. Organic manures also supply the traces amounts of micronutrients, which are generally not applied by the farmers to their crops. *Azospirillum* and *Aspergillus* are the potential biofertilizers and are capable to contribute nitrogen and phosphorus to a number of non-legumes. Kodo Millet *(Paspalum scrobiculatum* L.*)* is one of the important small millet crops of Madhya Pradesh particularly in Kymore plateau. It provides 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. It is mostly taken by small and marginal farmers in tribal areas under rainfed conditions with low productivity. Kodo millet grown in the soils of lower nutrient contents results in lower quality and quantity of produce. Therefore, manures are the only option for improving the quality and sustain the yield of kodo millet as well as soil health. In the light of these facts as well as for securing sustainable production of kodo-millet under the agro-climatic conditions of Kymore plateau region, the present investigation was conducted.

MATERIALS AND METHODS

The field experiment was carried out during rainy season 2016 and 2017 at the farmer's field in village Gudhar, Rewa (M.P.). The soil of the experimental field was silty clay-loam having pH 7.3, electrical conductivity 0.30 dS m^{-1}, organic carbon 6.75 g kg^{-1}, available-N 226 kg ha^{-1}, available-P_2O_5 23.0 kg ha^{-1},

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available-K_2O 374 kg ha^{-1} and available-S 12.8 kg ha^{-1}. The experiment was laid out in randomized-block design with three replications. The treatments comprised sixteen INM packages (Table 1). The kodo-millet variety JK-13 was sown on 12 and 14 July 2016 and 2017, respectively keeping a seed rate of 10 kg ha^{-1} and row spacing 25 cm and plant spacing 7.5 cm. The organic and inorganic sources of nutrients were applied as basal according to the specified treatments. The crop was grown under rainfed condition. The rainfall received during the crop season 2016 and 2017 was 681.0 and 704.6 mm with 33 and 37 rainy days, respectively. The crop was harvested on 17-19 October in both the years. The yield attributes and yield of kodo millet were recorded at harvest under each of the INM treatments.

RESULTS AND DISCUSSION

Yield attributes

The data (Table 1) reveal that the panicles/plant, number of grains/panicle, length of panicle and dry matter/plant were found to deviate significantly due to applied INM packages. Out of these packages, 100% NPK fertilizers (T_{15}) resulted in significantly higher yield-attributes over almost all other INM packages. The maximum values of panicle number (6.56/plant), grains count (237.5/ panicle), panicle length (14.86 cm), grains weight (1.24 g/panicle) and 1000-grains weight (6.36 g) and dry matter (14.05 g/plant) were recorded under T_{15} treatment. This may be owing to the excellent utilization of growth in sufficient amount as a result of better availability of plant nutrients and their translocation to sink during the course of panicle initiation and grain filling stages. These results corroborate with the findings of Kaushik *et al.* (2012), Kumar *et al.* (2015) and Dwivedi *et al.* (2016). The INM packages having inorganic plus organic sources of nutrients T_2 (100% N by vermicompost + rock phosphate) and T_6 (T_2 + biofertilizers) resulted in increased grains number (225.8 to 231.1/panicle), panicle length (14.04 to 14.71 cm), grains weight (1.17/panicle) and test weight (5.05 to 5.06 g). The increase in yield attributes in T_2 and T_6 packages was due to combined influence of all beneficial activities of earthworms and microorganisms which increased the supply of plant hormones in addition to supply of primary, secondary and micronutrients. Vermicompost is an excellent soil additive made

Table 1: Yield-attributes of kodo millet as influenced by INM treatments (mean of two years)

Treatments	No. of panicles/ plant	No. of grains/ panicle	Length of panicles (cm)	Weight of grains/ panicle (g)	Test weight (g)	Dry matter production/ plant (g)
T_1 50% N by 40 q VC ha^{-1} + 33.3 kg RP ha^{-1}	5.65	207.8	11.8	1.25	4.35	10.56
$T_2$100% N by 80 q VC ha^{-1} + 66.6 kg RP $^{-1}ha^{-1}$	5.84	225.8	14.0	1.17	5.06	12.44
$T_3$50% N by 50 q FYM ha^{-1} + 33.3 kg RP ha^{-1}	5.66	200.5	11.8	1.06	4.24	11.75
$T_4$100% N by 100 q FYM ha^{-1} + 66.63 kg RP ha^{-1}	6.18	211.1	12.5	1.06	4.86	12.65
T_5T_1 + 8 kg Biof. (Azos. + Asper.) ha^{-1}	5.76	205.1	12.2	1.05	4.54	13.75
T_6T_2 + 16 kg Biof. (Azos. + Asper.) ha^{-1}	6.07	231.1	14.7	1.17	5.05	13.56
T_7T_3 + 10 kg Biof. (Azos. + Asper.) ha^{-1}	6.06	207.8	11.9	1.07	4.46	12.05
T_8T_4 + 20 kg Biof. (Azos. + Asper.) ha^{-1}	6.05	211.8	13.0	1.06	4.86	12.55
T_9T_1 + 50% N by 50 q FYM ha^{-1} + 33.3 kg RP ha^{-1}	5.67	216.1	12.0	1.04	4.65	12.74
$T_{10}T_9$ + 17.9 kg Biof. (Azos. + Asper.) ha^{-1}	6.05	206.1	12.5	1.06	4.74	13.15
T_{11}50% N by FYM + GM + 33.3 kg RP ha^{-1}	5.86	218.5	13.2	1.16	4.86	13.95
$T_{12}T_{11}$ + 10 kg Biof. (Azos. + Asper.) ha^{-1}	5.86	203.5	12.3	1.05	4.77	11.58
T_{13}100% N by FYM + GM + 33.3 kg RP ha^{-1}	5.93	219.8	13.1	1.16	4.93	13.24
$T_{14}T_{13}$ + 20 kg Biof. (Azos. + Asper.) ha^{-1}	5.34	223.1	13.5	1.16	4.94	13.56
T_{15}100% inorganics ($N_{40}P_{20}K_{10}$)	6.56	237.5	14.8	1.24	6.36	14.05
T_{16}Absolute control	5.08	198.1	10.9	0.76	4.16	9.31
S.Em$\pm$	0.16	0.44	0.06	0.01	0.02	0.12
C.D. (P=0.05)	0.45	1.28	0.18	0.04	0.06	0.34

VC = vermicompost, FYM = farmyard manure, GM = green manure, Biof. = biofertilizers, RP = rock phosphate, Asper. = Aspergillus awamori, Azos. = Azospirillium brasilence up of digested and undigested compost and also contains a number of live and dried earthworms as well as cocoons. Worm casts contain five times more nitrogen, seven times more phosphorus and eleven times more potassium than ordinary soil, the main minerals needed for plant growth. It also contains a lot of beneficial soil micro-organisms (Singh and Chauhan, 2014). The results corroborate with those of Barick *et al.* (2008), Dwivedi *et al.* (2016) and Singh *et al.* (2013 and 2014).

Table 2: Effect of INM practicesw on yield and economics of kodo millet (mean of two years)

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Net income (Rs. ha^{-1})	B:C ratio
T_1 50% N by 40 q VC/ha + 33.3 kg RP/ha	19.25	35.65	34.8	30840	2.48
$T_2$100% N by 80 q VC/ha + 66.6 kg RP/ha	25.35	35.25	43.4	51950	4.47
$T_3$50% N by 50 q FYM/ha + 33.3 kg RP/ha	19.05	37.94	33.2	35569	3.24
$T_4$100% N by 100 q FYM ha^{-1}+ 66.63 kg RP ha^{-1}	23.25	37.94	37.8	42569	3.20
T_5T_1 + 8 kg Biof. (Azos. + Asper.)/ha	22.65	44.75	33.4	39450	2.82
T_6T_2 + 16 kg Biof. (Azos. + Asper.)/ha	26.55	42.06	38.6	39631	2.28
T_7T_3 + 10 kg Biof. (Azos. + Asper.)/ha	20.74	37.93	35.1	38793	3.30
T_8T_4 + 20 kg Biof. (Azos. + Asper.)/ha	23.75	42.05	35.9	42730	3.05
T_9T_1 + 50% N by 50 q FYM/ha + 33.3 kg RP ha^{-1}	22.74	39.35	36.4	36435	2.50
$T_{10}T_9$ + 17.9 kg Biof. (Azos. + Asper.)/ha	23.46	40.65	36.4	36595	2.40
T_{11}50% N by FYM + GM + 33.3 kg RP/ha	23.74	42.06	35.9	46706	3.77
$T_{12}T_{11}$ + 10 kg Biof. (Azos. + Asper.)/ha	23.15	33.79	40.4	43404	3.43
T_{13}100% N by FYM + GM + 33.3 kg RP/ha	24.46	40.65	37.4	44865	3.20
$T_{14}T_{13}$ + 20 kg Biof. (Azos. + Asper.)/ha	24.64	42.05	36.9	43455	2.94
T_{15}100% inorganics ($N_{40}P_{20}K_{10}$)	27.55	46.83	38.6	60098	5.46
T_{16}Absolute control	15.16	29.01	33.7	28451	3.30
S.Em$\pm$	0.09	0.10	0.46	--	--
C.D. (P=0.05)	0.25	0.28	1.33	--	--

Productivity parameters

Application of T_{15} (100% recommended NPK dose of fertilizers recorded the significantly higher grain (27.55 q ha^{-1}) and straw yield (46.83 q ha^{-1}) over most of the other treatments. This might be owing to the fact that NPK fertilizers provided immediate availability of major nutrients to the actively growing plants. The superiority of 100% NPK (T_{15}) over other treatments with respect to growth and yield attributes have mutually accompanied to give rise maximum output in the form of grain and straw yields. All these parameters were found beneficial in the increased production and transmission of photosynthates towards the sink. Amongst the integrated supply of nutrients, T_6 (100% N by vermicompost + rock phosphate + biofertilizers) and then T_2 (100% N by vermicompost + rock phosphate) resulted in the second and third best in productivity (26.55 and 25.35 q ha^{-1}, respectively). This might be attributed to higher availability of primary, secondary and micro-nutrients, higher occurrence of different beneficial microorganisms, production of growth-promoting hormones, antibiotics, enzymes in vermicompost (Kaushik *et al.*, 2012; Dwivedi *et al.*, 2016 and Pandey, 2018).The beneficial effect of vermicompost on rice has been reported by Barick *et al.*(2008) who found that substitution of chemical fertilizers through vermicompost by 40-60% of nitrogen would be better to reduce chemical fertilizers without affecting the crop yield and soil quality. The harvest index was also influenced significantly due to different treatments. The T_2 treatment gave the highest HI (43.41%), followed by T_{12} (40.44%) and then T_6 and T_{15} (38.60 to 38.62%). The increase in HI in these treatments might be due to increased translocation of photosynthates from source to the sink as compared to other treatments.

Economics

Application of 100% NPK fertilizers (T_{15}) resulted in the maximum net income of Rs.60098 ha^{-1} with 5.46 B:C ratio, followed by T_2 (Rs.51950 ha^{-1} with 4.47 B:C ratio) and then T_{11} giving net income of Rs.46706 ha^{-1}. The lowest net income only Rs.28451 ha^{-1} was obtained from the absolute control (T_{16}). This was eventual as the net income is directly positively correlated with the grain and straw yields obtained from those treatments. The second important factor is the cost of cultivation, which is negatively correlated with the net income. These two factors contributed towards higher or lower net income accordingly. The present findings evidently indicated that for achieving the highest net income, 100% recommended NPK fertilizers may be applied. In case kodo millet is to be grown with 100% organic sources of nutrients, then 100% N may be applied through vermicompost along with rock phosphate.

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