

Growth Dynamics, Yield and Economics of Pearl Millet (*Pennisetum glaucum*) as Influenced by Vermicompost and Fertilizers

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Abstract: A study was conducted during rainy seasons of 2003 and 2004 at College of Agriculture, Bikaner, to study growth dynamics, yield and economics of pearl millet (*Pennisetum glaucum* (L.) R.Br. Emend Stunz) as influenced by vermicompost and fertilizers. The results revealed that plant height, dry matter accumulation, total number of tillers at 40 DAS, yield attributes, physiological parameters, seed and stover yield, harvest index, nutrient uptake, net returns and B:C ratio increased significantly due to drilling of vermicompost @ 2 t ha⁻¹ over control, where as its drilling @ 1 t ha⁻¹ remained statistically at par with soil incorporation @ 2 t ha⁻¹. Maximum and significantly higher growth parameters, yield attributes, physiological parameters, yield, HI, nutrient uptake, net return and B:C ratio were recorded due to application of 90 kg N + 45 kg P₂O₅ ha⁻¹ as compared to control (N₀ P₀).

Key words: Fertilizers, pearl millet, vermicompost, physiological parameters, economics.

Pearl millet [*Pennisetum glaucum* (L.) R.Br. Emend Stunz] is a drought tolerant and dual purpose crop of rainfed area. Yield of this crop is greatly influenced by organic and inorganic fertilizers under rainfed condition of Rajasthan. Main reasons for low productivity (223 kg ha⁻¹) (Agricultural Statistics Raj., 2002-03) of this crop in the state are water and nutritional stresses. One of the easiest ways for boosting productivity of pearl millet is the use of balanced fertilizers to the undernourished crop. Integrated use of chemical fertilizers with organic manures has been found to be quite promising in maintaining high productivity and providing greater stability to crop production (Patidar and Mali, 2004). FYM is used as a major source of organic manure in field crops. In view of poor efficiency of FYM, vermicompost has been advocated as a good source of organic manure along with inorganic source for field crops (Roy and Singh, 2006). In view of its high cost, the easiest way to use this manure profitably in pearl millet could be to use it at low rates through drilling. Therefore, present investigation was carried out to investigate the growth dynamics of pearl millet as influenced by vermicompost and fertilizers.

Materials and Methods

The field experiment was conducted during rainy seasons of 2003 and 2004 at Agronomy Farm of College of Agriculture, Bikaner, (28°01'N and 73°22'E at 234.7 m above mean sea level). Soil of

the experimental plot was loamy sand in texture, alkaline in reaction (pH 8.24) with low organic carbon (0.075%). The available soil N, P and K were 112.7, 11.96 and 198.8 kg ha⁻¹, respectively. Vermicompost applied in experimental plots had 1.6% N, 1.4% phosphorus and 1.1% potash. The experiment was laid out in split-plot design with 3 replications. The treatments comprised 25 factorial combinations of five vermicompost levels viz. control, 1 t ha⁻¹ soil incorporation, 1 t ha⁻¹ drilling, 2 t ha⁻¹ soil incorporation and 2 t ha⁻¹ drilling allocated to main plots and five inorganic fertilizer levels viz., unfertilized control (N₀ P₀), N @ 30 kg ha⁻¹ + P₂O₅ @ 15 kg ha⁻¹ (N₃₀ P₁₅), N @ 60 kg ha⁻¹ + P₂O₅ @ 30 kg ha⁻¹ (N₆₀ P₃₀), N @ 90 kg ha⁻¹ + P₂O₅ @ 45 kg ha⁻¹ (N₉₀ P₄₅) and N @ 120 kg ha⁻¹ + P₂O₅ @ 60 kg ha⁻¹ (N₁₂₀ P₆₀) allotted to sub-plots. The pearl millet variety HHB 67 was sown on 10 and 14 July and harvested on 26 and 27 September during 2003 and 2004, respectively, with crop geometry of 45 cm x 12 cm and a seed rate of 5 kg ha⁻¹. The rainfall received during growing periods (July to September) was 221.2 mm in 2003 and 87.9 mm in 2004. The mean weekly minimum and maximum temperature during the crop season of 2003 fluctuated from 18.9 to 24.3°C and 34.2 to 38.9°C, respectively, and from 24.7 to 29.4°C and 36.9 to 42.4°C, respectively, during 2004. Average relative humidity varied from 45 to 76% in 2003 and 34 to 67% in 2004. Periodic dry matter accumulation was recorded at 20 day interval. Samples were oven dried at 70°C for about 72 hr and dry weight was recorded. Crop growth rates (CGR), relative

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Table 1. Effect of vermicompost and inorganic fertilizers on growth, yield attributes, yields, harvest index and economics of pearl millets (Pooled data of 2 years)

Treatments	Plant height (cm)	TotalNo. of tillers/Plant	Ear length (cm)	No.of effective tillers/meter	No. seed/ear	Test weight (g)	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)	Net return (Rs ha ⁻¹)	B:C ratio
A. Vermicompost (t ha⁻¹)											
Control	159.9	2.63	13.27	19.79	930	6.56	1372	2497	35.22	1269	1.124
1 t soil incorporation	175.6	2.99	14.78	21.70	1018	6.95	1538	2720	35.92	1397	1.125
1 t drilling	182.9	3.24	16.20	23.44	1086	6.98	1645	2861	36.33	2181	1.201
2 t soil incorporation	188.1	3.29	16.29	23.93	1114	7.01	1654	2873	36.37	1156	1.093
2 t drilling	200.7	3.57	17.70	25.59	1198	7.11	1798	3058	36.91		1.185
SEm±	2.7	0.05	0.30	0.35	17.2	0.06	27.9	38.9	0.26	2320	
CD (P=0.05)	8.0	0.16	0.89	1.05	51.7	0.17	83.8	116.6	0.78		
B. Inorganic fertilizers (kg ha⁻¹)											
N ₀ P ₀	149.1	2.44	11.98	18.47	880	6.62	1141	2176	34.26		0.946
N ₃₀ P ₁₅	170.5	2.97	14.83	21.48	1001	6.89	1486	2655	35.79	-486	1.141
N ₆₀ P ₃₀	186.8	3.25	16.23	23.53	1096	6.98	1716	2959	36.64	1433	1.231
N ₉₀ P ₄₅	199.6	3.50	17.4	25.25	1178	7.05	1832	3109	37.03	2487	1.238
N ₁₂₀ P ₆₀	201.3	3.56	17.78	25.73	1191	7.08	1832	3109	37.03	2702	1.173
SEm ±	2.3	0.05	0.27	0.34	14.0	0.06	27.2	35.6	0.19	2187	
CD (P=0.05)	6.5	0.13	0.78	0.95	39.5	0.16	76.4	100.3	0.55		

growth rate (RGR) and net assimilation rate (NAR) were calculated by standard procedures (Gardner *et al.*, 1985) for 20-40 days, 40-60 days and 60 days to harvest. Leaf area was measured with the help of leaf area meter at 20, 40, 60 DAS and at harvest and leaf area index (LAI) was calculated. The total number of tillers/plant was recorded at 40 days after sowing (DAS).

Three irrigations (30, 45 and 60 DAS) with 6 cm depth of water at the moisture level of 2 to 3.5% were given to crop due to high temperature and low rainfall during both crop seasons. Bikaner falls in Agro-climatic Zone 1 C, which is known as hyper arid partially irrigated north-western plain zone and in this zone without irrigation it is not possible to take better yield of pearl millet. Full amount of vermicompost was soil incorporated or drilled along with half of nitrogen and full amount of phosphate drilled at the time of sowing as per treatments. Remaining half of nitrogen was top dressed along with irrigation at 30 DAS. The irrigation requirement of pearl millet, however, is very low, but because of higher evaporation demand of atmosphere and low rainfall, crop was raised with recommended package of practices. The sun-dried bundles were threshed and winnowed and grain so obtained was weighed. The stover yield was obtained by subtracting the seed yield from the biological yield. The data were statistically analyzed for individual years and pooled over years through standard procedures. N and P were determined colorimetrically (Jackson,

1973) and K was determined by flame photometer (Richards, 1954).

Results and Discussion

Growth parameters

Application of vermicompost up to 2 t ha⁻¹, either incorporated or drilled in soil significantly increased total number of tillers/plant at 40 DAS, plant height and periodic dry matter accumulation (Tables 1 and 5). Soil incorporation of vermicompost @ 1 and 2 t ha⁻¹ improved growth parameters significantly over control (Table 1). Drilling of vermicompost further improved these growth parameters considerably. Thus, drilling of the vermicompost @ 2 t ha⁻¹ increased total number of tillers/plant, plant height and dry matter accumulation at harvest over control by 35.7, 25.5 and 45.8%, respectively. It suggests that drilling of vermicompost was more efficient than its soil incorporation in improving these growth parameters. Overall improvement in crop under vermicompost application appears to be due to better availability of nutrients in the root zone and plant system as vermicompost is known to improve the soil physical and biological properties including supply of all the essential nutrients for plant growth and development (Patidar and Mali, 2004).

Application of increasing levels of inorganic fertilizers up to N₉₀ P₄₅ progressively and significantly increased growth parameters. N₉₀ P₄₅

Table 2. Effect of vermicompost and inorganic fertilizer on dry matter accumulation and LAI of pearl millets (Pooled data of 2 years)

Treatments	Dry matter accumulation (g/mrl)				LAI			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
A. Vermicompost (t ha⁻¹)								
Control	12.68	54.64	145.49	176.40	0.883	2.330	3.008	2.693
1 t soil incorporation	13.36	61.18	170.49	207.94	0.941	2.603	3.454	3.093
1 t drilling	13.74	66.17	188.38	230.23	0.961	2.868	3.865	3.460
2 t soil incorporation	13.87	67.80	193.87	237.07	0.969	2.929	3.932	3.521
2 t drilling	14.38	72.33	210.18	257.25	0.990	3.135	4.271	3.781
SEm ±	0.14	0.97	2.64	3.22	0.012	0.040	0.060	0.054
CD (P=0.05)	0.41	2.91	7.90	9.64	0.036	0.121	0.179	0.161
B. Inorganic fertilizers (kg ha⁻¹)								
N ₀ P ₀	12.60	51.29	136.47	165.54	0.874	2.258	2.902	2.597
N ₃₀ P ₁₅	13.47	61.71	171.55	209.08	0.941	2.626	3.476	3.104
N ₆₀ P ₃₀	13.79	66.46	188.49	230.29	0.962	2.860	3.851	3.436
N ₉₀ P ₄₅	14.05	70.67	203.93	249.54	0.980	3.033	4.120	3.678
N ₁₂₀ P ₆₀	14.12	72.00	207.97	254.44	0.989	3.090	4.180	3.732
SEm ±	0.14	0.81	2.23	2.71	0.011	0.035	0.053	0.047
CD (P=0.05)	0.38	2.29	6.27	7.63	0.030	0.098	0.148	0.132

DAS = Days after sowing, LAI = Leaf area index, mrl = meter row length.

increased the tillers/plant, plant height and dry matter accumulation at harvest over control by 43.4, 33.8 and 50.7%, respectively. Significantly higher total number of tillers/plant, LAI, plant height and dry matter accumulation as a result of inorganic fertilization (Table 1) may be attributed to higher nutrients in the root zone as well as in plants. An adequate supply of nitrogen early in the life of a plant is considered important in promoting rapid vegetative growth and phosphorus in root proliferation and laying down primordia for its reproductive growth and seed formation. The results of this study are in close agreement with the findings of Chellamuthu (2000) and Singh and Agarwal (2004) who also reported significant improvement in growth parameters due to fertilizer application.

Physiological parameters

The physiological parameters, viz., LAI (Table 2), CGR, RGR and NAR (Table 3) were significantly influenced by the application of vermicompost at 2 t ha⁻¹ either drilled or soil incorporated over control and 1 t ha⁻¹ at all the stages of crop growth except LAI at 20 DAS. The results suggested that drilling of vermicompost @ 1 t ha⁻¹ was comparable with its soil incorporation at 2 t ha⁻¹ in improving all the physiological parameters (LAI, CGR, RGR and NAR) at all stages of crop growth (Table 3). Drilling of vermicompost @ 2 t ha⁻¹ increased CGR and RGR at 20-40 DAS, 40-60 DAS and 60-maturity by 38.1, 51.7, 57.8, and 11.0, 9.0, 5.1%, respectively, as compared to control.

The increase in LAI at 20, 40, 60 DAS and at maturity over control due to drilling of vermicompost @ 2 t ha⁻¹ was 12.1, 34.5, 42.0 and 40.4%, respectively. The increased plant growth with vermicompost may be due to improved availability of N, P and K as well as other micro-nutrients (Ghosh *et al.*, 2003). The observed improvement in growth parameters due to vermicompost application has also been reported in sorghum by Patidar and Mali (2004).

At all the stages and phases of crop growth, LAI, CGR, RGR and NAR increased significantly with increasing levels of fertilizers up to 90 kg N + 40 kg P₂O₅ ha⁻¹ (N₉₀ P₄₅), beyond which improvement was not significant. However, NAR did not differ significantly at N₃₀ P₁₅ and N₆₀ P₃₀ during 60 days-harvest. The increase in LAI at 20, 40, 60 DAS and at harvest over control due to N₉₀ P₄₅ was 12.1, 34.3, 42.0 and 41.6%, respectively.

Application of fertilizer @ N₉₀ P₄₅ increased NAR 20-40 days, 40-60 days and 60 - harvest stages by 17.8, 13.8 and 11.0%, respectively, as compared to control. Ghosh *et al.* (2003) also reported that application of N and P to pearl millet significantly increased LAI, CGR, RGR and NAR.

Yield attributes

Increasing levels of vermicompost from 0 to 2 t ha⁻¹ progressively increased yield attributes. Drilling of vermicompost was found more effective over its soil incorporation in improving these parameters, which is clearly evident from comparable values of

Table 3. Effect of vermicompost and inorganic fertilizers on CGR, RGR and NAR of pearl millets (Pooled data of 2 years)

Treatments	CGR (g m ⁻² day ⁻¹)			RGR (mg g ⁻¹ day ⁻¹)			NAR (g m ⁻² day ⁻¹)		
	20-40 DAS	40-60 DAS	60 to at harvest	20-40 DAS	40-60 DAS	60 to at harvest	20-40 DAS	40-60 DAS	60 to at harvest
A. Vermicompost (t ha⁻¹)									
Control	4.661	10.093	4.420	72.45	48.76	12.800	3.065	3.797	1.208
1 t soil incorporation	5.313	12.144	5.547	75.74	51.05	13.200	3.237	4.018	1.268
1 t drilling	5.825	13.578	6.199	78.28	52.12	13.330	3.326	4.093	1.280
2 t soil incorporation	5.992	14.006	6.398	79.02	52.33	13.870	3.367	4.100	1.283
2 t drilling	6.438	15.314	6.974	80.44	53.14	13.450	3.445	4.149	1.297
SEm ±	0.095	0.185	0.107	0.56	00.12	0.016	0.022	0.010	0.007
CD (P=0.05)	0.286	0.556	0.320	1.68	00.37	0.049	0.065	0.031	0.022
B. Inorganic fertilizers (kg ha⁻¹)									
N ₀ P ₀	4.298	9.464	4.147	69.86	48.77	12.839	2.934	3.681	1.173
N ₃₀ P ₁₅	5.359	12.203	5.560	75.90	50.96	13.161	3.257	4.029	1.271
N ₆₀ P ₃₀	5.852	13.558	6.192	78.31	51.96	13.319	3.312	4.086	1.283
N ₉₀ P ₄₅	6.291	14.806	6.756	80.59	52.83	13.426	3.456	4.173	1.301
N ₁₂₀ P ₆₀	6.430	15.106	6.884	81.27	52.88	13.416	3.481	4.188	1.308
SEm ±	0.078	0.158	0.079	0.43	0.09	0.014	0.020	0.010	0.006
CD (P=0.05)	0.219	0.444	0.222	1.20	0.27	0.400	0.056	0.028	0.018

these yield attributes recorded under drilling @ 1 t ha⁻¹ with its soil incorporation at 2 t ha⁻¹.

Vermicompost application increased the sink size in terms of effective tillers, flowering and seed setting. Thus, vermicompost drilled at 2 t ha⁻¹ increased seed setting and yield attributes (Table 1). The results are in agreement with those of Kathuria *et al.* (2003) who also reported significant improvement in yield attributes of pearl millet due to vermicompost application.

Application of inorganic fertilizers was found to have significant favorable effect on the yield parameters. These yield attributes increased progressively with increasing fertilizer levels up to the highest level of N₁₂₀ P₆₀. Each higher level of fertilizers significantly increased these yield attributes over just preceding level up to N₉₀ P₄₅ except test weight. Thus, N₉₀ P₄₅ enhanced effective tillers/m row length, ear length, grains/ear and test weight significantly over control by 45.2, 36.7, 33.9 and 6.5%, respectively. These findings confirm the results of Singh and Agrawal (2004).

Yield

Progressive and significant increase in seed and stover yield and HI of pearl millet was observed due to application of vermicompost. Thus, drilling of vermicompost enhanced these yields significantly by 426 kg ha⁻¹ and 561 kg ha⁻¹ representing 31% and 22.5% increases, respectively, over control (Table 1). Drilling of vermicompost was found to be significantly superior to its soil

incorporation in its effect on seed and stover yields of pearl millet. Out of two methods of application, vermicompost applied @ 2 t ha⁻¹ through drilling recorded significantly higher seed yield by 8.7% and 6.4%, respectively, over soil incorporation @ 2 t ha⁻¹. It is clearly evident from comparable values of seed and stover yields recorded under drilling of vermicompost @ 1 t ha⁻¹ with its soil incorporation at 2 t ha⁻¹. Maximum HI was recorded under vermicompost applied @ 2 t ha⁻¹ through drilling. The results of this study are in close agreement with the findings of Ghosh *et al.* (2003).

Data revealed that pearl millet responded to fertilizer application in terms of seed yield, stover yield and HI significantly (Table 1). Application of fertilizer @ N₉₀ P₄₅ increased seed yield, stover yield and HI by 60.6, 42.9 and 8.1%, respectively, as compared to unfertilized control. Where as fertilizer application @ N₉₀ P₄₅ remained statistically at par with N₁₂₀ P₆₀ in improving these parameters. These findings confirm the results of Singh and Agrawal (2004) who also observed significant improvement in yield, HI and protein content in pearl millet.

Nutrient uptake

Among vermicompost levels, maximum N, P and K uptake recorded by pearl millet crop was at 2 t ha⁻¹ through drilling, where as soil incorporation of vermicompost @ 2 t ha⁻¹ remained statistically at par with the drilling of vermicompost @ 1 t ha⁻¹ (Table 4).

Higher N, P and K uptake might be due to effective root system and increased concentration of nutrients in the soil. Findings of this investigation are in close conformity with those of Kathuria *et al.* (2003) who reported significant increase in nutrient uptake due to vermicompost application.

Data further revealed that increasing levels of inorganic fertilizers progressively increased N, P and K uptake by seed and stover up to the highest level of N₁₂₀ P₆₀ with comparable uptake under N₉₀ P₄₅ (Table 4). Additional application of fertilizer beyond N₉₀ P₄₅ did not significantly increase the nutrient uptake any further. Increased dry matter production of the crop at different stages including seed and stover yield at harvest coupled with higher nutrient contents of these plant parts seem to be responsible for increased uptake of these nutrients by the crop due to inorganic fertilization. The findings of this investigation are in conformity with those of Kathuria *et al.* (2003).

Table 4. Effect of vermicompost and inorganic fertilizer on total nutrient uptake by seed and Stover of pearl millet at harvest (Pooled data of 2 years)

Treatments	Nutrient uptake (kg ha ⁻¹)		
	N	P	K
A. Vermicompost (t ha ⁻¹)			
Control	37.80	7.80	55.13
1 t soil incorporation	44.98	9.12	63.89
1 t drilling	49.87	9.92	70.82
2 t soil incorporation	50.80	9.98	71.50
2 t drilling	57.40	10.97	79.97
SEm ±	0.84	0.15	1.27
CD (P=0.05)	2.51	0.47	3.82
B. Inorganic fertilizers (kg ha ⁻¹)			
N ₀ P ₀	30.45	6.36	45.01
N ₃₀ P ₁₅	42.62	8.75	60.88
N ₆₀ P ₃₀	52.01	10.29	73.46
N ₉₀ P ₄₅	57.36	11.17	80.46
N ₁₂₀ P ₆₀	58.40	11.22	81.51
SEm ±	0.87	0.137	1.10
CD (P=0.05)	2.44	0.385	3.09

Economics

The application of vermicompost @ 2 t ha⁻¹ through drilling was found better than the other

treatments in respect of net returns (Rs. 2320) and B:C ratio (1.185) (Table 1). Similarly 90 kg N + 45 kg P₂O₅ ha⁻¹ (N₉₀ P₄₅) also showed higher net return (Rs. 2702) and B:C ratio (1.238) over rest of the treatments. This was due to lesser cost of cultivation, higher productivity (1798 kg ha⁻¹ seed) and better market prices (Rs. 6/kg seed) of the produce. However, negative value of net return and B:C ratio were recorded under unfertilized control (N₀ P₀) due to high cost of cultivation and low productivity.

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