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Productivity of Barnyard millet (*Echinochloa frumentacea*) in relation to organic nutrition under rainfed conditions of Western Himalaya region

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ABSTRACT

To find out the efficacy of different organic materials as source of nutrients to barnyard millet (*Echinochloa frumentacea*), an experiment was laid out with 12 treatments consisting of different organic manures in a randomized block design with 3 replications during *kharif* 2005-2008 at Ranichauri. The results indicated that various organic nutrition treatments have significantly lower productivity of barnyard millet than recommended dose of fertilizers (RDF i.e. 40-20-20 kg N-P-K/ha) in the initial 2 years (2005 and 2006). However, from third year onwards, organic nutrition treatments of vermicompost (VC) + wild apricot-cake, WAC (50% N from each source) with and without *Azotobacter* produced statistically at par yield as that of RDF. Among the organic nutrition treatments tried, VC + WAC (50% N from each source) + *Azotobacter* on an average produced statistically similar yields (1.78 tonne/ha) as that of RDF (1.92 tonne/ha). The net returns and benefit to cost ratio were highest with RDF followed by VC + WAC (50% N from each source) + *Azotobacter*. Consequently that locally available WAC with VC can be a cheaper alternative to the inorganic fertilizers that can be used without significant losses in yields of barnyard millet.

Key Words: *Azotobacter*, *Echinochloa frumentacea*, Himalayan Region, Organic farming, Organic matter

Barnyard millet (*Echinochloa frumentacea)* is one of the important rainfed crops (90%) in the hills of Uttarakhand. It is cultivated in an area of 73,547 ha with low productivity (1.19 tonne/ha) that is far below the national average productivity of millets (1.40 tonne/ha). This region inhabited by farmers having poor resource base with marginal and highly scattered land-holding. The low yields are mainly attributed to poor nutrient status of acidic soils and limited use of nitrogen. Since the cost of inorganic fertilizers is high, full advantage has to be taken from on-farm organic sources to meet the nitrogen requirements of crops. Organic manures are known for their ameliorating value in acidic soils of the hills, besides their importance in meeting essential nutrient requirement of crops. Therefore, the integrated use of green manures, bio fertilizers and minerals to meet the requirements of crops is gaining considerable attention in the recent past. However, information on the effect of nutrient management solely through organic resources on barnyard millet productivity and its influence on soil-health are still lacking. In view of the above, the present study was under taken to assess the effect of different organic nutrition modules on the production of barnyard millet under hilly conditions.

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MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2005 and 2008 at G.B. Pant University of Agriculture and Technology, Hill Campus, Ranichauri, Uttarakhand situated at 30°18'N latitude, 78° 24' E longitude at an altitude of 1,827 m above mean sea level. The region with humid temperate climate, received during the crop season a total rainfall of 583.6, 800.5, 1,479.1 and 1,055.2 mm in 47, 48, 49 and 60 days during 2005, 2006, 2007 and 2008, respectively, as against an average rainfall of 898.5 mm distributed over 53 days. The meteorological data recorded at Hill Campus during *kharif* between 2005 and 2008 is presented in Table 1. The experimental soils was silty clay loam in texture with pH 5.8, low in available nitrogen (180 kg/ha), medium in available phosphorous (14 kg/ha) and high available potassium (389 kg/ha).

The experiment with 12 treatments was laid out in a randomized block design with 3 replications. The 12 treatments includes control, recommended dose of fertilizers (RDF i.e., 40-20-20 kg N-P-K/ha), vermicompost (VC) 2 tonne/ha, VC 4 tonne/ha, FYM 8 tonne/ha, wild apricot-cake (WAC) 4 tonne/ha, enriched compost (EC) 8 tonne/ha, VC + FYM (50% recommended dose of nitrogen (RDN) from each source), VC + WAC (50% RDN from each source), VC + WAC (50% recommended dose of nitrogen from each source) + *Azotobacter*, VC + EC (50%

Table 1. Meteorological data recorded during kharif season of four years

Months	2005		2006		2007		2008		Normal range (based on 25 years average)	
	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days
May	33.6	3	141.3	9	48.5	8	105.4	6	75.7	6
June	8.7	6	107.1	6	71.7	6	259.5	18	117.3	9
July	45.2	17	289.5	15	362.1	14	220.9	15	265.3	14
August	91.0	8	166.3	12	370.1	14	303.7	13	255.1	14
September	403.9	13	50.4	4	124.3	6	135.2	4	133.2	7
October	1.2	0	42.5	1	4.9	1	14.8	2	39.8	2
November	0.0	0	3.4	1		0	15.7	2	12.1	1
Total	583.6	47	800.5	48	1479.1	49	1055.2	60	898.5	53

recommended dose of nitrogen from each source), VC + FYM (50% recommended dose of nitrogen from each source) + *Azotobacter*. Barnyard millet 'PRJ-1' was sown in the second week of June and harvested in the first week of November using a seed rate of 10 kg/ha with plant spacing of 25 cm x 10 cm in all the 4 years of study. The crop was grown with organic inputs only. The FYM, Vermicompost, Enriched, wild apricot-cake on an average (mean of 4 years) contained 0.50, 2.10, 1.80, 2.25% nitrogen; 0.60, 1.40, 0.65, 1.30% phosphorus and 0.6, 1.5, 0.7, 1.7% potassium, respectively. *Azotobacter chroococcum* was used as a source of biofertilizer. The seeds of barnyard millet were first inoculated with *Azotobacter* 1 hour before sowing. Other packages of practices were followed as recommended for the crop under rainfed conditions. Organic manures were incorporated at the final land preparation. The benefit: cost ratio was calculated as the net income divided by the cost of cultivation of the crop.

RESULTS AND DISCUSSION

Growth, yield attributes and yield

The growth, yield attributing parameters and yield of barnyard millet have been significantly affected by various organic sources of nutrient. The data on growth parameter, (Table 2) indicates that the growth parameters of the crop were significantly higher with recommended dose of fertilizers while, it was at par with the treatment vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source) + *Azotobacter* and vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source).

The overall yield of barnyard millet was very less during 2005, it was because of very less rains during the crop season (Table 1). All the organic nutrition treatments significantly influenced the yield attributing characters. The number of ears/plant, ear length (cm) and 1,000-grain weight (g) were significantly superior with the recommended dose of fertilizers. The treatments, vermicompost + wild apricot-cake and vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source) + *Azotobacter* had produced at par ears/plant; ear length and 1,000 grain weight with the recommended dose of fertilizers (Table 2).

This could be attributed to better nutrient supply and synthesis of growth promoting substances as a result of combined application of manures and biofertilizers. These results are in conformity with Basavarajappa *et al.* (2003) who reported that application of enriched farmyard manure + *Azospirillum* recorded significantly higher total dry matter production, plant height, ear length and 1,000-grain weight and grain yield of foxtail millet. Singh *et al.* (2000) also revealed that increase in yield and yield attributing characters of wheat with inoculation of bio-fertilizers like *Azotobacter*.

The efficacy of different organic manures on grain and straw yields of barnyard millet (Table 2) revealed that recommended dose of fertilizers produced significantly higher grain and straw yields over all other treatments in all the years. During 2005, the grain yield was very low in all the treatments which may be because of very low rainfall against the normal range or it may be because of shifting of cultivation from inorganic condition to organic condition. However, the grain yield of barnyard millet subsequently increased by the years under organic conditions and during 4^{th} year (2008), the yield with organic treatments of vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source) + *Azotobacter* was found higher than the recommended dose of fertilizers and was at par with vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source). From the results it is also seen that application of vermicompost or farmyard manure along with wild apri-

Table 2. Yield attributes and yield of barnyard millet as influenced by different sources of organic manures

Treatment	No. of ears/ plant	Ear length (cm)	1,000-grain weight (g)	Grain yield (t/ha)				Straw yield (t/ha)			
				2005	2006	2007	2008	2005	2006	2007	2008
Control	2.9	15.7	3.7	0.20	0.66	1.12	1.10	3.61	2.89	3.21	3.30
RDF (40-20-20 N-P-K)	6.8	22.1	4.8	0.62	2.17	2.49	2.39	6.11	6.56	7.21	8.99
VC 2t/ha	4.0	17.9	4.2	0.21	0.85	1.81	1.35	4.11	3.39	4.91	4.53
VC 4t/ha	4.4	18.5	4.3	0.23	1.01	1.92	1.45	4.39	3.50	5.02	5.16
FYM 8t/ha	3.4	16.9	3.9	0.21	0.60	1.31	1.55	3.83	3.11	4.76	4.34
WAC 4t/ha	4.1	17.4	4.0	0.23	0.61	1.83	1.69	4.11	3.22	5.09	4.97
EC 8 t/ha	4.6	18.7	4.4	0.24	0.86	1.80	1.68	4.50	3.61	4.60	4.35
VC + FYM (50% RDN from each source)	5.4	20.2	4.6	0.25	1.11	2.19	1.84	4.72	3.33	6.00	5.64
VC + WAC (50% RDN from each source)	6.2	20.4	4.6	0.32	1.63	2.33	2.32	5.56	4.89	9.60	8.30
VC+ WAC (50% RDN from each source) + *Azotobacter*	6.2	21.1	4.8	0.36	1.82	2.45	2.51	5.67	5.67	9.80	8.70
VC + EC (50% RDN from each source)	4.8	19.4	4.5	0.24	1.03	2.06	1.83	4.61	4.17	5.04	6.32
VC + FYM (50% RDN from each source) + *Azotobacter*	5.0	20.1	4.7	0.25	1.29	2.10	1.98	5.34	4.56	5.47	6.02
SEm ±	0.3	0.7	0.1	0.10	0.09	0.01	0.09	0.23	0.34	0.49	0.45
CD (P=0.05)	0.8	2.0	0.2	0.33	0.27	0.31	0.25	0.71	1.34	1.45	1.32

Sale price (Rs/t): Barnyard millet, 7,000; Barnyard millet straw, 1,500; Wild apricot-cake (WAC), 2,000; Farmyard manure (FYM), 320; Vermicompost (VC), 5,000; Enriched compost (EC), 500; RDN: Recommeded dose of nitrogen

cot-cake is more beneficial than alone. It may be because of high moisture retention capacity and very fast decomposition rate and rice N content of wild apricot-cake which makes the very quick availability of nutrients and moisture to the crop. These findings reveal that supply of nutrients to barnyard millet exclusively through organic sources adequately supports the crop growth as the yield is at par with the recommended dose of inorganic fertilizers. Maximum grain yield of finger millet with combined application of organic manures and inorganic fertilizers has been reported by various workers (Kandasamy *et al.,* 2000 and Acharya *et al*., 1999).

Nutrient uptake and balance

During 2005, the nutrient uptake was lower, then increased progressively with the *in-situ* incorporation of organic manure due to sustained availability of nutrients. The highest uptake of N was recorded when vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source) + *Azotobacter* was applied indicating higher assimilation and uptake of nutrients. The lowest uptake of N P K was in the control. Similar trend was found with uptake of phosphorus and potassium (Table 3). The application of vermicompost + wild apricot-cake + *Azotobacter* recorded significantly higher residual soil nitrogen while the minimum content of N in the soil was found with control and recommended dose of N P K. Available phosphorus was significantly higher with vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source) + *Azotobacter* than recommended dose of inorganic fertilizers (Table 4). Increased availability of phosphorus in the soil was due to release of phosphorus with application of organic manure. The organic materials form a cover on sesqui-oxide and thus reduce the phosphate fixing capacity of the soil (Das *et al*., 2004). Similar trend was found with available K. Higher availability of K could be ascribed to addition of K to the available pool of soil through organic and inorganic sources besides the reduction in K fixation and release of K due to interaction of organic matter with clay (Katkar *et al*., 2002).

Economics

During 2005, the benefit: cost ratio with all the organic treatments was found negative. It was because of low grain yield during first year then it increased progressively over the years. At the end of the experiment (2008), the benefit: cost ratio with most of the treatments became

Table 3. Nutrient uptake (kg/ha) of soil and nutrient status (kg/ha) of soil after harvest (after 4 years of study) as influenced by different sources of organic manures

Treatment	Nutrient uptake											
	N				P				K			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
Control	27.0	29.6	31.0	33.0	5.4	6.7	6.9	7.1	20.5	23.1	24.8	25.6
RDF (40-20-20 kg N-P-K/ha)	62.0	65.1	65.4	68.0	14.3	15.9	16.7	16.8	49.2	50.8	53.4	54.8
VC 2 t/ha	32.0	36.5	37.5	40.9	8.9	9.1	9.6	10.2	35.6	35.9	36.8	38.9
VC 4 t/ha	33.0	38.1	39.9	43.5	9.8	10.6	10.9	11.8	33.9	35.4	36.8	37.0
FYM 8 t/ha	30.4	33.8	35.0	38.5	7.6	8.3	9.2	9.8	30.2	32.0	34.2	34.9
WAC 4 t/ha	36.5	41.6	43.8	48.9	10.8	11.9	13.8	14.8	40.5	42.0	44.0	45.8
EC 8 t/ha	41.9	46.3	48.2	53.2	11.9	12.8	13.8	14.9	43.8	45.9	46.7	48.5
VC + FYM (50% RDN from each source)	44.1	49.2	51.2	56.2	13.5	14.8	15.8	16.8	49.0	49.9	51.4	52.9
VC + WAC (50% RDN from each source)	44.9	52.9	54.0	56.9	15.3	15.9	16.8	17.3	49.8	52.6	53.2	54.1
VC + WAC (50% RDN from each source) + *Azotobacter*	64.9	68.9	69.5	72.9	15.8	16.5	17.1	17.9	49.5	52.8	53.8	55.6
VC + EC (50% RDN from each source)	51.1	55.9	57.2	60.6	13.2	15.9	16.2	17.9	48.1	49.8	51.0	52.8
VC + FYM (50% RDN from each source) + *Azotobacter*	55.2	59.9	64.5	65.5	14.2	15.8	17.0	17.9	49.5	50.7	52.1	53.0
SEm ±	0.7	0.7	0.7	0.7	0.4	0.4	0.4	0.4	0.8	0.8	0.9	0.9
CD (P=0.05)	1.9	2.1	2.1	2.2	1.1	1.1	1.3	1.4	2.2	2.3	2.5	2.6

Table 4. Available nutrients status of soil after harvest and economics as influenced by different sources of organic manures

Treatment	B:C ratio				Cost of cultivation (Rs/ha)	Available nutrients after harvest		
	2005	2006	2007	2008		N	P	K
Control	-0.18	0.080	0.53	0.520	8,300	182.5	9.7	442.0
RDF (40-20-20 kg N-P-K/ha)	0.44	1.670	2.01	2.220	9,372	183.5	10.1	436.5
VC 2 t/ha	-0.53	-0.320	0.23	-0.003	16,300	190.0	11.6	441.5
VC 4 t/ha	-0.66	-0.490	-0.14	-0.260	24,300	193.0	11.8	444.5
FYM 8 t/ha	-0.19	-0.004	0.83	0.950	8,900	192.1	10.3	447.5
WAC 4 t/ha	-0.37	-0.260	0.66	0.570	12,300	198.5	12.5	438.5
EC 8 t/ha	-0.07	0.260	1.14	1.010	9,100	201.5	11.8	448.5
VC + FYM (50% RDN from each source)	-0.30	0.010	0.99	0.690	12,600	206.5	11.9	456.0
VC + WAC (50% RDN from each source)	-0.26	0.310	1.15	1.010	14,300	214.5	12.5	451.1
VC+ WAC (50% RDN from each source) + *Azotobacter*	-0.23	0.480	1.22	1.130	14,345	219.6	13.1	458.3
VC+ EC (50% RDN rom each source)	-0.32	0.060	0.73	0.760	12,700	215.9	12.8	449.5
VC + FYM (50% RDN from each source) + *Azotobacter*	-0.23	0.250	0.81	0.810	12,645	219.0	13.0	449.8
SEm ±						7.1	0.6	2.0
CD (P=0.05)						20.0	1.8	5.8

positive and indicated that RDF produced highest benefit: cost ratio followed by vermicompost + wild apricot-cake (50% recommended dose of nitrogen from each source) + *Azotobacter*. The negative benefit cost ratio is because of lower prices (Rs 7/kg) of the produce, if the produce will be sold as organic produce with high selling price (Rs14/kg) then the ratio will be positive and more profitable (Table 4).

So, it can be concluded that locally available wild apricot-cake with vermicompost and *Azotobacter* inoculation is an ideal organic nutrition module to meet the nutritional requirement of the crop and is best alternative to inorganic fertilizers without significant losses in both grain and straw yields of barnyard millet and soil health.

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