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Influence of NPK fertilizers on yield and uptake of barnyard millet grain (*Echinochloa frumentacea* (Roxb.) Link) in Typic Rhodulstalf soil

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Abstract
A field experiment was conducted to investigate the combined effect of NPK (Nitrogen, Phosphorus and Potash) on the yield and uptake of Barnyard Millet Grain (*Echinochloa frumentacea* (Roxb.) Link) in Typic Rhodulstalf soil, *Rabi* 2017. The objective of study was to determine the optimum rate of NPK for barnyard miller. The thrice replicated treatments T_1:absolute control (without NPK), T_2:40-15-15 (NPK), T_3:40-20-15 (NPK), T_4:40-25-15 (NPK), T_5:50-15-15 (NPK), T_6:50-20-15 (NPK), T_7:50-25-15 (NPK), T_8:60-15-7.5 (NPK), T_9:60-20-7.5 (NPK), T_{10}:60-25-7.5 (NPK), T_{11}:60-15-15 (NPK), T_{12}:60-20-15 (NPK) and T_{13}:60-25-15 (NPK) kg ha^{-1} were tested in Randomized Complete Block Design (RCBD). The results revealed that maximum growth parameters responded significantly to NPK fertilizers. It is concluded that highest grain yield of 2019 kg ha^{-1} was recorded with the application of 60-20-15 NPK kg ha^{-1}. The increase in yield was 40.8% higher as compared to control (1196 kg ha^{-1}), where no fertilizer was used.

Keywords: Barnyard millet, Typic Rhodulstalf, grain and straw NPK uptake

Introduction
The genus *Echinochloa* (Poaceae) includes 35 species (Mabberley, 1997) [8] that are widely distributed in the warmer parts of the world. Majority of them are known as aggressive colonizer of disturbed habitat or weeds of cultivated field, while *Echinochloa utilis* Ohwi and Yabuno and *E. frumentacea* Link are the cultivated species. *E. utilis* (Japanaese barnyard millet) is domesticated in temperate region of both the old and new worlds. This species is cultivated in Japan, Korea and China. *E. frumentacea* (Indian barnyard millet) is grown in tropical region including India and Central Africa.
In India, it is an important dry land small millet crop. It is cultivated over a wide array of environmental conditions and poor soils and is mainly confined to tribal belts of Odisha, Maharashtra, Gujarat, Madhya Pradesh, Tamil Nadu and Bihar besides hills of Uttar Pradesh (Ram Vinod Kumar *et al.* 1997) [7].
In recent years there is huge awareness among people about healthy, nutritive millets and there is a demand for barnyard millet due to its nutritional quality and better adaptability. The demand for barnyard millet has risen drastically but the productivity of barnyard millet is relatively low. The reason behind is, it is mostly grown as a rainfed crop and is sown directly. Inspite of all this, due to the growing importance and demand, the area under barnyard millet is catching up under irrigated systems as alternate crop for command area systems, water stress/partially water logged conditions etc.
Increase in cropping intensity and introduction of high yielding varieties have caused substantial deplete of N and crop storage positive response to added N in the soil (Ali *et al*., 2004) [1]. Nitrogen plays a vital role in growth processes as it is an integral part of chlorophyll, protein and nucleic acid (Marschner, 1995; Jabbar *et al*., 2009) [11, 6]. It is viewed as the central element because of its role in substance synthesis (Mahboob *et al*.,) [9]. It constitutes 1.5 to 5 percent of the dry weight of higher plant (Nova and Loomis, 1981) [15]. Phosphorous insufficiency is common in most of the soils of Pakistan and application of phosphatic fertilizer is considered crucial for crop production (Memon, 1996) [12]. Phosphorus stimulates flourishing and seed formation. Its deficiency is directly related with 1000 grains weight (Iqbal and Chauhan, 2003) [5]. Potassium (K^+) is of unusual significance because of its live role in biochemical functions of the plant like activating various enzymes, improvement of protein, carbohydrates and fat concentration, developing tolerance against drought and resistance to frost, lodging, pests and disease attack (Marschner, 1995) [11].

The increase in intensity of cropping and production of high yielding fertilizer responsive cultivars has resulted in a considerable deplete of soil K reserves and eventually limits efficiency of other nutrients. It is thus necessary to devise a fertilizer technology facilitating use of NPK in apt combination for enhancing yield (Jabbar *et al*., 2009; NFDC, 2003) [6, 14].

The present study was therefore, Influence of NPK Fertilizers on Yield and Uptake of Barnyard Millet Grain (*Echinochloa frumentacea* (Roxb.) Link) in Typic Rhodulstalf soils

Materials and Methods

The experiment was conducted at Kappalur village, Thirumangalam district, during the year, 2018. The soil belonged to the textural class of sandy clay loam with a bulk density and particle density of 1.33 and 2.22 Mg m^{-3}, respectively and belongs to *Typic Rhodustalf*. The soil had a pH of 6.86, EC of 0.16 dS m^{-1} and organic carbon of 4.49 g kg^{-1}. The available nitrogen, phosphorus and potassium of experimental soil was 175, 15 and 209 kg ha^{-1}, respectively which was categorized as low, medium and medium status of soil fertility. The $CaCO_3$ content of the soil was 3.60 per cent. The DTPA extractable micronutrients 7.56, 1.32, 21.0 and 3.08 mg kg^{-1} of zinc, copper, iron and manganese, respectively. The micronutrients were estimated through Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), at the Department of Soils and Environment, AC&RI, Madurai.

The experiment was conducted in Randomized Complete Block Design (RCBD) with two replications. The net plot size of was 5.00 m × 4.00 m. Twelve fertilizer levels with one control plot (no fertilizer) were included under study. The treatments comprised of; T_1:absolute control (without NPK), T_2:40-15-15 (NPK), T_3:40-20-15 (NPK), T_4:40-25-15 (NPK), T_5:50-15-15 (NPK), T_6:50-20-15 (NPK), T_7:50-25-15 (NPK), T_8:60-15-7.5 (NPK), T_9:60-20-7.5 (NPK), T_{10}:60-25-7.5 (NPK), T_{11}:60-15-15 (NPK), T_{12}:60-20-15 (NPK) and T_{13}:60-25-15 (NPK) kg ha^{-1}.

The experimental field was ploughed twice with mould board plough followed by cultivator twice. A rotovator ploughing also executed twice so as to obtain a good tilth and the ridges and furrows where drawn with a 60cm. After drawing soil samples (for analyzing the pre-experimental soil parameters) at random from different spots of the field, the plots were formed according to the layout plan. MDU1 variety as been used for sowing.

The full dose of P were applied as basal. As per the treatment schedule, N&K was applied in three splits, 1/4th of N at 15th day, remaining half the dose of N was applied on 30 DAS and the remaining quarter quantity of N was applied on 45 DAS as top dressing for all the treatments. N, P & K were supplied through Urea, Single Super Phosphate and Muriate of Potash, respectively. The crop was kept free of weeds by manual hoeing and hand weeding to avoid possible competition between weed-crop. All other cultural practices were kept normal and identical for all treatments. Observations on desired parameters were recorded using standard procedures. The data collected were subjected to statistically analyzed using “Analysis of variance test”. The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other (Gomez and Gomez, 1984) [4].

Results and Discussion

Grain Yield (kg ha^{-1})

The data regarding grain yield is presented in Table 1. It is clear from the data that there was highly significant difference among treatments. The highest barnyard grain yield (2019 kg ha^{-1}) was obtained where 60-20-15 kg ha^{-1} NPK was applied. The lowest grain yield (1196 kg ha^{-1}) was obtained from control (without NPK fertilizer). The highest yield was obtained when NPK was applied and an increase in grain yield 40.8 per cent over the control. And harvest index ranged from 30.53 to 38.53.

The increase in yield trend from Table 1 showed increase in NPK resulted in increase of yield. However, there was decrease in certain level (60-25-15 kg ha^{-1}) might be due to nitrogen interaction with P and K. These results are in accordance with Sharma *et al*. (1998); Maqsood *et al*. (2001); Sharar *et al*. (2003) and Asghar *et al*. (2010) [18, 17, 10, 3] who concluded that grain yield of millets and cereal crops increased with application of NPK fertilizer.

Straw Yield (kg ha^{-1})

Data pertaining to the straw yield as affected by different NPK levels are given in Table 1. The analysis of variance revealed that different levels of NPK differ significantly from each other. Maximum straw yield (4595 kg ha^{-1}) was attained when NPK was applied at the rate of 60-20-15 kg ha^{-1} against minimum straw yield (1949 kg ha^{-1}) was observed from treatment where no fertilizer was applied. The straw yield was also influenced by different levels of fertilizers. Higher dose of fertilizer favored vegetative growth, DMP and development of more number of tillers resulted in higher straw yield. Similar, result is marked by Reddy and Reddy (2012) [16]

Table 1: Effect of different levels of NPK fertilizers on grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of barnyard millet in *Typic Rhodustalf* soils

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index	(%) increase over control
T_1	1196	1949	38.03	-
T_2	1711	3515	32.74	30.1
T_3	1740	3625	32.43	31.3
T_4	1761	3705	32.22	32.1
T_5	1776	3762	32.07	32.7
T_6	1825	3865	32.07	34.5
T_7	1850	3960	31.84	35.4
T_8	1671	3401	32.95	28.4
T_9	1681	3440	32.83	28.9
T_{10}	1688	3427	33.00	29.1
T_{11}	1801	3816	32.06	33.6
T_{12}	2019	4595	30.53	40.8
T_{13}	1961	4377	30.94	39.0
SEd	50	55		
CD (P=0.05)	101	112		

NPK uptake in grain (kg ha^{-1})

The soil application @ 60:20:15 kg ha^{-1} of NPK registered maximum N, P and K uptake of 14.13, 5.25 and 16.15 kg ha^{-1}, respectively. Where the minimum uptake is registered in without NPK fertilizer application (absolute control) depicted in table 2.

Table 2: Effect of different levels of NPK fertilizers on N, P and K uptake (kg ha^{-1}) in grain of barnyard millet in *Typic Rhodustalf* soils

Treatments	Grain Uptake (kg ha^{-1})			Straw Uptake (kg ha^{-1})		
	N	P	K	N	P	K
T_1	8.37	3.11	9.57	15.59	5.85	17.74
T_2	11.98	4.45	13.69	28.12	10.55	31.99
T_3	12.18	4.52	13.92	29.00	10.88	32.99
T_4	12.33	4.58	14.09	29.64	11.12	33.72
T_5	12.43	4.62	14.21	30.10	11.29	34.23
T_6	12.78	4.75	14.60	30.92	11.60	35.17
T_7	12.95	4.81	14.80	31.68	11.88	36.04
T_8	11.70	4.34	13.37	27.21	10.20	30.95
T_9	11.77	4.37	13.45	27.42	10.28	31.19
T_{10}	11.82	4.39	13.50	27.52	10.32	31.30
T_{11}	12.61	4.68	14.41	30.53	11.45	34.73
T_{12}	14.13	5.25	16.15	36.76	13.79	41.81
T_{13}	13.73	5.10	15.69	35.02	13.13	39.83
SEd	0.10	0.17	0.07	0.18	0.31	0.37
CD (P=0.05)	0.21	0.34	0.14	0.36	0.62	0.74

NPK uptake in Straw (kg ha^{-1})

The straw uptake of barnyard millet is increased in increase level of NPK fertilizer and the N uptake ranged from 15.59 to 36.76 kg ha^{-1}, P uptake ranged from 5.85 to 33.79 kg ha^{-1} and 17.74 to 41.81 kg ha^{-1} K uptake, respectively. The highest NPK uptake in straw was observed in soil application @ 60-20-15 NPK kg ha^{-1}.

Increased grain and straw uptake of N at higher levels of N might have resulted in initial buildup of plants due to vigorous growth and high photosynthetic rate which led to better uptake throughout the crop growth period. This P uptake may be higher due to the increased application of P. This increase in P uptake might be due to increased dry matter yield as well as P content. K uptake was mainly due to higher biological production under these treatments which increased the nutrient uptake. Similar findings were observed by Singh and Totawat (2002) [19], Nagalakshmi *et al.* (2006) [13], Ananthi *et al.* (2010) [2].

Conclusion

Among the different levels of NPK, the soil application of 60:20:15 kg NPK ha^{-1} registered higher yield and increased the uptake in grain and straw of barnyard millet. The productivity of barnyard millet is not on the rise as the land available for agriculture is declining especially in the semi-arid tropics mainly due to increase in population. On the other hand, the food productivity of staple food crops in these regions (e.g., barnyard millet) has to be increased in order to meet food demand.

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