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INFLUENCE OF NITROGEN AND POTASSIUM APPLICATION ON YIELD AND NUTRIENT UPTAKE IN PEARL MILLET

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ABSTRACT

A field experiment was carried out to study the effect of nitrogen and potassium on yield and nutrient uptake in pearl millet during *kharif,* 2013. At dry land farm of S.V. agricultural college, Tirupati. Eight nutrient management practices were imposed with three replications using RBD. All the data on yield, nutrient content and nutrient uptake were recorded as per standard procedures. The significantly highest grain yield was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}. With respect to the content and uptake of nutrients by the crop, the highest content and uptake of N, P and K were recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}. The least content and uptake of N, P and K was recorded with control. Similarly, in grain, the highest nitrogen, phosphorus and potassium content and uptake was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and the least was recorded with control. However, the highest B : C ratio was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and the lowest was noticed with control. Based on the results, it may be concluded that for higher production, pearl millet crop has to be supplied with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}. However, for optimum and economic production, application of 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} holds good.

KEY WORDS: Pearl millet, nitrogen and potassium application, grain yield, nutrient uptake.

INTRODUCTION

Pearl millet is commonly known as *bajra,* cattail, spiked or bulrush millet. Its grain is more nutritious and the protein content is not only high but it is also of good quality. The grain contains 11-19 per cent protein, 60-78 per cent carbohydrates and 3.0 - 4.6 per cent fat and also has good amount of phosphorus and iron. It has the maximum potential of all the millets and is mainly grown in drought prone areas and marginal soils. India is one of the largest producer of coarse cereals with as many as 10 predominantly rainfed crops, grown in diverse soils, climate and harsh environments. Pearl millet occupies fourth place in cereals and second place in coarse cereals and is the most widely cultivated millet next to Jowar in India. The trends in area, production and productivity of pearl millet suggest that area has increased marginally (2%) during last two years and productivity has gone up by 19 per cent (Yadav, 2011).

Normally pearl millet is grown under rainfed conditions and can fit into any of the cropping systems due to its shorter duration. Because of its high nutritive value, its demand has been increased in recent years. The potential of pearl millet as rainfed crop has not been fully exploited. Nitrogen and Potassium are two key inputs for realizing higher grain yields and quality in pearl millet. Application of potassium @ 200 kg K_2O ha^{-1} had higher grain yields than that of 100 kg K_2O ha^{-1} and control in bajra crop (Heidari and Jamshid, 2010). Yadav *et al*. (2011) reported that the grain yield of pearl millet increased with an increase in level of K_2O upto 60 kg ha^{-1}. But, 40 kg K_2O ha^{-1} proved to be more economical than 60 kg K_2O ha^{-1}. Jadhav *et al*. (2011) stated that application of 120 kg N ha^{-1} and 90 kg N ha^{-1} had similar grain yields. But they were significantly differ with 60 kg N ha^{-1} and control in pearl millet. Patel *et al*. (2013) conducted an experiment at the research farm of AICRP for dry land Agriculture, Sardakrushinagar and revealed that the highest seed yield (1361 kg ha^{-1}) was recorded with the application of recommended doses of 100 : 100 : 100 and 100 : 100 : 50 NPK kg ha^{-1} over control.

However, Information on optimum and economic dose of nitrogen and potassium requirement for higher grain yield and quality is lacking in rainfed pearl millet grown in Andhra Pradesh. Keeping this in view the present investigation has taken up to study the nutrient uptake and fix the optimum doses of nitrogen and potassium for *kharif* pearl millet crop.

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MATERIAL AND METHODS

The experiment was conducted during *kharif*, 2013 in field No. 99 at S.V. Agricultural college farm, Tirupati of Acharya N.G. Ranga Agricultural University. The experiment was laid out in a Randomized Block Design with eight treatments and replicated thrice *viz*., T_1: control (no fertilizers); T_2: 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 20 kg K_2O ha^{-1} (RDF); T_3:80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 20 kg K_2O ha^{-1}; T_4: 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 20 kg K_2O ha^{-1}; T_5: 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 40 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 40 kg K_2O ha^{-1}; T_7: 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 40 kg K_2O $ha^{-1}$and T_8: Application of N, P_2O_5 and K_2O based on Soil Test Values (78 kg N ha^{-1} + 21 kg P_2O_5 ha^{-1}+ 14 kg K_2O ha^{-1}). The crop was transplanted at a spacing of 45 cm x 15 cm. The pearl millet hybrid of PHB-3 was used for the experiment with 4 kg ha^{-1} seed rate. The soil of the experimental field was neutral in pH (7.35), normal in EC (0.068 dsm^{-1}), sandy loam in texture, medium in organic carbon (0.63 %), low in available nitrogen (150.52 kg ha^{-1}), high in available P_2O_5 (159.97 kg ha^{-1}) and high in available K_2O (422.01 kg ha^{-1}). The nitrogen application was done in two splits, 50 % of N, full dose of P_2O_5 and K_2O were applied as a basal and remaining 50 % N, at 30 days after transplanting of pearl millet. The grain obtained from the plot area was thoroughly sun dried to a safe moisture level of 14 per cent, weighted and expressed in kg ha^{-1}.Straw obtained from the plot was thoroughly sun dried to a constant weight and expressed in kg ha^{-1}.The relationship of economic yield to the total biological yield was denoted as harvest index and expressed in percentage.

Plant samples have been collected at 30, 60 DAT and at the time of harvest. The dried samples were powdered with Willey mill grinder and utilized for chemical analysis. Half gram of oven dried powdered plant material was digested with 10 ml of concentrated H_2SO_4 and catalyst mixture (K_2SO_4-Se). After digestion the volume was made upto 100 ml. Then filtered and the extract was used for N estimation. One gram of oven dried powdered plant material was digested with 10 ml of triacid mixture (HNO_3 : H_2-SO_4 : $HCLO_4$ @ 9:4:1). After digestion, the volume was made upto 100 ml. Then filtered and the extract was used for P and K estimation.Nitrogen content in the plant sample was estimated by the Kjeldhal method and expressed as per cent nitrogen. Phosphorus content in the plant sample was determined by vanadomolybdo phosphoric yellow colour method in nitric acid medium as described by Piper (1950). The intensity of the yellow colour was read at 420 nm by using spectrophotometer and expressed in percentage. Potassium in the triacid extract was determined (Piper,1950) by using flame photometer and the content was expressed in percentage.The uptake of nitrogen, phosphorus and potassium, in whole plant at harvest was calculated as follows.

Uptake of nutrients (kg ha^{-1})=

$$\frac{\text{Nutrient concentration} \times \text{Weight of drymatter (kg ha}^{-1}\text{)}}{100}$$

The data obtained on various parameters were statistically analyzed by following the analysis of variance for Randomized Block Design as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The results obtained from the present study were presented and discussed as below.

Grain yield, straw yield and harvest index

Nutrient management practices significantly influenced the grain yield of pearl millet.The highest grain yield (3839 kg ha^{-1}) was obtained with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 20 kg K_2O ha^{-1} , 80 kg N ha^{-1}+ 30 kg P_2O_5 ha^{-1}+ 20 kg K_2O ha^{-1} , and 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 40 kg K_2O ha^{-1} . All these treatments were superior to rest of the treatments (Table 1).

The lowest grain yield (1390 kg ha^{-1}) was recorded from T_1 (control) which was followed by 60 kg N ha^{-1}+ 30 kg P_2O_5 ha^{-1}+ 20 kg K_2O ha^{-1} and 60 kg N ha^{-1}+ 30 kg P_2O_5 ha^{-1}+ 40 kg K_2O ha^{-1} . All these treatments were significantly inferior to rest of the treatments. Low initial N status of soil limited the yield of pearl millet to lower level in control treatment. The increase in grain yields with enhanced N application could be ascribed to better plant growth and drymatter production due to higher photosynthesis. This was further supported by the fact that soil of the experimental field was low in available nitrogen (150.52 kg ha^{-1}). Thus, an increase in nitrogen supply might have increased all the growth parameters, yield attributing characters which ultimately contributed to increase in yield.

Table 1. Influence of nutrient management practices on grain yield, straw yield and harvest index of pearl millet crop

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Drymatter at harvest (kg ha^{-1})	Harvest index (%)	Benefit : Cost ratio
T_1 : Control (no fertilizers)	1390	2815	4108	33.05	0.97
T_2 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}(RDF)	2861	4815	5830	37.27	2.29
T_3 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	3501	5275	6460	39.89	2.92
T_4 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	3798	5465	7108	41.00	3.16
T_5 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	2965	4785	5982	38.26	2.31
T_6 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	3379	5185	6696	39.45	2.69
T_7 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	3839	5578	7539	40.77	3.11
T_8 : Application of N, P_2O_5 and K_2O based on soil test values	3360	5145	6430	39.51	2.91
SEm±	**44.596**	**50.325**	**59.786**	**0.147**	**0.041**
CD (P = 0.05)	**136.578**	**154.124**	**183.100**	**0.449**	**0.125**

Table 2. Influence of nutrient management practices on nitrogen content and uptake at different growth stages of pearl millet crop

Treatment	Nitrogen content (%)			Nitrogen uptake (kg ha^{-1})		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
T_1 : Control (no fertilizers)	2.02	1.93	1.36	18.12	64.61	55.79
T_2 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} (RDF)	2.51	2.20	1.59	26.98	97.43	92.78
T_3 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	2.70	2.39	1.62	31.27	113.64	104.44
T_4 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	2.84	2.69	1.94	38.60	134.29	137.67
T_5 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	2.49	2.25	1.59	26.41	91.05	95.20
T_6 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	2.73	2.56	1.84	35.17	110.56	122.95
T_7 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	2.88	2.72	1.99	42.93	137.73	150.19
T_8 : Application of N, P_2O_5 and K_2O based on soil test values	2.93	2.45	1.72	32.44	113.65	110.43
SEm±	**0.017**	**0.015**	**0.012**	**0.448**	**1.367**	**1.693**
CD (P = 0.05)	**0.053**	**0.047**	**0.037**	**1.371**	**4.188**	**5.185**

Table 3. Influence of nutrient management practices on phosphorus content and uptake at different growth stages of pearl millet crop

Treatment	Phosphorus content (%)			Phosphorus uptake (kg ha^{-1})		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
T_1 : Control (no fertilizers)	0.50	0.52	0.54	4.48	17.36	21.99
T_2 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} (RDF)	0.64	0.60	0.63	6.92	26.64	36.67
T_3 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	0.64	0.63	0.65	7.39	29.84	41.93
T_4 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	0.71	0.72	0.74	9.72	35.74	52.29
T_5 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	0.65	0.64	0.65	6.90	25.77	38.63
T_6 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	0.69	0.70	0.72	8.85	30.26	48.39
T_7 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	0.75	0.74	0.82	11.14	37.52	61.57
T_8 : Application of N, P_2O_5 and K_2O based on soil test values	0.68	0.63	0.64	7.52	29.00	40.83
SEm±	**0.004**	**0.004**	**0.005**	**0.117**	**0.360**	**0.678**
CD (P = 0.05)	**0.013**	**0.013**	**0.015**	**0.358**	**1.102**	**2.077**

Table 4. Influence of nutrient management practices on potassium content and uptake at different growth stages of pearl millet crop

Treatment	Potassium content (%)			Potassium uptake (kg ha^{-1})		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
T_1 : Control (no fertilizers)	3.92	8.74	9.97	35.15	291.67	409.49
T_2 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} (RDF)	4.21	9.03	10.75	45.31	398.56	626.77
T_3 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	4.41	9.45	11.33	51.08	450.13	732.15
T_4 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}	5.04	10.62	12.23	68.60	529.50	869.60
T_5 : 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	4.60	10.02	11.42	48.75	405.76	683.03
T_6 : 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	5.17	10.52	11.83	66.57	454.95	792.43
T_7 : 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}	5.32	11.07	12.88	79.14	561.38	972.36
T_8 : Application of N, P_2O_5 and K_2O based on soil test values	4.35	9.53	11.25	48.15	437.51	723.42
SEm±	**0.029**	**0.048**	**0.052**	**0.842**	**4.776**	**9.701**
CD (P = 0.05)	**0.088**	**0.146**	**0.158**	**2.579**	**14.636**	**29.712**

Increased grain yield due to varying levels of nutrients have also been reported by Yadav and Yadav, 2004 (30 kg K_2O).

Maximum straw yield (5578 kg ha^{-1}) was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}, 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}, 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and all these were superior to rest of the treatments. The lowest straw yield (2815 kg ha^{-1}) was obtained with control followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}. All these treatments were significantly inferior to rest of the treatments (Table 1).

Nitrogen application increases the activity of cytokinin in plant which leads to the increased cell-division and elongation. Nitrogen is a component of porphyrins of chloroplasts and hence, increased nitrogen fertilization increased the growth and yield of crop due to increased production of photosynthates. Varied responses in straw yield due to varied levels of nutrients have also been reported by several workers *viz*., Yadav and Yadav (2004), Rana *et al*. (2009), Yadav *et al*. (2011), Jadhav *et al*. (2011).

Under the present study, the treatments, T_7 and T_4 which supplied 100 kg N produced relatively higher drymatter, as is evident from dry matter production at harvest (Table 1) and hence have resulted in higher straw yield.

The data on harvest index revealed that the maximum value of harvest index (41.00%) was noticed with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} compared to all other treatments. This was followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}, 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and application of N, P_2O_5 and K_2O based on soil test values (Table 1). The lowest harvest index (33.05%) was noticed with control. The drymatter partitioning has been effective with increased level of nitrogen, thus, resulting in higher harvest index (Reddy *et al.*, 2016).

Nitrogen content and uptake

Nitrogen content estimated at 30, 60 DAT and at harvest were presented in Table 2. Nitrogen content in the crop steadily increased with advancement in age of the crop upto harvest.

At 30 DAT, the maximum nitrogen content was noticed in the crop with application of N, P_2O_5 and K_2O based on Soil Test Values which was on par with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and closely followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} . These treatments were superior to rest of the treatments. The lowest nitrogen content was noticed with control followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} . All these treatments were inferior to other treatments.

The highest nitrogen content at 60 DAT was noticed with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which, in turn, was on a par with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and closely followed by 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} andapplication of N, P_2O_5 and K_2O based on soil test values. These treatments were superior to all other treatments. The least nitrogen content at 60 DAT was noticed with control which was followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}.

At harvest, the highest nitrogen content was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which was superior over all other treatments and closely followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and application of N, P_2O_5 and K_2O based on soil test values. The lowest nitrogen content at harvest was noticed with control followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}. All these treatments were significantly inferior to other treatments.

In general, irrespective of the crop growth stages, the highest N content was noticed with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} as compared to rest of the treatments. On the other hand, control accounted for the lowest N content.

The highest nitrogen uptake was noticed at 30 DAT by crop with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which was superior to all other treatments and followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and application of N, P_2O_5 and K_2O based on soil test values. The lowest uptake of nitrogen by crop was recorded with control.

At 60 DAT and at harvest, the nitrogen uptake followed a similar trend. Significantly highest uptake of nitrogen at both these stages was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}. The next best treatments were 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and application of N, P_2O_5 and K_2O based on soil test values. However, at 60 DAT, T_7 was on par with T_4 while at harvest T_7 was superior over all other treatments.

The lowest uptake of nitrogen was recorded with control closely followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}. However T_2 was on par with T_5 at harvest while at 60 DAT, T_2 was superior over T_5. At these stages they were inferior to the rest of the treatments.

At all the growth stages, the highest uptake of nitrogen by the crop was noticed with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and lowest uptake of nitrogen was recorded with control . Added fertilizers increased the N content in plant by providing balanced nutritional environment inside the plant, and greater photosynthetic efficiency, which favoured better crop yield (Ghosh *et al*., 2009). Since the uptake of nutrient is a function of drymatter and nutrient content, the increased dry matter with higher N content resulted in greater uptake of nitrogen. Similar results were reported by Tetarwal and Rana (2006), Rana *et al*. (2009), Yadav *et al*. (2011) and Ansari *et al*. (2011). While increase in nitrogen and phosphorus uptake by sorghum straw due to increased levels of nitrogen and phosphorus has been reported by Heeta Sareen and Sharma (2010).

Phosphorus content and uptake

Phosphorus content in pearl millet increased from 30 DAT till harvest of the crop (Table 3). The highest phosphorus content at all the stages was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and was superior to all other treatments irrespective of growth stages. The next best treatment was 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which was superior over rest of the treatments. Significantly the least phosphorus content was noticed with control and it was closely followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} which was inferior to all other treatments.

As in the case of P content, the phosphorus uptake by the crop also has increased with advancement in age of the crop from 30 DAT to harvest.The highest phosphorus uptake by the crop at all the stages was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and application of N, P_2O_5 and K_2O based on Soil Test Values at all the three stages but the order of their sequence changed. At 30 DAT, T_7 was followed by T_4, T_6 and T_8 while at 60 DAT and at harvest the order was T_7, T_4, T_6, and T_3.

The lowest phosphorus uptake was noticed with control which was closely followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} at 30 and 60 DAT. At harvest, control treatment recorded least P uptake followed by 60 kg ha^{-1} + 30 kg ha^{-1} + 20 kg ha^{-1} and 60 kg ha^{-1} + 30 kg ha^{-1} + 40 kg ha^{-1} (T_5).

Increase in the level of nitrogen application in the form of urea which on nitrification forms hydrogen ions besides nitrate ions, thus, modifies the rhizosphere. This rhizosphere acidification results in the solubilization of insoluble phosphates and releases more orthophosphates into the soil solution. Moreover, higher concentration of nitrates in the soil solution exchange for orthophosphate ions of the exchange complex by anion exchange phenomenon. Thus, it increases the phosphate availability to the plants. The results were similar with Tetarwal and Rana (2006), Rana *et al*. (2009) and Sareen and Sharma (2010).

Potassium content and uptake

At 30 DAT, the treatment 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} resulted in maximum potassium content which was closely followed by the treatments *viz.*,80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} , 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which were superior to rest of the treatments (Table 4). The lowest content of potassium at 30 DAT was noticed with control and it was closely followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and application of N, P_2O_5 and K_2O based on Soil Test Values but inferior to all other treatments.

The highest content of potassium at 60 DAT was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which was superior over all other treatments and closely followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which were on par with each other and superior over rest of the treatments. The lowest content of potassium at this stage was recorded with control followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} but inferior to all other treatments.

At harvest, the highest content of potassium was obtained with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which was superior over all other treatments and closely followed by 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} . The lowest content of potassium at harvest was noticed with control followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and application of N, P_2O_5 and K_2O based on Soil Test Values but significantly inferior to rest of the treatments. Among the different stages of crop growth *i.e* at 30 DAT, 60 DAT and at harvest, the highest content of potassium was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and lowest content of potassium at different stages was noticed with control .

As in the case of N and P, the uptake of potassium by the crop steadily increased with advancement in age of the crop from 30 DAT up to harvest. The highest potassium uptake by the crop at all the stages was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} followed by three treatments *viz.,*100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} , 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} and 80 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} which were significantly superior to all other treatments.

At all stages, relatively lower potassium uptake was recorded with control and followed by 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} which were inferior to all other treatments. Better accumulation of dry matter in the form of shoot and root development has led to more uptake of potassium. Increased content and / or uptake of K due to increased nitrogen and potassium application has been reported by Yadav *et* al. (2011).

Influence of nutrient management practices on the benefit - cost ratio were worked out and the highest benefit : cost ratio (3.16) was recorded with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} which was on par with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1}+ 40 kg K_2O ha^{-1} (3.11). The least benefit - cost ratio (0.97) was recorded with control which was inferior to all other treatments.

CONCLUSION

The results of the present investigation revealed that the pearl millet crop has responded very well to the applied nitrogen up to 100 kg ha^{-1} as the soils of the experimental site is low in available nitrogen. But the crop did not show good response to applied potassium and the crop was responded up to 20 kg ha^{-1} only. This could be attributed to high available potassium in the soils of the experimental site. Application of soil test based fertilizers also resulted good yields with compared economics but lower than T_7. This shows that the RDF (60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}) has to be changed for optimizing the yield.

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