Pak. J. Bot., 39(4): 1083-1087, 2007.

GROWTH, YIELD AND NUTRIENTS UPTAKE OF SORGHUM IN RESPONSE TO INTEGRATED PHOSPHORUS AND POTASSIUM MANAGEMENT

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Abstract

Field experiment was undertaken to establish a balanced nutrients management for improved and economical production of sorghum. It was grown with P_2O_5 (80 kg ha^{-1}) and K_2O (40 kg ha^{-1}) as their sole and combined fertilization along with uniform level of N (120 kg ha^{-1}). Results indicated that P enhanced the crop growth, yield and nutrients uptake more than K and the best results were observed with their combined application. Maximum biological and grain yield were 31.7 and 2.26 t ha^{-1} under P+K. Uptake of N, P and K was also highest with P+K. Fertilizer use efficiency was highest for K alone (9.65 kg kg^{-1}) followed by P alone (8.45 kg kg^{-1}). Economic analysis showed maximum net return (NR) and relative increase in income (RII) with P+K treatment, while the value cost ratio (VCR) was slightly higher for P alone. Integration of P and K was better than used alone for improved and economical production of sorghum.

Introduction

Sorghum is the fifth most important cereal crop grown for human consumption in the world being surpassed only by rice, wheat, barely and corn. In Pakistan, it is grown on 0.34 million hectare with annual production of 0.21 million tonne and average yield 620 kg ha^{-1} (Anon., 2006a). Pakistani soils are deficient in N (100 %) and P (90 %) while deficiencies of K (20 %) are crop and soil specific, hence response to N and P is universal (Anon., 2003). Significant response to K application by cotton (Makhdum *et al.,* 2005; Pervez *et al.,* 2006) and sugarcane (Khan *et al.,* 2005) in Multan and Peshawer, respectively has been reported.

Fertilizers are an efficient exogenous source of plant nutrients. In Pakistan, fertilizer use is insufficient and imbalanced. Balanced fertilizer use, alongwith complementary use of organic and bio sources can help reverse environmental degradation by providing much needed nutrients to the soil, thereby increasing crop yields. Shrotriya (1998) reported that balanced application of NPK caused an increase in sorghum yield up to 122 % in India. Higher crop yield means more biomass to be ploughed back to maintain the supply of organic mater and vegetative cover, thus enhancing moisture retention, nutrient use efficiency and soil productivity (Bumb & Baanante, 1996).

Low usage of P in relation to N has been identified as one of the major factors limiting higher crop yields. In Pakistan, farmers mainly apply N accounting for 76.9% of total fertilizer usage, while P and K represent only 22.4% and 0.7%, respectively (Anon., 2006b). Usage of K_2O is only 0.027 million tonne compared to 0.851 million tonne of P_2O_5 and 2.927 million tonne N. This is very small quantity as compared to the crop requirement (Akhtar *et al.,* 2002). To achieve higher yield of crops it is essential to provide them the optimum level of their nutrients requirement. Therefore, present study

was conducted to see the extent and economics of sorghum response to balanced nutrients supply.

Materials and Methods

A field experiment was conducted on sorghum cv YSH-98 in randomized complete block design with three replicates. Before crop sowing composite soil samples from 0-30 cm depth were collected and analyzed. Soil had sandy loam texture, with pH 7.6, electrical conductivity 0.47 dS m^{-1}, available P 3.6 mg kg^{-1} and extractable K 105 mg kg^{-1}. Sorghum was sown in 5 m × 4 m plots in 60 cm spaced lines and seed rate was 23 kg ha^{-1}. Single super phosphate fertilizer was used for P, and sulphate of potash for K. Nitrogen (120 kg ha^{-1}) and other cultural practices were employed equally in all the treatments given below:

T_1 Control (without P and K fertilizer)
T_2 Phosphorus @ 80 kg P_2O_5 ha^{-1}
T_3 Potassium @ 40 kg K_2O ha^{-1}
T_4 Phosphorus + Potassium @ 80 + 40 kg ha^{-1}, respectively

After crop germination, seedlings were counted in 1 m^2 area of each treatment. At crop maturity, grain and straw samples were collected and analyzed for N, P and K (Anderson & Ingram, 1993). Plant height and biological / grain yield were also recorded.

For economic analysis, the cost incurred on P and K fertilizers, and income from sorghum grains and straw were taken into consideration. The following formulae as given were employed to find out the economic parameters (Anon., 1988).

Net return (NR) = Value of increased yield obtained - cost of P and K fertilizer
Value cost ratio (VCR) = Value of increased yield obtained / cost of P and K fertilizer
Relative increase in income (RII) (%) = (Net income / Income at control) × 100

Fertilizer use efficiency (FUE) of P and K was calculated using the following formula:

$$\text{FUE (kg grains kg}^{-1}\text{ nutrient)} = \frac{\text{Yield with fertilizer} - \text{Yield in control}}{\text{Nutrient (kg)}}$$

Data were analyzed statistically by analysis of variance and treatment means were compared by least significant difference test (Steel & Torrie, 1980).

Results and Discussion

Crop biometry: Germination count was highest with P+K fertilizer and lowest in control (Table 1); having significant difference. Plant population increased significantly by P but not by K, and the response was much better for combined use of P and K. Height of plants was also affected similarly being highest with P+K treatment. Significant differences among treatments were also observed for biological yield which was highest (31.7 t ha^{-1}) with P+K. Data also indicated that integrated use of both nutrients produced highest grain yield of 2.26 t ha^{-1}. Phosphorus gave significantly higher yield as compared to that with K.

Table 1. Effect of N and P nutrition on growth and yield of sorghum crop.

Treatments	Plants count (# m^{-2})	Plant height (cm)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})
T1 Control	28 b	193.2 b	18.8 d	1.34 d
T2 P alone	31 ab	240.7 a	28.1 b	1.98 b
T3 K alone	29 b	209.8 b	24.6 c	1.69 c
T4 P + K	34 a	253.9 a	31.7 a	2.26 a

*Means in a column with common letter(s) are not significantly different at $P \leq 0.05$

Table 2. Effect of N and P nutrition on NPK uptake and FUE in sorghum.

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	FUE (kg grain kg^{-1} nutrient)
T1 Control	173.6 c	23.4 b	109.5 b	-
T2 P alone	204.3 b	28.2 a	117.4 b	8.45
T3 K alone	196.4 b	24.3 b	134.7 a	9.65
T4 P + K	239.5 a	29.7 a	146.3 a	7.97

*Means in a column with common letter(s) are not significantly different at $P \leq 0.05$

Table 3. Economics of P and K fertilizer use for sorghum production (income and cost are in Rs ha^{-1}).

Treatments	Gross income	Fertilizer cost	Net income	Incremental income	Net return	VCR	RII (%)
T1 Control	34828	-	34828	-	-	-	-
T2 P alone	52660	2400	50260	15432	13032	6.43	151
T3 K alone	45255	1520	43735	8907	7387	5.86	130
T4 P + K	59920	3920	56000	21172	17252	5.40	172

Pervez *et al*., (2006) observed a significant response of cotton crop to enhanced levels of K fertilizer in Pakistani soils. Khan *et al*., (2005) studied the effects of different combinations of N, P and K fertilizers on sugarcane and found the best growth and yield of crop with combined application of NPK. Tanchev (1995) also indicated that combination of NPK fertilizers showed better results on the growth, height, tillering, panicle weight and thousand grain weight of sorghum. Improved crop growth and yield with P and K fertilization in the current study was most likely due to their deficiency in the field soil especially that of P which was only 3.6 mg kg^{-1}, whereas K was in the medium range. Sharma & Kumari (1996) reported that with increased K fertilizer application, sorghum grew better and had higher yields.

Nutrients uptake: There were significant differences among treatments for N, P and K uptake by sorghum (Table 2). Nitrogen uptake was improved with P and K application but the difference between these two was non significant; and their combined use surpassed their alone application. Sharma & Ramna (1993) indicated that application of K released the fixed NH_4^+ ion from soil and helped the crop for better uptake of nitrogen. Phosphorus uptake with P+K was highest (29.7 kg ha^{-1}) followed by P alone, and both showed significantly higher P uptake as compared with K alone and control. Application of K did not improve P uptake by sorghum significantly. Dongale & Kadrekar (1992) reported that N, P and K uptake, and apparent recovery of P in sorghum was appreciably higher with significant increases of P application.

Potassium uptake was highest under P+K followed by K alone treatment; both having non-significant difference. Application of P alone also increased K uptake over that in control, but their difference was non significant. Raza *et al*., (2005) reported that uptake and efficiency of NPK nutrients was increased due to their enhanced rate of application to maize crop.

Fertilizer use efficiency (FUE) was maximum for K alone (9.65 kg kg^{-1}) followed by P alone treatment (8.45 kg kg^{-1}) with a little difference (Table 2). It infers that each kilogram of P or K nutrient has almost the similar effect towards increasing the grain yield of sorghum. Here the comparison of P+K with P and K alone looks inappropriate, as in the combined treatment two different nutrients were applied. Raza *et al*., (2005) reported that recommended dose of NPK in maize gave better FUE values as compared to half or double doses. Similarly, Khan *et al*., (2006) found an improved uptake of N and K by wheat with their combined foliar application under rainfed condition.

Economics of fertilizer use: Addition of P and K fertilizers increased the financial returns relative to that achieved without them (Table 3). Net income and net return were highest under P+K application followed by P alone treatment. Fertilizer K also enhanced the returns but comparatively less than that with P fertilizer. Value cost ratio (VCR) was highest with P fertilizer alone (6.43) but it had a very little difference with K alone (5.86) and P+K treatment (5.40). This was due to two reasons; firstly because of lower price of P as compared to K fertilizer, and secondly due to more response of sorghum to P fertilizer for increasing the crop yield. Relative increase in income (RII) was highest (172 %) under P+K followed by P alone (151 %) and lowest with K alone (130 %). It shows that the combined application of P and K increased the sorghum yield more than their application alone and both have positive interaction.

In this study, VCR did not coincide with crop yield for the consideration of economic benefits, as most of the researchers have reported. Instead, the RII used by Yinbo *et al*., (1997) seemed to be more appropriate for economic analysis. Khaliq *et al*., (2006) are also of the same opinion after analyzing the financial data of fertilizer use in cotton. The parameter of net return also proved to match with the incremental income due to enhanced yield with P and K fertilizers. Present study revealed that the combined use of P and K fertilizer is better in economical terms for growing sorghum under rain fed conditions.

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(Received for publication 15 October 2006)