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Soil Test Crop Response Correlation Studies on Sorghum under Rainfed Condition

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Abstract—*A study was carried out on evaluation of targeted yield equation for sorghum (SPH-388) under rainfed condition. It revealed that the sorghum yield was increased with increasing levels of soil fertility. Whereas, the maximum yield was recorded where the balance application of fertilizer applied. A significant value of R^2 (0.79) indicate that 79 per cent variation in sorghum production was due to the contribution of fertilizers and soil available N, P and K. From the basic data of sorghum yield, soil available NPK, uptake of NPK by sorghum and fertilizer NPK applied, it revealed that 2.57 kg N, 0.94 kg P and 4.03 kg K were required for the production of per quintal of sorghum grain. In the sorghum production the per cent contribution of soil available nitrogen, phosphorus and potassium was 13.18, 85.62 and 26.61 %, respectively, whereas the contribution from fertilizer N, P and K was 64.58, 31.75 and 115.67 per cent, respectively. This basic data can be used for calculating the fertilizer doses of targeted yield on the basis of initial available N, P and K content in the soil.*

1. INTRODUCTION

Sorghum is the most important food and fodder crop of Maharashtra state. In Maharashtra, sorghum is grown on an area of 21.50 lakh hectares in Kharif season with the production of 39.11 lakh tones and average productivity of 1819kg ha^{-1}.

Sorghum grain contains about 10-12 percent protein, 3 per cent fats and 70 per cent carbohydrates. It is popular because of its wide adaptability, quick growing habit, drought resistance, high yielding ability, capacity of regeneration, palatability and high digestibility and above all, it has making quality.

Our farmers are likely to use too little or too much of fertilizer. Soil testing for fertility helps them to eliminated the guess work and apply fertilizer according to the needs of the crop. In this regard targeted yield approach evolved in which a combined use of soil as well as plant analysis is considered for formulating the fertilizer recommendations. Thus, it gives the fertilizer recommendations in balance and quantitative terms in relation to soil test values and crop requirement that is necessary to optimize the response to added fertilizer, maximum profit and to achieve desired yield target along with the maintenance of soil fertility.

2. MATERIALS AND METHODS

The field experiment was conducted on sorghum (SPH-388) on Typic ustrothents at the research farm of Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The field layout for crop consisted of four equal size strips in which a fertility gradient was created in the preceding season by applying the graded doses of N, P and K fertilizers to get sufficient range in soil test values which are essential for conducting a successful soil test crop response experiment. The preparatory crop i.e. Wheat (AKW-381) was grown in the preceding season on these for strips, so that the applied fertilize interacts with soil, plants and microbes and become a part of soil system. After the harvest of the gradient crop the standard field experiments were conducted in subsequent season by dividing each of four fertility strips into 27 plots. In each strip, 21 plots received fertilizer treatments with various combination s and levels of N, P and K and other 6 plots were kept as control (unfertilized). The level of nutrients for sorghum were N= 0,40,80 and 160, P=0,30,60 and 90 and K=0,40 and 80 kg K2o ha^{-1}. The fertilizer materials used were urea, single super phosphate and muriate of potash. Half doses of N and full dose of P and K were applied as basal by broadcasting and mixing in the soil by disking. The remaining half dose of N was top dressed after 30 DAS. The soil samples from 0-15 cm depth were collected from all the 108 plots before application of fertilizer and sowing of main crop i.e. sorghum.

The grain and straw yield for all the plots were recorded at the end of the experiment. The plant samples were analyzed for per cent content of N, P and K. Similarly, soil samples were analyzed for available N, P and K by alkaline $KMNO_4$, Olsen's and NH_4OAC method, respectively.

3. RESULT AND DISCUSSION

The perusal of data (Table 1) revealed that the grain and straw yield of wheat were increased with increasing the fertilizer level, however increase in the grain and straw yield were comparatively lower in case of higher level of fertilizer application during both the years of experimentation. Maximum grain yield i.e. 27.12 and 42.25 q ha^{-1} with the application of double the recommended dose of wheat during the year 2001-02 and 2002-03, respectively, whereas the lowest grain yield was recorded in control (unfertilized) plots. Tiwari *et. al.* (2002) reported that use of sub optimal dose of (50 % NPK) had caused 94 and 182 per cent increase in yield over control in soybean and wheat, respectively.

The available nitrogen, phosphorus and potassium content in the soil (Table 2) after harvest of wheat crop were found to be increased with increasing the fertilizer levels. The average increase in available nitrogen content over control were 19, 35,97 kg ha^{-1} during 2001-02 and 23, 41 and 112 kg ha^{-1} during 2002-03 in $L_{1/2}$, L_1 and L_2 fertility strip, respectively. Similar trend was also recorded in case of available phosphorus. The average increase over control was 2.0, 7.20 and 18 kg ha^{-1} during 2001-02 and 2.90, 8.10 and 12.30 kg ha^{-1} during 2002-03 in $L_{1/2}$, L_1 and L_2 fertility strip, respectively. Similar trend was also recorded in case of available potassium content in different fertility strips indicating that the fertility gradient showing a wide variation in soil fertility has been developed in respect of available n, P and K. Swarup and Singh (1989) revealed that continuous use of fertilizer N alone or in combination with P and K significantly enhanced the available NPK content in soil.

The sorghum yields (Table 3) showed increasing trend from L_0 to L_2 fertility strip. The average increase in grain yield of sorghum over control plots in different fertility strips were 2.74, 5.70 and 5.14 q ha^{-1} in $L_{1/2}$, L_1 and L_2 fertility strip, respectively. Similarly, in case of fodder yield, the average increase over control were 5.14, 8.49 and 10.16 q ha^{-1} in $L_{1/2}$, L_1 and L_2 fertility strip, respectively indicating that the sorghum yields increases with increasing residual fertility status of soil. The Maximum yield was obtained in the treatments where the NPK fertilizer was applied in balanced ratio as compared to their individual application. The results are conformity with that of Singh and Sharma (1978), Mali *et. al.*, (2000).

The perusal of data (Table 3) revealed that the nitrogen, phosphorus and potassium uptake in sorghum grain and straw increased with increasing fertilizer doses. Increasing trend in uptake of these nutrients was also observed with increasing soil available nutrients status. The mean N uptake by sorghum grain and fodder in different soil fertility strips $L_{0,}$ $L_{1/2}$, L_1 and L_2 were 60.67, 67.03, 76.15 and 78.79 kg ha^{-1}, respectively. As regards the phosphorus, it was noted that mean total uptake of phosphorus by sorghum grain and straw were found to be increased with increasing the soil fertility status. Similar trend was also observed in case of potassium uptake by sorghum. These results are in conformity with the findings of Hirpara *et. al.*, (1999).

The fertilizer dose based on targeted yield approach hinges around three parameters viz., i) nutrient requirement per quintal of sorghum grain ii) efficiency of available nutrients in soil and iii) efficiency of the applied fertilizer nutrients. The basic data presented in table 4 revealed that the sorghum crop showed differential nature in order to fulfill its requirement. The nutrient requirement per quintal production of sorghum grain were 2.57 kg N, 0.94 kg P_2O_5 and 4.03 kg K_2O, indicating that K requirement of sorghum was highest followed by nitrogen and least in respect of phosphorus. In sorghum production the soil contributed 13.18, 85.62 and 26.61 per cent nitrogen, phosphorus and potassium, respectively. Whereas, 64.58, 31.75 and 115.67 per cent contribution wee from applied fertilizer in respect of N, P_2O_5 and K_2O indicating that sorghum crop utilized maximum nitrogen and potassium from applied fertilizer and maximum phosphorus from soil available form. Utilization of fertilizer potassium goes up to 115.67 per cent, this might be due to the priming effect. Similar trend was reported by Ramamoorthy (1970), Sonar *et.al.* (1982) and Tamboli *et. al.* (1996).

The data in respect of sorghum yield, initial soil values and fertilizer doses applied were used to derive multiple regression equation. The equations were separately derived for control and fertilized plots.

Multiple regression equation for control plots:

$Y=428.974 + 1.184\ N + 0.005\ SN^2 + 70.968\ SP - 3.952\ SP^2 - 2.364\ SK + 0.008\ K^2$ $R^2=0.72^{**}$

Multiple regression equation for fertilized plots:

$Y= -3250.446 + 28.261\ SN^* - 0.061\ SN^2 - 26.508\ SP + 1.112\ SP^2 + 12.632\ SK - 0.023\ SK^2 + 35.275\ FN^{**} - 0.085$

$FN^2 + 0.440\ FP - 0.009\ FP^2 + 1.276\ FK - 0.009\ FK^2 - 0.037\ FNSN + 0.375FPSP + 0.016\ FKSK$ $R^2 = 0.79$

Where, FN, FP and FK are fertilizer NPK in kg ha^{-1}, SN, SP and SK are soil available NPK in Kg ha^{-1} and Y is sorghum yield q ha^{-1} .

A significant value of coefficient of determination (R^2 =0.72) indicate that the variation in the yield of control plots significantly dependent upon the available nutrients in soil. While, in fertilized plots the coefficient of determination (R^2 =0.79) value indicate that there were 79 per cent variation obtained in the sorghum yield due to the contribution of fertilizer and soil N, P and K. Bangar (1990) reported that the R^2 values for multiple regression equations above 0.66 indicated good fit, 0.65 to 0.45 moderate fit and below 0.45 as poor fit.

This information is valuable and of practical importance for efficient and judicious use of fertilizer in increasing food production.

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Table1: Yield (q ha^{-1}) of wheat (AKW-381) in different fertility gradient.

Fertility strips	2001-02			2002-03		
	Grain	Straw	Total	Grain	Straw	Total
L_0	9.10	10.37	19.47	16.12	19.30	35.42
$L_{1/2}$	19.37	27.12	46.49	34.50	37.75	72.25
L_1	23.00	30.37	53.37	40.50	45.80	86.30
L_2	27.12	30.12	57.24	42.25	48.20	90.46

Table 2. Available N, P and K (kg ha^{-1}) status in soil after harvest of wheat crop.

Available nutrient (kg ha^{-1})	2001-02				2002-03			
	Fertility gradient							
	L_0	$L_{1/2}$	L_1	L_2	L_0	$L_{1/2}$	L_1	L_2
Nitrogen	133	152	168	230	138	126	179	250
Phosphorus	8.50	10.50	15.70	26.50	6.30	9.20	14.40	18.60
Potassium	152	167	201	242	213	274	284	308

Table 3: Yield (q ha^{-1}) of sorghum (SPH-388) in different fertility gradient.

Grain yield (q ha^{-1})	Fertility gradient			
	L_0	$L_{1/2}$	L_1	L_2
2001	24.04	26.56	29.81	28.98
2002	23.01	25.96	28.63	28.42
Mean	23.52	26.26	29.22	28.66
Fodder yield(q ha^{-1})				
2001	73.81	79.42	82.39	83.92
2002	80.66	85.33	89.05	90.87
Mean	77.23	82.37	85.72	87.39
N uptake (kg ha^{-1})				
Grain	30.15	33.49	38.45	38.62
Straw	30.52	33.54	37.70	40.17
Total	60.67	67.03	76.15	78.79
P uptake (kg ha^{-1})				
Grain	9.88	12.28	14.54	14.38
Straw	12.28	13.38	14.18	14.78
Total	22.16	25.66	28.72	29.16
K uptake (kg ha^{-1})				
Grain	10.05	11.24	13.13	13.40
Straw	82.20	93.78	93.39	96.07
Total	92.25	105.02	106.52	109.47

Table 4: Basic information for development of targeted yield of sorghum (SPH-388)

Sr. No.	Basic Information	N	P_20_5	K_20
1	Nutrient requirement (kg) for production of one quintal of sorghum (NR)	2.57	0.94	4.03
2	Per cent contribution from soil (CS)	13.18	85.62	26.61
3	Per cent contribution from applied fertilizer (CF)	64.58	31.75	115.67

Table 5: Fertilizer requirement of Kharif sorghum (SPH-388) for different yield targets and soil test values.

Soil available nutrients (kg ha^{-1})	Yield target (q ha^{-1})			
	25	30	35	40
Nitrogen				
120	75.25	95.10	114.95	134.80
240	63.25	83.10	102.95	122.80
360	51.25	71.10	90.95	110.80
Phosphorus				
4	49.57	64.42	79.27	94.12
8	24.89	39.74	54.59	69.44
12	0	15.06	29.91	44.76
Potassium				
120	59.40	76.80	94.20	111.60
240	31.80	49.20	66.60	84.00
300	18.00	35.40	52.80	70.20