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IS PHOSPHORUS AND POTASSIUM FERTILIZATION OF MULTICUT FORAGE SORGHUM REWARDIVE IN HEAVY CLAY SOILS OF GUJARAT?

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SUMMARY

A two-year (2018 and 2019) field study was conducted at All India Coordinated Research Project on Sorghum (AICRP on Sorghum) centre, Surat, Gujarat to assess the effect of three levels of each of phosphorus (P) and potassium (K) *i.e.* 15, 30 and 45 kg/ha of P_2O_5 / K_2O in comparison to N alone fertilized control treatment on multicut forage sorghum (SSG 59-3). These treatments replicated thrice were evaluated in Randomized Block Design (RBD) in a deep clay soil that was medium for available K (207.2 kg/ha) and available P (21.3 kg/ha). Multicut forage sorghum crop performance measured in terms of dry fodder yield showed that application of $P_{45}K_{30}$ resulted in 83.8% improvement in dry fodder yields over no PK applied control (N alone) treatment and thus was promising to all other treatments. Crude protein and IVDMD values improved significantly with PK fertilization over control and highest crude protein (8.12 & 8.69%) and IVDMD (52.90 and 53.30%) values were recorded with $P_{45}K_{30}$ in both first and second cuts. However, based on net income and benefit cost ratio (₹ 87,781 and 3.91), application of $P_{45}K_{15}$ was promising. From the study it is concluded that in deep clay soils of Gujarat state, application of 45 kg P_2O_5 and 15 kg K_2O fertilizers along with 120 kg N is desired for realizing higher fodder yields and net incomes from multicut forage sorghum.

Key words : Fodder, Multi cut sorghum, Phosphorus, Potassium

Multi cut sorghum (*Sorghum bicolor* × *Sorghum sudanense*) with high fodder yields produced over prolonged period (up to 7 months) has gained prominence with dairy farmers in irrigated areas worldwide over single cut sorghum. In this direction, a multi cut sorghum 'SSG 59-3'variety was developed (Paroda and Lodhi, 1978) and that became popular in North India and were found to occupy 76.9% of 2.6 m ha total forage sorghum acreage (Prabhakar Babu, 2018). This high biomass producing multicut sorghum being rich in phosphorus (0.104% in whole plant at 38 days' age; Cavigelli and Thien, 2003) and potassium (1.007% in shoots; Saberi and Siti Aishah, 2013) are bound to remove more of these nutrients from the soil as compared to single cut sorghums. It has been proved that a phosphorus (Werner,1986) and potassium (K) deficit (Sharma and Kumari, 1996) grasses with slow growth and low tillering have poor productivity. Improved genotype and recommended nutrients application are very important to realize potential yield and quality in case of forage sorghum (Satpal *et al.,* 2019). Soil fertility data of Gujarat state reveals that 34 and 66% of samples are low and medium for available phosphorus (P) while 37 and 63% of soils are medium and high for available potassium (Mrutyunjay Swain and Kalamkar, 2016). Thus in these soils, application of P in all soils of state and K in medium fertilie soils assume prominence for enhancing forage productivity. As prices of P and K fertilizers is very high (₹117.51 & 38.24/kg P & K) as compared to N (₹12.83/kg) even after nutrient based subsidy (NBS) of ₹ 18.78, 33.51 and 12.28 per kg N, P and K fertilizers during 2020-21 and country relies on import of these fertilizers, enhancing their use efficiency brings enormous savings. Though studies were made to assess the response of multi-cut forage sorghum to graded levels of P (Roy *et al.,* 2015), K (Khanum Al Akbari and Umar, 2014) and NPK fertilizers (Satpal *et al.,* 2017), the combined impacts of P and K fertilizers were not assessed. Hence, the present study was made to fill this information gap.

MATERIALS AND METHODS

Field experiments were conducted for two consecutive *kharif* seasons of 2018 (July-November) and 2019 (July-October) at All India Coordinated Research Project on Sorghum center at Athwa Farm, Navsari Agricultural University, Surat (Gujarat) situated at 20°12′ N latitude and 72°52′ E longitude at an altitude of 11.34 m above mean sea level. Surat has a tropical savanna climate (Aw) with a mean annual rainfall of 120 cm from South-West monsoons. The experiment comprising of ten treatments formed by combination three levels of phosphorus (15, 30 and 45 kg P_2O_5/ha) and potassium (15, 30 and 45 kg K_2O/ha) along with nitrogen alone applied control (no PK) in RBD with 3 replications. Soil samples collected before start of the experiment each year from plough layer depth revealed that the deep clay soil was non-saline (EC: 0.36 & 0.39 dS/m), moderately alkaline (7.87 & 7.90 pH) was low for organic carbon (0.46 & 0.48%), available N (204.8 & 209.6 kg/ha), medium for available K (204.8 & 209.6 kg/ha) and available P (20.4 & 22.6 kg/ha) during 2018 & 2019 seasons. Multi-cut forage sorghum cultivar 'SSG 59-3' was used in the study. On a well prepared land, seeds were sown in rows at 25 cm apart in second week of July during both the years. A gross plot size of 20 m^2 was used in the study. Entire P and K fertilizers as per treatment through single super phosphate and muriate of potash were applied basal in last ploughing. Nitrogen as urea (120 kg/ha) was applied uniformly to all treatments, 45 kg N as basal and 45 kg top dressing at 30 days after sowing (DAS). After each fodder harvest, 30 kg N was top dressed. A rain fall of 117.3 and 163.4 cm was received in 41 and 71 days during 2018 and 2019.Three and two fodder cuts were taken at 45 days' interval during 2018 and 2019. Plant height, tiller number/ hill, green and dry fodder yields were recorded for each harvest. Data was presented on pooled basis. Crude protein and in vitro dry matter digestibility (IVDMD) was estimated in dried and grinded samples (2 mm sieve size), collected at 1st and 2nd cut. Fodder samples were analyzed for N content of whole plant and protein content was estimated by multiplying N content with 6.25 estimated by conventional micro-Kjeldal method (AOAC, 1995). IVDMD was determined as per Barnes *et al.* (1971). Economics were also worked out based on input price and out prices. A price of ₹1250/t of green fodder and ₹98.44 and 38.16/kg P and K fertilizer were used. Per every tonne of fodder harvested over control, ₹100 labour cost was added to cost of cultivation. Benefit cost ratio was worked as ratio of gross income to cost of cultivation. Factor productivity (t/kg) was worked as ratio of dry fodder yield (t) to that of fertilizer nutrients applied (kg). Data were analyzed in RBD and results are presented at five per cent level of significance (P=0.05) for making comparison between treatments. As the trend of data was similar during both the years of study, pooled analysis was carried and as year × treatment effects were not significant, data was presented on pooled basis.

RESULTS AND DISCUSSION

Data on plant height (cm), tiller number/ m row length, green and fodder yield (t/ha) of multi cut sorghum as influenced by various treatments on pooled basis are given in Table 1.

Growth attributes

Data (Table 1) shows marked differences in plant height (cm) of multicut sorghum due to impact of various fertilizer treatments. Application of 45 kg each of PK fertilizers ($P_{45}K_{45}$) being at a par with $P_{45}K_{30}$ has produced significantly taller plants than all other treatments in both first and second fodder cuts. Shortest plants were produced in no PK applied control (N alone) treatment in both the cuts. Control treatment has at par values as that of $P_{15}K_{15}$ during both the cuts indicating that low doses of PK fertilizers non-significant impacts. Further, all treatments with lower P dose (15-30 kg/ha) irrespective of level of K (15-45 kg) have at par plant heights as that of control during first cut. Tiller production showed different trend in each cut. Highest tiller number/ m row length were recorded with $P_{45}K_{45}$ in first cut while in second cut, $P_{30}K_{45}$ recorded the highest values. In general, multicut sorghum crop has a reduced tiller number in second cut as compared to their numbers in first cut in all treatments. Role of phosphorus in cell division and cell enlargement (Assuero *et al.,* 2004) and development of tillers in crop plants (Rodriguez *et al.,* 1998) partly explains the taller palnts and more tiller production in sorghum.

Fodder yield

Total dry fodder yield (t/ha) from two cuts following the trend of plant height and tiller number were significantly higher with $P_{45}K_{30}$than all other treatments. Dry fodder yieds realized with application of $P_{45}K_{30}$ (38.61 t/ha) were 83.8% higher than no PK

TABLE 1
Plant height, tiller number, green and dry fodder yield (t/ha) of multicut forage sorghum as influenced by P and K fertilization (pooled data)

Treatment	Plant height (cm)		Tiller number*		Green fodder yield (t/ha)			Dry fodder yield		
	I Cut	II Cut	I Cut	II Cut	I Cut	II Cut	Total	I Cut	II Cut	Total
$P_{15}K_{15}$	159.2	151.7	91.1	86.7	46.55	30.81	77.36	14.80	14.49	29.30
$P_{15}K_{30}$	161.7	157.5	126.7	103.3	39.18	26.38	65.56	15.42	12.94	28.36
$P_{15}K_{45}$	163.8	156.8	108.9	82.2	42.41	25.55	67.96	15.73	12.94	28.67
$P_{30}K_{15}$	170.2	162.0	117.8	110.0	46.74	28.45	75.19	15.22	14.49	29.71
$P_{30}K_{30}$	172.8	160.8	114.4	104.4	54.38	26.69	81.07	14.80	13.15	27.95
$P_{30}K_{45}$	169.9	152.2	133.3	135.6	44.38	31.00	75.38	18.01	14.80	32.82
$P_{45}K_{15}$	180.5	164.2	122.2	115.6	57.30	37.08	94.38	18.22	15.42	33.64
$P_{45}K_{30}$	191.0	173.2	123.3	122.2	60.49	34.11	94.60	19.05	19.57	38.61
$P_{45}K_{45}$	196.2	177.3	143.3	125.6	57.49	36.96	94.44	18.12	16.77	34.89
P_0K_0 (control)	159.2	145.5	124.4	95.6	41.87	25.28	67.15	12.84	8.18	21.01
S. Em±	4.93	2.97	2.10	1.80	3.00	1.92	3.77	0.80	0.96	1.21
C. D. (P=0.05)	14.51	8.74	6.30	5.40	8.83	5.64	11.09	2.36	2.82	3.56
CV (%)	7.01	4.54	14.26	13.84	14.97	15.55	11.64	12.09	16.45	9.71

*2018 Data

applied control (N alone application). However, in case of total green fodder yield, $P_{45}K_{15}$ treatment has at par yields as that of $P_{45}K_{30}$ and $P_{45}K_{45}$.Total green fodder yield of $P_{45}K_{15}$ treatment (94.38 t/ha) was 40.6% higher than control treatment. On mean basis, first and second cuts vastly differed in their contribution to total green fodder yields. This is evident from the fact that first cut has 63.2% contribution to total green fodder yields where as the contribution to total dry fodder yields by first cut is only 53.2%. A reduction in green and dry fodder yields in second cut over its first cut could be ascribed to reduced plant height and tiller numbers. Mean plant height and tiller number of multicut forage sorghum crop at first cut (172.5 cm and 120.5) was decreased by 11.4 cm and 12.4 numbers in second cut. Synergetic interaction between N and P in grain sorghum (Schlegel and Bond, 2017) and P and K in grain maize (Usherwood and Segars, 2001) explans the imapcts of balanced fertilization in grain crops in general. However, no significant gains in multicut sorghum performance was observed by Chaudhary *et al.* (2018). Enhanced growth and fodder yields in multicut sorghum due to P and K fertilization of current study were supported by findings of Satpal *et al.* (2017).

Fodder Quality

Data on quality of multicut forage sorghum as influenced by various treatments on pooled basis are given in Table 2. Data indicates significant improvements in crude protein and IVDMD due to PK fertilization over its no PK applied control in both the cuts. Maximum crude protein (CP) content (8.13 and 8.69 %, respectively) was estimated with $P_{45}K_{45}$ and $P_{45}K_{30}$ which was on a par with rest of the treatments except $P_{15}K_{15}$, $P_{15}K_{30}$ and $P_{15}K_{45}$ at first cut and $P_{15}K_{15}$, $P_{15}K_{30}$, $P_{15}K_{45}$ and $P_{30}K_{15}$ at second cut. Maximum *in-vitro* dry matter digestibility (IVDMD) (52.90 and 53.30 %, respectively) was estimated with $P_{45}K_{30}$ which was on a par with rest of the treatments except $P_{15}K_{15}$, $P_{15}K_{30}$ and $P_{15}K_{45}$ at first cut and $P_{15}K_{15}$, $P_{15}K_{30}$, $P_{15}K_{45}$ and $P_{30}K_{15}$ at second cut. The increase in

TABLE 2
Quality of multicut forage sorghum as influenced by P and K fertilization (pooled data)

Treatment	CP (%)		IVDMD (%)	
	I Cut	II Cut	I Cut	II Cut
$P_{15}K_{15}$	7.54	8.04	47.90	48.33
$P_{15}K_{30}$	7.78	8.24	48.43	49.53
$P_{15}K_{45}$	7.81	8.28	49.28	49.60
$P_{30}K_{15}$	7.94	8.36	51.00	51.00
$P_{30}K_{30}$	8.10	8.67	52.80	52.60
$P_{30}K_{45}$	8.08	8.68	51.40	52.63
$P_{45}K_{15}$	8.03	8.44	52.70	52.68
$P_{45}K_{30}$	8.12	8.69	52.90	53.30
$P_{45}K_{45}$	8.13	8.69	52.30	53.25
P_0K_0 (control)	6.93	7.14	47.53	47.08
S. Em±	0.08	0.06	0.71	0.62
C. D. (P=0.05)	0.24	0.19	2.11	1.86
CV (%)	1.77	1.30	2.41	2.12

TABLE 3
Economics of multicut forage sorghum cultivation as influenced by P and K fertilization (pooled data)

Treatment	Gross Returns (₹/ha)	Net Returns (₹/ha)	Benefit : Cost ratio	Factor productivity (t dry fodder/kg PK fertilizers applied)
$P_{15}K_{15}$	96700	69537	3.56	0.977
$P_{15}K_{30}$	81950	55344	3.08	0.630
$P_{15}K_{45}$	84950	57787	3.13	0.478
$P_{30}K_{15}$	93988	66388	3.41	0.660
$P_{30}K_{30}$	101338	72669	3.53	0.466
$P_{30}K_{45}$	94225	65656	3.30	0.438
$P_{45}K_{15}$	117975	87781	3.91	0.561
$P_{45}K_{30}$	118250	87559	3.85	0.515
$P_{45}K_{45}$	118050	86900	3.79	0.388
P_0K_0 (control)	84057	59057	2.36	-
S. Em±	-	2836	-	-
C. D. (P=0.05)	-	8338	-	-
CV (%)	-	12.21	-	-

CP and IVDMD content with increase in fertilizers levels mainly happens due to increase in Leaf : Stem ratio (L:S ratio), both protein and IVDMD were positively correlated with L:S ratio (Joshi *et al*., 2009).

Economics and factor productivity

Data on economics of multicut forage sorghum cultivation as influenced by various treatments on pooled basis are given in Table 3. Cost of cultivation of control treatment (₹25000) were increased with PK fertilization as function of their dose to the highest of ₹31150 with $P_{45}K_{45}$. Though gross revenues were highest with $P_{45}K_{30}$ (₹118250), net returns and benefit cost ratios have highest values (₹87781 and 3.91) with $P_{45}K_{15}$ application. It shows that combined application of P and K fertilizers ($P_{45}K_{15}$) have improved net revenues by 48.6% over no PK applied control treatment (₹59057). The increases in cost of fertilization far exceeded the additional revenues generated from fodder yield increase associated incomes, hence $P_{45}K_{15}$ has become promising to highest gross revenue giving $P_{45}K_{30}$ treatment. Similar results with respect of profits due to P and K fertilization were reported by Satpal *et al.* (2017) from studies at Hisar. Factor productivity of PK fertilizers was highest (0.977 t dry fodder/ kg PK applied) with $P_{15}K_{15}$. It decreased with increased K dose keeping P as constant in all tretaments.

CONCLUSION

From the two season study, It is concluded that applicaton of 45 kg phosphorus and 15 kg potassium ferilizers along with nitrogen by way of balanced nutrition could yield rich dividends by way of enhanced fodder yields, fodder quality and net revenues in deep clay soils of Gujarat.

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