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Effect of *in-situ* soil moisture conservation practices and its interaction with nutrients in yield, quality and economics of sorghum [*Sorghum bicolor* (L.) Moench]

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ABSTRACT : The present study was undertaken to find out the effect of *in-situ* soil moisture conservation practices and splitting of NPK fertilizers application on productivity of sorghum. The field experiment was conducted during *Kharif* season of 2004 to 2006 at Udaipur to study the effect of moisture conservation practices and fertilizers levels on sorghum. Results from the present investigation revealed that among soil moisture conservation practices, ridge and furrow practice recorded maximum plant height, dry matter accumulation plant^{-1} at 60 DAS and at harvest. On pooled basis, it recorded 12.10,10.47 and 10.95 per cent higher in grain, fodder and biological yields, 11.44 and 11.86 per cent in gross and net returns over compartmental bunds. Further results revealed that split application of fertilizers (½ + ½ and 1/3 + 1/3 + 1/3) recorded maximum growth. Growth yield attributes, yields NPK and protein content and uptake over control. On pooled basis, application of nitrogen 1/3+1/3+1/3 recorded 3.56, 18.81, 13.17, 14.82 and 15.94 per cent higher in text weight grain, fooder, biological yields and not returns over control, respectively.

Key Words : *In-situ*, Sorghum, Yield, Economics, Nutrients

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Sorghum is an important staple food crop for large section of the people and also a main source of feed for cattle. In Rajasthan, it occupies about 6.0 lakh ha area out of which about 90 per cent area is under rainfed. Soil moisture conservation is among the important factors affecting soil physical properties and crop yield. Ridge and furrow moisture conservation practice modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance and soil moisture content. This difference results in a change of number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water and agricultural chemicals. This in turn controls erosion, runoff and crop performance (Khan *et al*., 2001). Sorghum is a highly nutrient exhaustive crop. Among fertilizers used, NPK fertilizers have great effect in increasing the yield of crops. Thus, an adequate nutrition is important to improve good quality of sorghum. The present study was undertaken to find out the effect of in situ soil moisture conservation practices and splitting of NPK fertilizers application on productivity of sorghum during *Kharif* 2004, 05 and 2006.

RESEARCH PROCEDURE

The field experiment was conducted during *Kharif* 2004 to 2006 at Udaipur to study the effect of moisture conservation practices and fertilizers levels on sorghum. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction. The organic carbon and available N, P_2O_5 and K_2O in soil are presented yearly in Table A.

The experiment was laid out in split plot design. The treatment consisted of three types of moisture conservation practices *viz.*, compartmental bunds, ridge and furrow and flat bed in main plot and three fertility levels [control, ½ + ½

Table A : Yearly availability of organic carbon, N P_2 O_5 and K_2O			
Particulars	Years		
	Kharif 2004	*Kharif* 2005	*Kharif* 2006
pH	7.92	7.92	7.98
EC	0.40	0.42	0.44
Organic carbon (%)	0.47	0.54	0.54
Nitrogen (kg ha^{-1})	284.90	290.00	287.90
Phosphorus (kg ha	21.80	20.50	20.80
Potassium (kg ha	358.75	360.85	364.75
Total rain (mm) during crop season	569.6	498.7	350.0
Genotype	CSH 14	CSH 14	CSH 14
Date of sowing	7.07.2004	6.07.2005	7.07.2006
Date of harvesting	16.10.2004	14.10.2005	10.10.2006

RDF (80 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1}) and 1/3 + 1/3+1/3 RDF (80 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1}] in sub plot resulting into 9 treatment combinations which were replicated three times. The soil moisture conservation practices applied as per the treatment combination at the time of sowing. Fertilizer was applied as per treatments, splitting of nitrogen and whole amount of phosphorus and potash was applied as per treatment in furrows opened manually at 45 cm rows. Required plant population was maintained by thinning at 25 days after sowing (DAS). Hoeing and weeding was carried out as per agronomic recommendation. Crop was harvested as per their maturity.

Research Analysis and Reasoning

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Moisture conservation practices :

It can inferred from the data in Tables 1 to 3 that among soil moisture conservation practices, ridge and furrow practice recorded maximum plant height, dry matter accumulation $plant^{-1}$ at 60 DAS and at harvest, total and grain weight of five panicles, test weight and yields during all the three years of experiment as well as on pooled data basis. On pooled basis, it recorded 12.10, 10.47 and 10.95 per cent higher in grain, fodder and biological yields; 11.44 and 11.86 per cent in gross and net returns over compartmental bunds.

Data further revealed that ridge and furrow practice recorded maximum NPK uptake by grain, fodder and total by the crop during the years of experimentation and on pooled basis recorded 11.39, 10.04, 10.82 per cent in nitrogen uptake; 11.21, 10.21, 10.61 per cent in phosphorous uptake and 12.58, 11.32 and 11.49 per cent higher in potassium uptake by grain, fodder and total uptake by the crop, respectively. Significant improvement in moisture content in soil also recorded under ridge and furrow method at various soil depths. On pooled basis this practice of moisture conservation recorded 5.81, 2.82 and 3.20 per cent higher soil moisture over flat bed method at 0-15, 15-30 and 30 cm to 45 cm soil depth. Data further revealed that ridge and furrow method recorded higher in available NPK and organic carbon content in soil after the harvest of sorghum crop. Significantly higher ear head weight was recorded in ridge and furrow practice. This might be because of the ridge and furrow practice that would have created a favourable physical environment for the increased mineralization and mobility of fertilizer, as noticed in improvement in available N, resulting in

Table 1 : Effect of soil moisture conservation practices and fertility levels on growth, yield attributes and yield of sorghum (pooled over three years)

Treatments	Days to 50% flowering (days)	Plant height (cm)	Dry matter accumulation (g $plant^{-1}$) at		Weight of 5 panicles(g)	Grain wt. of 5 panicles(g)	Test weight(g)	Yield (qha^{-1})			Harvest index (%)
			60 DAS	harvest				Grain	Fodder	Biological	
Conservation practices											
Compartmental bund	54.63	201.48	92.19	158.07	475.51	360.37	29.54	40.63	96.20	136.83	29.71
Ridge and furrows	54.37	205.97	96.21	162.71	490.96	380.74	29.95	45.53	106.27	151.80	29.95
Flat bed (check)	54.67	203.15	92.54	159.04	478.63	365.00	29.52	41.20	97.93	139.14	29.57
C.D. (P=0.05)	NS	1.15	0.99	1.32	8.40	4.96	0.256	1.47	3.02	4.98	NS
Fertility levels											
0:0:0	55.41	198.70	90.91	157.24	443.85	328.44	28.96	37.91	92.63	130.54	29.04
½ + ½ (80:40:30 NPK kg/ha)	54.11	204.67	93.99	160.25	496.67	387.59	30.06	44.41	102.94	147.35	30.14
$^1/_3$ + $^1/_3$ + $^1/_3$ (80:40:30NPKkg/ha)	54.15	207.22	96.04	162.32	504.63	390.74	29.99	45.04	104.83	149.88	30.05
C.D. (P=0.05)	0.230	1.28	0.78	0.87	8.05	7.06	0.279	1.19	2.11	2.98	NS

NS=Non-significant

Table 2: Effect of soil moisture conservation practices and fertility levels on nutrient content and uptake (pooled over three years)

Treatments	Nutrient content (%)							Nutrient uptake (%)								
	Nitrogen		Phosphorous		Potassium		Protein	Nitrogen			Phosphorous			Potassium		
	grain	fodder	grain	fodder	grain	fodder	in grain	grain	fodder	total	grain	fodder	total	grain	fodder	Total
Conservation practices																
Compartmental bund	1.618	0.5113	0.3107	0.1689	0.520	1.576	10.11	66.37	49.50	115.86	12.76	16.26	29.02	21.13	149.77	170.90
Ridge and furrows	1.625	0.5136	0.3118	0.1698	0.524	1.588	10.16	73.93	54.47	128.40	14.19	17.92	32.10	23.79	166.73	190.53
Flat bed (check)	1.622	0.5121	0.3115	0.1692	0.521	1.585	10.14	67.03	50.14	117.18	12.83	16.48	29.31	21.49	152.69	174.19
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	2.72	6.11	0.77	0.88	1.63	0.97	8.06	8.73
Fertility levels																
0:0:0	1.533	0.4969	0.2888	0.1628	0.500	1.494	9.58	58.24	46.44	104.67	10.95	15.00	25.95	18.96	137.57	156.54
½ + ½ (80:40:30 NPK kg/ha)	1.661	0.5179	0.3222	0.1704	0.522	1.615	10.38	73.73	52.99	126.72	14.23	17.40	31.62	23.14	162.81	185.95
$^{1}/_{3}$ + $^{1}/_{3}$ + $^{1}/_{3}$ (80:40:30NPKkg/ha)	1.671	0.5223	.03232	0.1747	0.542	1.640	10.44	75.35	54.69	130.05	14.60	18.26	32.86	24.32	168.81	193.13
C.D. (P=0.05)	0.022	0.0113	0.0050	0.0027	0.010	0.043	0.14	2.11	1.44	2.85	0.41	0.55	0.79	0.72	4.97	5.07

Table 3 : Effect of soil moisture conservation practices and fertility levels on available nutrients status of soil after harvest of crop, economics and moisture content of soil (pooled over three years)

Treatments	Nutrient status of soil				Economics			Soil moisture content (%) at		
	Nitrogen ($kgha^{-1}$)	Phosphorous ($kgha^{-1}$)	Potassium ($kgha^{-1}$)	Organic carbon ($g\ kg^{-1}$)	Gross returns ($Rs\ ha^{-1}$)	Net returns ($Rs\ ha^{-1}$)	B/C ratio	0-15 cm depth	15-30cm depth	30-45 cm depth
Conservation practices										
Compartmental bund	256.24	20.34	368.54	6.32	30846	27382	2.64	9.47	11.72	12.51
Ridge and furrows	259.89	20.67	371.11	7.41	34376	30777	2.85	10.02	12.05	12.91
Flat bed (check)	250.72	18.38	359.05	6.21	31317	28237	3.07	9.63	11.66	12.26
C.D. (P=0.05)	4.90	0.21	5.00	0.14	1017	1017	0.10	0.89	0.110	0.19
Fertility levels										
0:0:0	249.28	18.41	360.98	6.16	29121	26180	2.98	9.11	11.42	12.26
½ + ½ (80:40:30 NPK kg/ha)	255.86	20.45	366.88	6.85	33444	29862	2.78	9.92	11.91	12.63
$^{1}/_{3}$ + $^{1}/_{3}$ + $^{1}/_{3}$ (80:40:30NPKkg/ha)	261.71	20.52	370.84	6.94	33975	30353	2.80	10.07	12.09	12.79
C.D. (P=0.05)	3.62	0.19	4.19	0.09	617	617	0.06	0.35	0.128	0.17

higher nutrient uptake and crop growth, thus leading to higher ear head length and grain yield. This might have accommodated more number of grains with a provision of sufficient space for development of grains, leading to higher seed index. Significantly higher grain and dry fodder yield were obtained under ridge and furrow which was significantly at par with compartmental bund and both were superior over flat bed practice (Table 1) because of better crop growth, increased dry matter production and its distribution among leaves, stem and ear heads. Higher uptake of nutrients and improved yield components were also observed, mainly owing to favourable physical condition with greater moisture provided to the crop with this moisture conservation practice (Khurshid *et al*., 2006 and Yadav, 2010).

INM practices :

Data presented in Table 1 reveal that split application of fertilizers (1/2 +1/2 and 1/3 +1/3+ 1/3) recorded maximum all the growth, yield attributes, yields, NPK and protein content and uptake over control. On pooled basis, application of nitrogen 1/3+ 1/3+ 1/3 recorded 3.56, 18.81, 13.17, 14.82 and 15.94 per cent higher in test weight, grain, fodder, biological yields and net returns over control, respectively. The positive response of NPK fertilization on growth parameters could be ascribed to better nutritional environment, enabling the plants to absorb more nutrients as evident from the enhanced concentration and uptake of nutrients. An increased uptake of plant nutrients empowered the plant to manufacture more quality of photosynthates, which is reflected in more vegetative growth. The improvement in nutritional status of plant might have resulted in greater synthesis of amino acids, protein and other growth promoting substances which seems to have enhanced the maristematic activity and increased cell division and enlargement and their elongation resulting in higher plant height. The improvement in these parameters might have resulted in better inception and utilization of radiant energy leading towards higher photosynthesis and finally more accumulation of dry matter of individual plants. Data in Tables 1 to 3 further revealed that during all the years of experimentation as well as on pooled basis fertility level $1/3^{rd}$ + $1/3^{rd}$ + $1/3^{rd}$ recorded maximum NPK and protein content in grain, NPK content in fodder and their uptake. On pooled basis, $1/3^{rd}$ + $1/3^{rd}$ + $1/3^{rd}$ level recorded total N, P and K uptake over control by a margin of 24.25, 26.63 and 23.37 per cent, respectively. Data further revealed that $1/3^{rd}$ + $1/3^{rd}$ + $1/3^{rd}$ fertility level significantly recorded higher NPK and organic content in soil after the harvest of crop and on pooled basis recorded 261.71, 20.52 and 370.84 kg ha^{-1} of NPK and 6.94 g kg^{-1} of organic content in soil. Data in Table 3 revealed that this level also recorded maximum soil moisture content at 0-15, 15-30 and 30 cm to 45 cm of soil depth. On pooled basis this level recorded 10.54, 3.88 and 4.32 per cent higher soil moisture content at 0-15, 15-30 and 30 cm to 45 cm of soil depth over control, respectively. $1/3^{rd}$ + $1/3^{rd}$ + $1/3^{rd}$ fertility level recorded significantly superior values of all the yield attributing and yield character than other treatment. It was due to improve dry matter production and yield components with fertilizer application similar results were also obtained by Das *et al*. (2000) and Mali *et al.* (2000). The higher economic yield under $1/3^{rd}$ + $1/3^{rd}$ + $1/3^{rd}$ fertility level was mainly as a result of increased water holding capacity and nutrient supply, which helped the crop to receive optimum level of soil moisture and nutrient. It has resulted in the increased dry matter production, ear head weight, grain weight and 1000 grain weight and attributed for economic yield (Yadav, 2010). It is well emphasized that increasing rates of fertilizer, markedly improved over all growth of the crop in terms of dry matter production per plant by virtue of its impact on morphological and photosynthetic components alongwith accumulation of nutrients. This suggests greater availability of nutrients and metabolites for growth and development of reproductive structure, which ultimately led to realization of higher productivity of individual plants. One of the other probable reasons could be ascribed to earlier flowering, which might have provided greater duration for reproductive growth. The increased availability of nutrients and photosynthates might have enhanced number of flowers and their fertilization resulting in higher number of grains per panicle. Further, in most of cereals, greater assimilating surface at reproductive development results in better grain formation because adequate production of metabolites and their translocation towards grain as evident from improvement in nutrient concentration and their uptake. This might have resulted in increased weight of individual grain expressed in terms of test weight. Since the grain weight per panicle is dependent on number of grains per panicle and weight of individual grain, the significant improvement in grain weight per panicle under fertility levels could be ascribed to improvement in both these parameters. The results of present investigation are in close conformity with findings Sumeriya *et al*. (2007) and Sumeriya (2010).

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