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EFFECT OF MOISTURE MANAGEMENT IN ERODED SOILS ON RAINFED SORGHUM VARIETIES OF CENTRAL U.P.

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Abstract

A field experiment was conducted on light textured soil at Kanpur during *kharif* 2015 and 2016 to study the effect of moisture conservation practices (farmer's practice, ridging and furrowing and mulching) on splash loss, canopy development, water use, water use efficiency, root development, growth behaviour and yield of sorghum varieties (Suraj, Virat, Hi-tech-3201 and Ratna-40) under rainfed condition. Results revealed that variety 'Ratna-40 performed better with a yield level of 26.20 q ha^{-1}, total water use of 386.0 mm and also had a higher net return (Rs 32067 ha^{-1}) as well as B:C ratio (2.09). Organic residue mulching in between the crop rows at 25 DAS gave significantly higher grain yield (26.70 q ha^{-1}) and stover yield (86.29 q ha^{-1}) over ridging and furrowing as well as farmer's practice treatments. The higher WUE (7.51 kg grain ha^{-1} mm^{-1} of water) and net return (Rs 27970 ha^{-1}) were also recorded when mulching practice was adopted. Maximum splash loss was observed under farmer's practice followed by ridging and furrowing and minimum under mulching plot.

Keywords: Moisture management, varieties, splash loss, canopy development, yield attributes, yield, net return and B:C ratio.

Introduction

Indian agriculture is dominated by rainfed farming. Rainfed agriculture contributes to 42% of the national food grain production mainly through sorghum, millets and pulses, therefore dryland areas are important for the economy of the country and will continue to be so in future. Crop grown in rainfed condition are prone to water stress, owing to rapid loss of soil water from profile resulting in low water availability for root growth. Moisture conservation practices changes its structure, controls the weeds and improve the water holding capacity of soil (Rao *et al.*, 2010). The cultivation of sorghum hybrids was found more economical than traditional varieties. It seems to be desirable that local or improved varieties of sorghum may be replaced by sorghum hybrids for higher crop yield and profit even under rainfed condition (Mishra *et al.*, 2015). Therefore, the present investigation was undertaken to study the moisture conservation practice effects on growth, WUE, root development and yield of rainfed sorghum varieties in light textured eroded soil of Central Uttar Pradesh.

Materials and Methods

A field experiment on rainfed sorghum was conducted during *kharif* seasons of 2015 and 2016 at Soil Conservation and Water Management Farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur on eroded alluvial sandy loam and calcareous soil. The experimental site had a slope of 1.8% with the top soil washed out by water erosion. However, the area was made cultivable by bunding. Initial soil properties of the experimental field (0-25 cm depth) are given below:

(A) Mechanical composition
- Coarse sand = 55.1%
- Fine sand = 10.0 %
- Silt = 17.4%
- Clay = 16.6%

(B) Physical properties
- Bulk density = 1.38 Mg m^{-3}
- Particle density = 2.60 Mg m^{-3}
- Total porosity = 46.9%
- Field capacity = 18.3%
- Wilting point = 6.0 %
- Water holding capacity= 28.3%

(C) Physico-chemical properties
- pH = 7.8
- EC = 0.26 dSm^{-1}

D) Chemical properties
- Organic carbon = 0.31%
- Total-N = 0.029 %
- Available-N = 168.5 kg ha^{-1}
- Available P_2O_5 = 15.8 kg ha^{-1}
- Available K_2O = 193.0 kg ha^{-1}

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4 varieties and 3 *in-situ* moisture conservation practices were tested in the experiment (Table-1, 2 and 3). The treatments were replicated thrice in a factorial randomized block design. A uniform dose of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} was applied as basal at sowing through funnel attached with country plough. Additional 40 kg N ha^{-1} through Urea was top dressed in standing crop at optimum soil moisture condition. The gross plot size was 5.0 m x 3.6 m but the net plot size was 4.0 m 2.70 m. The crop was sown on July 16 and 22 using 15 kg seed ha^{-1}in rows 45 cm apart and harvested on November 20 and 23 in the respective seasons. At sowing time, available soil moisture in 100 cm soil profile was 231.8 and 202.0 mm (Av. 216.9 mm) during 2015 and 2016, respectively. Total rainfall during crop period was 318.2 and 397.3 mm during first and second year, respectively.

The plant canopy was measured with the help of a canopy frame (60 x 60 cm). Splash loss was recorded by splash cup of 10 cm diameter placed at 20 cm depth in each plot in one replication. The soil moisture was determined gravimetrically. The water use by the crop was calculated by summing up the values of depletion of soil moisture of profile during the entire crop season. The equation WUE = Y/ET (Viets, 1962) was used to calculate the water use efficiency of crop. Root studies were conducted at harvest by selecting 2 plants at random from each plot. The roots were freed with a fine jet of water spray and root development, water use as well as splash loss were done in one replication only.

Results and Discussion

Growth and yield

Among varieties, Ratna-40 and Hi-tech-3201 being at par produced significantly higher grain and stover yields of sorghum than other two varieties *i.e.* Virat and Suraj (Table-3). The grain yield of Ratna-40 as well as Hi-tech-3201 was higher because of significantly higher yield attributes *i.e.* panicle length, panicle girth, panicle weight, grains $panicle^{-1}$ and 1000-grain weight, but stover yield might be attributed to taller plants, more stem girth and functional leaves $plant^{-1}$ (Table-1). These results confirm the findings of Singh *et al.* (2013b) and Mishra *et al.* (2015). Grain and stover yields of sorghum were produced significantly higher under mulching followed by ridging and furrowing and lowest in farmer's practice. The grain yield increased being basically owing to significantly higher yield attributes, while stover yield is the combined effect of growth characters and yield attributes (Table-1). Higher yield of sorghum under mulching practice have already been reported by Singh *et al.* (2013 a) and Gabir *et al.* (2014). Virat, Hi-tech-3201 and Ratna-40 delayed panicle emergence and maturity as compared to Suraj (Table-1). It might be the genetic effect of different varieties and also due to their moisture utilization efficiency. These results are in agreement to the findings of Rao *et al.* (2013). Mulching practice delayed panicle emergence and maturity by 5 days than farmer's practice, while ridging and furrowing delayed these only 3 days. Such delay might be due to increased soil moisture in these treatments (Table-2), which was utilized by plants and prolonged the vegetative growth period. Harvest index was not influenced by varieties and moisture conservation practices (Table-3).

Canopy development and splash loss

Variety 'Suraj' showed relatively higher splash loss of soil as compared to other varieties (Table-3). The soil loss was found to be directly governed by crop canopy development. Since, maximum canopy was found in variety, 'Ratna-40' (Table-1), the soil loss was less in 'Ratna-40'. Variety 'Suraj' which had the lowest canopy showed maximum soil loss. Among moisture conservation practices, relatively higher splash loss of soil observed under farmer's practice (control) due to minimum vegetative canopy. The minimum splash loss showed under organic residue mulching treatment due to maximum leaf coverage (Table-1). These results are in conformity with the findings of Katiyar (2001).

Soil moisture status

Variety 'Suraj' was observed to have higher soil moisture up to one metre soil depth at almost all the stages of plant growth as compared to other varieties (Table-2). It might be associated with genetic make-up of different varieties. The highest soil profile moisture was observed under mulching treatment followed by ridging and furrowing at almost all the growth stages, which might be attributed firstly to arresting the runoff at the site of occurrence, thus providing more opportunity for the rain-water to inter into the soil, and secondly to reduction of surface evaporation and weeds particularly in case of mulching treatment. These results are in accordance with the views advocated by Katiyar (2001).

Consumptive use (CU)

Variety 'Ratna-40' resulted more periodic CU over other varieties (Table-2), which is attributed to more transpiration by the plants and higher water requirement variety. The minimum periodic CU was observed under organic residue mulch plot and maximum under farmer's practice at all the growth stages. Mulch is the material applied over the soil surface to check evaporation and weed emergence under the thick cover resulting saved water for long period. These results are supported by the findings of Katiyar (2001).

Total water use and water use efficiency

In case of varieties, TWU was maximum in Ratna-40 (386.0 mm) but WUE was highest in Hi-tech-3201 (6.82 kg grain ha^{-1} mm^{-1} of water). Higher TWU in these two varieties might be attributed to their better root development (Table-3) and crop canopy as well as comparatively longer crop duration (Table-1) as compared to other varieties. Higher grain yield of Ratna-40 and Hi-tech-3201 might has increased the WUE over other varieties (Table-2). Similar results have also been reported by Chand and Bhan (2002). Mulching treatment recorded lower TWU (355.9 mm) and higher WUE (7.51 kg grain ha^{-1} mm^{-1} of water) as compared to other moisture conservation practices. Higher WUE recorded by the crop grown under mulching practice might have been due to control of weeds and reduce evaporation loss as a result sufficient conserved water in the soil which in turn made it possible to utilize moisture by the crop more efficiently over other moisture conservation practices. Similar were the findings of Singh *et al.* (2012).

Root development

Variety 'Ratna-40' proved better in root development i.e. root depth, roots $plant^{-1}$ and dry weight of roots $plant^{-1}$ than other varieties (Table-3). The varietal differences in root development may be attributed to hereditary characteristics of varieties. The number of roots $plant^{-1}$ and dry weight of roots $plant^{-1}$ were maximum under mulching treatment, while these were minimum under farmer's practice. This is attributed to effective moisture conservation and its supply to crop, which in turn reflected on root growth. The depth of root was higher under farmer's practice in comparison to other moisture conservation practices.

Economics

Among varieties, Ratna-40 earned highest net return (Rs 32067 ha^{-1}) and B:C ratio (2.09) closely followed by Hi-tech-3201 (Table-3). It might be attributed mainly to higher gross income values but total cost of cultivation was similar in all tested varieties. As a practice of moisture conservation, mulching recorded the highest net return (Rs 27970 ha^{-1}). However, this treatment was failed to exhibit superiority in respect of B:C ratio (1.80) over ridging and furrowing (1.96) due to the additional cost of cultivation. Treatment of ridging and furrowing exhibited the highest B:C ratio. Both the moisture conservation practices exhibited the higher grain and stover yields as a result the highest economic viability being observed as compared to farmer's practice plot.

References

Chand M and Bhan S (2002). Root development, water use and water use efficiency of sorghum (*Sorghum bicolor*) as influenced by vegetative barriers in alley cropping system under rainfed condition. *Indian Journal of Agronomy,* **47(3):** 333-339.

Gabir SIMN, Khanna M, Singh M, Parihar SS, Mani I and Das TK (2014). Effect of conservation practices and fertilizer on sorghum (*Sorghum bicolor*) yield under rainfed conditions of Northern India. *Indian Journal of Agronomy,* **59(2):** 301-305.

Katiyar SC (2001). Soil loss, moisture and root growth of sorghum as influenced by moisture conservation practices. *Indian Journal of Soil Conservation*, **29(2):** 179-181.

Mishra JS, Thakur NS, Singh P, Kubsad VS, Kalpana R, Alse UN and Sujathamma P (2015). Productivity, nutrient use efficiency and economics of rainy season grain sorghum (*Sorghum bicolor*) as influenced by fertility levels and cultivars. *Indian Journal of Agronomy,* **60(1):** 76-81.

Rao SS, Patil JV, Umakant AV, Mishra JS, Ratnavathi CV, Shyam Prasad G and DayakarRao B (2013). Comparative performance of sweet sorghum hybrids and open pollinated varieties for stalk yield, biomass, sugar quality traits, grain yield and bioethanol production in tropical Indian conditions. *Sugar Technology*, **15(3):** 250-257.

Rao SS, Regar PL and Singh YV (2010). *In-situ* rain water conservation practices in sorghum under rainfed condition in arid regions. *Indian Journal of Soil Conservation,* **38(2):** 105-110.

Singh P, Sumariya HK, Solanki NS, Dubey RK, Tiwari RC, Azad M and Golada SL (2013b). Productivity and economics of sorghum (*Sorghum bicolor* L.) genotypes as influenced by different fertility levels. *Annals of Biology*, **29(3):** 311-316.

Singh P, Sumeriya HK and Kaushik MK (2013a). Effect of *in-situ* soil moisture conservation practices and its interaction with nutrients on yield, quality and economics of sorghum (*Sorghum bicolor*). *Advance Research Journal of Crop Improvement,* **4(2):** 88-92.

Singh RP, Yadav PN, Uttam SK, Katiyar SC and Tripathi AK (2012). Effect of moisture conservation and nutrient management on growth, yield and water use of sorghum. *Current Advances in Agricultural Sciences,* **4(1):** 37-40.

Viets FG (1962). Fertilizers and efficient use of water. *Advances in Agronomy*, **14**: 223-261.

Table 1: Plant growth and yield parameters of sorghum as affected by varieties and *in-situ* moisture conservation practices

(Average data of 2 years)

Treatment	Plant height (cm)	Stem girth (cm)	Days to panicle initiation	Days to maturity	Crop canopy development (%) Days after sowing				Panicle length (cm)	Panicle girth (cm)	Weight of panicle (g)	No. of grains $panicle^{-1}$	1000-grain weight (g)
					30	60	90	Maturity					
Varieties													
Suraj	188.6	6.0	74.9	123.9	31.2	56.3	71.9	48.8	19.0	16.0	77.2	2388.0	24.06
Virat	195.6	6.4	75.9	125.0	32.7	58.3	74.7	47.5	19.6	16.4	79.7	2488.0	24.67
Hi-tech-3201	190.6	7.5	77.1	125.5	34.7	61.0	78.4	50.5	22.2	19.0	91.3	2884.7	28.58
Ratna-40	202.1	6.9	77.5	126.2	35.7	62.5	80.6	51.9	23.3	19.4	93.8	2956.0	28.94
SE (d)	3.8	0.3	0.5	0.4	0.9	1.1	1.5	0.9	0.8	0.8	1.9	52.4	0.62
CD (P=0.05)	7.8	0.6	1.1	0.9	1.8	2.2	3.1	1.9	1.6	1.7	3.9	108.6	1.29
***In-situ* moisture cons. practices**													
Farmer's practice (control)	186.6	5.6	73.8	122.0	31.0	55.9	71.1	43.8	17.7	15.6	74.5	2275.5	23.00
Ridging & furrowing in between crop rows at 25 DAS	194.4	7.0	76.7	125.8	33.9	60.1	77.0	50.6	21.8	17.9	87.8	2769.1	27.03
Organic residue mulch @ 4t ha^{-1} on soil surface at 25 DAS	201.6	7.6	78.6	127.7	35.8	62.5	81.0	52.2	23.6	19.6	94.2	2993.0	29.54
SE (d)	3.2	0.2	0.4	0.4	0.4	0.4	0.7	0.4	0.7	0.6	1.6	46.4	0.53
CD (P=0.05)	6.6	0.5	0.9	0.8	0.8	0.9	1.4	0.8	1.4	1.3	3.4	96.3	1.10

Table 2: Soil moisture content up to one metre depth, consumptive use, total water use and water use efficiency of sorghum as affected by varieties and *in situ* moisture conservation practices

(Average data of 2 years)

Treatment	Soil moisture content up to 1 m depth (mm)					Consumptive use (mm) m^{-1} soil depth				Total water use (mm)	Water use efficiency (kg grain $ha^{-1}mm^{-1}$ of water)
	Sowing time	30 DAS	60 DAS	90 DAS	At harvest	Sowing to 30 DAS	30 DAS to 60 DAS	60 DAS at 90 DAS	90 DAS to at harvest		
Varieties											
Suraj	216.9	222.4	201.1	152.5	108.2	98.5	100.0	103.0	53.9	355.4	6.05
Virat	216.9	222.5	199.4	148.9	104.2	98.4	101.2	104.9	54.9	359.4	6.10
Hi-tech-3201	216.9	222.7	195.4	139.5	94.6	98.2	106.0	110.2	54.6	369.0	6.82
Ratna-40	216.9	222.7	187.2	122.9	77.6	98.2	114.2	119.0	54.6	386.0	6.78
***In-situ* moisture cons. practices**											
Farmer's practice (control)	216.9	222.1	188.5	126.0	82.6	98.8	112.3	116.9	53.0	381.0	5.36
Ridging and furrowing in between crop rows at 25 DAS	216.9	222.6	196.9	143.8	98.1	98.3	104.4	107.4	55.4	365.5	6.55
Organic residue mulch @ 4t ha^{-1} on soil surface at 25 DAS	216.9	222.9	202.0	153.0	107.7	97.8	99.8	103.3	55.0	355.9	7.51

Table 3: Root development, splash loss, yield and economics of sorghum as affected by varieties and *in situ* moisture conservation practices (Average data of 2 years)

Treatment	Root development				Splash loss ($t\ ha^{-1}$)	Grain yield ($q\ ha^{-1}$)	Stover yield ($q\ ha^{-1}$)	Harvest index (%)	Net return (Rs ha^{-1})	Benefit : cost ratio
	Root depth (cm)	No. of roots $plant^{-1}$		Dry weight of roots $plant^{-1}$ (g)						
		Primary	Secondary							
Varieties										
Suraj	14.8	22.8	87.8	5.66	4.62	21.51	71.36	23.16	16058	1.54
Virat	15.8	24.6	88.8	6.06	4.54	21.92	72.00	23.34	18172	1.61
Hi-tech-3201	18.2	27.1	93.1	6.79	4.06	25.17	81.18	23.67	24489	1.83
Ratna-40	20.1	28.6	97.0	7.60	3.67	26.20	83.96	23.78	32067	2.09
SE (d)	-	-	-	-	-	1.09	2.06	0.58	-	-
CD (P=0.05)	-	-	-	-	-	2.27	4.27	NS	-	-
***In situ* moisture cons. practices**										
Farmer's practice (control)	19.6	21.7	83.9	5.76	5.08	20.44	67.24	23.31	15961	1.55
Ridging and furrowing in between crop rows at 25 DAS	17.4	26.7	93.2	6.68	4.42	23.97	77.86	23.54	24160	1.96
Organic residue mulch @ 4t ha^{-1} on soil surface at 25 DAS	14.7	29.1	98.0	7.14	3.17	26.70	86.29	23.63	27970	1.80
SE (d)	-	-	-	-	-	0.89	1.80	0.47	-	-
CD (P=0.05)	-	-	-	-	-	1.85	3.74	NS	-	-