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Research Article

EFFECT OF MOISTURE MANAGEMENT IN ERODED SOILS ON RAINFED SORGHUM VARIETIES OF CENTRAL UTTAR PRADESH

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Abstract: A field experiment was conducted on light texture soil at Kanpur during *kharif* 2015 and 2016 to study the effect of moisture conservation practices. (Farmer's practices, 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 a variety "Ratna-40" performed better yield level of 26.20 Q/ha, total water use of 386.0 mm and also had a higher net return (Rs 32067 /ha.) 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) and stover yield (86.29 q/he) over and ridging furrowing as well as farmer's practice treatments. The higher WUE (7.51 kg grain /ha/ mm of water) and net return (Rs 27970q/ha.) were also recorded. When mulching practices were adopted. Highest splash loss was found under farmer's practice followed by ridging and furrowing and lowest under mulching plot.

Keywords: *Moisture management, Varieties, Splash loss, Canopy development, Yield attributes, Net return, B:C ratio*

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Introduction

Indian agriculture is dominated 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 cultivated in rainfed situation are prone to water stress, due to rapid loss of soil water from profile resultant in little water accessibility for root growth. Moisture conservation practices changes its structure, controls the weeds and improve the water holding capacity of soil [1]. The cultivation of sorghum hybrids was found mare economical them traditional varieties. It seems to be desirable that local or improved varieties of sorghum may be replaced by sorghum hybrids for higher cop yield and profit even under rainfed condition [2]. 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 C.S.Azad University of Agriculture and 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 Mgm^{-3}
Particle density	2.60 Mgm^{-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	0.26dsm^{-1}

(D) Chemical Properties

Organic Carbon	0.31 %
Total- N	0.029
Available - N	168.5 kg/ha
Availably P_2O5	15.8 kg/ha
Available K_2O	193.0 Kg/ha

Four 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 black design. Uniform close of 40kg N +40kg P_2O5+40kg K_2O /ha was applied as basal at sowing through funnel as attached with country plough.

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 growth (cm)	Days to panicle initiation	Days to maturity	Crop canopy development (%) Days after sowing 30	60	90	Maturity	Panicle Length (cm)	Panicle girth (cm)	Panicle Weight (g)	No. of grains/ panicle	1000 Grain Weight(g)
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 Conservation Practices													
Farmer's practices (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 the 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 residues mulch@ 4t/ha 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 yrs)

Treatment	Soil moisture Content up to one metre depth(mm) Sowing Time	30 DAS	60 DAS	90 DAS	At Harvest	Consumptive Use (mm) m^{-1} soil depth Sowing Time to 30 DAS	30 DAS to 60 DAS	60 DAS to 90 DAS	90 DAS to Harvest	Total Water Use (mm)	Water Use efficiency (Kg grain/ha/ mm of water)
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 Conservation Practices											
Farmer's practices (Control)	216.9	222.1	188.5	126.0	82.6	98.8	112.3	116.9	53.0	381.0	5.36
Ridging& Furrowing in between the 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 residues mulch@ 4t/ha 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, grain yield and economics of Sorghum as affected by varieties and in-situ moisture conservation practices (average data of 2 years)

Treatment	Root Development Root Depth (cm)	No. of Roots/ plant Primary	Secondary	Dry Weight of roots/ plant (g)	Splash Loss (t/ ha)	Grain Yield (q/ha)	Stover Yield (q/ha)	Harvest index (%)	Net Return (Rs. / ha)	Benefit: Cost Ratio
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	26.70	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 Conservation Practices										
Farmer's practices (Control)	19.6	21.7	83.9	5.76	5.08	20.44	67.24	23.31	15961	1.55
Ridging& Furrowing in between the 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 residues mulch@ 4t/ha 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	0.74	NS	----	----

Additional 40 kg N /ha through Urea was top dressed in standing crop at optimum soil moisture condition. The gross plot size was 5.0m x 3.6 m but the net plot size was 4.0m x 2.70m. The crop was sown on July 16 and 22 using 15 kg seed /ha in rows 45cm 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 262.0 mm (AV. 216.9mm) during 2015 and 2016, respectively. Total rainfall throughout crop period was 318.2 and 397.3 mm during first and second year, correspondingly. The plant canopy was measured with the help of a canopy frame (60x60cm). 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 [3] 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 flowing with a fine jet of water spray and root expansion, water use as well as splash loss were completed in single replication only.

Results and Discussion

Growth and Yield

Among varieties, Ratna -40 and Hi-tech-3201 being at per produced significantly higher grain and stover yields of sorghum than others two varieties *i.e.*, Virat and Suraj [Table-3]. The grain yield of Ratne-40 as well as Hi-tech-3201 was higher because of significantly higher yield attributes *i.e.*, panicle length, panicle girth, panicle weight, gains /panicle and 1000- grain weight, but Stover yield might be attributed to taller plants, more stem girth and functional leaves/ plant [Table-1]. These results confirm the findings of Singh *et al* (2013b) [4] and Mishra *et al* (2015). Grain and Stover yields of Jowar were yield considerably highest under mulching followed by ridging and furrowing and minimum in farmer's practice. The grain yield improved being basically due to significantly higher yield attributes, while Stover yield is the collective effect of growth characters and yield attributes [Table-1]. Higher yield of sorghum under mulching practice have already been reported by Singh *et al* (2013a) [5] and Gabir *et al* (2014) [6]. 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) [7]. 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 owing to increased soil moisture in these treatments [Table-2], which was utilized by plants and protracted the vegetative development period. Harvest index was not predisposed 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, comparatively highest splash loss of soil observed under farmer's practice (control) due to lowest 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) [8].

Soil Moisture Status

Variety Suraj was observed to have higher soil moisture up to one meter soil depth at almost all the stages of plant growth as compared to other varieties [Table-2]. It might be associated with genetic makeup 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 recurrence, thus providing more opportunity for the rain-water to inter into the soil, and secondary 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 mare 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 residues mulch plot and maximum under farmer's practice at all the growth stages. Mulch is the material applied over the soil surface to cheek evaporation, 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 (386.0mm) but WUE was highest in Hi-tech- 3201 (6.82 kg grain /ha/mm 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-4o and Hi-tech-3201 might have increased the WUF over other varieties [Table-2]. Similar results have also been reported by Chand and Bhan (2002) [9]. Mulching treatment recorded lower TWU (355.9 mm) and higher WUE (7.51 kg grains/ ha/ mm of water) as compared to other moisture conservation practices. The 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 findings of Singh *et al* (2012) [10].

Root Development

Variety Ratna- 40 proved better in root development *i.e*., root depth, roots/ plant and dry weight of roots/ plant than other varieties [Table-3]. The varietal difference in root development may be attributed to hereditary characteristics of varieties. The number of roots/ plant and dry weight of roots/ plant were higher under mulching treatment, while there were lowest under farmer's practice. This is attributed to efficient moisture conservation and it brings to crop, which in revolve reflected on root development. 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) 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). Still, this treatment was unsuccessful to reveal supremacy in respect of B: C ratio (1.80) over ridging and furrowing (1.96) owing to the supplementary 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 fields as a result the highest economic viability being observed as compared to farmer's practice plot.

Summary

It is found out the higher WUE (7.51 kg grain /ha/ mm of water) and net return (Rs 27970q/ha.) was also recorded. When mulching practices were adopted and highest splash loss was observed under farmer's practice followed by ridging and furrowing and least amount under mulching plot.

Application of research: This experiment is undertaken to study the moisture conservation practice effects on growth, WUE, root development and yield of rainfed sorghum varieties in light textured eroded soil.

Research Category: Soil Conservation and Water Management

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Study area / Sample Collection: C.S. Azad University of Agriculture and Technology, Kanpur, 208002

Cultivar / Variety / Breed name: Suraj, Virat, Hi-tech-3201 and Ratna-40

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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