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Influence of land leveling and planting pattern on productivity, water use efficiency and economic of sorghum (*Sorghum bicolar*)

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ABSTRACT

This study was conducted at Engineering farm, Navsari Agricultural University, Navsari, India, during winter 2016-17 using sorghum crop (Sorghum bicolar) to examine the effect of three land leveling (control or unleveled, conventional land leveling and leveling with laser guided land leveler) and three planting systems (ridge and furrow, double row bed planting and triple row bed planting). The laser guided land leveler significantly improved the growth attributes of sorghum as compared to the control whereas the growth attributes were recorded highest under double row bed planting. The highest yield attributes were recorded in laser guided land leveler. The best results of sorghum yield attributes were recorded under double row bed planting. In land leveling, laser guided land leveler significantly improved yield of sorghum (grain and fodder) as compared to control. Whereas, maximum sorghum yield was obtained under double row bed planting over rest planting system. The soil moisture distribution, water saving and water use efficiency were improved under laser guided land leveler with double row bed planting over rest of the treatments. The highest gross return, net return and benefit: cost ratio were obtained under laser guided land leveler with double row bed planting over rest of the treatments.

Keywords: Sorghum, land leveling, planting pattern, yield, WUE, economic

INTRODUCTION

Among the world's most important crops, sorghum (*Sorghum bicolor* (L.) Moench) comes on fifth rank. Till the green revolution, sorghum is second largest cereal in India, whereas, presently occupies third place in terms of area and production. Maharashtra accounts for the largest production, followed by Karnataka, Rajasthan and Tamil Nadu. Sorghum is the rainfed cereal and mainly grown in the semi-arid and arid parts of India. It is stable cereal for the some part of India as well as source of fodder for domestic animals. It is cultivated during both season in India i.e. rainy (*kharif*) and post rainy (*rabi*). The term Land Leveling generally applies to mechanize grading of agricultural land. Unevenness of the soil surface has adverse effect on the germination, nutrient movement and salt, soil moisture distribution pattern. Leveling improves germination and help in resource conservation. Land leveling using laser assisted land leveler equipped with drag scrapper is a process of smoothening the land surface within ±2 cm of its average micro-elevation. It is contemplated that laser levelers may play a significant role in improving resource use efficiency under surface irrigated systems in the black soil zone of Gujarat. Improvement in operational efficiency, water use efficiency, crop productivity and economic returns and environmental benefits has been reported as a result of precision land leveling when compared to traditional practice of land leveling. Planting pattern is an important factor for agricultural sustainability development in influencing the soil protection. Planting pattern is an agronomic practice that sustains the availability of resources (Sharma *et al.* 2015a, b). The effect of planting patterns on crop development is improved by the adjustment of row space and density. Raised bed planting systems has been associated with water management issues, to reduce the adverse impact of excess water on crop production or to irrigate crops. The selection of suitable sowing method plays an important role in the placement of seed at proper depth, which in turn ensures the better emergence and the subsequent growth. Broad bed and furrow have been found suitable for managing the deep black soil in India. In literature, very little to no data exist on application of raised bed planting on a precision laser leveled field. Coupling the two techniques has potential to further enhance the overall resource use efficiencies associated with sorghum production in Vertisols during winter season. The objective of this study was to

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evaluate land leveling and planting pattern on yield and economies of sorghum production at south Gujarat, India.

MATERIALS AND METHODS

The experiment carried out at Engineering farm, Navsari Agricultural University, Navsari, India, comes under Agro Climatic Zone-3 (South Gujrat Heavy Rainfall Zone-I) during winter 2016-17. Basically, the soils of this region are heavy textured with poor physical properties like: infiltration rate, permeability and drainage. The experiment consisted three land levels viz. control or unleveled (L_1), conventional land leveling (L_2) and leveling with laser guided land leveler (L_3) and three planting systems viz. ridge & furrow (B_1), double row bed sowing (B_2) and triple row bed sowing (B_3). The experiment was laid out in a factorial randomized block design with three replication. Sorghum (GJ-40) was sown in mid-October using 15 kg seed ha^{-1}. Row spacing was maintained 60 cm. Recommended dose of fertilizer N: P (80:40 kg ha^{-1}) was applied of which 50% N and 100% P as basal and 50% N after one month of sowing. All other cultivation processes were similar for all treatments. Five plants per plot were used for measurement of growth parameter and yield attributes. Grain and straw yields of sorghum were recorded at harvest. The soil samples for moisture content were taken at a 15 cm depth interval up to 30 cm depth by the gravimetric method. Measurements were taken at 30 days after sowing during growing season. The soil moisture content was calculated by the method suggested by Tripathi *et al.* (2018). Irrigation water was applied by surface irrigation method. First irrigation was applied just after sowing as a light irrigation whereas reset irrigation were applied one month of interval. Amount of water applied in different treatments was measured using Parshall flume during each irrigation (Chalodiya *et al.* 2017). The total water use during the cropping was calculated. In other words, water use efficiency (WUE; kg/ha/mm) is the yield per unit area of land per unit depth of water used by the crop (Tripathi *et al.* 2015). WUE was then calculated by dividing the grain yield (kg/ha) by the total amount of water (mm) applied in the field (Kumari *et al.* 2015; 2018). Economics was computed on the bases of uses the cost of inputs and income generated from output (grain and fodder yield), which computed using the current procurement price. The net return was calculated by subtracting the cost of cultivation incurred from sowing to harvesting, for each plot from the gross return and then benefit-cost ratio was worked out. The data gathered in each observation were statistically evaluated using analysis of variance technique (Gomez and Gomez 1984). The critical differences (CD) was computed to assess the significance of treatment means at 5% level of probability.

RESULTS AND DISCUSSION

Growth attributes

The growth parameters *viz*. plant height, drymatter accumulation and biological weight of sorghum were significantly affected by the different land leveling and planting methods (Table 1). The laser guided land leveler significantly improved the growth attributes of sorghum as compared to the control whereas conventional land leveling was at par with laser guided land leveler. The uniform moisture distribution to the entire field as a result of laser land leveling might have promoted better crop stand. The unleveled plots exhibited patchy growth indicating water stress on crop due to non-uniform soil moisture distribution (Wakchaure *et al.* 2015). Under planting pattern, the dry matter accumulation (106.7 g /plant) and biological weight (175.9 g /plant) of sorghum were recorded highest under double row bed sowing, which was at par to triple row bed and significantly higher than ridge and furrow. While, plant height (128.9 cm) was recorded non-significantly higher in double row bed as compared to other planting systems. Bed row planting allowed effective drainage of water from the plant's root zone and reduced the probability of water-logging and soil compaction by improving the infiltration and rhizospheric aeration and nutrient availability to plants, which ultimately led to better plant growth and yield (Schmidt and Zemadim 2015).

Yield attributes and yield

The number of panicle, panicle length, panicle girth and test weight were significantly affected by varying land leveling and planting methods

Table 1: Influence of land leveling and planting pattern on growth and yield attributes of sorghum

Treatment	Plant height (cm)	Drymatter accumulation (g/plant)	Biological weight (g/plant)	Panicle/ plant	Panicle length (cm)	Panicle girth (cm)	Test weight (g)
Land Leveling							
L_1	116.4	92.0	150.2	2.4	18.0	18.8	23.28
L_2	127.3	102.2	167.7	2.7	20.6	20.9	25.64
L_3	133.6	107.8	179.7	3.0	22.4	22.9	26.73
S.Em(±)	4.49	3.91	4.04	0.10	0.79	0.7	0.63
C.D (*p*=0.05)	13.45	11.73	12.1	0.30	2.35	2.11	1.88
Planting pattern							
B_1	122.1	92.3	153.7	2.5	18.7	19.1	23.91
B_2	128.9	106.7	175.9	2.8	21.8	22.2	26.46
B_3	126.2	102.9	168.0	2.8	20.6	21.2	25.29
S.Em(±)	NS	3.91	4.04	0.10	0.79	0.7	0.63
CD (*p*=0.05)	NS	11.73	12.1	0.30	2.35	2.11	1.88
L x B interaction	NS	NS	NS	NS	NS	NS	NS
CV	10.7	11.67	7.3	11.31	11.57	10.12	7.45

(Table 1). The highest no. of panicle, panicle length, panicle girth, and test weight were recorded (3.0 no./ plant, 22.4 cm, 22.9 cm, and 26.7 g, respectively), with laser guided land leveler followed by the conventional land leveling. Rajkumar *et al.* (2019) stated that the laser leveled field improved yield attributed of wheat as compared to farmer practise. The maximum values of no. of panicle (2.8/ plant), panicle length (21.8 cm), panicle girth (22.2 cm), and test weight (26.5 g) were recorded under double row bed sowing, which was at par with triple row bed sowing (Table 1). These results were agreed with those of Sharma *et al.* (2018).

The grain yield of sorghum (3.66t ha^{-1}) was recorded significantly higher in laser guided land leveler as compared to conventional land leveling. Maximum fodder yield (16.37 t ha^{-1}) was associated with laser guided land leveler, which was significantly higher than the control whereas at par with conventional land leveling. In conventional land leveling, the fodder yield (16.15 t ha^{-1}) was recorded significantly higher than control (13.95 t ha^{-1}). Hoque and Hannan (2014) also reported similar results. In planting pattern, maximum grain yield was observed with double row bed sowing (3.58 t ha^{-1}) followed by triple row bed (3.44 t ha^{-1}). While in ridge and furrow, grain yield (3.03 t ha^{-1}) was recorded significantly lower over other planting systems (Table 2). Similarly, the fodder yield of sorghum was significantly influenced by the planting patterns and highest yield (16.31 t ha^{-1}) was observed under double row bed sowing (16.13 t ha^{-1}). While, minimum fodder yield (14.02 t ha^{-1}) was recorded with ridge and furrow. Similar results were obtained by El-Sadek and Salem (2015) who reported that the 120:60 ridge: furrow ratio plots had increased the grain yield as compared to that from the 60:60 ridge/furrow ratio.

Table 2: Influence of land leveling and planting pattern on yield and economic of sorghum

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Land Leveling						
L1	3.19	13.95	32300.0	80483.2	48183.2	1.49
L2	3.21	16.15	34300.0	85196.2	50896.2	1.48
L3	3.66	16.37	37250.0	93114.3	55864.3	1.50
S.Em(±)	0.11	0.42	-	-	-	-
C.D (0.05)	0.34	1.26	-	-	-	-
Planting pattern						
B1	3.03	14.02	33791.7	78061.1	44269.4	1.31
B2	3.58	16.31	34608.4	91638.7	57030.3	1.65
B3	3.44	16.13	35449.9	89093.9	53643.9	1.51
S.Em(±)	0.11	0.42	-	-	-	-
CD (0.5)	0.34	1.26	-	-	-	-
L x B interaction	NS	NS	-	-	-	-
CV	10.25	8.17	-	-	-	-

Economics

The data (Table 2) revealed that adoption of laser guide land leveler and triple bed row planting increased cost of cultivation over other land leveling and sowing methods, respectively. The laser guide land leveler recorded maximum gross and net return of Rs 93144.3 and 55864.3 ha^{-1} followed by conventional sowing method, It was 15.69 and 15.94% higher than control (Table 2). The highest B:C ratio (1.50) was obtained with laser guide land leveler followed by control. Whereas, lowest B:C ratio (1.48) was obtained under conventional land leveling. In sowing methods, maximum gross and net return of Rs 91638.7 and 57030.3 ha^{-1} was observed with double row bed sowing followed by triple row bed. The highest (1.65) and lowest B:C ratio (1.31) were obtained with laser guide land leveler and ridge and furrow, respectively. Chalodiya *et al.* (2017) recorded similar results.

Irrigation time, applied irrigation, water saving and WUE

The results showed that irrigation time required per field was minimum (59 minute) in laser guided land leveler with triple row bed planting as compared to the rest of the treatments. It is also noticed that the average depth of water applied was minimum (230.4 mm) under laser guided land leveler with triple row bed planting as compared to rest of the treatments. Similarly, lowest quantity of irrigation water (16592 lits) was measured under laser guided land leveler with triple row bed planting, it was 25.74 % lower than control with ridge and furrow sowing. The highest water saving was recorded under laser guided land leveler with triple row bed planting (41.04%) followed by laser guided land leveler with double row bed planting (Table 3). Laser land leveling with improved planting technique can reduce evaporation and percolation losses from sorghum by enabling faster irrigation times and by eliminating depressions and therefore ponding of water in depressions that results in irrigation water savings increased as compared to other treatments (Naresh *et al.* 2014a).

Table 3: Irrigation time, depth of water applied, quantity of applied water, water saving and WUE influenced by land leveling and planting pattern

Treatment	Irrigation time/ treatment (hr:mm)*	Depth of water applied (mm)	Quantity of applied water (lit)	Water saving (%)	WUE (kg/ha/mm)
L_1B_1	1:18	325.0	23401	-	8.9
L_1B_2	1:20	258.6	18618	25.7	13.1
L_1B_3	0:59	248.7	17905	30.7	13.2
$L_2 B_1$	1:14	311.1	22398	4.5	9.3
$L_2 B_2$	0:59	246.1	17718	32.1	13.9
$L_2 B_3$	0:58	239.6	17253	35.6	13.8
$L_3 B_1$	1:10	289.1	20813	12.4	11.5
$L_3 B_2$	0:56	233.9	16837	39.0	16.7
$L_3 B_3$	0:55	230.4	16592	41.0	16.3

** hr:mm = hours: minute*

The maximum WUE (16.7 kg/ha/mm) was recorded under laser guided land leveler with double row bed planting followed by laser guided land leveler with triple row bed planting. It was recorded 20.52 and 27.40% higher than conventional land leveling with double row bed and control with double row bed, respectively. Similarly, WUE of sorghum under laser guided land leveler with triple row bed planting was obtained 18.00 and 23.18% higher than conventional land leveling with triple row bed and control with triple row bed, respectively. Higher grain yield and less water use in raised bed planting and precision land leveling compared to other treatments resulted in higher WUE. Naresh *et al.* (2014b) reported that the higher WUE in laser leveled field than unleveled. t may be concluded that the yield of sorghum was recorded higher under laser leveled plot as compared to conventional and unleveld plot. Double row planting system improved sorghum yield. Soil moisture distribution, quantity and depth of applied water, water saving, irrigation time and WUE were recorded higher under leveled land by laser leveler. Treatment laser guide land leveler with double bed row planting is best treatment which gave higher yield, irrigation water saving and return per rupees investment. Profitability of different treatments revealed that adoption of laser leveling technique with double row bed planting system in sorghum crops in black soil of south Gujarat.

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