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Effect of Seed Bed and Integrated Nitrogen Management on Growth and Yield of Sorghum (*Sorghum bicolor* L.)

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A B S T R A C T

A field experiment was conducted during *zaid* season of 2016 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.). The soil of experimental field was sandy loam having pH of 7.4 with 0.39% organic Carbon, available N, P, K, as 185.5, 36 and 98 kg ha^{-1} respectively. The experiment was laid out in Randomized Block Design with twelve treatments each replicated thrice, comprising of two seed bed *viz.*, S_1 (flat bed at 45 cm × 15 cm) and S_2 (ridge and furrow at 45 cm × 15 cm) and three nitrogen levels [N_1- (50% nitrogen through FYM + 50% nitrogen through urea); N_2- (50% nitrogen through poultry manure + 50% nitrogen through urea) and N_3- (100% nitrogen through inorganic fertilizer)] and bio-fertilizer B_1 (with *Azospirillum*) B_2 (without *Azospirillum*). Results revealed that S_2 (Ridge and furrow) with nitrogen levels of N_3 (100% nitrogen through inorganic fertilizer) and B_1 (with *Azospirillum*) recorded maximum grain yield (2.53 t ha^{-1}), stover yield (5.74 t/ha), and test weight (14.38 g) and was economically superior than other treatments giving maximum Gross return, Net return and BC ratio as (₹ 79300), (₹ 49490) and (2.66) respectively.

Introduction

Sorghum (*Sorghum bicolor* L.) is major source of food for millions of people in the semi-arid tropics. It is fourth most important cereal crop in world after wheat, rice and maize. It is a major dry land food grain crop Deshmukh *et al.*, (2014), and has potential of adoption to adverse climatic conditions. However, it is inferior in quality due to low protein content and presence of hydrocyanic acid Singh *et al.*, (2010). The use of agrochemicals causes the degradation of cultivable land and increasing agricultural pollution hence, creating unhealthy situation. In order to balance this situation organic farming may be a solution in which instead of using of chemicals, natural resources such as organic matters, manures and microbes are used. Organic farming system relies on large-scale application of animal wastes, farm yard manure (FYM), poultry manure (PM), compost, crop residues and green manuring, etc. which are best substitute for harmful chemicals.

The application of phosphate solubilising cultures, nitrogen fixers (*Azospirillum)* and increases the process of decomposition, releasing nutrients at a faster rate which

increases the nutrient uptake by plants. Hence, research efforts are required to find out the influence of combined use of farmyard manure, poultry manure, inorganic fertilizers and bio-fertilizers in satisfying the overall nutrient requirement of sorghum crop.

Materials and Methods

The experiment was carried out during *Zaid* season 2016 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.), which is located at 25° 24' 42" N latitude, 81° 50' 56" E longitude and at an altitude of 98 m above the mean sea level. This area is situated on the right side of the river Yamuna. The soil of experimental field was sandy loam, pH of soil was 7.4 with 0.39% organic Carbon. The experiment involving hybrid sorghum was laid out in Randomized Block Design with twelve treatments each replicated thrice, comprising of two seed bed *viz*., S_1 (flat bed at 45 cm × 15 cm) and S_2 (ridge and furrow at 45 cm × 15 cm) and three nitrogen levels [N_1= (50% nitrogen through FYM + 50% nitrogen through urea); N_2 (50% nitrogen through poultry manure + 50% nitrogen through urea) and N_3 (100% nitrogen through inorganic fertilizer)] and bio-fertilizer B_1 (with *Azospirillum*) B_2 (without *Azospirillum*). The variety used in the experiment was CSH-15.

Results and Discussion

Growth characters

Growth parameters of Sorghum, *viz.* plant height, dry weight crop growth rate, were significantly influenced by different seed bed and Integrated Nitrogen Management practices. Ridge and Furrow with N_3 (100% nitrogen through inorganic fertilizer) and B_1 (with *Azospirillum)* recorded maximum improvement in growth parameters, which were significantly superior to flatbed planting. The plant height of sorghum showed significant difference and highest plant height (207.05cm) was recorded under treatment T_{11} [Ridge and furrow + N_3 (100% nitrogen through inorganic fertilizer + B_1 (with *Azospirillum*)] at 100 DAS followed by treatment T_7 (Ridge and furrow + 50% N FYM + 50% N through urea + with *Azospirillum*), which recorded plant height (206.55cm) and was found to be at par to treatment $T_{11.}$

The probable reason for maximum plant height in treatment T_{11} was due to the good rate of mineralization of nutrients. The other reason for higher plant height could be due to the fact that ridge and furrow sowing helps in maintaining the favorable moisture condition for relatively longer duration (Kantwa *et al.,* 2006), and may also be due to increased availability of moisture as well as other factor like, aeration (Kshirsagar *et al.,* 2014) (Table 1).

Similar findings have been reported by Rathore *et al.,* (2006) and Tetarwal and Rana (2007). The dry weight of sorghum was significantly influenced by Seed bed and Integrated Nitrogen Management and the highest values was recorded in treatment T_{11} which recorded (132.30 g) followed by T_7 (132.10 g) at 100 DAS respectively and was found to at par to treatment $T_{11.}$

The probable reason for maximum dry weight in treatment T_{11} was due to the good rate of mineralization of nutrients and also because of taller plants. The other reason may be due to greater transfer of photosynthates from vegetative source to reproductive sink in this treatment. The maximum dry weight value under the ridge and furrow seed bed may be due to the better ambient environment for growth and development (Sharma *et al.,* 2015).

Table.1 Effect of seed bed and integrated nitrogen management on plant height, dry weight, and crop growth rate of sorghum (*Sorghum bicolor* L.)

Treatments		Plant height (cm)	Dry weight (g)	CGR (g/m^2/day)
T_1	Flat bed + 50% N FYM + 50% N Through urea + With *Azospirillum*	186.93	115.80	4.85
T_2	Flat bed + 50% N FYM + 50% N Through urea + Without *Azospirillum*	176.50	110.76	3.77
T_3	Flat bed + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	177.00	113.00	4.40
T_4	Flat bed + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	184.87	108.86	3.42
T_5	Flat bed + 100% N through inorganic fertilizer + With *Azospirillum*	189.73	118.23	5.85
T_6	Flat bed + 100% N through inorganic fertilizer + Without *Azospirillum*	176.53	122.10	5.37
T_7	Ridge and Furrow + 50% N FYM + 50% N Through urea + With *Azospirillum*	206.55	132.10	6.01
T_8	Ridge and Furrow + 50% N FYM + 50% N Through urea + Without *Azospirillum*	195.50	118.30	4.05
T_9	Ridge and Furrow + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	200.51	127.80	5.60
T_{10}	Ridge and furrow + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	185.87	119.20	5.35
T_{11}	Ridge and Furrow + 100% N through inorganic fertilizer + With *Azospirillum*	207.05	132.30	6.15
T_{12}	Ridge and Furrow + 100% N through inorganic fertilizer + Without *Azospirillum*	197.67	125.10	5.52
	F – test	S	S	S
	S. Ed. (±)	1.44	0.85	0.13
	C. D. at 5%	2.98	1.75	0.27

Table.2 Effect of seed bed and integrated nitrogen management on length of ear and test weight of sorghum (*Sorghum bicolor* L.)

Treatments		Length of ear (cm)	Test weight (g)
T_1	Flat bed + 50% N FYM + 50% N Through urea + With *Azospirillum*	21.93	10.76
T_2	Flat bed + 50% N FYM + 50% N Through urea + Without *Azospirillum*	20.20	9.02
T_3	Flat bed + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	22.06	10.87
T_4	Flat bed + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	19.80	8.87
T_5	Flat bed + 100% N through inorganic fertilizer + With *Azospirillum*	22.70	10.98
T_6	Flat bed + 100% N through inorganic fertilizer + Without *Azospirillum*	22.33	9.36
T_7	Ridge and Furrow + 50% N FYM + 50% N Through urea + With *Azospirillum*	25.70	12.92
T_8	Ridge and Furrow + 50% N FYM + 50% N Through urea + Without *Azospirillum*	21.70	10.11
T_9	Ridge and Furrow + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	23.86	11.62
T_{10}	Ridge and furrow + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	20.73	9.70
T_{11}	Ridge and Furrow + 100% N through inorganic fertilizer + With *Azospirillum*	27.40	14.38
T_{12}	Ridge and Furrow + 100% N through inorganic fertilizer + Without *Azospirillum*	21.83	10.31
	F – test	S	S
	S. Ed. (±)	0.17	0.16
	C. D. at 5%	0.36	0.34

Table.3 Effect of seed bed and integrated nitrogen management on grain yield, stover yield, harvest index and protein content of sorghum (*Sorghum bicolor* L.)

Treatments		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)	Protein content (%)
T_1	Flat bed + 50% N FYM + 50% N Through urea + With *Azospirillum*	2.16	5.02	30.08	10.17
T_2	Flat bed + 50% N FYM + 50% N Through urea + Without *Azospirillum*	2.09	4.93	29.77	8.60
T_3	Flat bed + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	2.22	5.10	30.32	10.01
T_4	Flat bed + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	2.17	5.09	29.88	8.70
T_5	Flat bed + 100% N through inorganic fertilizer + With *Azospirillum*	2.27	5.40	29.59	10.37
T_6	Flat bed + 100% N through inorganic fertilizer + Without *Azospirillum*	2.24	5.15	30.31	8.81
T_7	Ridge and Furrow + 50% N FYM + 50% N Through urea + With *Azospirillum*	2.50	5.73	30.37	11.30
T_8	Ridge and Furrow + 50% N FYM + 50% N Through urea + Without *Azospirillum*	2.34	5.40	30.23	9.47
T_9	Ridge and Furrow + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	2.42	5.69	29.83	10.69
T_{10}	Ridge and furrow + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	2.29	5.30	30.17	9.37
T_{11}	Ridge and Furrow + 100% N through inorganic fertilizer + With *Azospirillum*	2.53	5.74	30.59	12.02
T_{12}	Ridge and Furrow + 100% N through inorganic fertilizer + Without *Azospirillum*	2.31	5.45	29.76	9.88
	F – test	S	S	S	S
	S. Ed. (±)	0.04	0.08	0.09	0.17
	C. D. at 5%	0.09	0.17	0.18	0.35

Table.4 Effect of seed bed and integrated nitrogen management on cost of cultivation, gross return, net return and B: C ratio of sorghum (*Sorghum bicolor* L.)

Treatments		Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B: C ratio (%)
T_1	Flat bed + 50% N FYM + 50% N Through urea + With *Azospirillum*	35735	68300	32565	1.91
T_2	Flat bed + 50% N FYM + 50% N Through urea + Without *Azospirillum*	35535	66450	30915	1.86
T_3	Flat bed + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	34855	69900	35045	2.00
T_4	Flat bed + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	34655	68850	34195	1.98
T_5	Flat bed + 100% N through inorganic fertilizer + With *Azospirillum*	29810	72400	42590	2.42
T_6	Flat bed + 100% N through inorganic fertilizer + Without *Azospirillum*	29610	71550	41940	2.41
T_7	Ridge and Furrow + 50% N FYM + 50% N Through urea + With *Azospirillum*	35735	78650	42915	2.20
T_8	Ridge and Furrow + 50% N FYM + 50% N Through urea + Without *Azospirillum*	35535	73800	38265	2.07
T_9	Ridge and Furrow + 50% N Poultry manure + 50% N Through urea + With *Azospirillum*	34855	76850	41995	2.20
T_{10}	Ridge and furrow + 50% N Poultry manure + 50% N Through urea + Without *Azospirillum*	34655	72300	37645	2.08
T_{11}	Ridge and Furrow + 100% N through inorganic fertilizer + With *Azospirillum*	29810	79300	49490	2.66
T_{12}	Ridge and Furrow + 100% N through inorganic fertilizer + Without *Azospirillum*	29610	73450	43840	2.48

Market price of sorghum grain yield 20000 ₹/t; Market price of sorghum stover yield 5000 ₹/t

As a result, the crop may have used water more efficiently with enhanced photosynthetic potential (Zhang *et al.,* 2007). These findings are in accordance to that reported by Rathore and Gautam, (2003), Rathore *et al.,* (2006) and Tetarwal and Rana (2007).

The crop growth rate was also differed significantly by seed bed and Integrated Nitrogen Management. The maximum CGR (6.15 g/m^2/ day) value was recorded in treatment T_{11} at 80-100 days interval followed by treatment T_7 which recorded CGR as (6.01 g/m^2/ day) and was found to be at par to treatment $T_{11.}$

The probable reason for maximum crop growth rate in treatment T_{11} was due to the good rate of mineralization of nutrients. The improvement in crop growth rate in the plots under ridge and furrow planting system may be due to the favorable air, temperature within crop canopy as well as reduced water stress (Chakravarti *et al.,* 2010). Similar findings have been reported by Rathore *et al.,* (2006).

Yield and yield attributes of sorghum

A perusal of the table 2 clearly shows that there was significant influence of seed bed and integrated nitrogen management on ear length of sorghum among different treatments. Maximum ear length (27.40 cm) was recorded in treatment T_{11} followed by treatment T_7 which recorded ear length of 25.70cm. The table 2 also reveals that test weight also differed significantly among treatments and maximum value (14.38g) was recorded in treatment T_{11} followed by treatment T_7 which recorded test weight of 12.92g.

The probable reason for recording higher ear length and test weight in treatment T_{11} may be due to the result of improvement in soil properties in terms of fertility, microbial abundance and other physical properties of soil which reflected on higher ear length and test weight. These finding are in collaboration with those reported by Naphade *et al.,* (1990) and Raghuwanshi *et al.,* (1998).

An appraisal of table 3 clearly shows that grain yield and stover yield was significantly influenced by seed bed and integrated nitrogen management among various treatments. The maximum grain yield (2.53t/ha) was recorded in treatment T_{11} followed by treatment T_7 which recorded grain yield to a tune of (2.50 t/ha) and was found to be at par to treatment T_{11}. Similarly, stover yield recorded maximum value in treatment T_{11} (5.74t/ha) followed by treatment T_7 which recorded stover yield (5.73 t/ha) and was found to be at par to treatment T_{11}. Harvest index also differed significantly among treatments due to the influence of seed bed and integrated nitrogen management. The maximum harvest index value (30.59%) was recorded in treatment T_{11} followed by treatment T_7 which recorded harvest index as (30.37%). Similarly, protein content was significantly influenced by seed bed and integrated nitrogen management. The maximum value (12.02%) of protein content was recorded in treatment T_{11} followed by treatment T_7 which recorded protein % as 11.30%.

The probable reason for recording maximum grain yield, stover yield, harvest index and protein content might be due to better translocation of photosynthates from source to sink. The other reason may be due to better availability of nutrients which helped in continuous supply of nitrogen to the plants to maintain greenness of leaves for longer period which helped in greater dry matter accumulation which might have contributed to the development of sink and thereby increased the grain, stover yield, harvest

index and protein %. Painyuli *et al.,* (2013), stated that the ridge and furrow planting method, gave higher growth, attributes mainly because of advantages of better aeration, least compaction, better seedling establishment, more nutrient uptake due to better root growth and also avoidance of water logging over flat planting. These results are in conformity with those reported by Dixit *et al.,* (2005) and Khidrapure *et al.,* (2015).

Economics

An appraisal of the table 4 clearly shows that maximum Gross return (₹ 79300), net return (₹ 49490) and BC ratio (2.66) was recorded in treatment T_{11} followed by treatment T_{12} which recorded net return of (₹. 43840) and BC ratio 2.48. This may be due to higher grain yield and stover yield recorded in treatment T_{11} [Ridge and furrow + N_3 (100% nitrogen through inorganic fertilizer + B_1 (with *Azospirillum*)].

From the above findings, it can be concluded that for obtaining the maximum growth, yields and benefits from cultivation of sorghum, it should be sown by ridge and furrow method and 100% nitrogen should be provided through urea alone and seeds should be inoculated with *Azospirillum* culture before sowing. Although these findings are from one year experimentation, therefore it should be repeated to confirm the findings.

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