Assessing Impact of Broad Bed and Furrow Sowing in Cotton: Soybean (2:2) Intercropping in Vertisols under Semi-Arid Condition

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ABSTRACT: Water stress periods are common in rainfed agriculture. Activities aimed at conserving the rainwater should be adopted for improving the productivity of dryland. The major crops in Vidarbha are cotton and soybean. Rainfed farming plays an important role in agricultural economy of Vidarbha. It was observed that the drought situation may arise during crop growth period which may result in partial failure of crop. It was therefore felt worthwhile to adopt proper methods of *in-situ* moisture conservation so as to partially reduce the adverse effect of water stress in standing crop. The BBF technology adopted at AICRPDA, DR. PDKV, Akola involves the sowing of soybean crop on broad bed furrow with the use of tractor operated 4 row BBF planter. Soybean crop can be spaced at 30 or 45 cm with four rows and two adjacent furrows each having 30 cm width and 15 to 20 cm deep. In case of cotton the spacing between cotton rows can be kept as 90 cm while middle two rows can be sowed with soybean with 30 cm row spacing. In case of cotton: soybean (2:2), the highest mean yield of soybean (974 kg ha^{-1}) and cotton (750 kg ha^{-1}) were observed in treatment of BBF along with 50% N+100% P + 100% K through inorganic + 50% N through gliricidia (T_1N_3). The treatment BBF along with 50%N+100% P +100% K through inorganic +50% N through gliricidia have recorded 19.1% and 17.0% more grain yield over normal sowing for soybean and cotton crops respectively. The mean cotton equivalent yield was observed higher by 18.6% in BBF sowing as compared to flatbed sowing. The highest mean gross monetary (GMR) and net monetary returns (NMR) of Rs. 76624 and Rs. 32252 ha^{-1} were observed in BBF sowing as against of Rs.64014 and Rs. 19909 ha^{-1} in case of flatbed sowing.

Key words: *In- situ* conservation practices, productivity, soil moisture and crop growth.

Introduction

Present climate change scenario is inviting an attention towards best management practices that reduces soil erosion, sustains soil fertility and improves water management. This can be achieved by adopting *in-situ* soil and moisture conservation practices along with integrated nutrient supply for improvement of soil fertility as well as crop productivity on sustainable basis (George, 2010). Rainfed farming plays an important role in agricultural economy of Vidarbha region and covers about 89% cultivated land. The major crops are cotton and soybean. It was observed that the drought situation may arise during crop growth period which may result in partial failure of crop. To cope up with such crunch, it is necessary to find out the possibilities to survive the crop under contingent conditions by using some of the simple methods of *in-situ* moisture conservation (Padmanabhan, 2008). It was therefore, felt worthwhile to adopt proper methods of *in-situ* moisture conservation so as to partially meet out the adverse effect of water stress on standing crops. The moisture conservation practices like ridge and furrow helps in enhancing the plant height and yield attributes of sorghum, cowpea, bengal gram and sunflower (Somasundaram *et al*., 2000). *In-situ* moisture conservation practice *viz;* ridge and furrow + mulch have shown beneficial effect for getting good growth and higher yields in pulses; which subsequently led to higher net returns and B:C ratio (Allolli *et al*., 2008).

The broad bed and furrow system has been mainly developed at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) in India (Krantz 1981, Pathak *et al*., 1985). The recommended ICRISAT system consists of broad beds about 100 cm wide separated by sunken furrows of about 50 cm wide. The preferred slope along the furrow is between 0.4 and 0.8 percent in Vertisols. Two, three, or four rows of crop can be grown on the broad bed, and the bed width and crop geometry can be varied to suit the cultivation and planting equipment. In India, the system has been used mainly on deep Vertisols (heavy black clay soils sometimes called cotton soils). It has also increased double cropping by means of inter-cropping or sequential cropping with the use of BBF (Kampen, 1979; Kampen *et al*., 1981). The BBF technique works best on deep black soils in areas with dependable rainfall of 750 mm or more. The interventions like planting on changed land configuration (broad bed furrow or ridges and furrow) and incorporation of crop residues/organic sources and combination have been found effective in mitigating the adverse effect of water stress and improvement in soil physical and biological environment (Anonymous 2007, 2008 and 2009). Broad bed furrow planting improves *in-situ* moisture conservation and drainage in Vertisols and associated soils to facilitate effective management of rainwater (Joshi and Bhatia 2003). With this background, the experiment was undertaken to use BBF technique for cotton+

soybean intercropping system for assessing soil moisture, soil fertility improvement and to demonstrate this technique to the farmers.

Materials and Methods

The experiment was conducted at AICRPDA, Dr. PDKV, Akola research farm. It was undertaken during 2016-17. But the earlier treatments were reframed during 2017-18. However, during 2017-18, due to inadequate moisture the crops suffered (rainfall, 517.1 mm). Thus, only three years data (2018-19 to 2020-21) was considered for analysis and conclusion of the experiment. The soil in the experiment is of clayey texture, pH is 7.6 and EC is 0.16 dsm^{-1}. The organic C content is 0.51%. The available N, P and K content was 164.1, 15.6 and 286.4 kg ha^{-1}. The rainfall received during crop growing period was 830.1 mm in 41 rainy days for the year 2018, 817.9 mm in 47 rainy days for the year 2019 and 733.6 mm in 49 rainy days for the year 2020. In this experiment, the sowing was done in the month of June of every year with BBF planter having 4 crop rows on bed. The broad bed was of 90 cm with 2 furrows of 30 cm width and 15 cm deep. First and fourth row was of cotton, the second and third row (middle rows) was of soybean. The row spacing of cotton was 90 cm and in case of the soybean it was 30 cm. The BBF arrangement of crops with bed and furrow is shown in Figure 1. The cotton (Balwan Bt) and soybean (JS-335) crops were sowed with BBF planter. The experiment was laid with two main and 3 sub treatments. The trial was non replicated. The details of main and sub treatments are given below. The intercultural operations were carried out as per recommended package of practices for cotton and soybean crops. The soil samples were collected for estimation of soil moisture in BBF as well as normal sowing treatments. The ancillary observations of both the crops were recorded and final estimation of yield was done. The experiment was entirely undertaken in rainfed situation thus irrigation was not applied to any treatments.

Main treatments

T_1: BBF sowing

T_2: Normal sowing

Sub treatments

N_1: RDF of cotton (60:30:30)

N_2: 50% N+100% P + 100% K through inorganic + 50% N through FYM

N_3:50% N+100% P + 100% K through inorganic + 50% N through gliricidia

Fertilizer was applied to the cotton (main) crop. Separate fertilization of intercrop (soybean) was not applied.

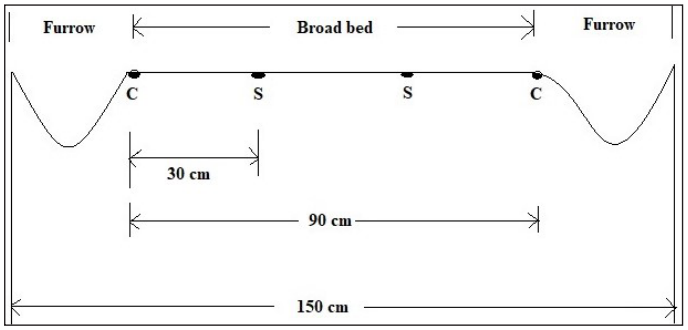

Fig. 1: BBF arrangement of crops with bed and furrow

Results and Discussion

The experiment was conducted during 2018-19 to 2020-21. Thus, three years data was considered for analysis and conclusion was drawn and results are presented here.

Crop productivity

The mean data (2018-19 to 2020-21) in terms of yield of cotton, soybean and cotton equivalent yield under different treatments (*kharif*) is given in Table 1. Similarly, the mean data (2018-19 to 2020-21) in terms of economics of cotton and soybean under different treatments is given in Table 2. From the mean data, it was observed that the treatments under BBF have performed better as compared to non BBF treatments in respect of yield of cotton and soybean. The highest mean yield of soybean (974 kg ha^{-1}) was observed in treatment BBF along with 50% N+100% P+100% K through inorganic + 50% N through gliricidia (T_1N_3) and for cotton, the highest mean yield of 750 kg ha^{-1} was observed in the treatment BBF along with 50% N+100% P + 100% K through inorganic + 50% N through gliricidia (T_1N_3). The treatment T_1N_3 (BBF along with 50% N+100% P + 100% K through inorganic + 50% N through gliricidia) have recorded 19.1% more grain yield over T_2N_3 (Normal sowing along with 50% N+100% P + 100% K through inorganic + 50% N through gliricidia) for soybean crop. The treatment T_1N_3 have recorded 17.0% more yield over T_2N_3 for cotton crop. The mean cotton equivalent yield observed was highest (1391 kg ha^{-1}) in treatment T_1N_3 in BBF sowing as compared to all other treatments. In treatment T_1N_3, 18.6% increase in cotton equivalent yield was observed over T_2N_3. The highest mean gross monetary (GMR) and net monetary returns (NMR) of Rs.76624 and Rs.32252 ha^{-1} were observed in BBF sowing as against of Rs.64014 and Rs.19909 ha^{-1} in case of flatbed sowing (Table 2). Similar results of the higher net return with B:C ratio for soybean cultivation under BBF drill as compared to cultivation under conventional seed drill were noticed (Gupta *et al*., 2017). Results from Pragathi Kumari *et al*. (2019) indicated significant effect of moisture conservation treatments on seed cotton yield. The performance of safflower was studied under BBF treatments (Sudhakar *et al*., 2017) in which productivity of safflower under

BBF method was more over conventional cultivation. They also observed that the cultivation of safflower under BBF method of planting gave higher net returns as compared to farmers practice with 21.6% higher than latter. These all results are in line with the results obtained through in this research which clearly indicates the benefits of BBF technology for yield enhancement in dryland agriculture for various crops.

Table 1: Effect of different treatments on yield of cotton and soybean

Treatments	Yield of cotton, kg ha^{-1}				Yield of soybean, kg ha^{-1}				Cotton Equivalent yield, kg ha^{-1}			
	2018-19	2019-20	2020-21	Mean	2018-19	2019-20	2020-21	Mean	2018-19	2019-20	2020-21	Mean
						BBF						
T1N1	515	703	596	605	846	775	691	771	1001	1225	1124	1117
T1N2	590	894	626	703	954	834	721	836	1138	1456	1177	1257
T1N3	558	1025	668	750	1168	954	799	974	1229	1668	1277	1391
						NBBF						
T2N1	494	548	520	521	716	656	638	670	905	990	1007	968
T2N2	547	691	546	595	859	715	673	749	1040	1173	1060	1091
T2N3	533	751	594	626	931	799	727	819	1067	1289	1149	1168
						% increase over NBBF						
T1N1	4.1	28.3	8.4	13.6	18.2	18.2	14.6	17.0	10.5	23.8	11.6	15.3
T1N2	7.8	29.3	7.1	14.7	11.0	16.7	14.6	14.1	9.3	24.1	10.9	14.8
T1N3	4.7	36.5	9.8	17.0	25.5	19.4	12.4	19.1	15.1	29.4	11.1	18.6

Table 2: Effect of different treatments on economics of cotton: soybean (2:2)

Treatments	Gross Monetary Return (GMR), Rs. ha^{-1}				Net Monetary Return (NMR), Rs. ha^{-1}			
	2018-19	2019-20	2020-21	Mean	2018-19	2019-20	2020-21	Mean
					BBF			
T_1N_1	55932	64155	63902	61330	14418	20458	21461	18779
T_1N_2	63825	76778	67391	69332	14619	25812	21512	20648
T_1N_3	68831	87028	74012	76624	25519	38826	32412	32252
					NBBF			
T_2N_1	50715	51699	58153	53522	9480	10829	18643	12984
T_2N_2	58275	61877	61318	60490	9439	13180	16523	13047
T_2N_3	59674	67520	64849	64014	16831	21968	20927	19909

Soil moisture

The soil moisture was recorded growth stage wise in different treatments under BBF and Non BBF at different depths and was given in Table 3 for the years 2018-19 to 2020-21. The highest soil moisture in different treatments (2018-19) was observed during vegetative stages of crop growth. It was also observed that the soil moisture status under BBF was higher as compared to non BBF treatments during every recorded month. Similar results from Sudhakar *et al*. (2017) was reported in which the average soil moisture for BBF method was found to be more than traditional method. During 2019-20, the higher soil moisture in different treatments was observed during flowering stages of crop growth. In the year 2020-21, the higher soil moisture in different treatments was observed during flowering stages of crop growth. From the soil moisture data, it can be concluded that the Broad Bed and Furrow (BBF) technology is most suitable technology for moisture conservation as compared to flat bed system and also during high intensity rainfall events, the excess water can be drained easily. Similar observations were recorded in line with this research by Prasad and Sudhakara Babu (1997). Among various modern and cost-effective technologies for efficient utilization of natural resources, effective rain water management with *in-situ* moisture conservation comprising of opening of furrow, intercropping, mulching etc. prove to be vital for attaining sustainable yields (Gokhale *et al*., 2012).

Conclusion

The treatments imposed under BBF sowing for cotton + soybean intercropping have shown better soil moisture status as compared to Non-BBF sowing treatments. The treatment BBF along with 50% N+100% P + 100% K through inorganic + 50% N through gliricidia (T_1N_3) was found better in respect of yield of soybean and cotton, higher GMR and NMR and conserved more moisture in cotton + soybean (2:2) intercropping system. The mean cotton equivalent yield was observed highest in BBF treatment as compared to other treatments and 18.6% increase

in cotton equivalent yield was observed over normal sowing system. Thus, it is recommended to use the BBF technology for sowing of cotton and soybean cropping system compared to flatbed system of sowing.

Table 3: Soil moisture at 0-15 and 15-30 cm depth at different crop growth stages from 2018-19 to 2020-21

Treatments	Depth (cm)	Soil moisture content (%)											
		2018-19				2019-20				2020-21			
		30/07	29/08	29/09	15/10	24/07	13/08	13/09	11/10	28/07	27/08	29/09	29/10
T_1N_1	0-15	30.82	29.98	24.10	20.16	23.18	26.20	30.42	29.37	31.34	30.41	28.38	24.72
	15-30	30.90	30.40	25.16	20.05	24.37	28.03	31.45	30.90	31.66	30.48	28.84	25.87
T_1N_2	0-15	30.78	30.23	25.04	21.25	23.78	26.55	30.49	29.70	31.58	30.63	28.64	25.92
	15-30	30.95	30.65	25.34	21.72	24.67	28.32	31.76	31.05	32.10	31.04	29.21	26.28
T_1N_3	0-15	31.03	30.79	24.86	21.65	24.28	26.74	31.04	29.26	31.61	31.01	29.54	26.49
	15-30	31.35	31.07	25.60	22.06	24.87	28.67	31.84	31.70	32.48	32.22	30.02	27.04
T_2N_1	0-15	29.22	28.12	23.04	18.01	22.38	25.48	29.61	28.87	31.10	29.64	27.62	24.22
	15-30	30.02	29.22	23.92	19.45	23.57	27.93	30.79	30.53	31.46	29.69	28.79	25.30
T_2N_2	0-15	30.11	29.18	23.80	20.00	22.98	25.68	29.84	28.90	31.28	29.70	27.66	24.66
	15-30	30.28	29.78	24.03	20.28	23.77	28.03	30.87	30.75	31.80	29.81	28.86	25.73
T_2N_3	0-15	30.07	29.00	23.85	20.03	23.18	25.85	30.14	28.96	31.20	30.11	29.00	25.34
	15-30	30.51	29.92	24.26	20.16	24.07	28.33	30.94	30.89	31.78	30.41	29.20	26.22

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