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ORIGINAL ARTICLE **OPEN ACCESS**

Improved Dryland Technologies for Sustainable Crop Productivity in Dry land conditions at Warkhed Village of Akola District of Maharashtra

A.B.Turkhede[1], M.B.Nagdeve[1], R.S.Mali[1], V.V.Gabhane[1], and R.S.Patode[1]
1-AICRP for Dryland Agriculture, Dr.PDKV, Akola (M.S)
Email- anilturkhede@gmail.com

ABSTRACT
Under dryland condition kharif crops depends upon the rainfall its onset, intensity and distribution which is highly unpredictable in this region and hence the productivity of the dryland crops is very low. In order to evaluate and disseminate the improved rainfed agro-technologies, on farmers field under different themes viz. varietal performance, rainwater management and foliar sprays were conducted at village Warkhed, Taluka Barshitakli, district Akola of Maharashtra State during 2012-13 to 2017-18 under AICRP for Dryland Agriculture, NICRA project.This study clearly indicated that advantage of adopting all improved rainfed agro-technologies for different crops in comparison with traditional farmer practices. Improved agro technologies resulted in overall increase in crop production from 5.00 to 20.67 %over the farmer practice. The percent increase in yield was highest with adopting of high yielding varieties recommended for rainfed area (4.07 to9.51 %), adoption of various in-situ moisture conservation measures in soybean (20.67 %) and in cotton (9.38 %) and foliar spray of nutrients in cotton crop (5.57 %). Hence, on farm interventions carried out through NICRA-project showed the worth of improved rainfed varieties and management practices for improved agro-technologies. NICRA project with its strong link between the technology developed by the scientist and the user of the technology is putting larger impact for the adoption of improved dryland agro technologies. This project also providing the feedback for refinement and upscaling improved dryland agro-technologies.
Keywords: kharif crops, dryland, rainfed area

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INTRODUCTION

The productivity of dryland crops is very low because of low and erratic rainfall characterized with low adoption of improved rainfed agro technologies. Conservation of water resources through adoption of various on farm water saving technologies can improve water use efficiency thus leading to higher productivity. Efforts are being made to increase the productivity in this region through efficient management of all available water resources including harvesting of rain water and its judicious utilization along with evaluation of varieties, foliar spray of nutrients, integrated nutrient management, tillage practices and contingency crop planning. In order to maximize crop productivity in this region, All India Co-ordinated Research Project launched NICRA project during 2012-18 to evaluate and disseminate the improved rainfed agro technology generated through Dryland Agricultural Research Centre to farmer's field. AICRP for Dryland Agriculture and National Innovations on Climate Resilient Agriculture (NICRA) project aims at interface research between the technologies developed by the university centre and requirement of farmers.

MATERIAL AND METHODS

On farm demonstrations were conducted for five years during 2012-13 to 2017-18 in village Warkhed situated in Barshitakli taluka of Akola district of Maharashtra. Under AICRP for Dryland Agriculture and "National Innovations on Climate Resilient Agriculture (NICRA) project"was implemented with various themes viz; varietal performance in soybean, opening of furrows, supplemental irrigation and foliar spray were studied through the demonstrations conducted in village on farmer's field.

The village Warkhed (Bk) in Barshitakli tahsil of Akola district of Maharashtra state is situated between77^{0}7' 00'' to 77^{0} 10' 00'' E longitude and 20^{0} 32' 30'' to 20^{0} 35' 00'' N latitude and covers and area of 198 ha. The mean elevation of the area is about 325 m above MSL. It is about 32 km south-east of Akola city.

The soils of the region are shallow(Entisols) to deep black (Vertisols), neutral to alkaline in reaction (7.2 to 8.4), electric conductivity of soil varied from 0.27 to 0.29 dsm^{-1}, low in available nitrogen and phosphorus and high to very high in available potassium.

The annual rainfall received during 2012-13 to 2017-18 varied from 492.6 to 1288 mm with average value of 778.3mm which was 16 % deficit over the mean normal rainfall. The rainfall received during *kharif* season (June-September) varied from 429.9 to 860.7 mm with mean value of 648.13 mm and during *rabi* season (October to March) varied from 62.7 to 427.3 mm with mean value of 130.16 mm. Out of total rainfall recorded at NICRA village 83.27 % received during the *kharif* season (June-September) whereas rest16.72 % received during the *rabi* season (October to March).

Table 1. Area, number of farmers and rainfall under different intercropping systems

Village	Cropping system and *Varieties	Year	Area (ha)	Number of farmers	Rainfall		
					N	A	Cropping season
Village WarkhedTaluka-Barshitakli, District- Akola	Soybean+Pigeonpea (4:2)	2015-16	6.40	16	807.0	796.5	613.0
	Soybean+Pigeonpea (6:1)	2016-17	6.40	16	807.0	852.8	741.8
	Sole Soybean	2017-18	7.20	18	807.0	518.3	456.1
			20.00	**50**			
Village Warkhed, Taluka-Barshitakli, District- Akola	Cotton+Greengram (1:1), Sole Cotton	2014-15	2.80	07	807.0	661.3	388.7
		2015-16	2.80	07	807.0	796.5	613.0
		2016-17	2.80	07	807.0	852.8	741.8
		2017-18	4.80	12	807.0	518.3	456.1
			13.20	**33**			
*Varieties - Soybean- JS 335, Pigeonpea- PKV Tara, *Bt.* Cotton–Mallika, Greengram - Utkarsha							

Table 1. Rainfall pattern during year 2012-13 to 2017-18

Year	Total Rainfall	Kharif (June – September)	Rabi (October-March)
2012-13	721.0	641.7	79.3
2013-14	1288.0	860.7	427.3
2014-15	691.3	570.1	121.2
2015-16	644.6	644.6	-
2016-17	832.3	741.8	90.5
2017-18	492.6	429.9	62.7
Average	**778.30**	**648.13**	**130.16**
% rainfall over total		**83.27**	**16.72**

RESULT AND DISCUSSION

Varietal demonstration

The farmers of the adopted village were not fully aware of improved rainfed cultivars. Most of the farmers were using the old varieties having low yield potential. Some farmers are also using the varieties sensitive to drought, diseases and insect pests. Hence, there is need to demonstrate the cultivation of improved drought tolerant with disease and insect resistance cultivars and their crop production technologies for enhancing production and economic viability in comparison to traditional varieties. Keeping these issues into considerations the demonstration of improved varieties recommended for the domain region of different crops were conducted in the area under study with following recommended package of practices.

In *kharif* season demonstrations of different varieties of soybean viz; JS-9305, JS-9560 and JS-335 were conducted on farmer's field. Among the different soybean varieties JS-9560 and JS-335 gave the highest average yield of soybean i.e 1251 and 1200 Kg ha^{-1} with net monetary returns Rs.18887 and 16379 ha^{-1} and B:C ratio of 1.85 and 1.74 as compared to soybean genotype JS-9305 having an yield of 1132 Kg ha^{-1} , net monetary returns 15334 $Rs.ha^{-1}$ and B:C ratio of 1.69. Sharma *et al* [9] reported that the productivity of oilseed crops per unit could be increase by adopting recommended management practices with suitable high yielding variety under rainfed conditions.

Table 2. Productivity and economics of soybean varieties under rainfed condition.

Particular/Year	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Mean
Yield							
JS-9305	1423	1041	983	987	1219	1140	**1132**
JS-9560	1725	1233	1029	1039	1288	1193	**1251**
JS-335	2184	907	939	922	1161	1087	**1200**
Net Monetary Returns							
JS-9305	28469	12656	16588	14740	8265	11286	**15334**
JS-9560	37746	19119	16685	16762	10170	12844	**18887**
JS-335	51153	5418	14821	12229	6645	8012	**16379**
B:C Ratio							
JS-9305	2.40	1.30	1.84	1.57	1.30	1.48	**1.69**
JS-9560	2.80	1.93	1.84	1.65	1.37	1.54	**1.85**
JS-335	3.20	1.40	1.75	1.48	1.24	1.34	**1.74**
Rain Water Use Efficiency							
JS-9305	1.90	0.95	3.95	1.60	1.73	2.60	**2.12**
JS-9560	2.30	1.98	4.14	1.68	1.83	2.62	**2.43**
JS-335	3.00	0.86	3.86	1.50	1.65	2.38	**2.20**

Rainwater Management

A large amount of rain water is lost as runoff and goes unutilized during rainy season. The rainwater can be conserved through in-situ moisture conservation techniques or through rainwater harvesting structure or techniques such as farm ponds, nala deepening and widening or cement nala bunds (CNB). The harvested water can be utilized judiciously as a life saving irrigation to agricultural crops at critical growth stages to cope with the prolonged dry spells.

Opening of furrows in soybean

Opening of furrows in soybean gave higher yield, net returns and B:C ratio over the farmers practice (without opening of furrows). The grain yield with opening of furrows of soybean varied from 983 to 1423 kg ha^{-1}(Table 2) with average value of 1364 Kg ha^{-1} which was 20.67 percent higher over the average value of grain yield under farmers practice (without opening of furrows).

Table 3. Productivity and economics of soybean under in-situ moisture conservation.

Particular/Year	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Mean
Yield							
With furrow opening	2566	1033	1022	1055	1302	1206	**1364**
Without furrow opening	1579	907	847	831	1202	1123	**1082**
Net Monetary Returns							
With furrow opening	61627	18106	16441	17168	10561	13224	**22854**
Without furrow opening	34058	8448	10641	10246	7788	9042	**13370**
B:C Ratio							
With furrow opening	3.46	1.85	1.81	1.71	1.38	1.55	**1.96**
Without furrow opening	2.71	1.40	1.52	1.14	1.28	1.38	**1.57**
Rain Water Use Efficiency							
With furrow opening	3.49	0.93	3.93	1.79	1.81	2.64	**2.43**
Without furrow opening	2.15	0.83	3.25	1.16	1.67	2.46	**1.92**

In respect of cotton crop, opening of furrows in each row at 30-35 days after sowing recorded higher seed cotton yield, net monetary returns and B:C ratio over farmers practice of without furrow opening. Seed cotton yield with opening of furrows varied from 1056 to 1899 kg ha^{-1} (Table 4) with average value of 1439 kg ha^{-1} which was 9.38 percent higher over as compared to farmers practice (without furrow opening).

The higher grain yield in soybean and cotton with opening of furrows in each row of soybean and cotton was due to increase in aeration and maintenance of soil moisture, which consequently resulted in better crop growth and development. Tumbare and Bhoite [11] and Makkhan Lal *et al.* [5] reported enhanced yield in crops grown under moisture conservation technique. Patil *et al*. [6] reported that moisture conservation technique like opening of furrows, ridges and furrows with tied ridging recorded significant higher yield of crops.

Table 4. Productivity and economics of cotton under in-situ moisture conservation.

Particular/Year	2011-12	2012-13	2015-16	2016-17	2017-18	Mean
Yield						
With furrow opening	1288	1397	1555	1899	1056	**1439**
Without furrow opening	1188	1175	1425	1755	981	**1304**
Net Monetary Returns						
With furrow opening	19400	38738	37845	34646	7652	**27656**
Without furrow opening	18200	41288	32238	29165	4068	**24992**
B:C Ratio						
With furrow opening	1.86	3.02	2.02	1.74	1.18	**1.96**
Without furrow opening	1.84	2.91	1.88	1.63	1.10	**1.87**
Rain Water Use Efficiency						
With furrow opening	1.95	1.82	2.41	2.70	1.90	**2.15**
Without furrow opening	1.86	1.56	2.21	2.50	1.23	**1.87**

Supplemental irrigation in soybean

Under rainfed condition, cultivation of soybean crop depends upon the rainfall received during the *kharif* season. The supplemental irrigation to rainfed crops results in higher yield especially if irrigation is provided at critical growth stage. Under limited irrigation conditions, one or two irrigations at flowering or pod development stage were given better results over no irrigation. Irrigation at pod development stage gave 13.09 percent higher grain yield over no irrigation. The net returns and B:C ratio increased with the frequency of irrigation and was highest with irrigation at pod development stage. The productivity enhancement of crops through front line demonstration on improved technologies and supplemental irrigation been reported by Dhaka *et al*. [2] and Sharma *et al*. [8].

Table 5. Productivity and economics of soybean under supplemental irrigation at pod development stage.

Particular/Year	2012-13	2015-16	Mean
Yield			
With irrigation	1061	1489	**1275**
Without irrigation	943	1274	**1108**
Net Monetary Returns			
With irrigation	16078	15749	**15913**
Without irrigation	12083	10474	**11278**
B:C Ratio			
With irrigation	1.62	1.58	**1.60**
Without irrigation	1.47	1.39	**1.43**
Rain Water Use Efficiency			
With irrigation	1.73	2.12	**1.93**
Without irrigation	1.53	1.85	**1.69**

Foliar spray

Due to early and semi determinate habit of *BT*. cotton hybrids, the rate of growth and rejuvenation capacity of the plant after flush of flowering is slow. When there is need to have more nutritional requirement after first bearing, the plant could not cope up with the nutritional requirements. Plants need additional nutrients to explore the potential yield and to achieve higher yield. Additional nutrition through foliar feeding is required over and above the normal fertilizer dose recommended. Application of 2% urea and 2% DAP at flowering and boll development stage respectively in cotton increased the seed cotton yield by 5.57 percent in the present study conducted.

In cotton crop, spraying of 2% urea at flowering and 2% DAP at boll development stage recorded higher seed cotton yield, net returns and B:C ratio over no spray (control). Seed cotton yield with spraying varied from 1110 to 1701 kg ha^{-1} with average value of 1328 kg ha^{-1} which was 5.57 percent higher over no spray treatment. Application of sprays also recorded higher NMR Rs. 35325/- ha^{-1}, B:C ratio 2.04 and RUWE by 2.44 kg $ha^{-1}mm^{-1}$ than without application of urea and DAP spraying. These results of effect of foliar sprays of 2% urea and 2% DAP at flowering and boll development stage respectively recorded higher yields are also in confirmation with the findings of Katkar *et al.* [3, 4] and Turkhede *et al.* [12].

In case of foliar application of fertilizer, the nutrients are supplied directly to targeted areas where they are required. A nutrient balance can be maintained by foliar feeding of plant nutrients which are available

to the growing crop at key growth stage when the plant needs them at the most. Similar findings are also reported by the Basavanneppa *et al.* [1] , Singh *et al*. [10] and Rajendran *et al.* [7].

Table 6. Productivity and economics of cotton under foliar spray of 2% urea at flowering and 2% DAP at boll development stage.

Particular/Year	2011-12	2012-13	2015-16	2016-17	Mean
Yield					
With foliar spray	1110	1233	1701	1268	**1328**
Without foliar spray	1075	1167	1605	1169	**1254**
Net Monetary Returns					
With foliar spray	42280	23932	58382	16709	**35325**
Without foliar spray	40663	21103	54761	12037	**32141**
B:C Ratio					
With foliar spray	2.94	1.67	2.17	1.38	**2.04**
Without foliar spray	2.86	1.60	2.11	1.28	**1.96**
Rain Water Use Efficiency					
With foliar spray	3.17	1.91	2.42	2.26	**2.44**
Without foliar spray	3.07	1.81	2.28	1.47	**2.15**

CONCLUSION

This study clearly indicated that advantage of adopting all improved rainfed agro-technologies for different crops in comparison to traditional farmer's practices, improved agro technologies resulted in overall increase in crop production from 5.00 to 20.67 %over the farmer's practices. The percent increase in yield was highest with adopting of high yielding varieties recommended for rainfed area (4.07 to9.51 %), followed by adoption of various in-situ moisture conservation measures in soybean (20.67 %) and in cotton (9.38 %) and foliar spray of nutrients in cotton crop which has resulted in 5.57 % increase. Hence, on farm interventions carried out through NICRA project under AICRP for Dryland Agriculture, Dr. PDKV, Akola showed the worth of improved rainfed varieties, management of *in situ* moisture conservation practices and foliar sprays for different agricultural crops. NICRA project with its strong link between the technology developed by the scientists and the user of the technology is putting larger impact on the adoption of improved dryland technologies. This project is also providing the feedback for refinement and upscaling of improved dryland agro-technologies.

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