Pigeonpea-Sunflower Intercropping System for Mitigating Climate Variability under Rainfed Condition in Western Maharashtra

V.M. Amrutsagar[1], S.K. Upadhye[1], S.V. Khadtare[1], R.M. Gethe[1], N.J. Ranshur[1] and G. Ravindra Chary[2]

[1]*All India Coordinated Research Project on Dryland Agriculture, Solapur - 413002 Maharashtra*

[2]*ICAR-Central Research Institute for Dryland Agriculture, Hyderabad - 500 059, Telangana*

Email: zarssolapur@gmail.com

ABSTRACT: The National Innovations on Climate Resilient Agriculture Project (NICRA), financed by ICAR, New Delhi through AICRPDA, CRIDA, Hyderabad, is being implemented at Narotewadi village, Solapur district, Maharashtra since 2011–12 as well as at Banegaon, Mardi and Raleras, North Solapur, since 2018-19. The main objective of the study was to mitigate climate variability and dry spell management by real time contingency plan implementation and preparedness through dryland technologies *viz.,* soil moisture conservation, foliar sprays, farm mechanization, intercropping systems, etc. The intercropping of pigeonpea + sunflower (1:2) was found to be one of the best climate resilient systems on medium black soils of Narotewadi village of Solapur district. Pigeonpea + sunflower (1:2) intercropping system recorded higher pigeonpea seed yield (638 kg ha^{-1}), sunflower seed yield (656 kg ha^{-1}) and pigeonpea equivalent yield (939 kg ha^{-1}) over farmers' practice of sole pigeonpea and sunflower (496 kg ha^{-1} and 555 kg ha^{-1}, respectively). Pigeonpea + sunflower (1:2) intercropping system also recorded maximum net returns and B:C ratio (Rs. 29968 ha^{-1} and 2.7 respectively) over the farmers' practice. Pigeonpea + sunflower intercropping system also recorded higher rainwater use efficiency of 1.7 and 1.9 kg ha^{-1}mm^{-1} compared to farmers' practice. The intercropping system thrived even during prolonged dry spells.

Key words: Climate variability, medium black soil, pigeonpea-sunflower intercropping system, rainfed

Introduction

In India, there is an increasing demand especially for pulses and oilseeds besides cereals to cope with the demand of increasing human population and to overcome malnutrition in the large section of society. Hence, there is a need to increase the pulse production. Since, there is limited scope for increasing pulse production through area expansion, the increasing demand can be met by increasing the productivity through adopting appropriate agronomic practices of which intercropping system is one of the best way to increase production (Rathod *et al*., 2004). Pigeonpea (*Cajanus cajan*) is an important pulse crop of dryland agriculture because of its ability to produce economic yield even under limited moisture conditions (Sharma *et al.,* 2010). When pigeonpea is grown as a sole crop, it is relatively inefficient because of its slow initial growth rate and harvest index (Willey *et al*., 1980). Therefore, it is grown as intercrop, which helps in efficient utilization of available resources for enhancing the productivity and profit. Intercropping is an age old practice being followed by farmers to achieve their domestic needs. The main advantage of intercropping is that the component crops are able to use the growth resources differently and make better overall use of growth resources than grown separately (Willey 1979). Intercropping system increases the total productivity in addition to bringing stability in production under rainfed conditions. Pigeonpea has slow initial growth and is planted at wider spacing. Therefore, a lot of space between rows remains unutilized during the initial crop growth period. This space can be utilized for growing of short-duration intercrops (Tiwari *et al*., 2011). Pigeonpea-based intercropping systems are less risky than shared (or optimal) sole crops over a wide range of expected yields or income. Reduced risk of pigeonpea-based intercrops was associated with higher productivity and lower variability of combined intercrop yields or income (Rao and Singh, 1990).

One of the most vulnerable sectors to climate change will be rainfed agriculture. Numerous issues, such as insufficient and variable rainfall, frequent dry spells, land degradation and low soil fertility, lack of agricultural inputs, poor technology distribution system, limited farmer investment capacity, etc., are now affecting crop output in India's rainfed areas. The vulnerability of rainfed lands to climate change and variability has been exposed by the effect of recent floods and prolonged drought in different parts of the country. Therefore, it is necessary to develop and demonstrate a technology which will sustain the crop growth and yield by mitigating climate variability. The well planned appropriate inter/sequence cropping system adopted by the farmers and also with other management practices of natural resource management (Singh *et al*., 2009) is useful for rainfed agriculture.

To address the problems of rainfed agriculture in the context of a changing climate, intercropping is an important cropping system. It also aids in the maximization of productivity and profitability by making efficient use of natural resources like land, light and water (Chandra *et al*., 2010). Inclusion of legumes as intercrops in cereals/fiber or oilseed crop would have a positive effect on the productivity, economics and fertility status of the soil. Keeping

this in view an attempt was made to evaluate different fiber/ oilseed/pulses based intercropping systems to bring stability in productivity and profitability against climate risk in selected village of Western Maharashtra.

Materials and Methods

The on-farm demonstrations of pigeonpea + sunflower intercropping system (1:2) were implemented during *kharif* of 2012-13, 2013-14, 2014-15, 2016-17 and 2017-18. The farmers in the selected village, Narotewadi of Solapur district was stratified based on size of holding into marginal (<1 ha), small (1-2 ha), medium (2-4 ha) and large farmers (>4 ha). Training programs on production skills of different crops/intercropping systems were imparted to the participants before conducting the demonstrations. The program is being implemented in Narotewadi village, Taluka North Solapur, District Solapur, Maharashtra located at 17° 41' N Latitude 75° 56' E Longitude and 483.6 m above sea level and at a distance of about 20 km from Solapur. The normal rainfall of the area is 721.5 mm. Total cultivable area in the village is 787 ha out of which 701 ha area is rainfed. The major soil types are shallow black soil (286.1 ha), medium black soil (294.8 ha) and deep black soil (206.1 ha). The major rainfed crops cultivated during *kharif* are pigeon pea, sunflower, pearl millet, green gram and black gram. The source of protective irrigation is open well and bore wells. The village received an average rainfall of 343.4 mm during cropping season of last five years from 2012-13 to 2017-18. The well distributed rainfall was observed during crop growth period of pigeonpea in 2016-17. The demonstrations on the improved intercropping systems along with the sole crops were conducted in 0.40 ha area on each farmers' site in selected village (Table 1). The standard package of practice was adopted in the study.

The economic analysis of inputs and output relationship and grain equivalent yield were worked out to quantify the benefits of interventions for last five years. Equivalent yield for each intercropping system was calculated based on the yield of individual crops in each intervention and their market prices prevailing at the time of experimentation for comparison of intercropping system with sole crop.

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

Location	Cropping system	Year	Area (ha)	Number of farmers	Rainfall (mm)	
					Normal	Cropping season
Village: Narotewadi (North Solapur) Dist Solapur	Pigeonpea + Sunflower (1:2); Sole pigeonpea; Sole Sunflower	2012-13	9.0	30	721.5	281.2
		2013-14	9.0	30	721.5	323.8
		2014-15	9.0	30	721.5	424.6
		2016-17	9.0	30	721.5	387.5
		2017-18	9.0	30	721.5	300.0
			45.0	**150**		

Results and Discussion

During the study period, a total of 150 farmers actively participated in the assessment of the pigeonpea + sunflower intercropping system (1:2) on a 45-ha area in medium black soils in the Narotewadi village, Taluka - North Solapur, and Dist-Solapur, Maharashtra. The results showed that intercropping of pigeonpea + sunflower (1:2) recorded higher pigeonpea equivalent yield (998.8, 909.2, 667.3, 1330.9, and 790.0 kg ha^{-1}, respectively during 2012, 2013, 2014, 2016 and 2017) compared to sole pigeonpea (Table 2). On an average, the intercropping system of pigeonpea + sunflower (1:2) significantly enhanced the pigeonpea equivalent yield 939 kg ha^{-1}.

Pigeonpea + sunflower (1:2) intercropping system recorded higher pigeonpea mean seed yield (638 kg ha^{-1}) and sunflower seed yield (656 kg ha^{-1}) over farmers' practice of sole pigeonpea and sunflower (496 and 555 kg ha^{-1}, respectively). Pigeonpea + sunflower (1:2) intercropping system also recorded maximum mean net returns and B:C ratio (Rs. 29968 ha^{-1} and 2.7 respectively) over the farmers' practice. The mean rainwater use efficiency (RWUE) was maximum in treatment pigeonpea + sunflower intercropping system i.e. 1.7 and 1.9 kg $ha^{-1}mm^{-1}$. Better seed yield of pigeonpea during 2016-17 was attributed to well distributed rainfall during crop growth period. This led to luxuriant crop growth and proper soil moisture at seed setting. The pigeonpea + sunflower (1:2) intercropping system was found most suitable for mitigating climate variability in Narotewadi, Dist. Solapur of Western Maharashtra. This may be due to, during the growth period of both the crops at early stage (45-50 days), sunflower requires more moisture and later stage (65-70 days) pigeonpea utilize more moisture. Hence, more stress on both the crops was not observed even during the dry spell as compared to other field crops. According to Turkhede *et al*. (2015 & 2018), intercropping systems significantly enhance grain equivalent production over sole crops while decreasing the yield of the main crop. In a study by Reddy *et al*. (2015), soybean+ pigeonpea system gave benefit to the extent of 40-60% in different sites of Kurnool in Andhra Pradesh, Aurangabad and

Table 2: Productivity and profitability of intercropping system of intercropping system of pigeonpea + sunflower (1:2) in medium black soil of Solapur, Maharashtra during year 2012-13 to 2017-18

Treatment	Seed yield (kg ha^{-1})			Pigeonpea equivalent yield (kg ha^{-1})	Net returns (Rs. ha^{-1})		B:C ratio		RWUE (kg ha^{-1}mm^{-1})	
	Improved practice	Farmers' practice								
Year	Pigeonpea + sunflower (1:2)	Sole pigeonpea	Sole sunflower		Pigeonpea + sunflower (1:2)	Farmers' practice	Pigeonpea + sunflower (1:2)	Farmers' practice	Pigeonpea + sunflower (1:2)	Farmers' practice
2012-13	584(822)*	486	720	999	36522	30576	3.14	3.00	2.07 (2.92)	1.72 (2.56)
2013-14	616 (535)	511	416	909	26487	19457	2.54	2.25	1.90 (1.70)	1.58 (1.28)
2014-15	390 (488)	316	384	667	14858	10172	1.87	1.66	0.92 (1.15)	0.74 (0.90)
2016-17	1050 (780)	817	705	1331	47990	35680	3.50	2.94	1.74	1.35
2017-18	500 (635)	350	550	790	23985	10350	2.23	1.58	1.83	1.33
Mean	638 (655.6)	496	555	939	29968	21247	2.7	2.3	1.7 (1.9)	1.3 (1.6)

*Figures in parenthesis are data for intercrop

Nandurbar districts of Maharashtra. Short duration intercrop used in the system might pay the farmer much needed interim income or meet the domestic requirement of food and fodder as reported by Rao (1991) and Ravindra Kumar *et al*. (2017).

Conclusion

In Vertisol soils of the Solapur region of Maharashtra, pigeonpea + sunflower (1:2) intercropping system was found to be more productive and remunerative than sole crops of pigeonpea and sunflower. Therefore, intercropping provides a solution for increasing yield per unit area, more diversified diet, and lowering crop failure risk under rainfed condition.

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