Int.J.Curr.Microbiol.App.Sci (2018) *7*(4): 1002-1009

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 04 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.704.109

Farmers Participatory Evaluation on Performance of Red gram + Soybean Intercropping *vis-a-vis* Sole Cotton under Rainfed Medium Soils of Telangana

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Keywords

Crop diversification, Redgram + soybean, Sole cotton, Cotton kapas equivalent yield, Technology gap, Technology index

Article Info

Accepted:
10 March 2018
Available Online:
10 April 2018

A B S T R A C T

Crop diversification with resource efficient and remunerative cropping systems is a sustainable agricultural practice. On farm demonstrations with diversified cropping system of Redgram + soybean *Vis-a-Vis* farmers' practice of sole cotton were conducted in ten farmer's locations of Warangal district of Telangana state. Crop diversification with red gram + soybean realized 29.9% higher (3706 kg ha^{-1}) mean cotton kapas equivalent yield over farmer's practice of cultivation of sole cotton (2852 kg ha^{-1}). Mean technology and extension gap were 594 kg ha^{-1} and 854 kg ha^{-1} respectively. Technology index ranged from 4.5 to 24.1% with an average value of 13.8%. The mean gross and net returns of diversified cropping system were Rs 155658 and Rs 119140, while sole cotton recorded a mean Rs 119784 and Rs 69529 of gross and net returns ha^{-1} respectively. Mean BC ratio of 4.3 was earned in improved cropping system as against the 2.4 under sole cotton system. Mean additional returns in improved cropping system were Rs 35874 ha^{-1} with a mean effective gain of Rs 49611 ha^{-1}. In Improved cropping systems, mean total productivity per day was 10.2 kg ha^{-1} day^{-1} with a mean profitability of Rs 326 per day as against the mean total productivity of 7.8 kg ha^{-1} day^{-1} in sole cotton system. Average Production Use Efficiency was 20.6 kg day^{-1} in improved cropping system, while in sole cotton system it was 17.3 kg day^{-1}. Mean Relative Productive Use Efficiency and Relative Economic Efficiency were 29.9 and 71.4 respectively indicated the edge in productive economic parameters indicating the profitability of diversified cropping system.

Introduction

Cotton is the most important commercial and fiber crop Telangana state grown in 16.51 lakh ha with a production of 49.40 lakh bales and productivity of 515 kg ha^{-1} (AICCIP 2014 - 15). Warangal is one of the major cotton growing districts of the state, with 2.5 lakh hectares of area. The crop is grown on diverse kinds of soils varying from fine textured black soils to coarse textured red soils. However, ¾th of the area spreads in rainfed light soils under continuous sole cotton over the years and farmers have been over enthusiastic on

cultivation of *Bt* cotton. Kapas yield of cotton is ranging from 10-12 q ha^{-1} in the district and with changing climate, occurrence of sucking pests and diseases, micro nutrient deficiencies, alteration of soil physiography making this ecosystem highly fragile and threatening the cotton productivity. On the other hand farmers are incurring high investment on cultivation of cotton by lending money from private firms and ultimately trapping in debts due to less remunerative price and unforeseen yield losses. This situation is forcing the farmers to extreme steps of suicides owing to debts. Further, ignoring of pulses in cropping pattern and dwindling of cattle population is leading to exhaustion of organic matter in light soils making the soil ecosystem more fragile with low moisture retentivity and poor fertility.

Under such circumstances, diversifying cropping systems by increasing the spatial and temporal heterogeneity of agricultural mosaics has been proposed as a feasible alternative to overcome the negative effects of modern agriculture (Burel *et al.,* 2013). Provision of species diversity by mixed cropping is considered as advantage over sole cropping. This diversification tends to promote yield stability because all the crops in a mixed cropping culture are not likely to be affected by weather vagaries or pests and diseases and prompts a farmer to resort to mixed cropping.

Soybean (*Glycine max* L.) is a dual purpose most important rainy season crop to meet pulse and oil requirements. It has a great nutritional significance, with over 38-40 % protein and 18-20% oil and has recognized as a potential supplementary source of edible oil. It is also highly adaptable to varying soil and climatic conditions, giving fairly high yields compared to other pulse crops (Padhi and Panigrahi, 2006). Soybean offers good potential to get involved in the cropping sequences or intercropping systems. It is a short duration (85 to 130 days depending on the latitude) leguminous energy rich crop. It is relatively tolerant to drought, excessive moisture, low pH and high aluminum content (Billore, 2014). Further its cultivation does not cause any allelopathic effect on companion/succeeding crops, extends benefits of 45 to 60 kg residual nitrogen per hectare to the succeeding crop and creates salutary physio-chemical environment in the soil for crop growth (Kumar *et al.,* 2012). Apart from these, the practice of intercropping also reduces the population density of insects-pests as the intercrop may not serve as their host (Viglizzo *et al.,* 2012). Intercropping also demonstrate weed control advantages over sole crops as intercrops are more effective than sole crops and usurp resources from weeds or suppress weed growth through allelopathy (Shennan, 2008). Soybean due to its trade and industrial significance and adaptability to varied agro-climatic conditions occupies greater part of potential cultivated area as an integral part of prevailing cropping systems in India and world over.

In Telanagana state, at present soybean is cultivated over 0.24 million hectares with an annual production of 0.25 million tones and productivity of 1036 kg ha^{-1} (Telangana Directorate of Economics and statistics 2017). However, productivity of soybean can further be increased by intercropping or with potential crop sequence. Area under soybean is increasing enormously in Northern Telanagana districts due to better yield potential and market price. Pigeon pea being a predominantly rainfed crop is one of the most important and potential component of intercropping in semi-arid areas. It is generally intercropped with sorghum, cotton and maize in northern Telangana districts. Soybean is also feasibly intercropped with pigeon pea for enhancing the potential of crop productivity. Keeping in view of the above, redgram inter cropped with soybean is evolved as an alternative sustainable and climate smart

cropping system to sole cotton in rainfed medium vertisols.

Materials and Methods

Front line demonstrations on Redgram + soybean intercropping was conducted by On Farm Research Centre All India Coordinate Research Project on Integrated Farming Systems in 10 farmer locations of Warangal district during the year 2016-17 with an objective to study the production potential of improved cropping system of Red gram + soybean intercropping in comparison with farmers practice of sole cotton under rainfed medium soils. An area of 0.4 ha per each location was chosen for study. Test varieties were LRG-41 and JS-335 for Redgram and soybean respectively. Redgram variety, LRG-41 matures in 180 days, suitable for cultivation in black cotton soils and tolerant to *Helicoverpa armigera* with a yield potential of 20-25 q ha^{-1} Soybean variety JS 335 comes to maturity in 90-95 days with yield potential of 20-25 q ha^{-1}. Sole cotton cultivation with *Bt* hybrid (farmer's practice) was compared as control. Sowings of crops in both the treatments were done during 2nd week to end of June month.

Intercropping of red gram and soybean g was done in additive row series in 1:5 ratio at a spacing of 30 x 5 cm for soybean and 15 cm apart with in plants of red gram row. Seed rate of 2 kg ha^{-1} and 70 kg ha^{-1} of redgram and soybean respectively was adopted. Seed treatment with thiram @ 3 g /kg of seed followed by 5ml of imidacloprid /kg of seed to prevent pest and diseases. All management practices for weed, nutrient, pest and diseases were adopted as per the recommendations of PJTSAU. A rainfall of 990 mm was received in 65 rainy days and the crop was maintained rainfed without any irrigations. The data on grain yield was collected by random crop cutting method. Cotton seed Equivalent yield was calculated by converting the seed yield of soybean and redgarm into cotton equivalent Yield on the basis of sale prices of respective crops.

$$\text{Cotton Equivalent Yield} = \frac{\text{(Redgram yield (kg ha}^{-1}\text{) x price of red gram (Rs kg}^{-1}\text{) + Soybean yield (kg ha}^{-1}\text{) x price of soybean (Rs kg}^{-1}\text{)}}{\text{Cotton kapas price (Rs/kg)}}$$

The check crop, cotton was cultivated with a *Bt* hybrid RCH 22, which has an yield potential of 25-30 q ha^{-1} and sown at spacing of 90 x 45 cm with a seed rate of 2.25 kg ha^{-1}. All the agronomic management practices were done in accordance with recommendations of PJTSAU and kapas yield was recorded by taking three pickings up to 160 days.

Benefit Cost ratio, gross and net returns were calculated based on grain yield and prevailing market price. Per day net returns were worked out by dividing total net returns with the duration of the crop.

The extension gap, technology gap and technology index were calculated as per the following formula drawn by Samui *et al.*, (2000).

Extension gap= Yield of Improved practice-Yield of farmers practice.

Technology gap= Potential yield –yield of improved practice

$$\text{Technology index} = \frac{\text{Technology gap}}{\text{Potential yield}} \text{ X } 100$$

Production and Economic indices are calculated based on following formulae.

Additional Returns=Extension gap X Sale price

Effective gain = Additional returns – Additional cost

Returns per rupee investment (Rs Re^{-1}) = Net Returns/Cost of Cultivation

Total Productivity (kg ha^{-1} day^{-1}) = Total productivity/365

Profitability (Rs ha^{-1} day^{-1}) = Total profitability/365

Production Use Efficiency is Efficiency measured in terms of yield/day

$$\text{Production Use Efficiency (kg ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Total grain yield of a system}}{\text{Period in days consumed to produce the yield}}$$

$$\text{Relative Productive Use Efficiency (\%)} = \frac{\text{Total Productivity in diversified cropping system –}}{\text{Total productivity in existing cropping system}} \times 100$$

$$\text{Relative Economic Efficiency (\%)} = \frac{\text{Net Returns of diversified cropping system - Net Returns of existing cropping system}}{\text{Net Returns of existing cropping system}} \times 100$$

Results and Discussion

Grain yield

Grain yield of soybean and pigeon pea was influenced by interaction of planting pattern and intercropping system. Initial slow growth of pigeon pea provided more space for soybean development and resulted in good yield of both the component crops. The Cotton Equivalent Yield of diversified cropping system of Redgram + soybean was ranging from 3264 kg ha^{-1} to 4107 kg ha^{-1} across the locations and was 16.3% - 37.3% higher than sole cotton crop yields (2650 kg ha^{-1} to 3070 kg ha^{-1}). Mean Cotton Equivalent Yield (Table 1) of improved cropping system of Redgram + soybean was 29.9% higher (3706 kg ha^{-1}) than over farmers practice of sole cotton yield (2852 kg ha^{-1}). Studies conducted at Adilabad, Telanagana state also indicated that Pigeon pea at 180 cm row spacing intercropped with six rows of soybean gave significantly higher pigeon pea equivalent yields than sole pigeon pea MRG-66 (Sreerekha and Dhurua 2009). Kasbe *et al.,* (2010) also reported maximum yield in interaction of planting pattern 4:2 and intercropping system soybean (JS-335) + pigeon pea (BSMR-736).

Economics

Diversified cropping system of pigeon pea +soybean earned gross returns ranging from Rs 137100 to Rs 172500 across the locations. While gross returns of sole cotton under farmers practice ranged from Rs 111300 to Rs 128940 (Table 2). The mean gross returns under improved cropping systems were Rs 155658 *via-a-vis* Rs 119784 in sole cotton. Net returns in improved cropping systems ranged from Rs 100450 to Rs 134200 with mean value of Rs 119140, while net returns of sole cotton varied from Rs 58800 to Rs 79690 with an average net return of Rs 69529. The returns on earned per rupee investment were ranging from Rs 3.7 to Rs 4.5 with mean BC ratio of Rs 4.3 in improved cropping system, where as in sole cotton system the benefit was Rs 2.1-2.6 per rupee cost with mean value of 2.4. Dubey *et al.,* (1991) reported 32 per cent more net returns due to planting of pigeon pea and soybean compared to sole pigeon pea. Halvankar *et al.,* (2000) also observed similar results.

Per day returns ranged from Rs 558 to 746 in improved cropping system with as an average of Rs 662.

Table.1 Grain yield, technology gap, extension gap and technology index were influenced under improved cropping system over farmers practice

Trial No	Grain yield (kg ha^{-1}) in Improved cropping systems		Cotton Equivalent Yield (Kg ha^{-1} in Improved system	Potential yield (kg ha^{-1}) of Improved system	Sole cotton yield (kg ha^{-1}) in Farmers practice	% increase in yield over farmers practice	Technology gap (kg ha^{-1})	Extension gap (kg ha^{-1})	Technology Index
	Soybean	Red gram							
1	1885	1650	3283	4300	2650	23.9	1017	633	23.7
2	1700	1720	3264	4300	2720	20.0	1036	544	24.1
3	2280	2100	4107	4300	3040	35.1	193	1067	4.5
4	1850	2060	3799	4300	2680	41.7	501	1119	11.7
5	2250	1965	3913	4300	2850	37.3	388	1063	9.0
6	2190	1805	3667	4300	2740	33.8	633	927	14.7
7	2010	1795	3547	4300	3050	16.3	753	497	17.5
8	2330	1835	3790	4300	2970	27.6	510	820	11.9
9	2380	1940	3957	4300	3070	28.9	343	887	8.0
10	2160	1870	3735	4300	2750	35.8	565	985	13.2
Mean	2103.5	1874	3706	4300	2852	29.9	594	854	13.8

Table.2 Economics as influenced under improved cropping system over farmers practice

Trial No	Cost of Cultivation (Rs ha^{-1})		Gross Returns (Rs ha^{-1})		Net Returns (Rs ha^{-1})		B: C ratio		Per day Net Returns (Rs ha^{-1})	
	Improved system	Farmers Practice	Improved system	Farmers Practice	Improved system	Farmers Practice	Improved system	Farmers Practice	Improved system	Farmers Practice
1	36250	52500	137875	111300	101625	58800	3.8	2.1	565	356
2	36650	50500	137100	114240	100450	63740	3.7	2.3	558	386
3	38300	49800	172500	127680	134200	77880	4.5	2.6	746	472
4	35700	46800	159550	112560	123850	65760	4.5	2.4	688	399
5	36400	49300	164325	119700	127925	70400	4.5	2.4	711	427
6	34720	46200	154025	115080	119305	68880	4.4	2.5	663	417
7	36300	54550	148975	128100	112675	73550	4.1	2.3	626	446
8	38450	53400	159175	124740	120725	71340	4.1	2.3	671	432
9	37400	49250	166200	128940	128800	79690	4.4	2.6	716	483
10	35000	50250	156850	115500	121850	65250	4.5	2.3	677	395
Mean	36517	50255	155657.5	119784	119141	69529	4.3	2.4	662	421

Table.3 Production and Economic indices as influenced under improved cropping system over farmers practice

Trial No	Additional Returns (Rs ha^{-1})	Effective gain (Rs ha^{-1})	Total productivity (kg ha^{-1} day^{-1})		Profitability (Rs ha^{-1} day^{-1})	Production Use Efficiency (kg ha^{-1} day^{-1})		Relative Productive Use Efficiency (%)	Relative Economic Efficiency (%)
			Improved system	Farmers Practice		Improved system	Farmers Practice		
1	26575	42825	9.0	7.3	278	18.2	16.1	23.9	72.8
2	22860	36710	8.9	7.5	275	18.1	16.5	20.0	57.6
3	44820	56320	11.3	8.3	368	22.8	18.4	35.1	72.3
4	46990	58090	10.4	7.3	339	21.1	16.2	41.7	88.3
5	44625	57525	10.7	7.8	350	21.7	17.3	37.3	81.7
6	38945	50425	10.0	7.5	327	20.4	16.6	33.8	73.2
7	20875	39125	9.7	8.4	309	19.7	18.5	16.3	53.2
8	34435	49385	10.4	8.1	331	21.1	18.0	27.6	69.2
9	37260	49110	10.8	8.4	353	22.0	18.6	28.9	61.6
10	41350	56600	10.2	7.5	334	20.7	16.7	35.8	86.7
Mean	35873.5	49611.5	10.2	7.8	326	20.6	17.3	29.9	71.4

While sole cotton system resulted in Rs 356 to 472 per day returns with mean of Rs 421. Higher economics in improved cropping systems over sole cotton system can be attributed to higher cotton equivalent yield, high gross and net returns and lower cost of cultivation. The findings of Billore *et al.*, (2002) also confirm that planting of pigeon pea 150 cm with five rows of soybean recorded maximum net returns of Rs.17, 226 ha^{-1}) and Rs.22, 035 ha^{-1} respectively.

Technology gap, extension gap and technology index

Mean Technology gap was 594 kg ha^{-1} and it ranged from 193 kg ha^{-1} to 1036 kg ha^{-1}. Whereas extension gap varied from 497 to 1067 kg ha^{-1} with average value of 854 kg ha^{-1} (Table 1). Technology index ranged from 4.5 to 24.1% with an average value of 13.8%.

Technology Index represents the feasible adaptability improved cropping systems from lab to land. Lower the technology index means more viability of innovative cropping system at farmer's field. Thus attaining higher yields almost close to potential yields will hasten up the adoption of improved cropping system interventions to increase the yield performance.

Production and economy indices

Additional returns in diversified cropping system ranged from Rs 20875 to 46990 ha^{-1} with mean additional returns of Rs 35874 ha^{-1} (Table 3). Effective gain ranged from Rs 36710 ha^{-1} to 58090 ha^{-1} with an average effective gain of Rs 49611 ha^{-1} in improved cropping system. Total productivity per day in improved cropping systems varied from 8.9 kg to 11.3 kg ha^{-1} day^{-1} with mean value of 10.2 kg ha^{-1} day^{-1} as against 7.8 kg ha^{-1} day^{-1} in sole cotton system which ranged from 7.3 to 8.4 kg ha^{-1} day^{-1}. Mean Profitability of diversified cropping system per day was Rs 326 and it ranged from Rs 275 to 368.

Production Use Efficiency of diversified redgram + soybean system ranged from 18.1 kg to 22.8 kg day^{-1} with an average of 20.6 kg day^{-1}, while it was 16.1 to 18.6 kg day^{-1} with mean of 17.3 in sole cotton system. Relative Productive Use Efficiency of redgram + soybean system fluctuated from 16.3 to 41.7% with an average of 29.9% whereas Mean Relative Economic Efficiency was 71.4% and it ranged from 53.2 to 88.3%.

Results obtained from computation of indices, yield and returns showed a significant advantage of intercropping redgram +soybean in exploiting the resources of the environment compared to sole cropping of cotton in rainfed regions of Telangana state.

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How to cite this article:

Md. Latheef Pasha, S. Sridevi, M. Goverdhan, P. Raghu Rami Reddy and Pragathi Kumari, Ch. 2018. Farmers Participatory Evaluation on Performance of Red gram + Soybean Intercropping *vis-a-vis* Sole Cotton under Rainfed Medium Soils of Telangana. *Int.J.Curr.Microbiol.App.Sci.* 7(04): 1002-1009. doi: https://doi.org/10.20546/ijcmas.2018.704.109