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Yield and economic advantages by adoption of cotton + redgram intercropping system under rainfed conditions of Mancherial district, Telangana state

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Abstract
A front line demonstration on production potential of cotton + redgram intercropping system under rainfed conditions in Mancherial district of Telangana state carried out in farmers fields during 2019-20, 2020-21 and 2021-22 under Krishi Vigyan Kendra of PJTSAU, Telangana. Intercropping of Cotton and Redgram was sown in 6:1 ratio with an objective of redgram as inter cropped with cotton is evolved as an alternative sustainable cropping system to sole cotton in rainfed conditions to improve the yields and income of the farmers in the Mancherial district of Telangana state. The average cotton equivalent yield was 2083 kg/ha, 2091 kg/ha and 1804 kg/ha respectively during 2019-20, 2020-21 and 2021-22 and the mean cotton equivalent yield was 1993 kg/ha. The mean increase of equivalent yield of demo is 15% over the check. The three years average mean LER value is 1.30 which denotes the benefits of an intercropping system to utilize the resources as against their pure stands. The higher gross(Rs. 1,17,069) and net returns (Rs. 98,338) in cotton + redgram intercropping over check sole cotton might be due to higher cotton equivalent yield, lower cost of cultivation during all the study years. The mean benefit cost ratio was 2.30: 1 and 1.71: 1 for demo and check respectively.

Keywords: Yield, economic advantages, cotton + redgram, intercropping system

Introduction
Cotton, an important fiber and commercial crop of India as well as in Telangana state. It's grown in 124.44 lakh ha with a production of 370 lakh bales and productivity of 505.46 kg ha-[1] (ICAR-CICR 2018). Among the states, Maharashtra was reported as leading in cotton acreage (44.05 lakh ha) followed by Gujarat (26.66 lakh ha), Telangana (18.59 lakh ha), Haryana (7.01 lakh ha) and Rajasthan (6.44 lakh ha). In Telangana state during 2019 area under cotton was 21, 14, 145 hectares as against 17, 96, 471 hectares during 2018-19. Among the districts, Nalgonda stood first with 2,73,699 ha followed by Adilabad (1,40,332 ha), Nagarkurnool (1,42,192 ha), Sangareddy (1,40,009 ha) and Asifabad (1,24,884 ha) and Mancherial 64,184 ha (www.agri.telangana.gov.in). The crop is grown on diverse kinds of soils varying from fine textured black soils to coarse textured red soils. About two-third of the cotton area in the district is under rain fed conditions and faces different abiotic stresses during the crop growth period resulted in less yields and increase in input costs ultimately reduced the cost benefit ratio.

Under such circumstances, intercropping cotton with other crops provides additional return, improves soil quality (if legume is included as intercrop), reduces climatic risks and chance of crop failure, enhances biodiversity and ensures greater use of resources (Maitra *et al*. 1999, 2001b; Maitra and Ray, 2019) [12, 11, 9]. As a widely spaced crop, cotton provides ample scope for adoption of intercropping system. Intercropping is a traditional farming practice of growing of two or more crop species concurrently so that they coexist for a significant part of their growing cycle and that they interact among themselves and with agro-ecosystem (Maitra *et al*. 2019; Gitari *et al*. 2020; Maitra and Gitari, 2020) [9, 10, 3, 8]. In recent years, it is often recognized that intercropping system can produce higher yield than sole cropping system.

Pigeon pea/redgram 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. Pigeonpea is suitable for inter-cropping with different crops like cotton, sorghum, pearl millet, greengram, blackgram, maize, soybean and groundnut for increasing production and maintaining soil fertility.

The initial slow growth rate and deep root system of pigeonpea offers a good scope for intercropping with fast growing early maturing and shallow rooted crops (Ramamoorthy *et al*., 2004) [20]. Pigeonpea has more advantages when it is grown under intercropped situation.
Keeping in view of the above, redgram inter cropped with cotton is evolved as an alternative sustainable cropping system to sole cotton in rainfed conditions to improve the yields and income of the farmers in the Mancherial and KB Asifabad districts of Telangana state.

Materials and Methods

Demonstration on Cotton + Redgram intercropping system under rainfed conditions was conducted as Front Line Demonstration by Krishi Vigyan Kendra, Bellampalli, Mancherial district under Professor Jayashankar Telangana State Agricultural University in 8 farmer locations of Mancherial district during the year 2019-20, 2020-21 and 2021-22. The demonstrations were carried out with an objective to study the production potential and system indices of Cotton+ Red gram intercropping system in comparison with farmer's practice of sole cotton under rainfed conditions.
An area of 0.4 ha per each location was chosen for study. Test varieties were selected WRG-65 and WRG-97 for Redgram varieties and the quality seed were distributed to the selected farmers. Sole cotton cultivation with *Bt* hybrid (farmer's practice) was compared as control. Sowings of crops in both the treatments were done during 1st fortnight of July during the three years.
Intercropping of Cotton and Redgram was sown in 6:1 ratio at a spacing of 90 x 60 cm for row to row and plant to plant for both cotton and redgram respectively. For sole cotton crop similar spacing were followed. All the management practices for weed, nutrient, pest and diseases were adopted as per the recommendations of PJTSAU. A rainfall of 1472, 1388 and 1112 mm was received during the three years of the study 2019-20, 2020-21 and 2021-22 respectively. The crop was grown under rainfed conditions only. The data on Plant population, cotton and redgram yields were collected by random crop cutting method.

Cotton equivalent yield (kg/ha)

Cotton Equivalent yield was calculated by converting the redgram yield into cotton equivalent Yield on the basis of sale prices of cotton and redgram crops.

LER (Land Equivalent Ratio)

Willey and Osiru (1972) [18] gave the idea of the LER and it is described as the proportionate land area required under a pure stand of crop species to yield the same product as obtained under an intercropping at the same management level. The LER of intercropped plots are estimated for each component crops separately by adding the estimated total of two varieties; the LER of the sole crop is taken as unity (1). LER can be calculated by the following expression.

$$LER = Yab/Yaa + Yba/Ybb$$

where,
Yab is the yield of "a" crop grown in association with "b" crop and Yba is the yield of "b" crop grown in association with "a" crop. Yaa and Ybb represent the yields of "a" and "b" crops grown in a pure stand, respectively.

The LER denotes the benefits of an intercropping system to utilize the resources as against their pure stands. The LER value greater than unity (1.0) indicates the advantages of the intercropping system and less than one (1.0) is considered as a poor performance of the intercrops (Maitra *et al.*, 2021) [7].
Cost of cultivation, gross returns, net returns and benefit cost ratio were calculated based on the market price of the inputs, labour cost and price of the produce during the study years.
The extension gap, technology gap and technology index were calculated as per the following formula drawn by Samui *et al.*, (2000) [16].

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

Technology gap = Potential yield –Yield of improved practice

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

Results and Discussion

The average plant population of sole cotton varied from 18,220 to 18,458 and mean population of three years is 18,303 and cotton + redgram plant population of cotton and redgram varies from 15,240+2490 to 15,560+2570 and mean population of three years is 15,357+2527 (Table 1). The plant population is not significantly affected due to introduction of redgram in cotton due to similar spacing 90cmx 60 cm followed in demo and check.

Table 1: Average plant population and yields of demo and check during 2019-20, 2020-21 and 2021-22

	Plant population (No/ha)			Yield (kg/ha)		
	Cotton + Red gram (Demo)		Sole Cotton (Check)	Cotton + Redgram (Demo)		Sole Cotton (Check)
2019-20	15,560	2570	18,458	1678	422	1791
2020-21	15,270	2490	18,230	1485	522	1696
2021-22	15,240	2520	18,220	1447	539	1583
Mean	15,357	2527	18,303	1537	494	1690

In the table 1 the results revealed that, the lower cotton yield was noticed in demo is 1537 kg/ha where as in higher cotton yields were noticed in sole cotton *i.e.*, 1690 kg/ha due to cultivation of intercrop. Oad *et al.*, (2007) [13] reported similar results. The yield advantage in intercropping is measured by using some competition functions like relative yield total (RYT), relative value total (RVT), and monetary advantage and base crop equivalent yield may be considered. In the cropping system/inter cropping system the yield of the system can be represented in equivalent yields of main crop. Highest crop equivalent yields recorded with cotton+ redgram intercropping system compare to sole cotton during the three years. The average cotton equivalent yield was 2083 kg/ha, 2091 kg/ha and 1804 kg/ha respectively during 2019-20, 2020-21 and 2021-22 and the mean cotton equivalent yield was 1993 kg/ha (Table 2). The CEY is less during the year of

2021-22 due to high market price of cotton kapas compare to other years. Generally the equivalent yields of any crops will depend on the yields and market price of main crop and inter crops. The average sole cotton yields were 1791 kg/ha, 1696 kg/ha and 1583 kg/ha respectively during 2019-20, 2020-21 and 2021-22 and the mean sole cotton yield was 1690 kg/ha. The average increase in yield of demo were 14%, 18.8% and 12.2% over check (sole cotton) and mean increase of yield of demo is 15% over the check (Table 2). Blaise *et al*., 2005 found that cotton + pigeonpea/redgram intercropping was one of the effective crop combination where mean cotton equivalent yield recorded high over sole cotton.

Table 2: Average CEY and other indices of demo and check during 2019-20, 2020-21 and 2021-22

	Cotton equivalent ratio		% increase in yield over check	Land equivalent ratio (LER)	Extension gap (kg/ha)	Technology gap (kg/ha)	Technology index
	Cotton +Red gram (Demo)	Sole Cotton (Check)					
2019-20	2083	1791	14.0	1.34	292	267	11.3
2020-21	2091	1696	18.8	1.30	395	259	11.0
2021-22	1804	1583	12.2	1.26	221	546	23.2
Mean	1993	1690	15.0	1.30	303	357	15.1

The average Land equivalent ratio (LER) is 1.34, 1.30 and 1.20 during the 2019-20, 2020-21 and 2021-22 respectively and the mean LER value is 1.30 (Table 2). The LER denotes the benefits of an intercropping system to utilize the resources as against their pure stands. The reason for large yield advantage in intercropping system is that the component crops differed in their use of natural resources and utilized them more efficiently resulting in higher yields per unit area than that produced by their sole crops (Udhaya Nandini and Latha., 2015) [17]. The LER value greater than unity (1.0) indicates the advantages of the intercropping system. In all the years the LER values are greater than one it means the cotton + redgram intercropping system is advantageous. Similar findings were noticed by Oad *et al.*, (2007) [13].

The average extension gap is 292 kg/ha, 395 kg/ha ad 221 kg/ha during the 2019-20, 2020-21 and 2021-22 respectively and the mean extension of gap of three years is 303 kg/ha.

The extension gap is the difference between the yield of improved practice (Demo) and the yield of farmer practice (Check). The mean technology gap and technology index of three years was 357 kg/ha and 15.1 respectively (Table 2). Technology Index represents the feasible adaptability of the improved cropping systems from lab to land. Lower the technology index means more viability/feasibility of the 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 (Latheef Pasha *et al.*, 2018) [6]. The lower technology index was observed during the 2019-20 and 2020-21 due to higher yields recorded with the intercropping system (Demo).

Table 3: Average Economic indices and per day net returns of demo and check during 2019-20, 2020-21 and 2021-22

	Cost of cultivation (Rs/ha)		Gross returns(Rs/ha)		Net returns(Rs/ha)		B:C ratio		Per day net returns (Rs/ha)	
	Demo	Check	Demo	Check	Demo	Check	Demo	Check	Demo	Check
2019-20	50250	52325	109610	94034	59306	41709	2.17	1.19	329	232
2020-21	49799	51848	100733	82256	50934	33408	2.02	1.69	283	186
2021-22	51804	52614	140865	118725	89061	66111	2.72	2.26	495	367
Mean	50618	52262	117069	98338	66434	47076	2.30	1.71	369	262

The mean cost of cultivation is 50618 Rs/ha and 52262 Rs/ha for demo and check respectively (Table 3). Similar results also reported by Oad *et al.*, 2007 [13]. The highest gross and net returns were recorded in cotton + redgram intercropping system (Demo) compare to sole cotton (Check) during all the study years. The mean gross returns Rs.117069 and Rs. 98338 and net reurns Rs.66434 and Rs. 47076 in demo and check respectively (Table 3). The higher gross and net returns were recorded in demo cotton + redgram intercropping over check sole cotton might be due to higher cotton equivalent yield, lower cost of cultivation during all the study years. Higher economics in improved cropping systems over sole cotton system can be attributed to higher cotton equivalent yield, market price of the both cotton and redgram. Similar findings also reported by Oad *et al.*, 2007 [13] Gnansambbandan *et al.*, 2000 [4] reported that under rainfed conditions cotton + redgram inter cropping system has shown positive combinations for better growth and yield contributing parameter and cost benefit ratio over sole cotton crop. Reddy *et al.*, 2001 [14] found that there were enhanced crop yields in intercropping systems ultimately increased gross and net return over sole crop. The benefit cost ratio recorded highest in demo field adoption of cotton + redgram inter cropping system over check sole crop during all the three years. The mean benefit cost ratio was 2.30: 1 and 1.71: 1 for demo and check respectively. The benefit cost ratio will depend on the returns and cost of cultivation. The higher returns and lower cost of cultivation recorded in cotton + redgram intercropping system over sole cotton ultimately increased the benefit cost ratio in demo field over check. Similar findings also reported by Oad *et al.*, 2007 [13] and Latheef Pasha *et al.*, 2018[6]. Krishnareddy *et al.*, 2001 [5] found that intercropping of cotton+ pigeon pea/redgram was beneficial than sole cropping of cotton in sense of monetary recoveries.

The highest mean per day net returns recorded as Rs 369/ha in demo with adoption of cotton + redgram intercropping system over check Rs.262 /ha (Table 3). This might be due to highest net returns recorded in intercropping system over sole cotton. Per day net returns value will depend on the net return and duration of the crops sown as intercrops and sole crops.

Conclusion

Adoption of cotton + redgram intercropping system under rainfed conditions recorded highest cotton equivalent yields,

net returns and benefit cost ratio over practicing of sole cotton crop during all the front line demonstrations conducted years. The LER values also recorded greater than unity (1.0) which indicates that the advantages of the cotton + redgram intercropping system over sole cotton.

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