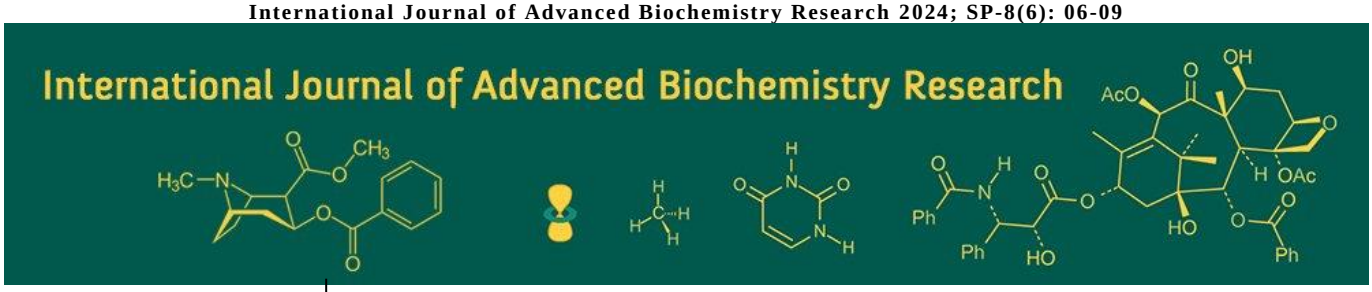

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Demonstration of Cotton + Redgram intercropping system under rainfed conditions of Telangana state

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Abstract
A front line demonstration on production potential of Cotton + Redgram intercropping system under rainfed conditions in Mahabubnagar district of Telangana state was carried out in farmers fields during 2017-18, 2018-19 and 2019-2020 under District Agricultural Advisory transfer of Technology centre (DAATTC), Mahabubnagar, PJTSAU, Telangana. Intercropping of Cotton and Redgram was sown in 4:1 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 Mahabubnagar district of Telangana state. The average cotton equivalent yield was 3025 kg/ha, 2382 kg/ha and 3698 kg/ha respectively during 2017-18, 2018-19 and 2019-20 and the mean cotton equivalent yield was 3035 kg/ha. The higher net returns (Rs. 89,912) 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 2.47: 1 and 2.06: 1 for demo and check respectively.

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

Introduction
Cotton is a major crop of Telangana state occupying 50 lakh ha though it is recommended for deep vertisols, farmers have been growing it in alfisols (65-70% of total area) under rainfed situations since two decades after introduction of *Bt* technology. Now a days *Bt* cotton yields are ranging from 1.0 to 1.2 t/ha. The crop is grown on diverse kinds of soils varying from fine textured black soils to coarse textured red soils. Most of the cotton area in the district is under rain fed conditions and faces different abiotic stresses during the crop growth period resulting 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, 9-10]. 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 *et al*. 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. Pigeonpea is suitable for intercropping 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 Pigeonpea has more advantages when it is grown under intercropped situation. Keeping in view of the above, Redgram inter cropped with cotton has evolved as an alternative sustainable cropping system to sole cotton in rainfed conditions to improve the yields and income of the farmers in the Mahabubnagar districts of Telangana state.

Materials and Methods

Demonstration on Cotton + Redgram intercropping system under rainfed conditions was conducted as Front Line Demonstration by District Agricultural Advisory Transfer of Technology Centre, Mahabubnagar district under Professor Jayashankar Telangana State Agricultural University in 12 farmer locations of Mahabubnagar district during the year 2017-18, 2018-19 and 2019-20. The demonstrations were carried out with an objective to study the production potential of Cotton+ Redgram 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 variety was selected PRG-176 for Redgram variety and the quality seed was distributed to the selected farmers. Sole Cotton cultivation with Bt (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 4:1 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 845.3, 504.4 and 829.3 mm was received during the three years of the study 2017-18, 2018-19 and 2019-20 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.

The extension gap, technology gap and technology index were calculated as per the following formula drawn by Samui *et al*., (2001) [11].

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 18,240 to 18,610 and mean population of three years is 18,389 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.The plant population is not significantly affected due to introduction of Redgram in cotton due to similar spacing 90cmx 60 cm.

In the Table 1 the results revealed that, the lower cotton yield was noticed in demo is 2136 kg/ha where as in higher cotton yields were noticed in sole cotton i.e., 2405 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 3025 kg/ha, 2382 kg/ha and 3698 kg/ha respectively during 2017-18, 2018-19 and 2019-20 and the mean cotton equivalent yield was 3035 kg/ha (Table 2). 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 2000 kg/ha, 1900 kg/ha and 3316 kg/ha respectively during 2017-18, 2018-19 and 2019-20 and the mean sole cotton yield was 2405 kg/ha. The average increase in yield of demo were 51.25%, 25.36% and 11.51% over check (sole cotton) and mean increase of yield of demo is 29.37% over the check (Table 2). Blaise *et al*., 2005 [2] found that Cotton + Pigeonpea/Redgram intercropping was one of the effective crop combination where mean cotton equivalent yield recorded high over sole cotton.

Table 1: Average plant population and yields of demo and check during 2017-18, 2018-19 and 2019-20

	Plant population (No/ha)			Yield (kg/ha)		
	Cotton + Redgram (Demo)		Sole Cotton (Check)	Cotton + Redgram(Demo)		Sole Cotton (Check)
2017-18	15355	2114	18610	1625	875	2000
2018-19	15719	2371	18240	1720	615	1900
2019-20	15600	2590	18319	3065	548	3316
Mean	15560	2358	18389	2136	679	2405

Table 2: Average Cotton Equivalent Yield and other indices of demo and check during 2017-18, 2018-19 and 2019-20

Year	Cotton equivalent ratio		% increase in yield over check	Extension gap (kg/ha)	Technology gap (kg/ha)	Technology index
	Cotton + Redgram (Demo)	Sole Cotton (Check)				
2017-18	3025	2000	51.25	1025	755	19.9
2018-19	2382	1900	25.36	482	1398	36.9
2019-20	3698	3316	11.51	382	82	2.1
Mean	3035	2405	29.37	630	745	19.6

The average extension gap is 1025 kg/ha, 482 kg/ha ad 382 kg/ha during the 2017-18, 2018-19 and 2019-20 respectively and the mean extension of gap of three years is 630 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 745 kg/ha and 19.6 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 2017-18 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 2017-18, 2018-19 and 2019-20

Year	COC (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
2017-18	34750	31000	120800	90000	86050	59000	2.4	1.9	575	393
2018-19	70660	73060	126882	101590	56222	28530	1.78	1.38	379	192
2019-20	57550	56900	185014	165800	127464	108900	3.23	2.92	855	702
Mean	54320	53653	144232	119130	89912	65476	2.47	2.06	592	429

The mean cost of cultivation is 54320 Rs/ha and 53653Rs/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.144232 ha^{-1} and Rs. 119130 ha^{-1} and net reurns Rs.89912 ha^{-1} and Rs. 65476 ha^{-1} 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 2.47: 1 and 2.06: 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]. Krishna Reddy *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 592/ha in demo with adoption of Cotton + Redgram intercropping system over check Rs.429 /ha. 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.

Table 4: Demonstration of Intercropping of Redgram in Cotton 2017-18

S. No	Name	Village/Mandal	Yield(kg/ha)		FP	Relative Equivalent Yield of cotton (kg $ha^{-1)}$
			Cotton	Redgram	Cotton	
1	C.Prabhakar Reddy	Chittanur/Marrikal	1250	1000	1750	2850
2	Gangadhara Reddy	Damagnapur/Marrikal	2000	750	2250	3200
	Average Yield		1625	875	2000	3025
	Cost of cultivation(Rs/ha)		34750		31000	
	Net returns(Rs/ha)		86050		59000	
	B:C ratio		2.4:1		1.9:1	

2018-19

S. No	Name	Village/Mandal	Yield (kg ha^{-1}) Demo		FP	Relative Equivalent Yield of cotton(kg $ha^{-1)}$
			Cotton	Redgram	Cotton	
1	M.Sathanna	Gopanpally/Devarakadra	1600	650	1700	2316
2	K Narayanreddy	Gopanpally/Devarakadra	1450	550	1650	2056
3	M.Ushanna	Gopanpaly/Devarakadra	2000	500	2220	2473
4	Shanthanna	Gopanpally/Devarakadra	1550	625	1700	2239
5	G.Narayanreddy	Gopanpally/Devarakadra	2000	750	2250	2826
	Average Yield		1720	615	1900	2382
	Cost of cultivation(Rs/ha)		70660		73060	
	Net returns(Rs/ha)		56222		28530	
	B:C ratio		1.78		1.38	

2019-20

S. No	Name	Village/Mandal	Yield (kg ha^{-1}) Demo		FP	Relative Equivalent Yield of cotton(kg ha$^{-1)}$
			Cotton	Redgram	Cotton	
1	M.Tirupati Reddy	Gopanpally/Devarakadra	3240	525	3450	3837
2	C.Narsimha	Gopanpally/Devarakadra	2913	595	3120	3603
3	K.Raghavulu	Gopanpaly/Devarakadra	2975	540	3320	3601
4	Srinivasulu	Gopanpally/Devarakadra	3170	510	3340	3762
5	Vijay Bhaskar Reddy	Gopanpally/Devarakadra	3025	570	3350	3686
	Average Yield		3065	3065	3316	3698
	Cost of cultivation(Rs/ha)		57550		56900	
	Net returns(Rs/ha)		127464		108900	
	B:C ratio		3.23:1		2.92:1	

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.

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