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Impact of improved production technologies on yield of rice fallow pulses in Cauvery delta zone

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Abstract
The Cauvery Delta Zone (CDZ) has a total land area of 1.45 million ha, which is equivalent to 11% of the state area. In this zone, rice fallow pulses are cultivated regularly after the *Samba* rice crop in December- January contributing a major share (>40%) to pulse production in the state. Nearly 3.1 lakh ha of *Samba* rice area is under rice fallow/ follow pulses and the yield realized ranged from 300 to 500 kg ha^{-1} which is low compared to the potential yield under irrigated conditions. Since there is a huge scope to increase the yield under this situation by creating awareness on latest technologies, Tamil Nadu Rice Research Institute, Aduthurai intervened by conducting Front Line Demonstrations (FLDs) with latest technologies as a full package. The package included improved practices *viz.* varieties and technologies for crop establishment, weed, nutrient, pest and disease management and moisture stress mitigation in blackgram and greengram. A total of 87 FLDs were conducted in Thanjavur, Tiruvarur, Nagapattinam, Trichy and Cuddalore districts during 2015- 18. The yield obtained in individual farmer's holding revealed that, in blackgram, a maximum grain yield of 753 kg ha^{-1} was obtained with latest technologies at Nannilam Block of Tiruvarur district which is 17.5% higher than farmer's practice (641 kg ha^{-1}). In terms of monetary advantage, 13.6% higher net return was realized. In greengram, a maximum grain yield of 688 kg ha^{-1} was obtained at Vadamattam of Tiruvarur district which is 23.3% higher than farmer's practice (558 kg ha^{-1}) with 21.3% increased net return. It is inferred that, the increase in awareness level on varieties, time of sowing, seed rate, seed treatment, machinery for rice harvest, herbicide application, foliar spray, moisture stress mitigation and pest and disease management contributed to higher yields and income.

Keywords: Cauvery Delta Zone, rice fallow pulses, blackgram, greengram.

Introduction
Pulses are the very vital component of the food and economy of the Indian subcontinent. The country is the largest producer and consumer of pulses. The area under pulses in India is 25 million hectare, production is 16.47 million tones and productivity is 652 kg ha^{-1} (Agricultural Statistics at a Glance, 2016) [1]. Among the pulses, blackgram and greengram contribute to 10% and 7% of the total pulses production of the country, respectively.

Though India accounts to 25% of the world's pulse production, the country is also the largest importer of pulses. The import in 2016 was 5.7 million tonnes of pulses. Despite the large production and import, the per-capita availability of pulses in India is only 43 g day^{-1} against the ICMR recommendation of 65 g day^{-1}.

In Tamil Nadu, the Cauvery Delta Zone (CDZ) has a total land area of 1.45 million ha, which is equivalent to 11% of the state area and this zone is the potential zone for pulse cultivation. In this zone, the average annual rainfall is about 1,078 mm and nearly 65 per cent of the total rainfall is received during the north east monsoon season (October to December). The soils are generally of alluvial origin and these soils have good capacity for adsorption and retention of water and plant nutrients.

The major share of pulses in Tamil Nadu in terms of area and production comes from the Cauvery Delta region. In this zone pulses are grown in a larger area under no tillage condition as a relay crop to make use of the residual moisture and nutrients (Nagarajan *et al.*, 2004) [8]. Normally, rice fallow pulses are cultivated regularly after the *Samba* rice crop in nearly 3.1 lakh ha in December- January contributing a major share (>40%) to pulse production in the state. Under rice fallow pulse cropping system, blackgram and greengram occupy an area of 1.98 lakh hectares. Generally, the grain yield ranged from 300 to 500 kg ha^{-1} depending upon the management practices followed during the crop growth period.

The reasons for low productivity are low adoption of high yielding varieties, non-availability of quality seeds in time, delay in sowing, inadequate plant population, low adoption of improved agronomic practices, heavy weed infestation, low adoption of foliar nutrient application, no supplemental irrigation and inadequate plant protection.

In CDZ, districts such as Thanjavur, Tiruvarur, Nagapattinam and Cuddalore account for 47% area and 53% of the total production of the state and there is a huge potential to increase the productivity of rice fallow pulses in this zone. In this context, Front Line Demonstrations (FLDs) were conducted in rice fallow blackgram and greengram in the farmers' fields in Thanjavur, Tiruvarur, Nagapattinam, Cuddalore and Trichy districts in order to increase the awareness among the farmers on improved technologies for increasing the productivity of rice fallow pulses.

Review of literature

The rice fallow pulses are cultivated only with residual moisture and nutrients. Since the pulse crop is sown as a relay crop before harvest of rice, field preparation and basal fertilizer application are not possible. Hence, for getting good yield, seed treatment with biofertilizers and foliar application of nutrients plays a vital role. In addition, grasses and broad leaved weeds are also dominant in the rice ecosystem which is causing more yield loss in the subsequent pulse relay crop.

Sandil *et al*. (2015) [10] reported that combined application of propaquizafop + imazethapyr herbicides as post emergence was more effective against mixed weed flora in soybean. Growth parameters, yield attributes and seeds yield were superior under this treatment. Panda *et al.* (2015) [9] reported that post-emergence application of propaquizafop + imazethapyr was found more remunerative in soybean. Kumar *et al.* (2018) [6] found that post-emergence tank mix combination of propaquizafop + imazethapyr at 20 DAS was more effective in reducing the dry weight of weeds and were comparable to hand weeding (20 and 40 DAS) in improving growth and yield of soybean.

Pulse crops generally respond very well to foliar nutrient application. Foliar nutrients are known to influence a wide array of physiological parameters like alteration of plant archetype, assimilate partitioning, promotion of photosynthesis, uptake of mineral ions, enhancing nitrogen metabolism, promotion of flowering, uniform pod formation, increased mobilization of assimilates to defined sinks, improved seed quality, induction of synchrony in flowering and delayed senescence of leaves (Sharma *et al.*, 2013) [11].

Gupta *et al.* (2011) [4] found out that application of 20 kg N ha^{-1} + rhizobium + PSB + PGPR + 2% urea spray at flowering and 10 days thereafter resulted in higher nodule number and nodule dry weight in chickpea. Devaraju and Senthivel (2018) [3] stated that application of pulse wonder @ 5 kg ha^{-1} spray increased the plant height, dry matter accumulation and yield attributes which resulted in higher yield (870 kg ha^{-1}) and higher net returns (Rs. 22149 ha^{-1}) with B:C ratio of 2.19 in blackgram.

Vinoth (2013) [14] concluded that soil application of recommended NPKS and $ZnSO_4$ at basal and foliar spray of 1.125% TNAU pulse wonder at flowering and 15 days later is the profitable nutrient management package to blackgram for getting higher income through higher yield and benefit cost ratio (2.45).

Materials and methods

In order to increase the awareness among the farmers on improved production technologies in rice fallow pulse cultivation, Front Line Demonstrations were conducted in CDZ with a objective of getting more yield under rice fallow blackgram and greengram. A total of 87 FLDs (66 in blackgramand 21 in greengram) were conducted under rice fallow situation in Thanjavur, Tiruvarur, Nagapattinam, Cuddalore and Trichy districts during 2015- 2018.

The latest production technologies in comparison with the farmers' practices were demonstrated in the selected farmer's holdings. The package technology included improved varieties and technologies for crop establishment, weed, nutrient, pest and disease management and moisture stress mitigation as follows:

Variety	ADT 3and ADT 6 blackgram and ADT 3 greengram
Time of sowing	December – January
Seed rate	30 kg ha^{-1}
Seed treatment	Seed treatment with polymer (3 ml kg^{-1} of seeds), imidachloprid (1.5 ml kg^{-1} of seeds), *P. fluorescens* (10 g $kg^{-1}$of seeds), rhizobium (30 g kg^{-1} of seeds) and phosphobacteria (30 g kg^{-1} of seeds)
Method of sowing pulse and rice harvest	Sowing rice fallow pulse on appearance of hair line cracks in a waxy soil (moisture) condition and harvesting rice crop 4 to 6 days later by either mini combine or chain/belt type combine harvester
Herbicide application	Application of imazethapyr 10% SL @ 500 ml ha^{-1} and quizalofop ethyl 5% EC @ 1 l ha^{-1} when weeds are at 2- 3 leaf stage
Foliar spray	Pulse wonder @ 5 kg ha^{-1} at flowering
Stress mitigation	PPFM foliar spray @ 1 ml l^{-1} and supplemental irrigation with harvested water in farm pond using mobile sprinkler
Plant protection measures	Monitoring of pests and diseases throughout the crop period and spraying of thiomethoxam @ 100 g ha^{-1} against sucking pests, chlorantraniliprole @ 150 ml ha^{-1} against pod borers, carbendazim @ 250 g ha^{-1} against powdery mildew and soil application of *P. fluorescens* @ 2.5 kg ha^{-1} against root rot disease

Results

The grain yield obtained under Improved Practices and Farmers' Practices were given in Table 1.

Table 1: Grain yield of blackgram and greengram under Improved Practices (IP) and Farmers' Practices (FP) in Cauvery Delta Zone

S. No.	Block	Blackgram			Greengram		
		No. of holdings	Grain yield (kg ha^{-1})		No. of holdings	Grain yield (kg ha^{-1})	
			IP*	FP*		IP*	FP*
I.	**Thanjavur**						
	Kumbakonam	4	663	555	1	546	444
	Thirupananthal	2	665	559			
	Thiruvidaimaruthur	11	657	552	8	550	459
II.	**Tiruvarur**						
	Kodavasal	4	670	559	2	561	456
	Mannargudi	1	610	510			
	Nannilam	10	625	535	3	544	455
	Thiruthuraipoondi	2	578	498	1	578	507
	Thirumarugal				1	528	429
	Thiruvarur	1	667	561	2	504	415
	Valangaiman	7	595	507			
III.	**Nagapattinam**						
	Alangudi	2	654	556			
	Anathandavapuram	1	566	493			
	Keezhaparuthigudi	1	752	640			
	Kuthalam	8	704	612	1	583	498
	Mayiladuthurai	1	627	520			
	Nagapattinam				1	467	379
	Pazhinjanallur	2	627	524			
	Sembanarkovil				1	596	477
	Thirumarugal	2	719	624			
IV.	**Cuddalore**						
	Kothattai	2	701	580			
	Odakanallore	2	630	527			
	Sathamangalam	1	617	523			
IV.	**Trichy**						
	Kumaravayalur	2	727	603			

IP*: Improved Practices, FP*: Farmers' Practices

The block-wise average yield revealed that higher grain yield of 752 kg ha^{-1} was recorded in blackgram in Keelaparuthigudi in Nagapattinam district which is 17.5% higher than farmer's practice (640 kg ha^{-1}). With respect to the yield in the individual farmer's holding, a maximum grain yield of 753 kg ha^{-1} was obtained at Nannilam Block of Tiruvarur district which is 17.5% higher than farmer's practice (641 kg ha^{-1}) which fetched 13.6% higher net return.

The block-wise average yield of greengram revealed that higher grain yield of 596 kg ha^{-1}was recorded in Senbanarkoil block of Nagapattinam which is 24.9% higher than farmer's practice (477 kg ha^{-1}). When comparing the yield in the individual farmer's holding, a maximum grain yield of 688 kg ha^{-1} was obtained at Vadamattam of Tiruvarur district which is 23.3% higher than farmer's practice (558 kg ha^{-1}) with 21.3% increased net return.

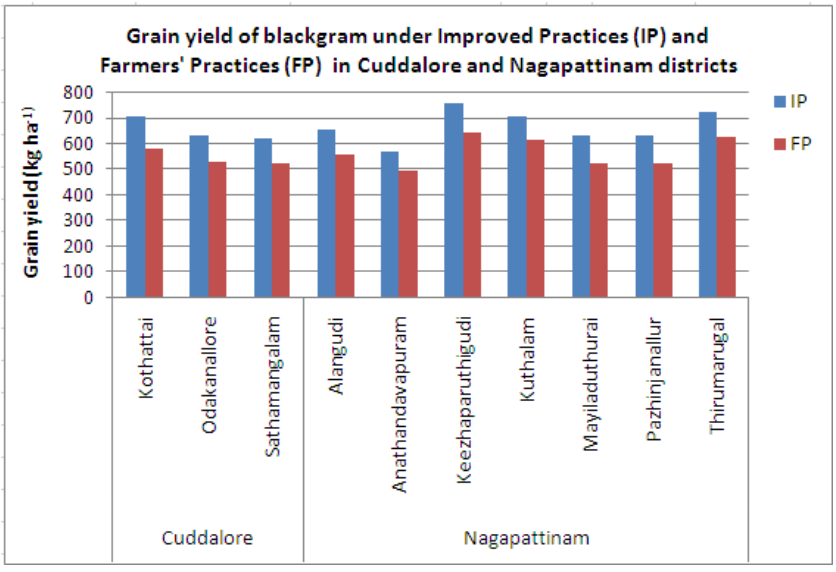

Fig 1: Grain yield of blackgram under Improved Practices (IP) and Farmers' Practices (FP) in Cuddalore and Nagapattinam districts

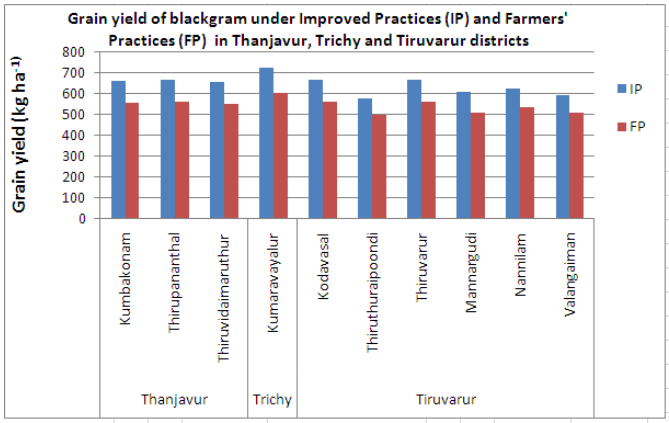

Fig 2: Grain yield of blackgram under Improved Practices (IP) and Farmers' Practices (FP) in Thanjavur, Trichy and Tiruvarur districts

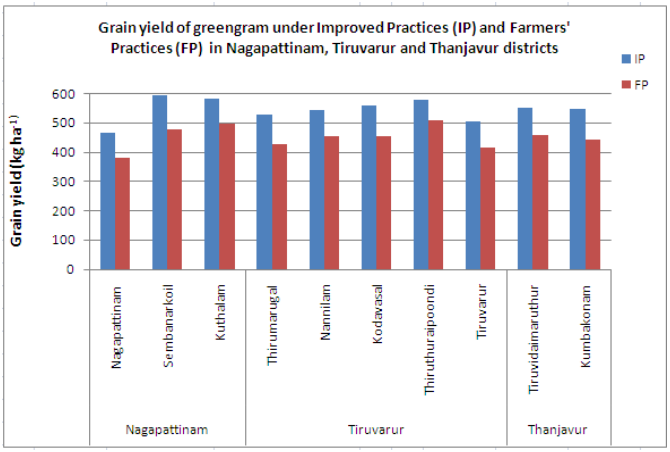

Fig 3: Grain yield of greengram under Improved Practices (IP) and Farmers' Practices (FP) in Nagapattinam, Tiruvarur and Thanjavur districts

Discussion

Adoption of suitable variety, using good quality seeds and correct seed rate, treating the seeds with pesticides, biofertilizers and biocontrol agents, sowing at optimum soil moisture condition, rice harvest using mini combine/ chain/ belt type harvester, weed management through herbicides, supplementing nutrients through foliar spray, moisture stress mitigation and adoption of proper pest and disease management measures played a vital role in increasing the grain yield when compared to the Farmers' Practices.

In the rice fallow pulse cultivation, weed management and foliar nutrition play a vital role in influencing the grain yield. Proper weed management eliminates the two major issues namely the completion for moisture and nutrients which are the most limiting factors under rice fallow pulse cultivation since the crop is raised only with residual moisture and nutrients. The importance of weed management in getting good yield was reported by Sandil *et al*. (2015) [10], Panda *et al.* (2015) [9] and Kumar *et al.* (2018) [6].

Since the rice fallow pulse seeds are sown in the standing rice crop before rice harvest, basal fertilizer application is not possible and hence foliar spray plays a very vital role in supplementing the soil residual nutrient supply. Kumar *et al.* (2013) [5] also reported that foliar spray is certainly considered as a supplement to soil nutrient application. Foliar nutrients also facilitate easy and quick absorption of nutrients. The improper pod filling is one of the major causes for low yield in pulses. The nutrient sprays could improve the physiological efficiencies and play a significant role in raising the crop yields (Dashora and Jain, 1994) [2].

Foliar supplement of nutrients could have enhanced the level of available nutrients resulting in better plant growth and development (Uddling *et al.*, 2007) [13]. TNAU pulse wonder would have accelerated various metabolic processes by means of macro and micronutrients (Kumar *et al.*, 2018) [6]. The presence of macro and micro nutrients and growth promoters in pulse wonder could able to increase the plant growth and yield.

Nutrients applied through foliage are absorbed better, leading to better activity of functional root nodules (Solaiappan *et al.*, 2002) [12]. The foliar nutrients might have supplemented the nutrient demand of the crop at the critical stages, resulting in better growth and development of the crop and ultimately the yield attributing characters and grain yield (Manivannan *et al.*, 2002) [7]. In addition to foliar spray of nutrients, PPFM (Pink Pigmented Facultative Methylotroph) 1ml l^{-1} foliar spray and supplemental irrigation using harvested water in farm pond were helpful in moisture stress mitigation and getting good yield.

Summary and conclusion

It is inferred that, the increase in awareness level on varieties, seed quality, seed rate, seed treatment, time of sowing, correct type of machinery for rice harvest, use of herbicides, foliar spraying of nutrients, stress mitigation and pest and disease management played a vital role in increasing the grain yield when compared to the Farmers' Practices which contributed to higher yields and income.

The very important aspects which contributed to increased yield are improved varieties, maintenance of optimum plant population through adoption of correct seed rate, optimum sowing time and suitable machinery for rice harvest, use of herbicides for effective management of grasses and broad leaved weeds and supplemental irrigation for alleviating terminal moisture stress. Averaged over all districts, 14.4% increase in net return in blackgram and 16.4% in greengram was realized with Improved Practices. Hence, it can be concluded that increase in awareness level on improved production technologies contributed to higher yields and income in rice fallow blackgram and greengram cultivation in CDZ.

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