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Crop Diversification of Cotton (*Gossypium hirsutum*) based Cropping System for High Resource Use Efficiency

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ABSTRACT

Background: Cotton production is labour intensive in almost all the developing countries where it is picked by hand. However, due to acute labour shortage in recent times, mechanized harvesting is gaining momentum. Mechanized harvesting requires the application of defoliants, which reduces the cost of labour used for picking cotton and maximum cotton can be picked in a single pick (one picking) and providing timely sowing of next crop. So, farmers can get benefit of two crops instead of one single long duration cotton crop. Researchers have conducted various studies on defoliation in cotton using different chemicals and different defoliation methods. However, in India their usage could not be exploited much due to their limited availability.

Methods: A field experiment entitled "Studies on defoliants in high density planting cotton-greengram sequence" was conducted during 2018-2019 and 2019-2020 on clay soils at Agricultural College Farm, Bapatla. Crop diversification of cotton with pulses (Greengram) is an alternative cropping system for monocropping of cotton to get higher returns and high land use efficiency.

Result: Total cotton equivalent yield was highest with dropp ultra @ 250 ml ha^{-1} (D_1) which was on par with Etherel @ 3000 ppm (D_3) in 2018 and in pooled data. 80% boll opening recorded maximum total cotton equivalent yield, which was on par with node above cracked boll. Land use efficiency and production use efficiency were highest in late sown (80% boll opening) plots. The highest net returns and returns per rupee investment were noticed with application of defoliant dropp ultra @ 250 ml ha^{-1} (D_1) and at 80% boll opening.

Key words: Cotton, Greengram, Land use efficiency, System productivity.

INTRODUCTION

Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. In India, there are ten major cotton growing states which are divided into three zones, *viz.* north zone, central zone and south zone. North zone consists of Punjab, Haryana and Rajasthan. Central zone includes Madhya Pradesh, Maharashtra and Gujarat. South zone comprises Andhra Pradesh, Telangana, Karnataka and Tamil Nadu. In Andhra Pradesh Kurnool, Guntur, Anantapur are the major cotton producing districts. Lower yields were recorded due to uneven opening of bolls and labour-intensive methods of cultivation, poor harvesting skills, lack of irrigation facilities, coupled with non-availability of quality seeds. Defoliation is an important management practice associated with high yields and high quality in cotton. It allows earliness in crop. Timely defoliant application leads to earliness in cotton with synchronous maturity, vacating the field 10-15 days earlier than the normal cotton. It paves way for introduction of short duration pulses like greengram in sequence. Thus farmers will get benefit of two crops in terms of production and profit instead of one long duration crop. Rotating cotton with crops less susceptible to the pests and diseases (*i.e.* wheat or pulses) in order to break the cotton/pest life cycle is also feasible. The inclusion of such crops will help to improve the economic situation of small and marginal farmers because of the higher income from such crops. Therefore, this study was carried out to determine the most productive, resource-use-efficient, remunerative and sustainable cropping system.

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MATERIALS AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla, which is situated in coastal region of Krishna Agro-Climatic Zone of Andhra Pradesh during *kharif* 2018-19and 2019-20. The soil of the experimental field was clay in texture, neutral in reaction, medium in organic carbon and low in available nitrogen, medium in phosphorus and high in available potassium during both the years. The experiment was laid out in Split plot design with four replications and nine treatments. The main plots were three defoliants *viz.*, Dropp Ultra (Thiadizuron+Diuron) @ 250 ml ha^{-1} (D_1), mepiquat chloride @ 100 ml ha^{-1} (D_2) and Etherel @ 3000 ppm (D_3). The sub plots consisted of three times of applications *viz.*, 80% boll opening (T_1), NACB - node above cracked boll (T_2) and NAWF- node above white flower (T_3)

in *kharif* cotton. Cotton variety Suraj was sown on 07thAugust 2018 and 5th August, 2019 with a spacing of 60 cm × 15 cm. Fertilizers @ 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} were applied due to high density planting of cotton variety, uniformly in the form of urea, single superphosphate and muriate of potash. Entire quantity of phosphorus was applied basally. Nitrogen and potassium were applied in three splits at 30, 60 and at 90 DAS. Recommended cultural practices and plant protection measures were followed throughout the crop growing season. Total number of fully opened leaves on main stem and branches were recorded before application of chemical defoliants and at alternate days interval of application up to 21 days after defoliant spray and calculated as the ratio of number of leaves present on the plant after spraying of defoliants to the number of leaves present on the plant before spraying defoliants and expressed in percentage. After picking of cotton in different treatments, the stubbles were removed. The experimental plots were not ploughed and the original layout was not disturbed during both the years of study. Pre-sowing irrigation was given after harvest of each treatment and paraquat was applied in those treatmental plots to arrest the regrowth of cotton stubbles. Sowing of greengram was done at three different dates, after picking of seed cotton only once as per the treatmental maturity. Seeds of greengram were sown at a spacing of 30 cm×10 cm on 11-01-2019 in NAWF plots, on 20-01-2019 in NACB plots and on 03-02-2019 in 80 per cent boll opened plots during first year of study (2018-19) and on 07-01-2020 in NAWF plots, on 18-01-2020 in NACB plots and on 27-01-2020 in 80 per cent boll opened plots during second year of study (2019-20), respectively. Data was taken on plant height, drymatter production and yield.

System productivity in terms of cotton equivalent yield, land use efficiency and production use efficiency and economics were calculated.

Cotton equivalent yield =

$$\frac{\text{Yield of greengram (kg)} \times \text{Price of greengram kg}^{-1}}{\text{Price of cotton kg}^{-1}}$$

The land use efficiency was worked out by dividing total duration of crops in individual sequence by 365 days and multiplied by 100 (Tomar and Tiwari, 1990). Production efficiency values were obtained by dividing total net returns and yield of a sequence by total duration of crop sequence (Tomar and Tiwari, 1990). Statistical analysis for the data was done following the analysis of variance technique for split-plot design as suggested by Gomez and Gomez (1984). Statistical significance was tested by applying F-test at 0.05 level of probability and critical differences were calculated for those parameters, which were found significant ($p< 0.05$) to compare the effects of different treatments.

RESULTS AND DISCUSSION

Performance of *rabi* greengram after cotton

Early termination of cotton was possible with defoliants applied at accurate time without compromising the cotton yield and quality, which facilitated sowing of next crop on the same land. In this experiment, different defoliants were tried at different times in *kharif* cotton. Then greengram was sown in the plots as and when the cotton crop was harvested. Residual effect of defoliants on greengram crop growth and yield was studied in terms of plant height, drymatter accumulation and haulm yield and seed yield during both the years of study.

Plant height (cm) of greengram

Plant height of greengram was not affected by defoliation treatment and times of application during both the years and in pooled data (Table 1). The interaction effect between these two factors was also found non-significant. During both the years and in pooled data, numerically the highest plant height was obtained in Etherel @ 3000 ppm applied in cotton as defoliant. As regards time of application, early sown crop *i.e* in node above white flower (NAWF) recorded maximum plant height during both the years and in pooled data, respectively.

Dry matter accumulation at harvest (kg ha^{-1})

There were no significant differences in drymatter accumulation of greengram at harvest due to defoliants applied to previous crop during both the years and in pooled data. However, time of application exerted significant differences in drymatter accumulation of greengram. During first year of experiment, greengram sown in Node Above Cracked Boll (NACB-T_2) plots recorded highest drymatter and was found to be on par with early sown plots (T_3- Node Above White Flower (NAWF) and superior over late sown plots (T_1- 80% Boll Opening) The same trend was observed during second year of experiment in 2019 and in pooled data.

Seed yield (kg ha^{-1})

During both the years, among the various preceding defoliant treatments, the highest greengram seed yield was recorded under Dropp Ultra @ 250 ml ha^{-1} which was on par with Etherel @ 3000 ppm and superior over Mepiquat chloride @ 100 ml ha^{-1}. In pooled data, D_1 (Dropp Ultra @ 250 ml ha^{-1}) was significantly superior over other treatments. During both the experimented years and in pooled data, Node Above Cracked Boll (NACB) sown treatment recorded highest yield which was on par with early sown plots *i.e* node above white flower treatment which in turn was on par with late sowing (T_1- 80% boll opening) treatment during two years of experiment and in pooled data. Interaction between these two factors was found to be non-significant during both experimented years and in pooled data.

Haulm yield (kg ha^{-1})

Preceding defoliants and its time of application at different stages had a significant effect on haulm yield of greengram (Table 2). The highest haulm yield was recorded under Dropp Ultra @ 250 ml ha^{-1} (D_1) which was significantly superior over Etherel @ 3000 ppm (D_3) and Mepiquat chloride @ 100 ml ha^{-1} (D_2) during both the years and also in pooled

Table 1: Plant height (cm) and drymatter accumulation (kg ha^{-1}) at harvest of greengram during *rabi* in sequence after *kharif* cotton during 2018-19, 2019-2020 and pooled data.

Treatment	2018-19		2019-20		Pooled data	
	Plant height (cm) at harvest	Dry matter accumulation at harvest (kg ha^{-1})	Plant height (cm) at harvest	Dry matter accumulation at harvest (kg ha^{-1})	Plant height (cm) at harvest	Dry matter accumulation at harvest (kg ha^{-1})
Defoliants						
D_1- Dropp ultra	43.5	2547	46.7	2805	45.1	2676
D_2- Mepiquat chloride	42.6	2337	47.3	2596	44.9	2466
D_3-Etherel	44.1	2582	47.6	2841	45.9	2711
SEm±	1.72	86.5	1.69	81.5	1.73	83.8
CD (p = 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	13.7	12.0	12.4	10.3	13.3	11.1
Time of application						
T_1- 80% Boll opening	42.7	2322	46.7	2580	44.7	2451
T_2- NACB	42.5	2618	47.2	2877	44.8	2748
T_3-NAWF	43.1	2526	47.7	2784	45.4	2655
SEm±	1.78	62.4	1.39	58.1	1.38	59.8
CD (p = 0.05)	NS	185	NS	173	NS	178
CV (%)	14.2	8.7	10.2	7.3	10.6	7.9
Interaction						
D*T	NS	NS	NS	NS	NS	NS
T*D	NS	NS	NS	NS	NS	NS

Table 2: Seed and haulm yield (kg ha^{-1}) of greengram during *rabi* in sequence after *kharif* cotton during2018-19, 2019-2020 and pooled data.

Treatment	2018-19		2019-20		Pooled data	
	Seed yield	Haulm yield	Seed yield	Haulm yield	Seed yield	Haulm yield
Defoliants						
D_1- Dropp ultra	562	1778	575	1891	568	1834
D_2- Mepiquat chloride	516	1254	517	1432	517	1343
D_3-Etherel	526	1406	558	1573	542	1490
SEm±	10.3	78.8	11.2	71.6	8.3	74.9
CD (p = 0.05)	36	273	39	248	29	259
CV (%)	6.7	18.4	7.1	15.2	7.3	16.7
Time of application						
T_1- 80% Boll opening	514	1333	524	1506	519	1420
T_2- NACB	559	1564	565	1747	562	1656
T_3-NAWF	531	1541	560	1642	545	1591
SEm±	11.9	63.9	11.0	62.5	11.5	62.6
CD (p = 0.05)	35	190	33	186	34	186
CV (%)	7.7	15.0	7.0	13.3	7.3	13.9
Interaction						
D*T	NS	NS	NS	NS	NS	NS
T*D	NS	NS	NS	NS	NS	NS

data. With regards to time of application node above cracked boll (T_2) recorded highest drymatter which was on par with T_3 during 2018-19.

The same trend was followed in 2019-20 and in pooled data. Lowest haulm yield was obtained in T_1 plots which was significantly inferior over other treatments in 2018, whereas it was at par with T_3(node above white flower) during 2019 and in pooled data. The interaction was found to be non-significant during the two years of study as well as in pooled data.

Greengram germination, plant height, drymatter and yield (seed and haulm) were not affected by residual defoliants. 90% defoliation and 80% boll opening was recorded with high rates of Dropp Ultra and Etherel, however no adverse effects was obtained either on cotton or greengram in sequence. This study suggested that,

Table 3: System productivity interms of total cotton equivalent yield (kg ha^{-1}) of cotton-greengram sequence.

Treatment	2018-2019				2019-2020				Pooled data			
	Greengram yield (kg ha^{-1})	Cotton equivalent yield (kg ha^{-1})	Cotton yield (kg ha^{-1})	Total cotton equivalent yield (kg ha^{-1})	Greengram yield (kg ha^{-1})	Cotton equivalent yield (kg ha^{-1})	Cotton yield (kg ha^{-1})	Total cotton equivalent yield (kg ha^{-1})	Greengram yield (kg ha^{-1})	Cotton equivalent yield (kg ha^{-1})	Cotton yield (kg ha^{-1})	Total cotton equivalent yield (kg ha^{-1})
Defoliants												
D_1- Dropp ultra	562	719	2006	2725	575	730	2114	2844	568	724	2060	2784
D_2- Mepiquat chloride	516	661	1392	2053	517	657	1439	2096	517	659	1416	2074
D_3-Etherel	526	673	1955	2627	558	709	1758	2467	542	691	1857	2547
SEm±	10.3	13.2	74.4	79.8	11.2	14.2	94.7	97.6	6.6	10.5	73.0	75.2
CD (p = 0.05)	36	257	257	276	39	49	328	338	23	36	253	260
CV (%)	6.7	6.7	14.4	11.2	7.1	7.1	18.5	13.7	4.2	5.2	14.2	10.6
Time of application												
T_1- 80% Boll opening	514	658	2032	2690	524	666	1984	2650	519	662	2008	2670
T_2- NACB	559	716	1887	2602	565	718	1732	2450	562	717	1810	2526
T_3-NAWF	531	679	1434	2113	560	711	1595	2307	545	695	1515	2210
SEm±	11.9	15.2	88.1	87.3	11.0	14.0	73.1	72.4	10.0	13.0	67.2	67.4
CD (p = 0.05)	35	45	262	259	33	42	217	215	30	39	200	200
CV (%)	7.7	7.7	17.1	12.3	7.0	7.0	14.3	10.2	6.4	6.5	13.1	9.5
Interaction												
D*T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T*D	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

defoliants can be efficiently used (Dropp Ultra and Etherel) found to be safe for cotton- greengram sequence. These views confirm the previous findings of Foote *et al.* (2015) and Du ming-wei *et al.* (2013). Defoliants used in cotton (Thidiazuron + Diuron) did not show any detrimental effects on legume (clover and Austrian pea) as reported by Foote *et al.* (2015).

Total system productivity

The total system productivity in terms of cotton equivalent yield are presented in Table 3 and depicted in Fig 1. Data revealed that the total cotton equivalent yield was highest with Dropp Ultra @ 250 ml ha^{-1} (D_1) which was on par with Etherel @ 3000 ppm (D_3) during first year of experiment and in pooled data. During second year of study, Dropp Ultra alone recorded significantly highest total cotton equivalent yield. As regards time of application, (T_1) 80% Boll Opening recorded maximum total cotton equivalent yield which was on par with Node above Cracked Boll during both the years and in pooled data, respectively. The lowest total cotton equivalent yield was obtained with Node Above White Flower (T_3) during both the years and in pooled data. In 2019, it was found on par with node above cracked boll.

Cotton-greengram sequence in late sown (80% Boll Opening) treatment used the land for more period in a year having highest land use efficiency (LUE) of 66.0% and 64.7% during 2018-19 and 2019-2020, respectively followed by cotton- greengram (node above cracked boll) with 63.6% and 63.3% LUE during both the years (Table 4).

Production Use Efficiency (Table 5) in terms of yield and returns was more in 80% boll opening during both the years, respectively. During first year of experiment node above cracked boll also had highest production use efficiency in terms of kg ha^{-1} day^{-1}. These results were similar with Buttar and Singh (2013).

Economics of cropping system (cotton-greengram)

The highest gross returns, net returns and returns per rupee investment (Table 6) were noticed with application of defoliant Dropp Ultra @ 250 ml ha^{-1} (D_1) and defoliants applied at 80% Boll Opening (T_1). These results are in conformity with the findings of Rajni *et al.* (2011) and Mrunalini *et al.* (2019).

Table 4: Land use efficiency of cotton-greengram sequence.

Defoliants	Time of application	2018-19				2019-20			
		Cotton (180)*	Geengram (75-80)*	Total duration (days)	LUE (%)	Cotton (180)*	Greengram (75-80)*	Total duration (days)	LUE (%)
Dropp Ultra	T_1 (80% Boll opening)	173	68	241	66.0	165	71	236	64.7
	T_2 (Node above cracked boll)	159	73	232	63.6	156	75	231	63.3
	T_3 (Node above white flower)	150	75	225	61.6	147	76	223	61.1
Mepiquat chloride	T_1 (80% Boll opening)	173	68	241	66.0	165	71	236	64.7
	T_2 (Node above cracked boll)	159	73	232	63.6	156	75	231	63.3
	T_3 (Node above white flower)	150	75	225	61.6	147	76	223	61.1
Etherel	T_1 (80% Boll opening)	173	68	241	66.0	165	71	236	64.7
	T_2 (Node above cracked boll)	159	73	232	63.6	156	75	231	63.3
	T_3 (Node above white flower)	150	75	225	61.6	147	76	223	61.1

*Figures in parenthesis are actual duration of the crops.

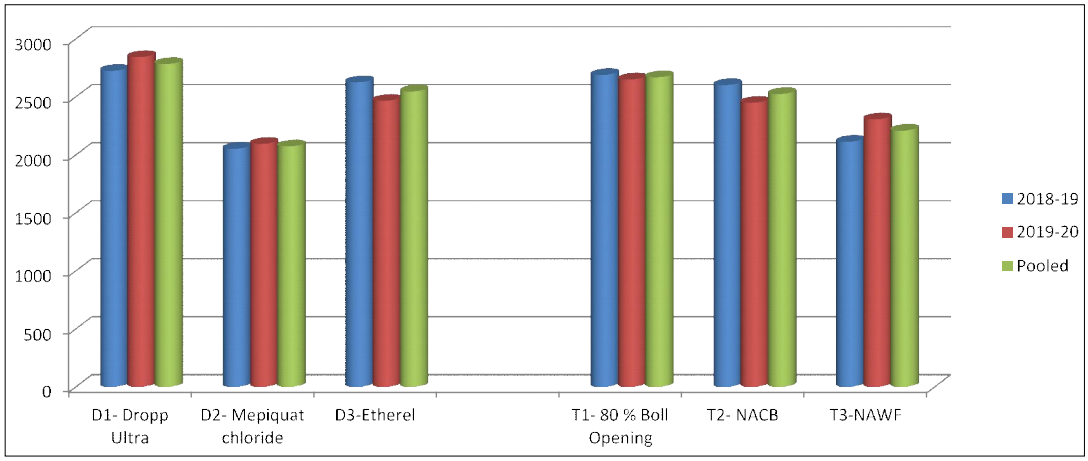

Fig 1: System productivity interms of total cotton equivalent yield (kg ha^{-1}) of cotton-greengram sequence.

Table 5: Production use efficiency of cotton-greengram sequence.

Defoliants	Time of application	2018-19		2019-2020	
		Production use efficiency (Rs. ha^{-1} day $^{-1}$)	Production use efficiency (kg ha^{-1} day $^{-1}$)	Production use efficiency (Rs. ha^{-1} day $^{-1}$)	Production use efficiency (kg ha^{-1} day^{-1})
Dropp Ultra	T_1 (80% Boll opening)	308.4	11.2	308.5	11.0
	T_2 (Node above cracked boll)	299.7	11.2	267.1	10.6
	T_3 (Node above white flower)	190.5	9.4	240.9	10.3
Mepiquat chloride	T_1 (80% Boll opening)	308.4	11.2	308.5	11.0
	T_2 (Node above cracked boll)	299.7	11.2	267.1	10.6
	T_3 (Node above white flower)	190.5	9.4	240.9	10.3
Etherel	T_1 (80% Boll opening)	308.4	11.2	308.5	11.0
	T_2 (Node above cracked boll)	299.7	11.2	267.1	10.6
	T_3 (Node above white flower)	190.5	9.4	240.9	10.3

Table 6: Economics of cropping system (cotton-greengram) in pooled data.

Treatment	Pooled data						
	Greengram yield (kg ha^{-1})	Cotton equivalent yield (kg ha^{-1})	Cotton yield (kg ha^{-1})	Total cotton equivalent yield (kg ha^{-1})	Gross returns (₹.ha^{-1})	Net returns (₹.ha^{-1})	Returns per rupee investment
Defoliants							
D_1- Dropp Ultra	568	724	2060	2784	153176	80692	2.1
D_2- Mepiquat chloride	517	659	1416	2074	114099	41570	1.6
D_3-Etherel	542	691	1857	2547	140068	65214	1.9
Time of application							
T_1- 80% Boll Opening	519	662	2008	2670	146844	73555	2.0
T_2- NACB	562	717	1810	2526	138910	65621	1.9
T_3-NAWF	545	695	1515	2210	121588	48299	1.7

CONCLUSION

Based on the study, Defoliants applied to cotton had no adverse effect on growth and yield of greengram in sequence. Considering the system, cotton-greengram in sequence, defoliant dropp ultra gave highest total cotton equivalent yield, which was on par with Etherel. Application of defoliants at 80% boll opening noticed maximum total cotton equivalent yield and it was comparable with defoliants applied at node above cracked boll (NACB).Concluded that, instead of monocropping of cotton, we can go for cotton-greengram cropping system as it is productive and remunerative.

Conflict of interst: None.

REFERENCES

Buttar, G.S. and Singh, S. (2013). Effect of Ethrel dose and time of application on growth, yield and duration of *Bt* cotton in semi arid region of Punjab. Journal of Cotton Research and Development. 27(1): 60-62.

Du Ming-Wei., Renxiao Ming., Tian Xiao-Li., Duan Liu-Sheng., Zhang Ming-Cai, Tan Wei-Ming and Li Zhao-Hu. (2013). Evaluation of harvest aid chemicals for the cotton-winter wheat double cropping system. Journal of Integrative Agriculutre. 12(2): 273-282.

Foote, W., Edmistein, K., Wells, R. and Jordan, D. (2015). Defoliant effects on cover crop germination, cover crop growth and subsequent cotton development. The Journal of Cotton Science. 19: 258-267.

Gomez, A.K. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons.

Mrunalini, K., Sree Rekha, M., Murthy, V.R.K. and Jayalalitha, K. (2019). Impact of harvest-aid defoliants on yield and economics of high-density cotton. Indian Journal of Agricultural Research. 53(1): 116-119.

Rajni Deol, J.S. and Brar, A.S. (2011). Effect of chemical defoliation on boll opening percentage, yield and quality parameters of Bt cotton. Indian Journal of Agronomy. 56(1):74-77.

Tomar, S.S. and Tiwari, A.S., (1990). Production potential and economics of different crop sequence. Indian Journal of Agronomy. 35(1): 30-35.