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Growth and yield of ELS cotton as influenced by method of planting, intercrops and fertilizer management in summer season

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Abstract

A field experiment was carried out during summer 2019 in field No. NA 2 at Eastern Block farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during 2019 to find out the establishment techniques of ELS cotton, suitable intercrops in between cotton rows and fertilizer management. The experiment field was geographically located in western agro climatic zone of Tamil Nadu at 11°N latitude and 77°E longitude and at an altitude of 426.7 meters above the Mean Sea Level (MSL). The texture of the experimental site was sandy clay loam. The experiment was laid out in randomized block design consist of two crop establishment methods *viz.*, transplanted cotton and direct seeded cotton and three different levels of fertilizer *viz.*, 75%, 100%, 125% NPK and three intercrops *viz.*, green gram, black gram and onion. Observations were recorded for survival percentage, growth and yield characters of cotton. Assessment of intercrop productivity. The results revealed that transplanted seedlings improved the survival rate of 20.45 % over the normal direct seeded cotton. Transplanted cotton seedling intercropped with black gram along with 125% fertilizer level gave higher growth and seed cotton yield of 3392.91Kgha⁻¹.

Keywords: Seedling transplanting, inter crop, seed cotton equivalent yield, land equivalent ratio, monetary equivalent ratio and weed smothering

Introduction

Cotton (*Gossypium hirsutum* L.) is not only India's most important fiber and cash crop also in the world. Because of its higher economic value among the cash crops, cotton is widely known as "King of Natural Fiber" and "White Gold" and also plays a significant role in the worldwide agricultural and industrial economy. It is widely grown in world tropical and subtropical regions in the more than 70 countries. Among that India is the one of the most important grower of cotton, contributes 60-75% of fibre to Indian textiles, more than one million metric ton of animal feed and cooking oil and 40 million metric ton of cotton stalks as biomass, also contributing nearly one-third of agricultural Gross Domestic Product (GDP) of the country. It is cultivated in India over an area of 125.84 lakh ha with a productivity of 486.33 kg.ha⁻¹ and the production is 360.48 lakh bales (Anonymous, 2019) [2]. In India, Tamil Nadu stands 1st in productivity (796.88 Kg ha⁻¹) instead of 11th position in area and production (Anonymous, 2019) [2].

Effective planting techniques are an essential non-monetary input, So as to ensure optimum plant population to get higher productivity. Cotton system is ideally suitable for intercropping because of the relatively longer duration, wider spacing and its slow growth in the initial stages to obtain a maximum yield of cotton crop along with additional returns from intercrops (Chaudhari *et al.*, 2006; Rajpoot *et al.*, 2016) [3, 17]. It has been recorded that various cotton-based intercropping systems increase income of farmers by 30-40 % (Khan *et al.*, 2001) [12]. In some of the cotton-growing regions in other countries, intercropping of cotton with legumes such as green gram, black gram and peanut and maybe even non-legumes such as foxtail millet, maize, chilli, onion etc was found to be profitable. Pulses play an important role in Indian agriculture and having unique ability of biological nitrogen fixation, deep root system, mobilization of insoluble soil nutrients and bringing qualitative changes in soil physical properties make them known as "soil fertility restorers". Pulses are the main source of protein for the bulk of population, which is mostly vegetarian. Pulses grown in intercropping are seen as an alternative and sustainable way to introduce N into agro ecosystems of lower inputs (Jayakumar and Surendran, 2017) [9]. Direct nitrogen transfer to accompanying crops occurs mainly through the excretion of nitrogen from the legume nodules, providing an immediate source of nitrogen to non-legume crops.

The use of legumes in intercrops thus contributes some nitrogen to non-legumes component crop and some residual nitrogen to the following crops. The possibility of more efficient use of resources such as sunlight, nutrient, and water in intercropping systems is higher leading to increased biodiversity, higher production stability, and restored soil fertility.

Materials and methods

The experiment was carried out during summer 2019 in field No. NA 2 at Eastern Block farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore. The experiment field was geographically, located in Western agro climatic zone of Tamil Nadu at 11°N latitude and 77°E longitude and at an altitude of 426.7 meters above the Mean Sea Level (MSL). The texture of the experimental site was sandy clay loam, slightly alkaline (pH 8.24) with low soluble salts (EC 0.53 dS/m). Initial soil nutrient status showed that low in available nitrogen (207 kg ha⁻¹), medium in available phosphorus (20 kg ha⁻¹) and high in available potassium (757 kg ha⁻¹). The experiment was laid out in Randomized Block design with eleven treatments and three replications. Such as T₁: Cotton seedling transplanting + Green gram + 75% RDF, T₂: Cotton seedling transplanting + Black gram + 75% RDF, T₃: Cotton seedling transplanting + Onion + 75% RDF, T₄: Cotton seedling transplanting + Green gram + 100% RDF, T₅: Cotton seedling transplanting + Black gram + 100% RDF, T₆: Cotton seedling transplanting + Onion + 100% RDF, T₇: Cotton seedling transplanting + Green gram + 125% RDF, T₈: Cotton seedling transplanting + Black gram + 125% RDF, T₉: Cotton seedling transplanting + Onion + 125% RDF, T₁₀: Cotton seedling transplanting + 100% RDF, T₁₁: Normal Sowing + Recommended package of practices. For this study, ELS Cotton variety (Co14) was selected with a duration of 150 - 180 days and the intercrop viz., Black gram (Co 6), Green gram (Co 8) and onion (Co (on) 5) were used. Polythene cups were used with a dimension of 11 cm height and 6 cm diameter was used and approximately 100 gm of well decomposed and sterilized coco-pith was taken as medium and filled it in polythene cups. Delinted cotton seeds were sown at the depth of 3 cm at one seed per cup. Watering was done with rose cane regularly till emergence completed, there after watering was given as per requirement. After field preparation transplanting was done with 18 days old cotton seedlings with recommended spacing of 100 x 60 cm at 10 cm depth with the help of hand hoe. Cotton seeding was done on the same day by dibbling as per the treatment schedule. Two rows of black gram, green gram seeds and onion bulbs were dibbled in between the cotton rows on the same day of transplanting and harvested the intercrops. The recommended dose of fertilizer for ELS cotton (150:60:60 NPK Kg ha⁻¹). Based on the fertilizer recommendation, fertilizer treatment was followed as per the treatment. Then irrigate the field with plenty of water. Entire dose of P and K were applied as basal and 1/3rd of N was applied as basal. Remaining 2 splits of N were applied at the time of 45 and 65 DAT. Observations were recorded for growth parameters like survival percentage, plant height, Leaf Area Index (LAI), yield parameters like seed cotton yield (Kg ha⁻¹), lint yield (Kg ha⁻¹), Ginning percentage. The experimental data on different characters of observation was statistically analyzed as described. Wherever the results were significant, critical differences was worked out at five per cent level. The treatment differences that were

non significant were denoted as NS.

Results and Discussion

Growth parameters

Survival and Mortality percentage

Survival rate, Mortality of germinated seedlings and percentage of survival rate increased over normal sowing as influenced by methods of crop establishment techniques, intercropping and fertilizer management was presented in Table 1. Data indicated that Survival percentage of cotton seeds was 77.78% under direct sowing, which was significantly lower than the Survival percentage (86.60 %) recorded under nursery raised for transplanting. Germinated seedlings mortality was markedly higher under direct sowing (22.22 %) compared to nursery raised for transplanting (13.00 %), this can be due to regular irrigation of the nursery. Unlike nursery, the soil surface temperature was very high (sometimes >50 °C) compared to ambient atmospheric temperature due to low germination of direct seeded cotton and higher germinated seedlings mortality. Due to more mortality of the germinated seedlings even after 20 to 30 DAS, it was not feasible to maintained optimum plant stand under direct sown crop (even after repeated gap filling). In the transplanted cotton, mortality percentage after transplanting was low, resulting in better plant stand compared to direct sown crop. Similar results were also reported by (Kamel *et al.*, 2004; Rajpoot *et al.*, 2016) [11, 17]. Effect of Crop establishment and intercropping system was not significant on Survival percentage and had significant difference on mortality of germinated seedlings and Survival rate increased over normal sowing.

Plant height

Plant height plays an important role in determining the morphological frame work related to plant type and canopy development in cotton. Cotton seedling transplanting intercropped with black gram along with 125 % NPK fertilizer recorded higher plant height of 50.96 cm at 30DAS, 89.47 cm at 60 DAS, 115.82 cm at 90 DAS, 118.53 cm at 120 DAS and 137.05 cm at harvest (Table 2) over the direct sown crop. Lower plant height was observed in the direct seeded cotton, 26.31 cm at 30 DAS, 64.60 cm at 60 DAS, 84.36 cm at 90 DAS, 98.32 cm at 120 DAS and 116.82 cm at harvest. There was nonsignificant difference observed in plant height at 120 DAS and at harvest. Rajakumar also reported that the transplanted crop with high plant density resulted in increased plant height (65.3 and 65.2 cm) over the direct sown crop. The transplanted crop was 1.7 % higher in plant height and increased the number of nodes on the main stem compared to direct seeding (Ahmad *et al.*, 2018) [11].

Leaf area index (LAI)

Leaf area is an indication of total assimilating area and increase in Leaf Area Index (LAI) favours higher photosynthetic activity of the plant. Cotton seedling transplanting intercropped with black gram along with 125 % RDF recorded higher LAI of 0.52 at 30 DAS, 1.54 at 60 DAS, 4.18 at 90 DAS, 4.55 at 120 DAS and 4.93 at harvest over the direct sown crop (Table 3). Lower LAI was observed in the direct seeded cotton, 0.08 at 30 DAS, 0.50 at 60 DAS, 2.27 at 90 DAS, 3.61 at 120DAS and 4.39 at harvest. There was nonsignificant difference observed in LAI at 120 DAS and at harvest.

Yield parameters

Boll Setting Percentage

Boll setting percentage was significantly influenced by crop establishment and intercropping, recorded higher boll setting percentage in cotton seedling transplanting + black gram along with 125 % fertilizer 65.53 % at 90 DAS, 41.07 % at 120 DAS and 74.00 % at harvest followed by cotton seedling transplanting + green gram along with 125 % RDF 53.03 % at 90 DAS, 35.16 % at 120 DAS and 70.11 % at harvest and the lowest was recorded in direct seeded cotton 31.71 % at 90 DAS, 27.26 % at 120 DAS and 57.31 % at harvest (Table 4). Dong *et al.* (2005) [6] noticed the peak blooming five days earlier in transplanting system than in normal planting system and also blooming period was extended by five weeks longer in transplanted plants. The number of bolls retained per unit area in transplanting system was significantly higher than those in normal planting system. Number of early-season flowers and number of bolls retained per unit area in transplanting system were significantly higher than those in direct seeding in china (Li *et al.*, 2000) [13]. Rajakumar and Gurumurthy (2008) [16] found that planting through poly bag seedlings recorded higher boll setting percentage of 33.43 as against 30.29 per cent under direct seeding.

Seed cotton yield (Kg ha⁻¹)

Seed cotton yield is considered as economic yield which was significantly influenced by crop establishment, intercropping and nutrient management on transplanted ELS cotton (Table 4). Cotton seedling transplanting intercropped with black gram along with 125 % RDF recorded higher seed cotton yield of 2513 Kg ha⁻¹ followed by cotton + green gram along with 125 % RDF (2431 Kg ha⁻¹). Lower seed cotton yield of 1518 Kg ha⁻¹ was observed with the direct seeded cotton. Increased yield in transplanted cotton over farmers' practice was 17 to 30% under irrigated condition; whereas in rainfed circumstances, increased yield advantage in transplanted crops was due to several causes, such as plants get soil moisture stored in dibbled cotton for nearly four months rather than 2-3 months. The increase in seed cotton yield in transplanted plots was due to significantly more number of sympodial branches and bolls plant⁻¹. The weight of bolls and seed cotton yield plant⁻¹ were also significantly higher in transplanted plots compared to dibbled cotton which contributed to greater extent for increased yield in the former (Salakinkop, 2011) [18]. Better response to increased level of fertilizer might be due to better nutritional environment, increasing the availability of N, P and K resulted in increased number of sympodial branches plant⁻¹. Increased fruiting points might be due to the cumulative effect of increased LAI, DMP, sympodial branches as the result of higher nutrient uptake (Jayakumar *et al.*, 2014; Marimuthu *et al.*, 2014) [10, 15].

Lint yield (kg ha⁻¹)

The lint yield was significantly influenced by crop establishment, intercropping and nutrient management on transplanted ELS cotton (Table 4). Cotton seedling transplanting intercropped with black gram along with 125 % RDF recorded higher lint yield of 622.12 kg ha⁻¹ followed by Cotton seedling transplanting intercropped with green gram along with 125 % RDF (553.72kg ha⁻¹) and the lower lint yield of 393.69 kg ha⁻¹ was observed with the direct seeded cotton.

Assessment of intercrop productivity

Seed cotton equivalent yield (SCEY)

The seed cotton equivalent yield (SCEY) varied significantly with intercropping systems and nitrogen sources (Table 5). Cotton + onion along with 125% RDF resulted in the maximum cotton equivalent yield of 3392.91Kg ha⁻¹ followed by cotton + black gram along with 125% RDF (3276.31 kg ha⁻¹). This was due to the higher yield from onion intercrops and lesser reduction in cotton yield compared with green gram, in which also CEY is higher in some of the inter cops (Chellaiah and Gopalaswamy, 2000) [4]. CEY is greater in intercrops, this might be due to the better yield of cotton and intercrops due to the application of higher level of fertilizer (Jayakumar and Surendran, 2017) [9]. Maitra *et al.* (2000) [20]; Tabib *et al.* (2014) [19] observed that overall production in intercropping system was typically higher in terms of cotton equivalent yield than in the sole stand.

Land equivalent ratio (LER)

The land equivalent ratio (LER) is the main index of intercropping advantage and intercrop productivity. LER values were greater than one in the intercropping system (Table 5) indicating the yield advantage of intercropping over sole cropping of cotton. The LER varied significantly due to the crop establishment and different level of nutrient, cotton seedling transplanted + black gram along with 125% RDF recorded maximum LER (2.07) as compared to the other cropping systems. Lowest LER (1.26) was recorded in seedling transplanted cotton + onion along with 100% RDF. This is clearly indicated that the productivity and advantages was greater with the intercropping of cotton + black gram along with 125 % NPK when compared with other intercropping systems. Yield advantages in intercropping system over sole cropping was also reported by (Das *et al.*, 2012; Eskandari, 2012; Islam *et al.*, 2004; Tabib *et al.*, 2014) [5, 7, 8, 19]. However, LER in intercropping treatments compared with mono cropping of cotton was ascribed to better utilization of natural (land and light) and added (fertilizer and water) resources.

Monetary Equivalent Ratio (MER)

Monetary Equivalent Ratio was recorded highest in cotton seedling transplanting + onion + 125 % fertilizer (2.92) followed by cotton seedling transplanting + onion + 100 % fertilizer (2.62) and lower 1.28 (Table 5) in cotton seedling transplanting + green gram + 75 % RDF.

Weed Smothering efficiency (WSE)

Weed Smothering efficiency was highest in cotton seedling transplanting + green gram + 125 % RDF is 68.99 % at 20 DAS and 77.95 % at 40 DAS followed by cotton seedling transplanting + green gram + 125 % RDF is 64.30 % at 20 DAS and 72.46 % at 40 DAS and lowest WSE was recorded in cotton seedling transplanting + 100 % RDF is 26.32 % at 20 DAS and 31.17 % at 40 DAS (Table 5).

Conclusion

It was concluded that 18 days old ELS cotton seedling transplanting was good than direct seeding. Seedling transplantation cotton + black gram along with 125 % fertilizer recommendation was the best combination in relation to growth attributes and yield attributes. Assessment of intercrop productivity was recorded higher under inter cropping situation than farmers practice.

Table 1: Survival and Mortality % of ELS cotton as influenced by establishment technique, intercropping and nutrient management during summer 2019

Treatment	Survival Percentage	Mortality percentage	Survival rate increased over normal sowing
T1-Trans.+ G. gram + 75 % RDF	80.58	17.42	3.40
T2- Trans.+ B. gram + 75 % RDF	82.22	17.78	5.40
T3- Trans.+ Onion + 75 % RDF	84.07	15.93	7.48
T4. Trans.+ G. gram + 100 % RDF	84.44	15.56	7.89
T5. Trans.+ B. gram + 100% RDF	85.29	15.71	8.80
T6-Trans.+ Onion + 100 % RDF	84.07	12.93	7.48
T7 -Trans.+ G. gram + 125% RDF	91.12	8.89	14.64
T8-Trans.+ B. gram + 125 % RDF	97.78	2.22	20.45
T9 -Trans.+ Onion + 125 % RDF	88.89	11.11	12.50
T10 -Transplanting + 100 % RDF	87.53	12.47	11.14
T11-Normal sowing	77.78	22.22	0.00
SEd	5.25	0.72	0.77
CD(p=0.05)	NS	1.53	1.65

Table 2: Plant height of ELS cotton as influenced by establishment technique, intercropping and nutrient management during summer 2019.

Treatment	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T1-Trans.+ G. gram + 75 % RDF	37.27	69.61	86.78	94.41	116.62
T2- Trans.+ B. gram + 75 % RDF	38.71	74.06	92.90	100.08	108.10
T3- Trans.+ Onion + 75 % RDF	39.46	76.11	94.47	105.33	113.15
T4. Trans.+ G. gram + 100 % RDF	39.61	78.38	96.17	107.87	116.90
T5. Trans.+ B. gram + 100% RDF	40.54	79.41	99.67	110.32	122.14
T6-Trans.+ Onion + 100 % RDF	39.24	76.77	96.94	107.14	112.92
T7 -Trans.+ G. gram + 125% RDF	44.61	85.88	111.00	117.61	131.99
T8-Trans.+ B. gram + 125 % RDF	50.96	89.47	115.82	118.53	137.05
T9 -Trans.+ Onion + 125 % RDF	41.71	83.75	109.25	116.27	123.49
T10 -Transplanting + 100 % RDF	41.54	80.57	100.89	113.94	121.98
T11-Normal sowing	26.31	64.60	84.36	98.32	116.82
SEd	2.56	4.84	6.14	6.61	7.35
CD(p=0.05)	5.49	10.39	13.18	NS	NS

Table 3: Leaf area index (LAI) of ELS cotton as influenced by establishment technique, intercropping and nutrient management during summer 2019.

Treatment	30 DAS	60 DAS	90DAS	120 DAS	At Harvest
T1-Trans.+ G. gram + 75 % RDF	0.24	1.04	2.34	3.61	4.36
T2- Trans.+ B. gram + 75 % RDF	0.28	1.15	2.59	3.81	4.55
T3- Trans.+ Onion + 75 % RDF	0.32	1.16	2.74	3.86	4.56
T4. Trans.+ G. gram + 100 % RDF	0.32	1.19	2.89	4.00	4.71
T5. Trans.+ B. gram + 100% RDF	0.32	1.25	3.11	4.15	4.77
T6-Trans.+ Onion + 100 % RDF	0.34	1.22	3.15	4.10	4.60
T7 -Trans.+ G. gram + 125% RDF	0.42	1.53	3.73	4.49	4.90
T8-Trans.+ B. gram + 125 % RDF	0.52	1.54	4.18	4.55	4.93
T9 -Trans.+ Onion + 125 % RDF	0.39	1.40	3.53	4.37	4.83
T10 -Transplanting + 100 % RDF	0.37	1.34	3.47	4.29	4.79
T11-Normal sowing	0.08	0.50	2.27	3.61	4.39
SEd	0.02	0.08	0.20	0.25	0.28
CD(p=0.05)	0.05	0.17	0.43	NS	NS

Table 4: Boll setting percentage, Seed cotton yield, Lint yield, ginning percentage of ELS cotton as influenced by as influenced by establishment technique, intercropping and nutrient management during summer 2019.

Treatment	Boll setting percentage	Seed cotton Yield (Kg/ha)	Lint yield (Kg/ha)	Ginning percentage
T1-Trans.+ G. gram + 75 % RDF	57.24	1725	417.24	27.34
T2- Trans.+ B. gram + 75 % RDF	60.18	1806	459.22	28.05
T3- Trans.+ Onion + 75 % RDF	61.57	1835	462.40	28.65
T4. Trans.+ G. gram + 100 % RDF	62.95	1892	468.20	28.90
T5. Trans.+ B. gram + 100% RDF	64.33	2148	487.62	29.59
T6-Trans.+ Onion + 100 % RDF	62.64	2158	487.33	28.81
T7 -Trans.+ G. gram + 125% RDF	70.11	2431	553.72	30.90
T8-Trans.+ B. gram + 125 % RDF	74.00	2513	622.12	30.90
T9 -Trans.+ Onion + 125 % RDF	65.51	2416	553.16	30.60
T10 -Transplanting + 100 % RDF	65.38	2291	507.39	30.00
T11-Normal sowing	57.31	1518	393.69	27.70
SEd	3.95	126	31.06	1.76
CD(p=0.05)	NS	271	66.63	NS

Table 5: Seed cotton equivalent yield (SCEY), Land equivalent Ratio (LER), Monetary Equivalent Ratio (MER) and Weed Smothering Efficiency (WSE) ELS of cotton as influenced by establishment technique, intercropping and nutrient management

Treatment	SCEY	LER	MER	WSE	
				20DAS	40DAS
T ₁ -Trans.+ G. gram + 75 % RDF	2073	1.49	1.28	47.43	59.50
4T ₂ - Trans.+ B. gram + 75 % RDF	2561	1.96	1.65	44.12	56.79
T ₃ - Trans.+ Onion + 75 % RDF	2690	1.42	2.57	41.23	52.83
T ₄ - Trans.+ G. gram + 100 % RDF	2191	1.61	1.32	60.68	69.59
T ₅ - Trans.+ B. gram + 100% RDF	2356	1.89	1.51	55.13	64.08
T ₆ -Trans.+ Onion + 100 % RDF	2540	1.26	2.62	53.16	66.65
T ₇ -Trans.+ G. gram + 125% RDF	2406	1.78	1.44	68.99	77.95
T ₈ -Trans.+ B. gram + 125 % RDF	2554	2.07	1.63	64.30	72.46
T ₉ -Trans.+ Onion + 125 % RDF	2908	1.48	2.92	60.26	71.06
T ₁₀ -Transplanting + 100 % RDF				26.32	31.17
T ₁₁ -Normal sowing					

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