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RESEARCH ARTICLE

Nutrient Uptake and Post-Harvest Soil Nutrient Status of Extra Long StapleCottonas Influenced by Establishment Methods, Intercropping and Nutrient Management

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ABSTRACT

A field experiment was conducted at Eastern Block Farm, Department of Agronomy, TNAU, Coimbatore, during the summer of 2019 with the objective of finding outthe nutrient uptakeandthe post-harvest soil nutrient statusof Extra Long Staple (ELS) cotton under methods of crop establishment, intercropping and nutrient management. The experiment was laid out in a randomized block design with three replications. The treatments consisted,*viz.*T_1: Transplanting + Green gram + 75% RDF, T_2 : Transplanting + Black gram + 75% RDF, T_3 : Transplanting + Onion + 75% RDF, T_4 : Transplanting + Green gram + 100% RDF, T_5 : Transplanting + Intercrop with Black gram + 100% RDF, T_6 : Transplanting + Onion + 100% RDF, T_7 : Transplanting + Green gram + 125% RDF, T_8 : Transplanting + Black gram + 125% RDF, T_9 : Transplanting + Onion + 125% RDF, T_{10} : Transplanting + 100% RDF, T_{11} : Direct seeding + Recommended package of practices. Nutrient uptake was higher in transplanted cotton intercropped with black gram followed by thegreen gram with the application of 125% RDF followed by 100% RDF which was significantly influenced by crop establishment techniques, intercropping and different doses of fertilizer level.Available soil nutrients were higher in direct-seeded cotton compared to transplanted cotton.

Keywords: *Transplanting cotton; Nutrient uptake; Available nutrients*

INTRODUCTION

Cotton (*Gossypium spp*.) is considered the "King of Natural Fiber and White Gold" and plays a significant role in the worldwide agricultural and industrial economy. It is widely grown in tropical and subtropical regions of the world in more than 70 countries. Cotton, the “White Gold” enjoys a premier position among all commercial crops in India and meets about 65 % requirements of the Indian textile industry. Effective planting techniques are an essential non-monetary input to ensure optimum plant population to get higher productivity. The transplanted crop was germinated and established in a protected environment with proper management. Transplanting crops reduces the number of irrigation in the main field. It saves up to4 to 5 irrigation compared to direct seeded crops. The peak blooming period was 5-10 days earlier in the transplanting system, and also it was extended by one week longer in transplanted plants than in direct seeding (Dong *et al.*, 2005).

The cotton system is ideally suitable for intercropping because of the relatively long duration, wider spacing, and slow growth in the initial stages. Hence maximum yield of cotton crop along with additional returns from intercrops can be obtained. Legumes grown in intercropping are seen as an alternative and sustainable way to introduce Nitrogen into agroecosystems of lower inputs. There is a lack of research work; therefore, an attempt has been made in the present study to explore the possibilities of post-harvest soil nutrient status, soil available status, and yield of cotton under seedling transplanting, intercropping, and nutrient management in Extra Long Staple cotton.

MATERIAL AND METHODS

A field experiment was conducted at Eastern Block Farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, during the summer of 2019 with the objectives to find out the post-harvest soil nutrient status, and soil available

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status of cotton under seedling transplanting, intercropping, and nutrient management in Extra Long Staple cotton. The experiment was laid out in a randomized block design with three replications. The treatments consisted of cotton seedling establishment techniques, suitable intercrops, and fertilizer management T_1: Transplanting + Intercrop with Green gram + 75 % RDF, T_2: Transplanting + Intercrop with Black gram + 75 % RDF, T_3: Transplanting + Intercrop with Onion + 75 % RDF, T_4: Transplanting + Intercrop with Green gram + 100 % RDF, T_5: Transplanting + Intercrop with Black gram + 100 % RDF, T_6: Transplanting + Intercrop with Onion + 100 % RDF, T_7: Transplanting + Intercrop with Green gram + 125 % RDF, T_8: Transplanting + Intercrop with Black gram + 125 % RDF, T_9: Transplanting + Intercrop with Onion + 125 % RDF, T_{10}: Transplanting + 100 % RDF, T_{11}: Direct seeding + Recommended package of practices. The experiment plot was slightly alkaline pH (8.24) with low soluble salts (EC 0.53 dS m^{-1}) and organic carbon (0.36 %). Initial 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}).Two rows of black gram, green gram, and onion were sown/planted with a 10 cm spacing between two cotton rows. Well-decomposed farm yard manure (FYM) @ 10 t ha^{-1} was incorporated at the time of the second harrowing and leveled during the cropping season to all the treatments including the control plot. TNAU Micronutrient mixture was applied as basal @ 3 kg ha^{-1}.The recommended dose of fertilizer (150:60:60 NPK kg ha^{-1}) was applied. Delinted cotton seeds were sown at a depth of 3 cm at one seed per cup. Watering was done with rose cane regularly till emergence was completed. Thereafter watering was given as per requirement and taken care of for cotton seedlings. Transplanting was done with 18 days old cotton seedlings with a recommended spacing of 100 x 60 cm at 10 cm depth with the help of a hand hoe. The polyethylene cups were compressed before planting. The seedling was taken carefully and planted with the surrounding soil. Cotton seeding was done on the same day by dibbling as per the treatment schedule. Nitrogen, Phosphorus, and Potassium were applied in the form of urea (46 % N), single super phosphate (16 % P_2O_5), and muriate of potash (60 % K_2O), respectively. The entire dose of P and K was applied as basal and 1/3rd of N was applied as basal. The remaining 2 splits of N were applied at the time of 45 and 65 DATbased on the nutrient management treatment schedules. Plant protection measures were taken as per the crop production guide.

RESULTS AND DISCUSSION

NUTRIENT UPTAKE (kg ha^{-1})

Total Nitrogen (kg ha^{-1})

As indicated in the table. 1 it was observed that cotton seedling transplanting showed 36.56 %, 12.67 %, 8.24 %, 8.86 %, and 9.08 %, respectively increased nitrogen uptake than direct seeding cotton at 30, 60, 90, 120 DAS and at harvest stages. Cotton seedling transplanting intercropped with black gram along with 125 % RDF recorded significantly higher uptake of 9.78, 72.28, 149.80, 171.10, and 173.52 kg ha^{-1}, respectively at 30, 60, 90, 120 DAS and at harvest over the direct sown crop, which was on par with 125 % fertilizer with cotton seedling transplanting intercropped with green gram at 30 DAS, 60 DAS and 90 DAS. This was due to the continuous replenishment of nutrients in the root zone and enhanced transport of dissolved nutrients by mass flow, due to the optimum availability of moisture content. As a result of better availability of moisture and nutrients throughout the growth stages, led to better uptake of nutrients. And also it was due to the continuous availability of water and nutrients to the crop and split application of N which resulted in minimal loss of nutrients thereby making them available continuously to the crop (Jayakumar *et al.*, 2014).

Lower nitrogen uptake 4.93, 55.88, 129.55, 148.75, and 150.05 kg ha^{-1}respectivelyat 30, 60, 90, 120 DAS and at harvest over the direct sown crop, which was on par with cotton seedling transplanting intercropped with green gram along with 75 % RDF at 30 DAS. There was no significant difference observed in nitrogen uptake in 120 DAS and at harvest.

Total Phosphorous (kg ha^{-1})

Cotton seedling transplanting recorded 48.22 %, 20.55 %, 20.42 %, 23.20 %, and 22.83 % respectively at 30, 60, 90, 120 DAS and at harvest stages increased phosphorous uptake than the direct seeding.Higher uptake of nutrients in both component crops in the intercropping situation was due to reduced competition for available nutrients and because of the difference in duration and variation in

Table1.Nitrogen uptake of ELS cotton as influenced by intercropping and nutrient management during summer 2019

Treatment	Nitrogen uptake (kg ha^{-1})				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
T_1-Trans.+ G. gram + 75 % RDF	5.90	55.97	130.67	150.43	151.48
T_2-Trans.+ B. gram + 75 % RDF	6.49	58.55	135.51	156.50	159.68
T_3-Trans.+ Onion + 75 % RDF	6.82	60.50	138.29	159.59	161.21
T_4-Trans.+ G. gram + 100 % RDF	7.28	62.13	140.11	161.40	163.47
T_5-Trans.+ B. gram + 100 % RDF	7.61	65.02	142.94	165.57	165.80
T_6-Trans.+ Onion + 100 % RDF	7.67	63.35	139.13	160.50	162.38
T_7-Trans.+ G. gram + 125 % RDF	9.06	68.55	148.24	170.52	172.40
T_8-Trans.+ B. gram + 125 % RDF	9.78	72.28	149.80	171.10	173.52
T_9-Trans.+ Onion + 125 % RDF	8.72	67.37	147.24	169.58	170.76
T_{10}-Transplanting + 100 % RDF	8.38	66.15	139.88	166.95	169.73
T_{11}-Direct seeding	4.93	55.88	129.55	148.75	150.05
SEd	**0.49**	**3.57**	**4.06**	**9.78**	**9.90**
CD (p=0.05)	**1.05**	**7.66**	**8.70**	**NS**	**NS**

Note: Trans. – Transplanting, B.gram – Black gram, G.gram – Green gram

the rooting habit like shortened roots which spreads horizontally and also better root growth which might be the reason for higher nutrient uptake than direct seeded cotton. The result was also proven by (Hemeid *et al.*, 2018). Different doses of nutrient application increase uptake by seed cotton and stalk yield (Babaria *et al.*, 2010). Similarly,Rana et al. (2014) observed higher nutrient use efficiency.

Cotton seedling transplanting intercropped with black gram along with 125 % RDF recorded significantly higher phosphorous uptake at 2.21, 9.74, 19.20, 23.69, and 25.10 kg ha^{-1} respectively at 30, 60, 90, 120 DAS and harvest over other

treatments, whereas it was on par with cotton seedling transplanting intercropped with green gram along with125 % RDF at all the growth stages as indicated in the table.2. The direct seeded cotton recorded lower phosphorous uptake at 0.83, 6.84, 13.71, 15.46, and 16.62 kg ha^{-1} respectively at 30, 60, 90, 120 DAS and at harvest.

Table 2. Phosphorus uptake of ELS cotton as influenced by intercropping and nutrient management during summer 2019

Treatment	Phosphorus uptake (kg ha^{-1})				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
T_1-Trans.+ G. gram + 75 % RDF	0.99	7.08	15.02	15.94	17.69
T_2-Trans.+ B. gram + 75 % RDF	1.12	7.50	15.84	17.26	18.73
T_3-Trans.+ Onion + 75 % RDF	1.24	7.92	16.36	18.94	19.63
T_4-Trans.+ G. gram + 100 % RDF	1.40	8.23	16.63	19.26	20.22
T_5-Trans.+ B. gram + 100 % RDF	1.64	8.74	17.23	20.18	21.09
T_6-Trans.+ Onion + 100 % RDF	1.65	8.59	17.03	19.42	21.81
T_7-Trans.+ G. gram + 125 % RDF	2.04	9.63	18.95	22.86	24.30
T_8-Trans.+ B. gram + 125 % RDF	2.21	9.74	19.20	23.69	25.10
T_9-Trans.+ Onion + 125 % RDF	1.93	9.44	18.22	22.34	23.68
T_{10}-Transplanting + 100 % RDF	1.81	9.22	17.81	21.41	23.13
T_{11}-Direct seeding	0.83	6.84	13.71	15.46	16.62
SEd	**0.11**	**0.53**	**1.05**	**1.25**	**1.33**
CD (p=0.05)	**0.23**	**1.13**	**2.25**	**2.68**	**2.85**

Note: Trans. – Transplanting, B.gram – Black gram, G.gram – Green gram

Total Potassium (kg ha^{-1})

Potassium uptake in cotton seedling transplanting was 49.54 %, 20.59 %,11.38 %, 8.25 %, and 7.66 % respectively at 30, 60, 90, 120 DAS, and harvest increased over the direct seeded cotton. Cotton seedling transplanting intercropped with black gram along with 125 % RDF recorded significantly higher potassium uptake at 6.61, 72.30, 139.64, 160.93, and 175.65 kg ha^{-1}, respectively at 30, 60, 90, 120 DAS and at harvest than other treatments was given in table no. 3. This was in line with the earlier findings of Anitha *et al.* (2006) who opined that the higher available soil moisture provided due to increases the availability of nutrients in the soil by the different dose of fertilizer and thereby increased the nutrient uptake. Similar findings were reported by Devi *et al.* (2018).

The direct seeded cotton recorded lower potassium uptake at 2.21, 51.61, 117.47, 139.37 152.42 kg ha^{-1} respectively at 30, 60, 90, 120 DAS and at harvest.

Available soil nutrients status

Direct-seeded cotton holds 10.27 %, 22.55 %, and 7.67 % more NPK than cotton seedling transplanting. The application of plant macronutrients in the right proportion, optimum quantity at right time, and correct application method are the keys to increasing crop yield. Higher Nitrogen and potassium availability was obtained in direct seeded cotton (179.95 kg ha^{-1}, 676.37 kg ha^{-1}) was given in table no. 4. which was due to the continuous application of nutrients and growing pulses as intercrop in between the cotton rows which might have increased the availability of Nitrogen. Similar findings were also been reported byJayakumar and Surendran (2017). Cotton seedling transplanting intercropped with black gram along with 125 % RDF left more available soil phosphorous (25.10 kg ha^{-1}) in the soil after harvest which might be due to increasing the soil nutrient availability with the higher dose of fertilizer. This finding was in confirmation byBabaria *et al.* (2010); Solunke *et al.* (2011); Rajpoot *et al.* (2014).

Cotton seedling transplanting intercropped with green gram along with 75 % RDF had lesser post-harvest soil available nitrogen (145.48 kg ha^{-1}). Lower available soil phosphorous (16.62 kg ha^{-1}) was obtained from the plots of direct-seeded cotton. Between the treatments, cotton seedling transplanting intercropped with onion along with 125 % RDF had lower available soil potassium (545.33 kg ha^{-1}).

Table 3. Potassium uptake of ELS cotton as influenced by intercropping and nutrient management during summer 2019

Treatment	Potassium uptake (kg ha^{-1})				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
T_1-Trans.+ G. gram + 75 % RDF	2.81	56.07	124.64	141.41	152.93
T_2-Trans.+ B. gram + 75 % RDF	3.13	58.71	128.33	145.23	158.09
T_3-Trans.+ Onion + 75 % RDF	3.55	60.28	129.77	147.05	160.41
T_4-Trans.+ G. gram + 100 % RDF	3.82	63.67	130.70	150.40	162.21
T_5-Trans.+ B. gram + 100 % RDF	4.12	65.54	133.12	153.47	166.54
T_6-Trans.+ Onion + 100 % RDF	4.32	64.77	128.96	148.82	161.57
T_7-Trans.+ G. gram + 125 % RDF	5.55	71.01	137.52	158.44	173.68
T_8-Trans.+ B. gram + 125 % RDF	6.61	72.30	139.64	160.93	175.65
T_9-Trans.+ Onion + 125 % RDF	5.05	70.04	139.27	157.57	171.42
T_{10}-Transplanting + 100 % RDF	4.84	67.54	133.65	155.76	168.16
T_{11}-Direct seeding	2.21	51.61	117.47	139.37	152.42
SEd	**0.29**	**3.96**	**4.76**	**9.11**	**9.91**
CD (p=0.05)	**0.63**	**8.49**	**10.20**	**NS**	**NS**

Note: Trans. – Transplanting, B.gram – Black gram, G.gram – Green gram

Table 4. Post-harvest available Nutrients of ELS cotton as influenced by intercropping and nutrient management during summer 2019

Treatment	Available Nutrient (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
T_1-Trans.+ G. gram + 75 % RDF	145.48	17.34	637.58
T_2-Trans.+ B. gram + 75 % RDF	159.68	18.73	658.91
T_3-Trans.+ Onion + 75 % RDF	160.95	19.63	653.30
T_4-Trans.+ G. gram + 100 % RDF	163.09	20.22	654.44
T_5-Trans.+ B. gram + 100 % RDF	169.13	21.30	663.53
T_6-Trans.+ Onion + 100 % RDF	152.78	21.16	616.46
T_7-Trans.+ G. gram + 125 % RDF	150.05	24.30	616.33
T_8-Trans.+ B. gram + 125 % RDF	169.40	25.10	557.00
T_9-Trans.+ Onion + 125 % RDF	170.76	23.68	545.33
T_{10}-Transplanting + 100 % RDF	173.46	23.13	642.07
T_{11}-Direct seeding	179.95	16.62	676.37
SEd	**7.44**	**1.33**	**31.66**
CD (p=0.05)	**15.97**	**2.85**	**67.92**

Note: Trans. – Transplanting, B.gram – Black gram, G.gram – Green gram

Conclusion

As an overall conclusion, available soil nutrients and nutrient uptake of cotton were significantly influenced by crop establishment techniques, cotton intercropping, and different doses of fertilizer level. Available soil nutrients were found to be higher in direct-seeded cotton compared to transplanted cotton. Transplanted cotton recorded early and better vegetative growth results in higher yield along with improved nutrient uptake than direct seeded cotton. NPK uptake was higher in transplanted cotton intercropped with black gram followed by the green gram with the application of 125 % RDF followed by 100 % RDF.

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Ethics statement

Since no people or animals were used as participants in these field investigations, no particular licences were needed.

Originality and plagiarism

The work and/or words of others used have been properly cited, and authors guarantee that the material they wrote and submitted was their original work.

Consent for publication

Each author gave their consent for the article's publication.

Competing interests

There were no conflicts of interest when this article was published.

Data availability

All the data of this manuscript are included in the MS. There is no need for an additional external data source. If the MS needs to be changed in any way, the relevant author can be contacted through the appropriate official mail; monicaa591997@gmail.com.

Author contributions

Research grant-MM, KV, Idea conceptualization-MM, KV, NS, Experiments-MM, KV, Guidance –KV, NS, AK, Writing original draft –MM,Writing- reviewing &editing –MM, KV, NS, AK.

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