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Research Article
Evaluation of Suitable Intercrop and Nutrient Management on Weed Control and Seed Cotton Yield

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Abstract

Background and Objective: Cotton is an important commercial crop cultivated in India for its raw fiber to meet the demand of textile industry. Cotton is a wide spaced slow growing crop initially and consequently vulnerable for weed infestation. Development of appropriate intercropping system will curtail the weed problem and in addition with nutrient management will increase the yield of cotton. Therefore, the field experiment on evaluation of suitable intercrop and nutrient management on weed control and seed cotton yield was carried out. **Materials and Methods:** The experiments were laid out in a split plot design with three replications. Intercropping system viz., C1: Cotton sole, C_2: Cotton+Blackgram, C_3: Cotton+Greengram and C_4: Cotton+Cluster bean were allotted to main plot. The intercrops residues were incorporated at 65 DAS. The sub-plot consisted of 6 treatments viz., N_1: 100% RDF (Recommended dose of fertilizer: 80:40:40 kg NPK/ha), N_2: 75% RDF, N_3: 75% RDF+biofertilizers, N_4: 75% RDF+5% Morinda leaf extract spray, N_5: 75% RDF+5% Vilvam leaf extract spray, N_6: 75% RDF+5% Annona leaf extract spray. **Results:** Intercropping system established significant smothering effect in controlling weeds combined with nutrient management. Among the different intercropping system and nutrient management, cotton+blackgram intercropping with integrated nutrient management involving application of 75% RDF+seed treatment and soil application of biofertilizers recorded low weed density and higher seed cotton yield (1619 and 1715 kg ha^{-1} during winter 2007 and Summer 2007-2008, respectively). **Conclusion:** Cotton+blackgram intercropping system with application of 75% RDF+seed treatment and soil application biofertilizers may be recommended for weed smothering and for obtaining higher seed cotton yield.

Key words: Intercropping, weed smothering, nutrient management, seed cotton yield

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cotton is an important fibre crop which provides the basic raw material (cotton fibre) to cotton textile industry not only for India but of the entire world, hence it is known as "the king of apparel fibre". The area under cotton cultivation in India (10.15 million ha) is the highest in the world, i.e., 25% of the world area[1].

Cotton being a long duration and wide spaced crop having the habit of growing at slower rate in early stages and thus much of vacant interspace remains unutilized[2]. It is indeed worthy to use land fully well by resorting to the introduction of intercrops. It has unique capacity to raise the unit profitability without unduly disturbing the cotton ecosystem. Intercropping is a common and ancient practice in India and many other countries of the developing world where average holding is small. If two or more crops are simultaneously grown in same field, at least one may give something if the other fails[3]. Intercropping thus provides some sort of insurance against total failure. The wide interspace of cotton facilitates way for weed infestation and cause nearly 45% of the total loss. Intercropping smoothers the weeds and pave way to reduce the usage of herbicides which are efficient, economical and ecofriendly[4].

Furthermore, intercropping of legumes is an important aspect for biological farming systems not only for weed control but also reducing the leaching of nutrients, pest control and soil erosion[5]. Intercropping has to be promoted due to several unfavorable effects caused by chemical agriculture.

Nutrient management in cotton is another area to be addressed in integrated manner due to the overlap of vegetative and reproductive structures during the active growth phase. The nutrient demand at this vegetative stage results in reduction of root growth due to less partitioning of assimilates to the root and ultimately reduced capacity to absorb nutrients[6]. An excess of nutrient applied, especially N before the crop attains the grand growth period could revert the crop to putting up more of vegetative growth. Judicious nutrient management is the pre-requisite to increase the productivity of cotton and to meet the industrial demand.

Based on this background, the field study was programmed to evaluate suitable intercrop and nutrient management on weed control and seed cotton yield.

MATERIALS AND METHODS

Description of study area: Field trial was conducted at Agricultural College and Research Institute, Madurai, Tamil Nadu, India during Summer 2007 and Winter 2007-2008. The experimental location experiences tropical climate with summer extending from March-August and winter from August-February. The experimental field was infested with *Trianthema portulacastrum* Linn. (42%), *Cyperus rotundus* L. (34%), *Cynodon dactylon* (L.) Pers. (14%), *Phyllanthus niruri* L. (3) and other minor weeds. The soil of the experimental site was vylogam series, a member of fine loamy kaolinite, with a pH of 8.1 and 6.9 and an EC of 0.31 dS m^{-1} and 0.42 dS m^{-1}.

Experimental materials: Cotton variety SVPR 2 with duration of 150-165 days was chosen for this study. Blackgram (*Vigna mungo*) variety VBN (Bg) 4, greengram (*Vigna radiata*) cultivar Pusa bold and cluster bean (*Cyamopsis tetragonaloba* (L) Taub.) cultivar Pusa Navbahar were chosen as intercrops. The biofertilizers include *Azospirillum*+ Phosphobacteria+Silicate solubilizing bacteria each at 2.6 kg ha^{-1}. For tree leaf extracts preparation fresh leaves of selected tree species viz., *Annona squamosa*, *Morinda tinctoria* and *Aegles marmellos* were collected from the trees found in the campus. The leaf extract for each of the above species were prepared by grinding fresh leaves with distilled water at 1:1 proportion and kept for 6 h and the extract was filtered, which served as a stock solution. About 5% of leaf extract prepared from stock solution was sprayed twice during the crop growth phase during the early morning hours at 60 and 80 days after sowing as per the treatment schedule. Leaf extracts were sprayed at 60 and 80 DAS.

Design and arrangement of experiment: The experiments were laid out in a split plot design with three replications. Intercropping system viz., C_1: Cotton sole, C_2: Cotton+ Blackgram, C_3: Cotton+Greengram and C_4: Cotton+Cluster bean were allotted to main plot. The intercrops residues were incorporated at 65 DAS. The sub-plot consisted of 6 treatments viz., N_1: 100% RDF (Recommended dose of fertilizer: 80:40:40 kg N, P, K/ha), N_2: 75% RDF, N_3: 75% RDF+ biofertilizers, N_4: 75% RDF+5% Morinda leaf extract spray, N_5: 75% RDF+5% Vilvam leaf extract spray, N_6: 75% RDF+5% Annona leaf extract spray.

Data collection: The observations on weed density and seed cotton yield was recorded. Weed density of grasses, sedges and broad leaved weeds were recorded at 20th DAS. Quadrate (0.25 m^2) was placed at four randomly selected places in each plot and the number of individual weed species were recorded and expressed in number m^{-2} as suggested by Burnside and Wicks[7]. The seed cotton obtained from net plot area was shade dried, weighed at each picking and yields of all picking were pooled and computed to kg ha^{-1}.

Statistical analysis: Data were statistically analyzed following the procedure given by Gomez and Gomez[8]. The weed density were analyzed and the square root transformed values were arrived. A two-way ANOVA was used to determine significant difference among intercropping system and nutrient management. Wherever the results were significant, critical differences were worked out at 5% level and non significant results were noted as non-significant (N.S.).

RESULTS AND DISCUSSION

Weed density: Intercropping system showed remarkable results in weed smothering effect and yield of cotton.

Grasses: Intercropping system established significant smothering effect in controlling the grassy weeds (Table 1) during Summer and Winter. Cotton intercropped with blackgram (C_2) admitted least grassy weeds per unit area (8.6 and 12.8 grasses m^{-2} during Summer 2007 and Winter 2007-2008, respectively). It was followed by cotton+ clusterbean (C_4), which also had smothered the weed density (9.4 and 14.0 grasses m^{-2} during Summer 2007 and Winter 2007-2008, respectively). The weed suppression effect was also exhibited by cotton+greengram intercropping (C_3). Bhullar *et al.*[9] also reported the weed smothering effect of intercrops. Heavy weed infestation of 14.0 and 17.2 grasses m^{-2} was noticed under sole cotton (C_1) during Summer 2007 and Winter 2007-2008, respectively.

Sedges: The data on sedges population reveal that the cropping system had appreciable suppression effect on sedges (Table 2) during the two seasons of experimentation. During both the seasons of study, blackgram as an intercrop in cotton (C_2) effectively controlled the sedges population (3.1 and 3.5 m^{-2}) than the other systems. It was closely followed by cotton+clusterbean intercropping system (C_4) (3.6 and 3.8 m^{-2}) and cotton+green gram (3.7 and 4.4 m^{-2}) during both the seasons. Maximum weed population was noticed under pure stand (C_1) of cotton (4.8 and 5.8 m^{-2}) during both the seasons of study.

Broad leaved weeds: Different intercropping system had significant effect on the control of broad leaved weed (Table 3) during the two seasons. Similar trend as observed in grasses and sedges was observed in broad leaved weeds also. Blackgram combination registered the remarkable reduction in broad leaved weed population (8.5 and 10.7 during Summer 2007 and Winter 2007-07, respectively). It was followed by cotton+clusterbean (C_4) combination which suppressed the broad leaved weed density and registered 9.4 and 11.9 m^{-2} during Summer 2007 and Winter 2007-07, respectively. Cotton+greengram intercropping (C_3) also showed suppression effect on broad leaved weed population which recorded 10.5 and 12.7 m^{-2} during Summer 2007 and Winter 2007-07, respectively. Existence of broad leaved weeds was maximum in pure stand (C_1) of cotton (12.2 and 14.0 m^{-2}) during both the seasons of study.

Table 1: Effect of intercropping system, nutrient management and tree leaf extract spray on grasses (m^{-2}) of cotton

Summer 2007						Winter 2007-2008					
Treatments	C_1	C_2	C_3	C_4	Mean	Treatments	C_1	C_2	C_3	C_4	Mean
N_1	14.3 (3.781)	8.9 (2.982)	11.0 (3.317)	9.6 (3.097)	10.9 (3.294)	N_1	17.5 (4.179)	13.0 (3.603)	15.6 (3.946)	14.2 (3.766)	15.1 (3.874)
N_2	13.9 (3.728)	8.5 (2.914)	10.7 (3.271)	9.3 (3.049)	10.6 (3.241)	N_2	17.1 (4.130)	12.7 (3.563)	15.3 (3.911)	13.9 (3.726)	14.8 (3.832)
N_3	14.2 (3.768)	8.8 (2.964)	10.9 (3.295)	9.5 (3.082)	10.8 (3.277)	N_3	17.3 (4.157)	12.9 (3.590)	15.5 (3.936)	14.1 (3.751)	15.0 (3.858)
N_4	13.9 (3.728)	8.5 (2.915)	10.7 (3.264)	9.3 (3.049)	10.6 (3.239)	N_4	17.2 (4.145)	12.7 (3.561)	15.2 (3.898)	13.8 (3.710)	14.7 (3.828)
N_5	13.8 (3.715)	8.6 (2.932)	10.8 (3.283)	9.2 (3.033)	10.6 (3.241)	N_5	17.1 (4.131)	12.7 (3.560)	15.3 (3.911)	13.9 (3.723)	14.8 (3.831)
N_6	13.9 (3.728)	8.5 (2.915)	10.7 (3.267)	9.3 (3.046)	10.6 (3.239)	N_6	17.1 (4.131)	12.6 (3.454)	15.2 (3.895)	13.9 (3.726)	14.7 (3.824)
Mean	14.0 (3.741)	8.6 (2.937)	10.8 (3.283)	9.4 (3.060)		Mean	17.2 (4.145)	12.8 (3.570)	15.4 (3.916)	14.0 (3.734)	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	0.032	0.045	0.089	0.091		S.Ed	0.025	0.081	0.149	0.161	
CD (p = 0.05)	0.077	NS	NS	NS	CD (p = 0.05)	0.062	NS	NS	NS		

Figures in parenthesis indicate square root transformed values, Main plot (Intercropping system): C_1: Cotton sole, C_2: Cotton+Blackgram, C_3: Cotton+Greengram, C_4: Cotton+Cluster bean, Subplot (Nutrient management): N_1: 100% RDF (Recommended dose of fertilizer: 80:40:40 kg N, P, K/ha), N_2: 75% RDF, N_3: 75% RDF+biofertilizers, N_4: 75% RDF+5% Morinda leaf extract spray, N_5: 75% RDF+5% Vilvam leaf extract spray, N_6: 75% RDF+5% Annona leaf extract spray

Table 2: Effect of intercropping system, nutrient management and tree leaf extract spray on sedges (m^{-2}) of cotton

Summer 2007						Winter 2007-2008					
Treatments	C_1	C_2	C_3	C_4	Mean	Treatments	C_1	C_2	C_3	C_4	Mean
N_1	4.9 (2.213)	3.2 (1.788)	3.7 (1.923)	4.5 (2.121)	4.1 (2.011)	N_1	5.9 (2.427)	3.7 (1.922)	4.5 (2.119)	4.0 (1.999)	4.5 (2.117)
N_2	4.7 (2.144)	3.1 (1.760)	3.7 (1.920)	3.5 (1.870)	3.8 (1.923)	N_2	5.7 (2.384)	3.5 (1.870)	4.4 (2.097)	3.0 (1.731)	4.2 (2.021)
N_3	4.9 (2.212)	3.2 (1.789)	3.9 (1.965)	3.3 (1.816)	3.8 (1.945)	N_3	5.9 (2.428)	3.7 (1.922)	4.5 (2.121)	4.1 (2.023)	4.6 (2.123)
N_4	4.7 (2.165)	3.1 (1.760)	3.7 (1.823)	3.5 (1.870)	3.8 (1.930)	N_4	5.7 (2.386)	3.5 (1.870)	4.4 (2.097)	3.8 (1.947)	4.4 (2.075)
N_5	4.6 (2.144)	3.0 (1.731)	3.7 (1.923)	3.4 (1.840)	3.7 (1.910)	N_5	5.7 (2.385)	3.4 (1.842)	4.4 (2.097)	3.8 (1.947)	4.3 (2.068)
N_6	4.7 (2.166)	3.0 (1.730)	3.6 (1.897)	3.3 (1.814)	3.7 (1.902)	N_6	5.8 (2.405)	3.4 (1.872)	4.3 (2.072)	3.8 (1.947)	4.3 (2.067)
Mean	4.8 (2.174)	3.1 (1.760)	3.7 (1.925)	3.6 (1.888)		Mean	5.8 (2.402)	3.5 (1.878)	4.4 (2.101)	3.8 (1.947)	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	0.021	0.050	0.093	0.100		S.Ed	0.014	0.044	0.082	0.088	
CD (p = 0.05)	0.050	NS	NS	NS		CD (p = 0.05)	0.034	NS	NS	NS	

Figures in parenthesis indicate square root transformed values, Main plot (Intercropping system): C_1: Cotton sole, C_2: Cotton+Blackgram, C_3: Cotton+Greengram, C_4: Cotton+Cluster bean, Subplot (Nutrient management): N_1: 100% RDF (Recommended dose of fertilizer: 80:40:40 kg N, P, K/ha), N_2: 75% RDF, N_3: 75% RDF+biofertilizers, N_4: 75% RDF+5% Morinda leaf extract spray, N_5: 75% RDF+5% Vilvam leaf extract spray, N_6: 75% RDF+5% Annona leaf extract spray

Table 3: Effect of intercropping system, nutrient management and tree leaf extract spray on broad leaf weeds (m^{-2}) of cotton

Summer 2007						Winter 2007-2008					
Treatments	C_1	C_2	C_3	C_4	Mean	Treatments	C_1	C_2	C_3	C_4	Mean
N_1	12.3 (3.504)	8.7 (2.947)	10.6 (3.253)	9.6 (3.097)	10.3 (3.200)	N_1	14.1 (3.755)	10.9 (3.301)	12.8 (3.577)	12.1 (3.478)	12.5 (3.528)
N_2	12.1 (3.474)	8.5 (2.915)	10.4 (3.224)	9.3 (3.048)	10.1 (3.165)	N_2	13.9 (3.728)	10.7 (3.271)	12.6 (3.457)	11.8 (3.428)	12.2 (3.494)
N_3	12.3 (3.505)	8.7 (2.948)	10.6 (3.255)	9.6 (3.095)	10.3 (3.201)	N_3	14.1 (3.755)	10.8 (3.286)	12.8 (3.578)	12.1 (3.471)	12.5 (3.523)
N_4	12.1 (3.476)	8.5 (2.914)	10.4 (3.224)	9.4 (3.062)	10.1 (3.169)	N_4	13.9 (3.728)	10.6 (3.256)	12.6 (3.550)	11.9 (3.446)	12.3 (3.495)
N_5	12.0 (3.461)	8.4 (2.895)	10.3 (3.209)	9.4 (3.062)	10.0 (3.157)	N_5	13.9 (3.728)	10.6 (3.256)	12.7 (3.564)	11.7 (3.416)	12.2 (3.491)
N_6	12.1 (3.474)	8.4 (2.894)	10.5 (3.238)	9.3 (3.048)	10.1 (3.163)	N_6	13.9 (3.728)	10.7 (3.269)	12.6 (3.550)	11.8 (3.433)	12.3 (3.495)
Mean	12.2 (3.482)	8.5 (2.919)	10.5 (3.234)	9.4 (3.068)		Mean	14.0 (3.737)	10.7 (3.273)	12.7 (3.561)	11.9 (3.446)	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	0.021	0.067	0.124	0.134		S.Ed	0.013	0.050	0.092	0.100	
CD (p = 0.05)	0.051	NS	NS	NS		CD (p = 0.05)	0.031	NS	NS	NS	

Figures in parenthesis indicate square root transformed values, Main plot (Intercropping system): C_1: Cotton sole, C_2: Cotton+Blackgram, C_3: Cotton+Greengram, C_4: Cotton+Cluster bean, Subplot (Nutrient management): N_1: 100% RDF (Recommended dose of fertilizer: 80:40:40 kg N, P, K/ha), N_2: 75% RDF, N_3: 75% RDF+biofertilizers, N_4: 75% RDF+5% Morinda leaf extract spray, N_5: 75% RDF+5% Vilvam leaf extract spray, N_6: 75% RDF+5% Annona leaf extract spray

Table 4: Effect of intercropping system, nutrient management and tree leaf extract sprays on seed cotton yield (kg ha^{-1}) of cotton

Summer 2007						Winter 2007-2008					
Treatments	C_1	C_2	C_3	C_4	Mean	Treatments	C_1	C_2	C_3	C_4	Mean
N_1	1595	1723	1690	1565	1643	N_1	1675	1861	1803	1645	1746
N_2	1445	1480	1475	1290	1423	N_2	1525	1570	1560	1495	1538
N_3	1650	1910	1782	1625	1742	N_3	1732	1998	1954	1724	1852
N_4	1480	1525	1495	1295	1449	N_4	1560	1614	1585	1455	1554
N_5	1485	1535	1505	1310	1459	N_5	1564	1620	1601	1459	1561
N_6	1490	1540	1510	1315	1464	N_6	1580	1627	1604	1462	1568
Mean	1524	1619	1576	1400		Mean	1606	1715	1685	1540	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	49	71	138	142		S.Ed	45	55	110	110	
CD (p = 0.05)	120	143	NS	NS		CD (p = 0.05)	110	111	NS	NS	

Main Plot (Intercropping system): C_1: Cotton sole, C_2: Cotton+Blackgram, C_3: Cotton+Greengram, C_4: Cotton+Cluster bean, Subplot (Nutrient management): N_1: 100% RDF (Recommended dose of fertilizer: 80:40:40 kg N, P, K/ha), N_2: 75% RDF, N_3: 75% RDF+biofertilizers, N_4: 75% RDF+5% Morinda leaf extract spray, N_5: 75% RDF+5% Vilvam leaf extract spray, N_6: 75% RDF+5% Annona leaf extract spray

In general all the intercrops suppressed the weed considerably and established themselves as an efficient tool in minimizing the weed population. This could be due to smothering effect of companion crops[10]. Such depressive effect on weed growth by intercropping might be ascribed to the larger canopy cover obtained by leguminous intercrops which intercepted much of incident light and also competed better for other inputs with weeds, creating harsh environment for weed growth[11].

Nutrient management and tree leaf extract did not influence the weed population during the two seasons of study period. Similarly the combination of intercropping,

nutrient management and the leaf extracts spray also did not show any appreciable influence on weed population during both the seasons.

Seed cotton yield: Intercropping system, nutrient management and botanicals treatment showed significant response interms of seed cotton yield (Table 4). Among the intercropping system cotton with blackgram intercropping system recorded higher seed cotton yield of 1619 and 1715 kg ha^{-1} under during Summer and Winter season respectively. Harisudan *et al.*[12] reported that intercropping blackgram with cotton suppressed the weed growth and thereby the nutrient uptake by weeds is avoided which facilitated more availability and uptake of nutrients by cotton. Relatively, weeds, pest and disease incidence was curtailed resulting in healthy and vigorous establishment of cotton with higher yield. In addition the incorporated legume has released the nutrient at steady and balanced rate which was available to the crop at later stages[13,14]. Cotton+clusterbean cropping system reduced the seed cotton yield significantly.

Among the nutrient management, application of 75% RDF along with biofertilizers viz., *Azospirillum*, phosphobacteria and silica solubilizing bacteria recorded higher seed cotton yield (1742 and 1852 kg ha^{-1}) during Summer and Winter season. The yield increase might be due to the growth, multiplication and unfailing colonization of biofertilizer around rhizosphere region, which supplied the nutrients continuously. In addition *in situ* incorporation of intercrop residue would have released nutrients slowly. Integrated nutrient management has considerable importance as to take remedial measures in fertility management and boosting the production[15]. The positive outcomes of integrated nutrient management on improving soil fertility and increasing the yield were found by various researchers in many areas[16,17]. However, application of 75% RDF alone has recorded low seed cotton yield. Low availability of nutrients reduced the growth and led to low N, P and K uptake which in turn finally resulted in poor yield.

CONCLUSION

Based on the result of the field study cotton+blackgram intercropping may be recommended as suitable intercropping system for weed smothering combined with application of 75% RDF+application of biofertilizers viz., *Azospirillum*, phosphobacteria and Silica solubilizing bacteria could be recommended for higher seed cotton yield.

SIGNIFICANCE STATEMENT

The field study revealed that cotton+blackgram as significant intercropping system for weed smothering and application of 75% RDF+combined application of *Azospirillum*, phosphobacteria and Silica solubilizing bacteria as a biointegrated nutrient management strategies for higher seed cotton yield. The results of the field experiment will help the researchers to uncover the critical areas of intercropping system and integrated management that many researchers were not able to explore. Thus a new theory on cotton based intercropping system and integrated nutrient management may be arrived at.

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