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Effect of Integrated Nutrient Management on Red Leaf Index, Insect Pest and Disease in Cotton and Soybean Intercropping System

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Authors' contributions

This work was carried out in collaboration between all authors. Author AMP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VVA and DNK managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at All India Coordinated Research Project on Soybean, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India to study the integrated nutrient management practices on red leaf index, insect pest and disease in cotton and soybean intercropping system in 1:2 row proportion during June 2016. The study was undertaken to evaluate the sources of nutrients to red leaf index and incidence of insect pest and diseases. The field experiment was laid out in randomised complete block design with three replications and twenty treatments. Treatment comprised of organic and inorganic sources of nutrients used in different combinations. Soybean introduced as intercrop in cotton with 40 x 10 cm spacing for soybean and 120 x 60 cm for cotton. Results found that there was no visual symptoms of leaf reddening at October 1st and lowest red leaf index was observed in T_{17} (T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}). Lower incidence of *Spodoptera* larvae (*Spodoptera litura*

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Fabricius) was observed in T_{16} (T_1 + Gliricidia 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}), T_{17} (T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}) and T_{18} (T1 + Vermicompost 1.25 t ha^{-1} + Pongamia 2.5 t ha^{-1}) at 40 DAS. Lowest pod borer (*Cydia ptychora* Meyr.) incidence was observed in T_{18} compared to other treatments. Lower per cent disease incidence of angular leaf spot of cotton was observed in T_{18} than other treatments at 85 DAS. Lower per cent disease incidence of *Alternaria* leaf blight of cotton was observed in T_{16}, T_{17} and T_{18} compared to other treatments at 65 days after sowing. Integrated nutrient management in cotton and soybean intercropping systems reduced the red leaf index and provide resistance to crop to withstand against insect pest and disease.

Keywords: Integrated nutrient management; intercropping; insect pests; disease.

1. INTRODUCTION

Cotton is in predominant position among all cash crops in India and retained its unique fame as 'king of fibre' and 'white gold' because of its higher economical value among all cash crops. Long growing period and indeterminate growth habit exposes cotton crop to various stresses such as water deficit, water-logging, salinity, high or low temperature, cloudiness, nutrient deficiency *etc.* and abiotic stresses especially insect pests and pathogen. These stresses reduce the supply of photosynthates. Among the physiological factors, leaf reddening, bad boll opening and boll shedding and drying of squares are the main causes for low yield. Red leaf syndrome was observed first time by [1] who recognized yellow and red leaf blight as a physiological disorder and attributed it to mineral deficiency, although exact element was not identified. Leaf reddening is more of a physiological disorder than a disease of cotton. In India its symptoms differ from region to region [2]. The red leaf syndrome is wide spread but its occurrence is not consistent. The yielding ability is not drastically reduced when it occurs at post flowering stage in American upland cotton but yield is reduced when it occurs at flowering or vegetative stage. The yield was reduced as the plant growth was arrested because of poor rate of photosynthesis in developing red leaves [3]. Cotton is infested with excess of insect pests starting from seedling to harvest. Among them sucking pests contribute substantial losses to Bt cotton.

Extensive usage of inorganic fertilizers and pesticide residues in agriculture has led to environmental problems such as pesticide residues in food commodities, bioaccumulation and biomagnifications of pesticide in food chain and loss of soil health. Suitable management practices like intercropping and judicious combination of organic and inorganic manures are considered as ecologically viable, economically feasible and environmentally sound. Both reduced and excessive supply of many plant nutrients could possibly aggravate susceptibility to pests and diseases. INM (integrated nutrient management) ensures optimal crop growth, development and resists against pests and diseases. This study was undertaken to evaluate the various sources of nutrients to sustain the productivity and pest and disease incidence in Bt cotton and soybean intercropping system.

2. MATERIALS AND METHODS

A field experiment was conducted to study the integrated nutrient management on red leaf index in cotton and insect pest and disease incidence in BT cotton and soybean intercropping system in 1:2 row proportion during June 2016 at UAS, Dharwad. The field experiment was laid out in randomised complete block design with three replications and twenty treatments. RDF (recommended dose of fertilizer) was applied to both crops in intercropping system according to population (100:50:50 and 40:80:25 kg N, P_2O_5 and K_2O kg ha^{-1} for Cotton and Soybean, respectively). As per the treatments the organic manure [FYM (farm yard manure)] and green leaf manures (gliricidia and pongamia) were applied 15 days before sowing of the crop. Vermicompost was spot applied to soil before dibbling of seeds. Sowing was done by adopting 120 cm x 60 cm row spacing for cotton and 40 cm x 10 cm for soybean in intercropping system (1:2) during *kharif* season on 12.6.2016. As per the treatments the organic manure (FYM) and green leaf manures (gliricidia and pongamia) were applied 15 days before sowing of the crop. Vermicompost was spot applied to soil before dibbling of seeds.

2.1 Red Leaf Index Estimation

For quantitative estimation of degree of leaf reddening in cotton, observations were recorded at October 1st, 15th, 30th and Novmber 15th during 2016 as outlined by [4]. The number of leaves

showing signs of reddening, partly or wholly were divided into five categories on the visual observations.

Grade '0' – When all the leaves were green or less than three leaves showed signs of reddening.

Grade '1' – When three leaves showed reddening.

Grade '2' – When more than three leaves were showing signs of reddening but young leaves were green.

Grade '3' – When all the leaves were showing reddening in patches.

Grade '4' – When the whole plant turned red.

2.2 Observation on Incidence of Insects and Diseases

2.2.1 *Spodoptera* larvae [*Spodoptera litura* (F.)] per meter row length (mrl)

Soybean plants were beaten with some sort of stick and it consist of beating sheet (or pan) under the area being beaten. A beating sheet is basically just a piece of heavy duty cloth stretched across two diagonal pieces of wood joined at the center. Observations were made at three places in each plot and mean was reported in number per meter row length (mrl).

2.2.2 Pod borer incidence (*Cydia ptychora*)

Before harvesting of soybean crop, incidence of pod borer was recorded by uprooting five randomly selected plants in each intercropping system excluding border rows. Total number of pods per plant and larvae per pod was recorded.

2.2.3 Disease score

Disease scores were made for Angular leaf spot and *Alternaria* leaf blight using disease rating scale (0-9) developed by [5].

Rating	Description
0 -	No infection
1 -	1-10 per cent of infection
3 -	10 – 25 per cent of infection
5 -	25-50 per cent of infection
7 -	50 – 75 per cent of infection
9 -	> 75 per cent of infection

PDI is Per cent disease index

$$PDI = \frac{\text{Sum of numerical ratings} \times 100}{\text{Number of leaves observed} \times \text{Maximum disease rating}}$$

2.3 Statistical Analysis and Interpretation of Data

Statistical analysis was carried out based on mean values obtained. The level of significance used in 'F' and 'T' test was P = .05. The treatment means were compared by Duncan's Multiple Range Test (DMRT) at 0.05 level of probability [6].

3. RESULTS AND DISCUSSION

3.1 Red Leaf Index in Cotton

Red leaf index differed significantly due to INM (integrated nutrient management) treatments except at October 1st, when there was no visual symptom of reddening (Table 1). At October 15th, 30th and November 15th, the highest red leaf index was observed in cotton sole crop and it was on par with T_1 (100 % RDF for cotton and soybean). Lowest red leaf index was observed in T_{18} (T_1 + Vermicompost 1.25 t ha^{-1} + Pongamia 2.5 t ha^{-1}). It was due to the very nature of vermicompost, which supplies sufficient micronutrients in form to available plants readily, which react with native soil nutrients in a way that enhances their availability to crops thus resulting in improved physiological function of plants against red leaf index in low temperature conditions. Similar results were observed by [7], who reported that the red leaf was caused by the deficiency of nitrogen and micronutrients in leaves grown on light textured soil.

3.2 Incidence of *Spodoptera litura* in Soybean

Incidence of *Spodoptera litura* (mrl^{-1}) in soybean differed significantly due to INM treatments (Table 2). Among the different treatments in the intercropping system, highest number of *Spodoptera* larvae (1.87 larve mrl^{-1}) was observed in T_3 (150 % RDF for cotton and soybean) and was on par with T_2 (125 % RDF for cotton and soybean) (1.78 larvae mrl^{-1}). Higher dose of chemical fertilizers induces succulent and susceptible plant. Lower incidence of *Spodoptera litura* (mrl^{-1}) was observed in INM treatments. Therefore, integration of chemical fertilizers with green manures and vermicompost reduced the incidence of *Spodoptera litura* in soybean. Vermicompost is the organic manure obtained by earthworm and microbes induced biodegradation of organic wastes, contains major and minor nutrients, secondary elements, plant growth regulators and antibiotics and vast populaton of fungi, bacteria, actinomycetes and protozoa [8].

Table 1. Red leaf index in cotton as influenced by INM in cotton and soybean intercropping system during 2016-17

Treatments	Red leaf index			
	October 1st	October 15th	October 30th	November 15th
T_1: 100 % RDF for cotton and soybean	0.70 (0)	1.11ab (0.73)	1.30a-c (1.2)	1.33a (1.27)
T_2: 125 % RDF for cotton and soybean	0.70 (0)	0.87d (0.27)	1.10bc (0.7)	1.05cd (0.6)
T_3: 150 % RDF for cotton and soybean	0.70 (0)	0.91d (0.33)	1.20bc (0.9)	1.11b-d (0.73)
T_4: 100 % FYM and RDF for cotton and soybean (RC)	0.70 (0)	1.02b-d (0.53)	1.32ab (1.3)	1.25a-c (1.07)
T_5: T_1 + FYM 2.5 t ha^{-1}	0.70 (0)	1.03b-d (0.58)	1.21bc (1.0)	1.17a-d (0.87)
T_6: T_1 + FYM 5 t ha^{-1}	0.70 (0)	0.98b-d (0.47)	1.25bc (1.1)	1.28ab (1.13)
T_7: T_1 + Gliricidia 2.5 t ha^{-1}	0.70 (0)	0.94b-d (0.40)	1.08c (0.7)	1.22a-d (1.00)
T_8: T_1 + Gliricidia 5 t ha^{-1}	0.70 (0)	0.98cd (0.47)	1.26a-c (1.1)	1.25a-c (1.07)
T_9: T_1 + Pongamia 2.5 t ha^{-1}	0.70 (0)	1.02b-d (0.53)	1.13bc (0.8)	1.28ab (1.13)
T_{10}: T_1 + Pongamia 5 t ha^{-1}	0.70 (0)	0.87b-d (0.27)	1.11bc (0.7)	1.16a-d (0.87)
T_{11}: T_1 + Vermicompost 1.25 t ha^{-1}	0.70 (0)	1.08d (0.67)	1.19bc (0.9)	1.25a-c (1.07)
T_{12}: T_1 + Vermicompost 2.5 t ha^{-1}	0.70 (0)	0.95a-c (0.40)	1.08c (0.7)	1.25b-d (1.07)
T_{13}: T_1 + FYM 2.5 t ha^{-1} + Gliricidia 2.5 t ha^{-1}	0.70 (0)	0.95b-d (0.40)	1.11bc (0.7)	1.11a-d (0.73)
T_{14}: T_1 + FYM 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}	0.70 (0)	0.94b-d (0.40)	1.17bc (0.9)	1.13a-d (0.80)
T_{15}: T_1 + FYM 2.5 t ha^{-1} + Vermicompost 1.25 t ha^{-1}	0.70 (0)	0.91cd (0.33)	1.11bc (0.7)	1.14a-d (0.80)
T_{16}: T_1 + Gliricidia 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}	0.70 (0)	0.91d (0.33)	1.17bc (0.9)	1.10b-d (0.73)
T_{17}: T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}	0.70 (0)	0.87d (0.27)	1.08c (0.7)	1.04cd (0.60)
T_{18}: T_1 + Vermicompost 1.25 t ha^{-1} + Pongamia 2.5 t ha^{-1}	0.70 (0)	0.98b-d (0.47)	1.07c (0.7)	1.01d (0.53)
T_{19}: Cotton sole crop (100 % RDF and FYM)	0.70 (0)	1.22a (1.00)	1.47a (1.7)	1.33a (1.27)
T_{20}: Soybean sole crop (100 % RDF and FYM)	-	-	-	-
Mean	**-**	**1.00**	**1.20**	**1.20**
S.Em. ±	**-**	**0.04**	**0.06**	**0.06**
C.V. (%)	**-**	**11.8**	**12.3**	**11.0**

Means followed by the same letters do not differ significantly (0.05) by DMRT; RC – Recommended Check; Figures in the parenthesis are original values and analyzed data are subjected to square root transformations

Table 2. Incidence of *Spodoptera litura* in soybean at 40 DAS and pod borer incidence in soybean at 85 DAS and angular leaf spot disease and *Alternaria* leaf blight disease in cotton as influenced by INM in cotton and soybean intercropping system during 2016-17

Treatments	*Spodoptera* larvae at 40 DAS (per mrl)	Pod borer incidence at 85 DAS (number of larvae per pod)	Angular leaf spot disease (PDI)	*Alternaria* leaf blight disease (PDI)
T_1: 100 % RDF for cotton and soybean	1.39 (1.44) d	1.10 (0.70) c-e	8.13 (1.00) ab	8.13 (1.00) a
T_2: 125 % RDF for cotton and soybean	1.78 (2.67) ab	1.39 (1.44) b	10.1 (1.67) ab	10.1 (1.67) a
T_3: 150 % RDF for cotton and soybean	1.87 (1.56) a	1.65 (2.22) a	12.1 (2.33) a	12.1 (2.33) a
T_4: 100 % FYM and RDF for cotton and soybean (RC)	1.58 (2.00) b-d	1.42 (1.52) ab	8.13 (1.00) ab	10.1 (1.67) a
T_5: T_1 + FYM 2.5 t ha^{-1}	1.54 (1.89) c-d	1.35 (1.33) bc	8.13 (1.00) ab	8.13 (1.00) a
T_6: T_1 + FYM 5 t ha^{-1}	1.65 (2.22) b-d	1.25 (1.07) b-d	10.1 (1.67) ab	8.13 (1.00) a
T_7: T_1 + Gliricidia 2.5 t ha^{-1}	1.58 (2.00) b-d	1.23 (1.04) b-d	8.13 (1.00) ab	10.1 (1.67) a
T_8: T_1 + Gliricidia 5 t ha^{-1}	1.54 (1.89) b-d	1.16 (0.89) b-e	8.13 (1.00) ab	8.13 (1.00) a
T_9: T_1 + Pongamia 2.5 t ha^{-1}	1.62 (2.11) b-d	1.35 (1.33) bc	8.13 (1.00) ab	12.1 (2.33) a
T_{10}: T_1 + Pongamia 5 t ha^{-1}	1.58 (1.44) d	1.10 (0.70) c-e	12.1 (2.33) a	12.1 (2.33) a
T_{11}: T_1 + Vermicompost 1.25 t ha^{-1}	1.39 (1.56) cd	1.19 (1.00) b-e	10.1 (1.67) ab	10.1 (1.67) a
T_{12}: T_1 + Vermicompost 2.5 t ha^{-1}	1.43 (2.11) b-d	1.01 (0.52) de	10.1 (1.67) ab	10.1 (1.67) a
T_{13}: T_1 + FYM 2.5 t ha^{-1} + Gliricidia 2.5 t ha^{-1}	1.61 (2.22) b-d	1.30 (1.22) bc	8.13 (1.00) ab	10.1 (1.67) a
T_{14}: T_1 + FYM 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}	1.65 (2.22) a-c	1.35 (1.33) bc	8.13 (1.00) ab	12.1 (2.33) a
T_{15}: T_1 + FYM 2.5 t ha^{-1} + Vermicompost 1.25 t ha^{-1}	1.39 (1.39) a-c	1.42 (1.52) ab	10.1 (1.67) ab	12.1 (2.33) a
T_{16}: T_1 + Gliricidia 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}	1.43 (1.56) d	1.20 (0.96) b-d	10.1 (1.67) ab	8.13 (1.00) a
T_{17}: T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}	1.07 (0.67) cd	1.22 (1.00) b-d	8.13 (1.00) ab	8.13 (1.00) a
T_{18}: T_1 + Vermicompost 1.25 t ha^{-1} + Pongamia 2.5 t ha^{-1}	1.15 (0.89) e	0.93 (0.37) e	5.42 (0.67) b	8.13 (1.00) a
T_{19}: Cotton sole crop (100 % RDF and FYM)	-	-	12.1 (2.33) a	12.1 (2.33) a
T_{20}: Soybean sole crop (100 % RDF and FYM)	1.77 (2.67) ab	1.43 (1.48) ab	-	-
Mean	**1.53**	**1.26**	**9.26**	**10.0**
S.Em. ±	**1.44**	**0.08**	**1.50**	**1.56**
C.V. (%)	**8.53**	**11.2**	**26.2**	**27.0**

Figures in the parenthesis indicate original values and analyzed data are $\sqrt{x+0.5}$ *values; Means followed by the same letters do not differ significantly (0.05) by DMRT; RC – Recommended Check*

3.3 Pod Borer Incidence in Soybean

Incidence of pod borer (*Cydia ptychora*) in soybean differed significantly due to INM treatments (Table 2). Among the different treatments, T_3 (150 % RDF for cotton and soybean) recorded higher pod borer incidence (1.65 larvae pod^{-1}) in soybean and it was on par with sole soybean (1.43 larvae pod^{-1}). However, lower pod borer incidence in soybean was recorded in T_{18} compared to other treatments. The decrease in pod borer incidence was to the tune of 77 per cent over T_3 (150 % RDF for cotton and soybean). Similar results were observed by [9], who reported that lower aphid (*Aphis gossypii*) infestation on bhendi and leaf hoppers in brinjal was observed with application of vermicompost. However, green manure and vermicompost treatments showed lower incidence of angular leaf spot disease. Vermicompost undergoes decomposition to produce organic acids and releases the macro and micro nutrients in soil. They are involved in shikimate pathway, responsible for biosynthesis of phenolics, lignins and phytoalexins, which provide resistance to plants [10].

3.4 Incidence of Angular Leaf Spot in Cotton

Incidence of angular leaf spot in cotton differed significantly due to INM treatments (Table 2). Among the different treatments, T_3 [150% RDF (recommended dose of fertilizers)] for cotton and soybean) (12.1 PDI) and cotton sole crop (12.1 PDI) recorded the highest incidence of angular leaf spot in cotton. Application of higher dose of chemical fertilizers beyond the optimum dose increased the susceptibility to disease.

3.5 Incidence of *Alternaria* Leaf Blight Disease in Cotton

Incidence of *Alternaria* leaf blight disease in cotton differed significantly due to INM treatments (Table 2). Among the different treatments, the highest incidence of *Alternaria* leaf blight disease in cotton was observed in T_3 (150 % RDF for cotton and soybean) [12.1 PDI (Per cent disease index)] and cotton sole crop (PDI). However, lower per cent disease incidence of *Alternaria* leaf blight of cotton was observed in T_{16}, T_{17} and T_{18}. Similarly, green manures like gliricida and pongamia after decomposition produce organic acids, which accelerates synthesis of pathogenesis related proteins [11].

4. CONCLUSION

Integrated nutrient management treatments *viz.,* T_{16}, T_{17} and T_{18} produced resistance to the plants to withstand against leaf reddening, insect pests and also very nature of pongamia and vermicompost due to pesticidal property against diseases results in economic yield in cotton and soybean intercropping system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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