

Original Research Article

Integrated Nutrient Management to Sustain the Productivity of Soybean in Cotton and Soybean Intercropping System

ABSTRACT

Aim: A field experiment was conducted to study the integrated nutrient management on growth components of soybean, resource use efficiency and economics of cotton and soybean intercropping system.

Study design: Randomised complete block design with three replications and twenty treatments.

Place and Duration of Study: Plot number '101' of 'D' block, All India Coordinated Research Project on soybean, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka (India) during *kharif* 2015 and 2016.

Methodology: 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 in cotton and soybean intercropping system in 1:2 row proportion, soybean introduced as intercrop in cotton with row spacing of cotton 120 cm and soybean 30 cm.

Results: Results of the study indicated that significantly higher soybean growth attributes were observed in sole soybean than intercropped soybean, except for plant height. Among the intercropping system, T_3 (150 % RDF for cotton and soybean) recorded significantly higher number of branches plant, leaf area per plant, leaf area index dry matter production and total number of nodules per plant. Intercropping of cotton and soybean resulted in more efficient utilization of resource. Among the intercropping system, T_3 (150 % RDF for cotton and soybean) recorded higher biomass and leaf area of cotton and soybean intercropping system. Among the different treatments, significantly higher gross returns and net returns were recorded in T_3 (150 % RDF for cotton and soybean) and it was on par with T_2 (125 % RDF for cotton and soybean) and T_{17} (T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}) during both years and in pooled data. Among the different treatments, significantly higher BC ratio was recorded in T_{16} (T_1 + Gliricidia 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}) compared to rest of the intercropping systems and sole cotton and soybean during both years and in pooled data. However, T_{16} was on par with T_2 (125 % RDF for cotton and soybean) during 2015-16.

Conclusion: Farmers can adopt a fertilizer dose of 125 : 62.5 : 62.5 N, P_2O_5 and K_2O kg ha^{-1} in cotton and soybean intercropping system or 100 : 50 : 50 N, P_2O_5 and K_2O kg ha^{-1} along with Gliricidia + Pongamia 2.5 t ha^{-1} each for cotton and soybean intercropping for profitable yields in rainfed situation.

Keywords: Integrated nutrient management; cotton; soybean; economics

11 1 . INTRODUCTION

12

13 Agriculture is one of the most vulnerable and adaptation-prone sources of livelihood facing
 14 climate change. Among the different field crops, cotton (*Gossypium hirsutum* L.) is one of
 15 the most important cash crops that provide fiber to the textile industries around the world.
 16 According to the rough estimation regarding the world production of cotton, 80% comes from
 17 Brazil, China, India, Pakistan, Turkey, USA, and Uzbekistan. This crop contributes a major
 18 portion to the gross national product (GNP) of many countries. Hence, there is need for
 19 sustainable intensification, i.e., increasing productivity from existing agricultural lands while
 20 minimizing the negative environmental effects and ensuring the future needs of food
 21 production, has been proposed as a central means to restrict further land clearing for
 22 agriculture and transform agriculture and food systems to operate in a more sustainable way
 23 [1]. The approach emphasizes reducing the use of external inputs such as industrial
 24 fertilizers and pesticides that further pressurize the environment and climate. It builds on
 25 spatio-temporal functional diversification of the agroecosystem and the combination of crop
 26 species and traits that support and make better use of ecosystem services [2]. Intercropping
 27 represents a within-field diversification strategy that is based on ecological intensification. It
 28 refers to the cultivation of two or more crops together in time and space, and it is an ancient
 29 practice of cropping that aims to maximize productivity per land area using only few external
 30 inputs. Intercropping helps in the total production of different commodities with higher returns
 31 under dryland conditions, besides better utilization of natural and scarce resources per unit
 32 time [3]. Soybean, being a short duration and short stature legume, the crop has greater
 33 ability to fix atmospheric nitrogen. It occupies prime position in intercropping system.
 34 Intercropping of cotton with short duration legume like soybean was found more
 35 remunerative than sole cotton [4 and 5]. Application of organic manures along with inorganic
 36 fertilizers helps to rejuvenate the degraded soils and ensures sustainability in crop
 37 production. Suitable management practices like intercropping and judicious combination of
 38 organic and inorganic manures are considered ecologically viable, economically feasible and
 39 avoid environmental pollution. In addition, combination of organic and inorganic manures
 40 works like slow release fertilizers for providing balanced nutrients to plants. Keeping these
 41 facts in view the present study was undertaken.

42

43 2. MATERIAL AND METHODS

44

45 Field experiment was carried out to study the INM practices on growth components of
 46 soybean, resource use efficiency and economics of cotton and soybean intercropping
 47 system in 1:2 row proportion during *kharif* 2015 and 2016 at plot 101 'D' block, All India Co-
 48 ordinated Research Project on Soybean, Main Agricultural Research Station, University of
 49 Agricultural Sciences, Dharwad, Karnataka (India), which is located at latitude of 15° 26' N
 50 and 75° 07' E longitude with an altitude of 678 m above mean sea level. Soil was clay with
 51 pH 7.3, 0.51% organic carbon, 281 kg ha⁻¹ available N, 34 kg ha⁻¹ available P₂O₅ and 312 kg
 52 ha⁻¹ available K₂O and 0.35 dsm⁻¹ EC. The experiment was laid out in randomised complete
 53 block design with three replications and twenty treatments as given in the tables. Sowing
 54 was done by adopting 120 cm x 60 cm row spacing for cotton and soybean introduced as
 55 intercrop with 40 cm x 10 cm in 1:2 row proportions during *kharif* season on June 12th, 2016.
 56 Organic manure (FYM) and green leaf manures (gliricidia and pongamia) were applied 15
 57 days before sowing of the crop according to the treatments. Vermicompost was spot applied
 58 to soil before dibbling of seeds. RDF was applied to both crops in intercropping system

59 according to population (100:50:50 and 40:80:25 kg N, P₂O₅ and K₂O ha⁻¹ for Cotton and
60 Soybean, respectively).

61

62 **2.1 Growth parameters of soybean**

63 **2.1.1 Plant height**

64 The plant height was measured from ground level to the tip of the main shoot and their mean
65 was expressed as plant height in centimeters (cm).

66 **2.1.2 Number of branches per plant**

67 The number of branches per plant was counted from five tagged plants and their mean was
68 recorded as number of branches per plant.

69 **2.1.3 Leaf area per plant**

70 Leaf area was recorded by leaf area meter. The top, middle and bottom leaves were
71 collected from five selected plants at random from each plot and leaf area was measured by
72 using leaf area meter (LICOR LI 3000A). The leaf area from top, middle and bottom of plant
73 was multiplied with number of leaves per plant (top, middle and bottom leaves). The leaf
74 area per plant was expressed in decimeter squares (dm²).

75 **2.1.4 Leaf area index**

76 Leaf area index (LAI) was calculated as per the procedure given by [6].

77 **2.1.5 Dry matter production**

78 The five randomly selected plants were used to record the dry matter production at at
79 harvest. The plants were uprooted and separated into leaves, stem and pods. They were
80 oven dried separately at 70°C for 48 hours and the total dry weight gram per plant (g plant⁻¹)
81 was recorded.

82 **2.1.6 Total number of nodules per plant**

83 The plants were carefully removed from the soil without damaging the roots and roots were
84 dipped gently in a bucket containing water to remove the soil and then nodules were
85 counted. The number of effective root nodules was counted in randomly selected five plants.

86 **2.2 Resource efficiency of the system**

87 **2.2.1 Biomass**

88 It was measured by using the following formula at harvest of cotton and expressed in
89 kilograms per hectare (kg ha⁻¹).

90 Biomass (kg ha⁻¹) = Summation of dry matter production per plant of both the crops x plant
91 population per hectare of respective crops.

92 **2.2.2 Leaf area**

93 It was measured by using the following formula at harvest of cotton and expressed in
94 centimeter squares per hectare (cm² ha⁻¹).

95 Leaf area (cm² ha⁻¹) = Summation of leaf area per plant of both the crops x plant population
96 per ha of respective crops

97 **2.3 Economics of the system**

98 The prices of the inputs that prevailed during experimentation were considered for working
99 out the cost of cultivation.

100 Gross return (Rs. ha⁻¹) was calculated on the basis of market price of the produce during
101 harvest period. Net return (Rs. ha⁻¹) was calculated by deducting the cost of cultivation (Rs.
102 ha⁻¹) from gross return. Benefit cost ratio (BC) was worked out as follows.

103 Gross returns (Rs. ha⁻¹)

104 BC ratio = _____

Cost of cultivation (Rs. ha⁻¹)

2.4 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 $P = 0.05$. The treatment means were compared by Duncan's Multiple Range Test (DMRT) at 0.05 level of probability [7].

3. RESULTS AND DISCUSSION

3.1.1 Soybean growth attributes

Plant height differed significantly due to INM treatments during both the years and in pooled data (Table 1). Among the different treatments, T₃ (150 % RDF for cotton and soybean) recorded the highest plant height during both years and in pooled data. Number of branches per plant differed significantly due to INM treatments during both the years and in pooled data (Table 1). Significantly higher number of branches per plant was observed in sole soybean than intercropped soybean. Among the intercropping systems, T₃ recorded the highest number of branches per plant during both years and in pooled data. Leaf area differed significantly due to INM treatments during both the years and in pooled data (Table 1). At 60 DAS, the highest leaf area was observed in sole soybean than intercropped soybean during 2016-17 and in pooled data. At 60 DAS, T₃ (150 % RDF for cotton and soybean) recorded higher leaf area and it was on par with T₂ (125 % RDF for cotton and soybean) and T₁₇ (T₁ + Vermicompost 1.25 t ha⁻¹ + Gliricidia 2.5 t ha⁻¹) during 2016-17 and in pooled data. LAI differed significantly due to INM treatments during both the years and in pooled data (Table 2). At 60 DAS, significantly higher LAI was observed in sole soybean than intercropped soybean during both years and in pooled data. Among the intercropping systems at 60 DAS, the highest LAI was observed in T₃ (150 % RDF for cotton and soybean) during both years and in pooled data. Dry matter production differed significantly due to INM treatments during both the years and in pooled data (Table 2). Significantly higher dry matter production was observed in sole soybean than intercropped soybean during both years and in pooled data. Among the intercropping systems, T₃ (150 % RDF for cotton and soybean) recorded the highest dry matter production during both years and in pooled data. Total number of nodules per plant differed significantly due to INM treatments during both the years (Table 2). Among the intercropping treatments at 60 DAS, T₄ recorded higher number of nodules per plant during both years and in pooled data. The results are in agreement with the findings of [8 and 9], who also reported that combined application of organic and inorganic nutrients was superior over inorganic alone.

3.1.2 Biomass and leaf area of the system

When two or more crops grown together in an intercropping system, the component crop yield may be lower compared to their sole crop yields due to inter-specific competition for growth resources viz., light, moisture, nutrients due to increased population pressure per unit land area or demand exceeding supply or due to both. Biomass differed significantly due to INM treatments during both the years. At harvest, the highest biomass recorded in T₃ during both years and in pooled data (Table 3). Leaf area differed significantly due to INM treatments during both the years. Similar trend was followed for leaf area of the system.

3.1.3 Economics of the intercropping system

Gross returns differed significantly due to INM treatments during both the years and in pooled data (Table 4). Among the different treatments, significantly higher gross returns were recorded in T_3 (150 % RDF for cotton and soybean) and it was on par with T_2 (125 % RDF for cotton and soybean) and T_{17} (T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}) during both years and in pooled data. All the intercropping systems recorded significantly higher gross returns than sole crops in both years and in pooled data. The higher gross returns with these treatments were due to better performance of component crops in terms of yields and also due to higher price of cotton. Net returns differed significantly due to INM treatments during both the years and in pooled data (Table 4). Among the different treatments, significantly higher net returns were recorded in T_2 (125 % RDF for cotton and soybean) and it was on par with T_3 (150 % RDF for cotton and soybean) and T_{16} (T_1 + Gliricidia 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}) and T_{17} (T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}) during both years and in pooled data and T_{18} (T_1 + Vermicompost 1.25 t ha^{-1} + Pongamia 2.5 t ha^{-1}) during 2015-16. All the intercropping systems recorded significantly higher net returns than sole crops in both years and in pooled data. BC ratio differed significantly due to INM treatments during both the years and in pooled data (Table 4). Among the different treatments, significantly higher BC ratio was recorded in T_{16} (T_1 + Gliricidia 2.5 t ha^{-1} + Pongamia 2.5 t ha^{-1}) compared to rest of the intercropping systems and sole cotton and soybean during both years and in pooled data. However, T_{16} was on par with T_2 (125 % RDF for cotton and soybean) during 2015-16. The higher BC ratio was due to better performance of component crops, which gave higher productivity and net returns, helping in getting higher BC ratio. The results are in agreement with the findings of [10], where cotton variety Narsimha intercropped with soybean (JS-335) recorded significantly higher seed cotton equivalent yields, maximum net returns and BC ratio.

4. CONCLUSION

Farmers can adopt a fertilizer dose of 125 : 62.5 : 62.5 N, P_2O_5 and $K_2O \text{ kg ha}^{-1}$ in cotton and soybean intercropping system or 100 : 50 : 50 N, P_2O_5 and $K_2O \text{ kg ha}^{-1}$ along with Gliricidia + Pongamia 2.5 t ha^{-1} each for cotton and soybean intercropping for profitable yields.

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Table 1: Plant height, number of branches per plant at harvest and leaf area per plant at 60 DAS of soybean as influenced by INM in cotton and soybean intercropping system

Treatments	Plant height (cm)			Number of branches per plant			Leaf area plant ⁻¹ (dm ²) at 60 DAS		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	33.8hi	36.2ef	35.0h	5.21k	5.10h	5.15g	11.9g	11.0i	11.4f
T ₂ : 125 % RDF for cotton and soybean	33.8hi	38.0a	35.9ef	6.42c	6.73bc	6.58b	13.2bc	13.4b	13.3b
T ₃ : 150 % RDF for cotton and soybean	38.1a	38.1a	38.1a	6.51b	6.74bc	6.62b	13.4b	13.4b	13.4b
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	36.9b	37.8ab	37.3b	6.34d	6.46d	6.40c	13.2bc	12.9c-f	13.0b-d
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	34.2gh	32.1h	33.1i	5.52h	5.80g	5.66f	12.7d-f	12.3gh	12.5e
T ₆ : T ₁ + FYM 5 t ha ⁻¹	34.3f-h	36.1f	35.2gh	5.56g	6.17ef	5.86de	12.6ef	12.5f-h	12.6de
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	34.7e-g	36.9cd	35.8fg	5.33j	6.33e	5.83ef	12.6ef	12.7d-g	12.6de
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	34.2gh	37.2bc	35.7fg	5.42i	6.45d	5.94de	12.6ef	12.8c-f	12.7c-e
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	33.9h	36.5d-f	35.2gh	5.22k	6.11f	5.66f	12.5f	12.6e-h	12.6de
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	34.1gh	36.8c-e	35.5	5.26j	6.20ef	5.73f	12.6ef	12.7d-g	12.6de
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	34.9d-f	36.2ef	35.5f-h	5.81f	6.05f	5.93de	12.8c-f	12.5f-h	12.6de
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	35.1c-e	36.3d-f	35.7fg	5.84f	6.20ef	6.02d	12.7d-f	12.6b-d	12.7c-e
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	35.4cd	37.9a	36.7b-d	6.20e	6.65bc	6.43c	13.0b-e	13.1b-d	13.1bc
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	35.3c-e	37.9a	36.6cd	6.17e	6.63cd	6.40c	12.9c-f	13.1b-e	13.0b-d
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	35.5cd	37.8ab	36.7b-d	6.23e	6.57cd	6.40c	13.1b-d	13.0b-d	13.0b-d
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	35.1c-e	37.9a	36.5de	6.16e	6.70cd	6.43c	12.9c-f	13.1bc	13.0b-d
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	36.4b	38.0a	37.2bc	6.32d	6.77b	6.55bc	13.1b-d	13.2bc	13.2b
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	35.6c	38.0a	36.8b-d	6.28d	6.75b	6.52bc	13.1b-d	12.2h	12.6de
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	33.2i	34.1g	33.6i	6.92a	7.20a	7.06a	14.3a	14.9a	14.6a
Mean	34.9	36.9	35.9	5.93	6.40	6.17	12.9	12.8	12.8
S.Em. \pm	0.21	0.21	0.44	0.03	0.05	0.09	0.13	0.12	0.28
C.V. (%)	5.22	6.74	5.35	8.53	7.64	8.12	11.6	12.5	11.4

Means followed by the same letters do not differ significantly (0.05) by DMRT; RC – Recommended Check

Table 2 : Leaf area index at 60 DAS, dry matter production and total number of nodules per plant at harvest of soybean as influenced by INM in cotton and soybean intercropping system

Treatments	Leaf area index at 60 DAS			Dry matter production (g plant ⁻¹)			Total number of nodules per plant		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	2.96e	2.76f	2.86c	5.21k	5.10h	5.15g	21.0f	21.6i	21.3i
T ₂ : 125 % RDF for cotton and soybean	3.30bc	3.35b	3.33b	6.42c	6.73bc	6.58b	22.3b-e	24.1b-d	23.2b-d
T ₃ : 150 % RDF for cotton and soybean	3.35b	3.36b	3.36b	6.51b	6.74bc	6.62b	22.5b-e	24.1bc	23.3bc
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	3.29bc	3.22cd	3.26b	6.34d	6.46d	6.40c	23.0bc	24.2b	23.6b
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	3.16cd	3.08de	3.12bc	5.52h	5.80g	5.66f	21.9d-f	22.1h	22.0h
T ₆ : T ₁ + FYM 5 t ha ⁻¹	3.16cd	3.12de	3.14bc	5.56g	6.17ef	5.86de	22.0d-f	22.1gh	22.10gh
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	3.15de	3.18cd	3.16bc	5.33j	6.33e	5.83ef	21.7ef	22.7f	22.2gh
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	3.16cd	3.19cd	3.17bc	5.42i	6.45d	5.94de	21.8d-f	22.8f	22.3e-h
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	3.13de	3.15cd	3.14bc	5.22k	6.11f	5.66f	21.7ef	22.6fg	22.1gh
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	3.14de	3.17cd	3.15bc	5.26j	6.20ef	5.73f	21.7ef	22.6fg	22.1gh
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	3.20cd	3.13de	3.16bc	5.81f	6.05f	5.93de	22.1c-e	22.1gh	22.1gh
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	3.19cd	3.14de	3.16bc	5.84f	6.20ef	6.02d	22.2b-e	22.3gh	22.2f-h
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	3.25bc	3.28c	3.27b	6.20e	6.65bc	6.43c	22.6b-e	22.4f-h	22.5d-h
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	3.22cd	3.27c	3.25bc	6.17e	6.63cd	6.40c	22.5b-e	23.4e	22.9b-f
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	3.27bc	3.25c	3.26b	6.23e	6.57cd	6.40c	22.7b-d	23.4e	23.0b-e
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	3.22cd	3.29c	3.25b	6.16e	6.70cd	6.43c	22.3b	23.5e	22.9c-g
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	3.28bc	3.31c	3.29b	6.32d	6.77b	6.55bc	23.1b-d	23.8c-e	23.4bc
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	3.27bc	3.04e	3.16bc	6.28d	6.75b	6.52bc	22.8b-d	23.7de	23.2bc
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	4.77a	4.96a	4.87a	6.92a	7.20a	7.06a	24.4a	25.1a	24.7a
Mean	3.23	3.31	3.22	5.93	6.40	6.17	22.3	23.0	22.7
S.Em. \pm	0.03	0.03	0.07	0.03	0.05	0.09	0.31	0.13	0.50
C.V. (%)	11.1	12.9	11.6	8.53	7.64	8.12	5.92	7.82	6.800

Means followed by the same letters do not differ significantly (0.05) by DMRT; RC – Recommended Check

Table 3: Biomass and leaf area of cotton and soybean at harvest as influenced by INM in cotton and soybean intercropping system

Treatments	Biomass (kg ha ⁻¹)			Leaf area (cm ² ha ⁻¹)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	1,045n	1,046i	1,046h	17,922j	18,249l	18,086j
T ₂ : 125 % RDF for cotton and soybean	1,152bc	1,225b	1,188b	18,729b-d	20,396b	19,562b
T ₃ : 150 % RDF for cotton and soybean	1,160b	1,215b	1,187b	18,780b-d	20,170c	19,475bc
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	1,136de	1,171de	1,153cd	18,827bc	19,136h	18,982ef
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	1,081j-l	1,120h	1,100g	18,175hi	18,645k	18,410i
T ₆ : T ₁ + FYM 5 t ha ⁻¹	1,084jk	1,137f-h	1,111fg	18,308f-h	18,949ij	18,629h
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	1,066m	1,152e-g	1,109fg	18,082ij	19,382fg	18,732gh
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	1,075k-m	1,165de	1,120fg	18,185g-i	19,629e	18,907fg
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	1,066m	1,146e-g	1,106g	18,037ij	19,094hi	18,565hi
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	1,069lm	1,162d-f	1,116fg	18,082ij	19,415f	18,749gh
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	1,091ij	1,130gh	1,110fg	18,375fg	18,893j	18,634h
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	1,103hi	1,152e-g	1,128ef	18,445ef	19,239gh	18,842fg
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	1,106gh	1,180d	1,143de	18,653cd	19,692e	19,172d
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	1,118fg	1,186cd	1,152cd	18,583de	19,866d	19,224d
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	1,127ef	1,168de	1,148d	18,690cd	19,616e	19,153de
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	1,133de	1,205bc	1,169bc	18,584de	20,022cd	19,303cd
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	1,141cd	1,207bc	1,174b	18,899b	20,043c	19,471bc
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	1,133de	1,212b	1,172b	18,751b-d	20,099c	19,425bc
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	1,677a	1,731a	1,704a	25,689a	27,462a	26,575a
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	-	-	-	-	-	-
Mean	1,078	1,195	1,164	17,889	19,894	19,363
S.Em. ±	4.30	7.95	6.41	63.7	58.2	61.0
C.V. (%)	12.3	11.2	11.4	9.23	9.45	9.10

Means followed by the same letters do not differ significantly (0.05) by DMRT; RC – Recommended Check

Table 4: Economics as influenced by INM in cotton and soybean intercropping system

Treatments	Gross returns (Rs. ha ⁻¹)			Net returns (Rs. ha ⁻¹)			Benefit cost ratio		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	1,21,920j	1,66,669h	1,44,294h	76,839f	1,13,497hi	95,168g	2.70g-i	3.13f	2.92fg
T ₂ : 125 % RDF for cotton and soybean	1,41,035a	1,78,396ab	1,59,716ab	93,917a	1,23,188a	1,08,553a	2.99a	3.23bc	3.11b
T ₃ : 150 % RDF for cotton and soybean	1,41,647a	1,79,743a	1,60,695a	92,492a	1,22,498ab	1,07,495ab	2.88bc	3.14ef	3.01cd
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	1,39,328a-c	1,73,358c-e	1,56,343c-e	83,247c	1,09,187j	96,217fg	2.48k	2.70j	2.59j
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	1,27,645g-i	1,69,431g	1,48,538g	80,064de	1,13,760h	96,912fg	2.68hi	3.04g	2.86h
T ₆ : T ₁ + FYM 5 t ha ⁻¹	1,28,601gh	1,69,823fg	1,49,212fg	78,520ef	1,11,652i	95,086g	2.57j	2.92i	2.74i
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	1,26,983hi	1,72,440fg	1,49,712fg	81,202c-e	1,18,569de	99,886de	2.77ef	3.20cd	2.99de
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	1,27,950g-i	1,73,059fg	1,50,504fg	82,869cd	1,19,888cd	1,01,378cd	2.84cd	3.25b	3.05c
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	1,25,143i	1,70,733g	1,47,938g	79,362ef	1,16,862ef	98,112ef	2.73f-h	3.17d-f	2.95ef
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	1,26,609hi	1,71,555g	1,49,082g	81,528c-e	1,18,384de	99,956de	2.81de	3.23bc	3.02cd
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	1,30,276fg	1,70,050fg	1,50,163fg	82,695cd	1,14,379gh	98,537ef	2.74fg	3.05g	2.90f-h
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	1,32,789f	1,70,607f	1,51,698f	82,708cd	1,12,436hi	97,572e-g	2.65i	2.93i	2.79i
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	1,35,897de	1,74,188de	1,55,042de	88,316b	1,18,517de	1,03,416c	2.86cd	3.13f	2.99de
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	1,35,586e	1,74,068e	1,54,827e	88,005b	1,18,397de	1,03,201c	2.85cd	3.13f	2.99de
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	1,37,632b-e	1,73,994de	1,55,813de	87,551b	1,15,823fg	1,01,687cd	2.75fg	2.99h	2.87gh
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	1,36,430c-e	1,75,901c-e	1,56,166c-e	91,349a	1,22,730a	1,07,040ab	3.03a	3.31a	3.17a
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	1,39,500ab	1,77,830a-c	1,58,665a-c	91,919a	1,22,159ab	1,07,039ab	2.93b	3.19cd	3.06bc
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	1,38,751a-d	1,76,283b-d	1,57,517b-d	91,170a	1,20,612bc	1,05,891b	2.92b	3.17d-f	3.04cd
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	95,493k	1,28,495i	1,11,994i	54,094g	88,026k	71,060h	2.31l	3.18de	2.74i
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	89,802l	1,01,350j	95,576j	52,860g	64,408l	58,634i	2.43k	2.74j	2.59j
Mean	1,28,950	1,67,398	1,50,943	81,285	1,12,498	98,905	2.71	3.05	2.90
S.Em. ±	953	631	808	953	631	808	0.02	0.01	0.01
C.V. (%)	10.4	11.3	10.5	13.7	12.0	11.7	7.12	7.35	6.41

Means followed by the same letters do not differ significantly (0.05) by DMRT; RC – Recommended Check;
Market price: Cotton : 5000 and 4700 Rs. q⁻¹ during 2015-16 and 2016-17, respectively; soybean : 3500 and 2750 Rs. q⁻¹ during 2015-16 and 2016-17, respectively.