

Influence of integrated nutrient management on nutrient uptake by cotton and soybean in intercropping system

ABSTRACT

A field experiment was conducted to study the influence of integrated nutrient management practices on nutrient uptake by cotton and soybean intercropping system in 1:2 row proportion during *kharif* 2015 and 2016 plot 101 'D' 101 plot of All India Coordinated Research Project on Soybean, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India. The study was undertaken to evaluate the sources of nutrients for efficient uptake by the cropping system. 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 revealed that uptake of nitrogen, phosphorus and potassium were significantly higher in T₃ (150 % RDF for cotton and soybean) and it was on par with T₂ (125 % RDF for cotton and soybean). It could be concluded that application of 125 : 62.5 : 62.5 N, P₂O and K₂O kg ha⁻¹ in cotton and soybean intercropping system or 100 : 50 : 50 N, P₂O₅ and K₂O kg ha⁻¹ along with Gliricidia + Pongamia 2.5 t ha⁻¹ each for cotton and soybean intercropping was found to be optimum for efficient mineralization of nutrients for higher nutrient uptake by the crop .

Key words: Cotton, Soybean Intercropping, Nutrient uptake, Integrated nutrient management

1. INTRODUCTION

Cotton is the most important fiber crop in the world and the lint is used to make processed cotton, which is woven into fabrics, either alone or combined with other fibers. Recently, input-responsive varieties and high-tech production technologies will go a long way to meet the increasing demand for the natural fiber. The increase in productivity alone could not benefit the cotton. Cotton being a long duration, wide spaced, slow growing at early stage offers a great scope for intercropping of short duration, fast growing, non-competitive intercrops with dissimilar growth habit and productive that utilize the available resources very efficiently and effectively. Intercropping enables crop diversification within agro eco-region and ensures better return to the growers. Intercropping of cotton with soybean is more for production sustainability than yield advantage under rainfed condition [1]. As per the package of practice of UAS, Dharwad, cotton and soybean intercropping (1:2 rows) is recommended with spacing of cotton 120 cm x 60 cm and soybean in 40 cm rows [2]. Although the use of chemical fertilizers is the fastest way of counteracting the pace of nutrient depletion, its increasing costs and limited availability deter the farmers from using these inputs in balanced proportions and in recommended quantities. The ability to take advantage of the natural resources is a major step toward economic prosperity for a country

like India, as usage of chemical fertilizers for crop production is expensive, mainly because of shortfall in availability and problems of environmental pollution [3]. Agronomic management practices viz., intercropping and judicious combination of organic and inorganic manures is considered ecologically viable, economically feasible and avoids environmental pollution. In addition, combination of organic and inorganic manures works like slow release fertilizers for providing balanced nutrients to plants consequently improve uptake of nutrients [4]. Considering this fact the present investigation was undertaken.

2. MATERIAL AND METHODS

Two years field experiment was carried out at plot 101 'D' block All India Coordinated Research Project on soybean, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka (India) during kharif 2015-16 and 2016-17. The geographical co-ordinates of Dharwad are 15° 26' N latitude and 75° 07' E longitude with an altitude of 678 m above mean sea level. Dharwad comes under Northern Transition Zone (Zone-8) of Karnataka (India) which lies between the Western Hilly Zone (Zone-9) and Northern Dry Zone (Zone-3). The soil was medium black cotton belonging to *vertisols*. The soil pH was neutral, organic carbon, available nitrogen, phosphorus and potassium in soil were optimum for crop growth. The details on soil physical and chemical properties of soil were furnished in Table 1. The rainfall received during the crop growing period from July to December was 308 mm during 2015 and June to December was 462 mm during 2016. The field experiment was laid out in randomised complete block design with three replications and twenty treatments as given in the tables. Sowing was done by adopting 120 cm x 60 cm row spacing for cotton (Neeraja Bt) and 40 cm x 10 cm for soybean (DSb 21) in intercropping system (1:2) during kharif season on 09.07.2015 and 12.06.2016. According to 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. Recommended dose of fertilizer (RDF) was applied to both crops in intercropping system according to population (100:50:50 and 40:80:25 kg N, P₂O₅ and K₂O₅ ha⁻¹ for Cotton and Soybean, respectively). Cotton occupied 100% population and soybean introduced with 67% population due to area of crops covered in the intercropping system (1:2). Based on nutrient content of plants and dry matter production, uptake of nitrogen, phosphorus and potassium were worked out by using following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Per cent nutrient concentration}}{100} \times \text{Biomass (kg ha}^{-1}\text{)}$$

Statistical analysis was carried out based on mean values obtained using MSTAT-C statistical package. 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 .05 level of probability in which means followed by the same letters do not differ significantly ($P = .05$) [8].

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87 **Table 1: Physical and chemical properties of the soil experimental site (0-30**
 88 **cm depth)**

Particulars	Value	Methods employed
1. Physical properties		
Particle size distribution		International pipette method [5]
Coarse sand (%)	6.25	
Fine sand (%)	14.32	
Silt (%)	27.14	
Clay (%)	52.47	
Textural class	Clay	
2. Chemical properties		
Organic carbon (%)	0.51	Walkey and Black method [6]
pH (1:2.5, Soil: Water)	7.30	Potentiometric method using pH meter [6]
Electrical conductivity (dS m ⁻¹) at 25 ⁰ C	0.35	Conductivity using EC bridge [6]
Available N (kg ha ⁻¹)	281	Alkaline permanganate method [6]
Available P ₂ O ₅ (kg ha ⁻¹)	34	Olsen’s method [6]
Available K ₂ O (kg ha ⁻¹)	312	Flame photometry method [6]

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91 3. RESULTS AND DISCUSSION

92 3.1 Nutrient uptake by cotton

93 Nitrogen uptake differed significantly due to integrated nutrient management (INM)
94 treatments during both the years and in pooled data (Table 2 and 3). Among the different
95 treatments at 50 per cent flowering, T₃ (150 % RDF for cotton and soybean) recorded
96 significantly higher nitrogen uptake and it was on par with T₂ (125 % RDF for cotton and
97 soybean) compared to rest of the intercropping systems during both years and in pooled
98 data. At harvest, T₃ (150 % RDF for cotton and soybean) recorded significantly higher
99 nitrogen uptake and it was on par with T₂ (125 % RDF for cotton and soybean) during 2015-
100 16 and in pooled data and also with T₁₇ (T₁ + Vermicompost 1.25 t ha⁻¹ + Gliricidia 2.5 t ha⁻¹)
101 and T₁₈ (T₁ + Vermicompost 1.25 t ha⁻¹ + Pongamia 2.5 t ha⁻¹) during 2016-17. Due to the
102 release of organic acids and CO₂ in the process of decomposition and will make unavailable
103 P into available form and also release K into soil solution. In addition to this population and
104 diversity of beneficial microorganisms will be enhanced in the soil. Due to rapid growth,
105 nitrogen fixation, greater biomass accumulation, nutrient conservation in their green tissue
106 and mineralization of the nutrients allowing increase in the nutrient uptake by crops. During
107 decomposition process organic acids like citric acid buteric acid acetic acid etc are produce
108 as intermediary products and these acids make unavailable form of P₂O₅ to available form
109 of P₂O₅. Therefore, organic and green manures produce proper mineralization of nutrients in
110 the soil consequently increased the uptake of nutrients. [9], who reported that application of
111 organic manures, resulted in increase in available N, P₂O₅ and K₂O of soil.

112 Phosphorus uptake differed significantly due to INM treatments during both the
113 years and in pooled data (Table 4 and 5). Among the different treatments at 50 per cent
114 flowering, T₃ (150 % RDF for cotton and soybean) recorded the highest phosphorus uptake
115 and it was on par with T₂ (125 % RDF for cotton and soybean), T₄ (100 % FYM and RDF for
116 cotton and soybean) and T₁₇ (T₁ + Vermicompost 1.25 t ha⁻¹ + Gliricidia 2.5 t ha⁻¹) during
117 both years and in pooled data. At harvest, T₃ recorded significantly higher phosphorus
118 uptake and it was on par with T₂ (125 % RDF for cotton and soybean) during both years and
119 in pooled data and also with T₁₇ and T₁₈ (T₁ + Vermicompost 1.25 t ha⁻¹ + Pongamia 2.5 t
120 ha⁻¹) during 2016-17. Due to balanced supply of nutrients to the crops throughout the crop
121 growth period as FYM, vermicompost and green leaf manure undergo decomposition during
122 which series of nutrient transformation takes place and helps in their higher availability to the
123 crops. Proper mineralization of nutrients by manures improved the nutrient by cotton.

124 Potassium uptake differed significantly due to INM treatments during both the years
125 and in pooled data (Table 6 and 7). Among the different treatments, T₃ (150 % RDF for
126 cotton and soybean) recorded higher potassium uptake and it was on par with T₂ (125 %
127 RDF for cotton and soybean) compared to rest of the intercropping systems and sole cotton
128 at 50 per cent flowering and at harvest during both years and in pooled data. The results
129 suggested that addition of organics not only increased the availability of these nutrients in
130 soil, but also favoured the release of nutrients from organic sources through mineralization
131 by microorganisms and uptake by the crop. Higher uptake of nitrogen, phosphorus and
132 potassium by cotton is due to higher yield in T₃ and T₂. The substantial quantity of addition of
133 organic manures with these treatments enhanced the soil organic carbon over RDF alone.
134 The results are in agreement with the findings of [10], who observed that recycling ensures
135 the return of major portion of nutrients recovered by the crop back to mother earth.

136 3.2 Nutrient uptake by soybean

137 Nitrogen uptake differed significantly due to INM treatments during both the years
138 and in pooled data (Table 2 and 3). Among the different treatments at 50 per cent flowering,
139 T_3 (150 % RDF for cotton and soybean) recorded significantly higher nitrogen uptake and it
140 was on par with T_2 (125 % RDF for cotton and soybean) compared to rest of the
141 intercropping systems during both years and in pooled data. At harvest, T_3 (150 % RDF for
142 cotton and soybean) recorded significantly higher nitrogen uptake and it was on par with T_2
143 (125 % RDF for cotton and soybean) during 2015-16 and in pooled data and also with T_{16}
144 (T_1 + Gliricidia 2.5 t ha⁻¹ + Pongamia 2.5 t ha⁻¹), T_{17} (T_1 + Vermicompost 1.25 t ha⁻¹ +
145 Gliricidia 2.5 t ha⁻¹) and T_{18} (T_1 + Vermicompost 1.25 t ha⁻¹ + Pongamia 2.5 t ha⁻¹) during
146 2016-17. Results are in agreement with the findings of [11], who also reported that
147 integrated application of vermicompost + gliricidia equivalent to RDF recorded higher
148 available N, P₂O₅ and K₂O over RDF + FYM (5 t ha⁻¹).

149 Phosphorus uptake differed significantly due to INM treatments during both the
150 years and in pooled data (Table 4 and 5). Among the different treatments, T_3 (150 % RDF
151 for cotton and soybean) recorded significantly higher phosphorus uptake and it was on par
152 with T_2 (125 % RDF for cotton and soybean) compared to rest of the intercropping systems
153 and sole soybean at 50 per cent flowering and at harvest during both years and in pooled
154 data, except at 50 per cent flowering during 2015-16 and also with T_{16} (T_1 + Gliricidia 2.5 t
155 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}
156 (T_1 + Vermicompost 1.25 t ha⁻¹ + Pongamia 2.5 t ha⁻¹) in 2016-17 at harvest.

157 Potassium uptake differed significantly due to INM treatments during both the years
158 and in pooled data (Table 6 and 7). Among the different treatments, T_3 (150 % RDF for
159 cotton and soybean) recorded significantly higher potassium uptake and it was on par with
160 T_2 (125 % RDF for cotton and soybean) compared to rest of the intercropping systems and
161 sole soybean at 50 per cent flowering and at harvest during both years and in pooled data
162 and also with T_{17} (T_1 + Vermicompost 1.25 t ha⁻¹ + Gliricidia 2.5 t ha⁻¹) and T_{18} (T_1 +
163 Vermicompost 1.25 t ha⁻¹ + Pongamia 2.5 t ha⁻¹) in 2016-17 at harvest. Similarly, [12]
164 observed higher organic matter in soil due to application of FYM and vermicompost after the
165 harvest of wheat crop, which was attributed to addition of more biomass.

166 3.3 Total uptake by cotton + soybean

167 Nitrogen uptake differed significantly due to INM treatments during both the years
168 and in pooled data (Table 2 and 3). Among the different treatments at 50 per cent flowering,
169 T_3 (150 % RDF for cotton and soybean) recorded significantly higher nitrogen uptake and it
170 was on par with T_2 (125 % RDF for cotton and soybean) compared to rest of the
171 intercropping systems during both years and in pooled data. At harvest, T_3 (150 % RDF for
172 cotton and soybean) recorded significantly higher nitrogen uptake and it was on par with T_2
173 (125 % RDF for cotton and soybean) during 2015-16 and in pooled data and also with T_{17}
174 (T_1 + Vermicompost 1.25 t ha⁻¹ + Gliricidia 2.5 t ha⁻¹) and T_{18} (T_1 + Vermicompost 1.25 t ha⁻¹
175 + Pongamia 2.5 t ha⁻¹) during 2016-17. The higher uptake of nitrogen, phosphorus and
176 potassium is due to higher uptake by cotton and soybean.

177 Phosphorus uptake differed significantly due to INM treatments during both the
178 years and in pooled data (Table 4 and 5). Among the different treatments at 50 per cent
179 flowering, T_3 (150 % RDF for cotton and soybean) recorded significantly higher phosphorus
180 uptake and it was on par with T_2 (125 % RDF for cotton and soybean) compared to rest of
181 the intercropping systems during both years and in pooled data. At harvest, T_3 (150 % RDF
182 for cotton and soybean) recorded significantly higher phosphorus uptake and it was on par
183 with T_2 (125 % RDF for cotton and soybean) during 2015-16 and in pooled data and also

184 with T₁₇ (T₁ + Vermicompost 1.25 t ha⁻¹ + Gliricidia 2.5 t ha⁻¹) and T₁₈ (T₁ + Vermicompost
185 1.25 t ha⁻¹ + Pongamia 2.5 t ha⁻¹) during 2016-17.

186 Potassium uptake differed significantly due to INM treatments during both the years
187 and in pooled data (Table 6 and 7). Among the different treatments at 50 per cent flowering,
188 T₃ (150 % RDF for cotton and soybean) recorded significantly higher potassium uptake and
189 it was on par with T₂ (125 % RDF for cotton and soybean) compared to rest of the
190 intercropping systems during both years and in pooled data. At harvest, T₃ (150 % RDF for
191 cotton and soybean) recorded significantly higher potassium uptake and it was on par with
192 T₂ (125 % RDF for cotton and soybean) during 2015-16 and in pooled data and also with T₁₇
193 (T₁ + Vermicompost 1.25 t ha⁻¹ + Gliricidia 2.5 t ha⁻¹) during 2016-17. Use of organic
194 manures along with recommended dose of fertilizers results in release of nutrients which are
195 available to crop for longer period. Biodegradation of manures exerted favorable effect on
196 the release of nutrients, which depended on type, quantity of residues and stage of
197 decomposition [13].

198 4. CONCLUSIONS

199 Farmers can adopt a fertilizer dose of 125 : 62.5 : 62.5 N, P₂O and K₂O kg ha⁻¹ in
200 cotton and soybean intercropping system or 100 : 50 : 50 N, P₂O₅ and K₂O kg ha⁻¹ along with
201 Gliricidia + Pongamia 2.5 t ha⁻¹ each for cotton and soybean intercropping for efficient
202 utilization of mineral nutrients in soil to get profitable yields.

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Table 2: Nitrogen uptake by cotton and soybean and cotton + soybean intercropping system at 50 per cent flowering as influenced by INM in cotton and soybean intercropping system

Treatments	Nitrogen uptake (kg ha ⁻¹)								
	Cotton			Soybean			Cotton + soybean		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	43.2g	47.7h	45.5h	75.1i	83.0m	79.1k	118h	130l	124k
T ₂ : 125 % RDF for cotton and soybean	57.0ab	62.4a	59.7a	97.4a	106a	101a	154a	168a	161a
T ₃ : 150 % RDF for cotton and soybean	59.2a	64.1a	61.6a	98.3a	108a	103a	157a	172a	164a
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	53.9bc	58.3b	56.1b	93.1b	102b	97.6b	147b	160b	153b
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	48.2d-f	52.4fg	50.3d-g	80.5gh	88.1h-k	84.3g-i	128f	140h-j	134i
T ₆ : T ₁ + FYM 5 t ha ⁻¹	48.4d-f	53.2d-g	50.8c-g	80.6gh	89.3h-j	84.9gh	129f	142g-i	135hi
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	47.3ef	51.5g	49.4fg	79.2h	87.2i-l	83.2h-j	126fg	138ij	132ij
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	47.3ef	52.7e-g	50.0e-g	79.3h	87.4h-l	83.3h-j	126fg	140h-j	133i
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	45.2fg	50.4gh	47.8gh	77.2hi	84.1lm	80.6jk	122gh	134kl	128jk
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	47.5ef	51.2g	49.3g	78.2hi	86.3j-m	82.2h-k	125fg	137jk	131ij
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	48.2d-f	53.2d-g	50.7c-g	80.1gh	90.5g-i	85.3gh	128f	143gh	136hi
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	51.1cd	55.1c-f	53.1b-e	83.1fg	91.3f-h	87.2fg	134e	146fg	140gh
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	51.2cd	55.8b-e	53.5b-d	87.1de	96.1de	91.6de	138c-e	151de	145d-f
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	50.2c-e	55.2c-f	52.7b-f	86.0ef	94.4d-f	90.2ef	136de	149ef	142e-g
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	51.5cd	56.1b-d	53.8bc	89.2cd	98.0cd	93.6cd	140cd	154cd	147c-e
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	50.6c-e	54.9c-f	52.7b-e	84.4ef	93.6e-g	89.0ef	135e	148ef	141fg
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	52.2c	57.1bc	54.7b	91.2bc	100bc	95.7bc	143bc	157bc	150bc
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	51.8cd	56.3b-d	54.0bc	90.1b-d	98.1cd	94.1cd	142bc	154cd	148cd
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	51.4cd	56.1b-d	53.8bc	-	-	-	51.4j	56.1n	53.8m
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	-	-	-	77.2hi	84.5k-m	80.8jk	77.2i	84.5m	80.8l
Mean	50.3	55.0	52.6	84.6	93.1	88.7	128	140	137
S.Em. \pm	1.11	0.95	1.03	1.04	1.22	1.13	1.71	1.38	1.56
C.V. (%)	9.25	7.54	7.96	8.35	8.91	9.1	18.8	16.4	13.2

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

Table 3: Nitrogen uptake by cotton and soybean and cotton + soybean intercropping system at harvest as influenced by INM in cotton and soybean intercropping system

Treatments	Nitrogen uptake (kg ha ⁻¹)								
	Cotton			Soybean			Cotton + soybean		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	64.1f	74.2h	69.1e	140j	134k	137g	204k	208j	206i
T ₂ : 125 % RDF for cotton and soybean	77.2a	85.2ab	81.2a	162a	173a	167ab	239a	258ab	248a
T ₃ : 150 % RDF for cotton and soybean	78.1a	86.1a	82.1a	163a	174a	168a	241a	260a	250a
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	73.1b	83.2b-d	78.1b	158b	168d	163c-e	230b	251de	241bc
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	68.0de	79.1g	73.5d	144hi	158j	151f	210hi	237i	225h
T ₆ : T ₁ + FYM 5 t ha ⁻¹	68.1de	79.1g	73.6d	146gh	159ij	152f	214hi	238i	226f-h
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	67.3e	82.2c-f	74.7cd	144hi	164ef	154f	211ij	246fg	229e-g
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	67.4e	82.5c-e	74.9cd	144hi	165e	154f	211ij	247ef	229ef
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	66.1ef	81.0d-g	73.5d	142ij	162g	152f	208j	243gh	225gh
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	66.2ef	81.3d-g	73.7d	143i	163fg	153f	209j	244fg	227e-h
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	68.1de	80.3e-g	74.2d	147gh	160hi	153f	215gh	240hi	227e-h
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	70.1cd	81.1d-g	75.6cd	148fg	161gh	154f	218fg	242gh	230e
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	70.1cd	83.9a-c	77.0bc	152de	171bc	161c-e	222de	255b-d	238cd
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	70.1cd	83.9a-c	77.0bc	151e	170c	160e	221ef	254cd	237d
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	71.0bc	83.2b-d	77.1bc	154cd	168d	161de	225cd	251de	238cd
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	70.1cd	84.3a-c	77.2bc	150ef	172ab	161de	220ef	256a-c	238cd
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	72.1bc	85.1ab	78.6b	156bc	173a	164bc	220c	258ab	243b
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	71.1bc	85.1ab	78.1b	155c	173a	164cd	226c	258ab	242b
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	71.2bc	80.1fg	75.7cd	-	-	-	71.2m	80.1l	75.7k
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	-	-	-	142ij	127l	134g	142l	127m	134j
Mean	70.0	82.2	76.1	149	163	156	208	233	225
S.Em. ±	0.79	0.71	0.75	0.90	1.12	1.02	1.03	1.26	1.15
C.V. (%)	7.8	6.4	6.8	6.2	5.4	5.9	17.3	19.5	18.4

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

Table 4: Phosphorus uptake by cotton and soybean and cotton + soybean intercropping system at 50 per cent flowering as influenced by INM in cotton and soybean intercropping system

Treatments	Phosphorus uptake (kg ha ⁻¹)								
	Cotton			Soybean			Cotton + soybean		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	8.40k	9.53f	8.91k	11.7j	13.5i	12.6i	20.1k	23.0k	21.6k
T ₂ : 125 % RDF for cotton and soybean	14.8a	16.6a	15.7ab	24.3b	27.5a	25.9a	39.1a	44.1a	41.6a
T ₃ : 150 % RDF for cotton and soybean	15.1a	17.1a	16.1a	26.0a	29.0a	27.5a	41.2a	46.1a	43.7a
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	14.1ab	16.0ab	15.0a-c	21.6c	24.4b	23.0b	35.8b	40.4b	38.1b
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	9.80ij	11.1ef	10.4h-k	17.5ef	19.8d-f	18.7d-f	27.3f-h	31.0f-h	29.1f-h
T ₆ : T ₁ + FYM 5 t ha ⁻¹	10.2h-j	11.4d-f	10.8g-k	17.8ef	20.1d-f	19.0d-f	28.0fg	31.5e-g	29.8fg
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	9.20jk	10.5ef	9.88i-k	16.3fg	18.1fg	17.2fg	25.5hi	28.7hi	27.1hi
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	9.47i-k	10.3ef	9.88i-k	16.7f	19.5ef	18.2ef	26.3gh	29.8gh	28.1gh
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	8.90jk	10.0ef	9.48jk	13.8hi	15.3hi	14.5hi	22.7j	25.4jk	24.0j
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	9.00jk	10.2ef	9.64i-k	14.6gh	16.2gh	15.4gh	23.6ij	26.5ij	25.0ij
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	10.5g-i	12.6c-f	11.6f-j	17.9ef	20.3d-f	19.1d-f	28.5fg	32.9ef	30.7ef
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	11.2f-h	12.4c-f	11.8f-i	18.3ef	21.4de	19.8de	29.5d-f	33.9de	31.7d-f
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	12.4c-f	14.2a-d	13.3c-f	19.3de	22.1cd	20.7cd	31.8cd	36.3cd	34.0cd
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	12.1d-f	13.1b-e	12.6d-g	19.2de	21.2de	20.2de	31.4de	34.3de	32.8de
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	13.1b-d	14.3a-d	13.7b-f	20.7cd	23.8bc	22.2bc	33.9bc	38.1bc	36.0bc
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	11.7e-g	13.0b-e	12.3e-h	17.6ef	21.2de	19.4de	29.3ef	34.2de	31.7d-f
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	14.0ab	15.5a-c	14.8a-d	21.1cd	24.2bc	22.7bc	35.1b	39.8b	37.5b
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	13.4bc	15.1a-c	14.3a-e	21.3c	24.1bc	22.7bc	34.8b	39.3b	37.0b
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	12.7c-e	14.3a-d	13.5c-f	-	-	-	12.7l	14.3l	13.5l
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	-	-	-	12.5ij	14.2hi	13.3i	12.5l	14.2l	13.3l
Mean	11.6	13.0	12.3	18.3	20.9	19.6	28.4	32.2	31.2
S.Em. ±	0.41	0.86	0.68	0.65	0.73	0.67	0.77	0.90	0.84
C.V. (%)	19.2	20.4	18.7	20.1	21.3	19.4	26.1	13.2	12.4

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

Table 5: Phosphorus uptake by cotton and soybean and cotton + soybean intercropping system at harvest as influenced by INM in cotton and soybean intercropping system

Treatments	Phosphorus uptake (kg ha ⁻¹)								
	Cotton			Soybean			Cotton + soybean		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	64.1f	74.2h	69.1e	140j	134k	137g	204k	208j	206i
T ₂ : 125 % RDF for cotton and soybean	77.2a	85.2ab	81.2a	162a	173a	167ab	239a	258ab	248a
T ₃ : 150 % RDF for cotton and soybean	78.1a	86.1a	82.1a	163a	174a	168a	241a	260a	250a
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	73.1b	83.2b-d	78.1b	158b	168d	163c-e	231b	251de	241bc
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	68.0de	79.1g	73.5d	144hi	158j	151f	212hi	237i	225h
T ₆ : T ₁ + FYM 5 t ha ⁻¹	68.1de	79.1g	73.6d	146gh	159ij	152f	214hi	238i	226f-h
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	67.3e	82.2c-f	74.7cd	144hi	164ef	154f	211ij	246fg	229e-g
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	67.4e	82.5c-e	74.9cd	144hi	165e	154f	211ij	247ef	229ef
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	66.1ef	81.0d-g	73.5d	142ij	162g	152f	208j	243gh	225gh
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	66.2ef	81.3d-g	73.7d	143i	163fg	153f	209j	244fg	227e-h
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	68.1de	80.3e-g	74.2d	147gh	160hi	153f	215gh	240hi	227e-h
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	70.1cd	81.1d-g	75.6cd	148fg	161gh	154f	218fg	242gh	230e
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	70.1cd	83.9a-c	77.0bc	152de	171bc	161c-e	222de	255b-d	238cd
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	70.1cd	83.9a-c	77.0bc	151e	170c	160e	221ef	254cd	237d
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	71.0bc	83.2b-d	77.1bc	154cd	168d	161de	225cd	251de	238cd
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	70.1cd	84.3a-c	77.2bc	150ef	172ab	161de	220ef	256a-c	238cd
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	72.1bc	85.7ab	78.6b	156bc	173a	164bc	228c	258ab	243b
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	71.1bc	85.1ab	78.1b	155c	173a	164cd	226c	258ab	242b
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	71.2bc	80.1fg	75.7cd	-	-	-	71.2m	80.l	75.7k
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	-	-	-	142ij	127l	134g	142l	127m	134j
Mean	70.0	82.2	76.1	149	163	156	208	233	225
S.Em. ±	0.79	0.71	0.75	0.90	1.12	1.02	1.03	1.26	1.15
C.V. (%)	14.7	7.20	13.2	8.25	9.40	7.26	23.1	20.1	19.2

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

Table 6: Potassium uptake by cotton and soybean and cotton + soybean intercropping system at 50 per cent flowering as influenced by INM in cotton and soybean intercropping system

Treatments	Potassium uptake (kg ha ⁻¹)								
	Cotton			Soybean			Cotton + soybean		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	31.4g	34.8h	33.1h	44.5h	51.1j	47.8i	76.0i	86.0i	81.0i
T ₂ : 125 % RDF for cotton and soybean	46.8a	52.3a	49.5a	63.2a	73.1a	68.2a	110a	125a	117a
T ₃ : 150 % RDF for cotton and soybean	47.3a	53.8a	50.5a	64.7a	74.2a	69.5a	112a	128a	120a
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	42.6b	47.3b	45.0b	59.4b	68.1bc	63.8b	102b	115b	108b
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	34.5d-f	38.2fg	36.3fg	51.3e-g	59.1gh	55.2fg	85.9g	97.4g	91.6g
T ₆ : T ₁ + FYM 5 t ha ⁻¹	35.7c-e	40.1ef	37.9ef	54.2c-e	62.2ef	58.2de	89.9f	102f	96.1f
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	33.4e-g	37.3f-h	35.3f-h	50.3fg	58.1hi	54.2f-h	83.8gh	95.4gh	89.6h
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	33.5e-g	37.4f-h	35.4f-h	51.5d-f	59.3gh	55.4fg	85.0g	96.8gh	90.9gh
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	32.5fg	36.1gh	34.3gh	48.4g	56.5i	52.5h	80.9h	92.7h	86.8gh
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	33.2e-g	37.6f-h	35.4f-h	50.0fg	57.1hi	53.6gh	83.3gh	94.7gh	89.0h
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	36.2cd	40.4ef	38.3ef	54.2c-e	62.6ef	58.4de	90.5f	103f	96.7gh
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	36.9cd	42.2de	39.5de	54.5cd	63.2ef	58.9de	91.4f	105ef	98.4ef
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	38.2c	43.3c-e	40.7de	58.4b	66.1cd	62.2bc	96.6de	109c-e	103ef
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	37.9c	42.3de	40.1de	55.4c	64.1de	59.8cd	93.4ef	106d-f	99.9cd
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	37.4c	42.2de	39.8de	59.4b	68.2bc	63.8b	96.8de	110cd	103d-f
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	38.6c	44.9b-d	41.7cd	54.5cd	63.1ef	58.8de	93.1ef	108c-e	100cd
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	37.3c	43.1de	40.2de	60.4b	69.3b	64.8b	97.7cd	112bc	105de
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	41.4b	46.2bc	43.8bc	60.0b	68.5bc	64.3b	101bc	114b	108b
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	37.4c	42.3de	39.8de	-	-	-	37.4k	42.3k	39.8k
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	-	-	-	52.1d-f	60.8fg	56.5ef	52.1j	60.8j	56.5j
Mean	37.5	42.2	39.8	55.1	63.5	59.2	88.0	100	96.1
S.Em. ±	0.87	1.00	0.94	0.95	0.82	0.88	1.30	1.42	1.36
C.V. (%)	12.1	7.84	11.6	9.75	6.83	8.41	19.6	13.2	17.2

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

Table 7: Potassium uptake by cotton and soybean and cotton + soybean intercropping system at harvest as influenced by INM in cotton and soybean intercropping system

Treatments	Potassium uptake (kg ha ⁻¹)								
	Cotton			Soybean			Cotton + soybean		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁ : 100 % RDF for cotton and soybean	57.4i	68.2i	62.8h	76.1g	84.2j	80.2h	133j	152l	143f
T ₂ : 125 % RDF for cotton and soybean	72.3a	77.4ab	74.8a	95.1a	103a	99.3a	167a	181a	174a
T ₃ : 150 % RDF for cotton and soybean	73.1a	78.3a	75.7a	96.2a	104a	100a	169a	182a	175a
T ₄ : 100 % FYM and RDF for cotton and soybean (RC)	68.2b	72.3d-h	70.3bc	91.1b	97.2b-d	94.2c-e	159b	169d-f	164bc
T ₅ : T ₁ + FYM 2.5 t ha ⁻¹	60.1f-h	70.1hi	65.1f-h	83.1de	90.4i	86.7g	143gh	160k	151e
T ₆ : T ₁ + FYM 5 t ha ⁻¹	61.2e-g	70.4g-i	65.8e-g	85.6cd	91.1i	88.4fg	146fg	161jk	154de
T ₇ : T ₁ + Gliricidia 2.5 t ha ⁻¹	59.1g-i	72.2d-h	65.6e-g	82.1ef	95.2d-f	88.7fg	141hi	167f-h	154de
T ₈ : T ₁ + Gliricidia 5 t ha ⁻¹	59.2g-i	72.3d-h	65.8e-g	83.1de	96.2c-e	89.7f	142hi	168e-g	155de
T ₉ : T ₁ + Pongamia 2.5 t ha ⁻¹	58.2hi	71.1f-h	64.7gh	80.2f	93.6f-h	86.9g	138i	164h-j	151e
T ₁₀ : T ₁ + Pongamia 5 t ha ⁻¹	57.9hi	71.4e-h	64.6gh	80.9ef	94.1e-g	87.5fg	138i	165g-i	152de
T ₁₁ : T ₁ + Vermicompost 1.25 t ha ⁻¹	62.2ef	70.5g-i	66.3e-g	86.1c	91.3hi	88.7fg	148ef	161i-k	155de
T ₁₂ : T ₁ + Vermicompost 2.5 t ha ⁻¹	62.1ef	71.2f-h	66.6d-g	86.4c	92.3g-i	89.3fg	148ef	163i-k	156d
T ₁₃ : T ₁ + FYM 2.5 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	63.9de	74.5cd	69.2b-d	89.6b	98.2bc	93.9de	153cd	172cd	163c
T ₁₄ : T ₁ + FYM 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	63.3de	73.6c-f	68.4b-e	87.1c	98.2bc	92.7e	150d-f	171c-e	161c
T ₁₅ : T ₁ + FYM 2.5 t ha ⁻¹ + Vermicompost 1.25 t ha ⁻¹	63.1de	73.4d-g	68.2b-e	92.3b	98.5bc	95.4cd	155bc	171c-e	163c
T ₁₆ : T ₁ + Gliricidia 2.5 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	65.2cd	74.3c-e	69.7bc	86.2c	99.2b	92.7e	151de	173c	162c
T ₁₇ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Gliricidia 2.5 t ha ⁻¹	63.9de	76.3a-c	70.1bc	92.2b	103a	97.9ab	156bc	180ab	168b
T ₁₈ : T ₁ + Vermicompost 1.25 t ha ⁻¹ + Pongamia 2.5 t ha ⁻¹	66.7bc	75.1b-d	70.9b	91.2b	101a	96.5bc	157b	177b	167b
T ₁₉ : Cotton sole crop (100 % RDF and FYM)	62.1ef	73.2d-g	67.7c-f	-	-	89.7f	62.1l	73.2n	67.7h
T ₂₀ : Soybean sole crop (100 % RDF and FYM)	-	-	-	85.1cd	94.2e-g	-	85.1k	94.2m	89.7g
Mean	63.1	73.0	68.0	86.8	96.2	91.5	142	160	154
S.Em. \pm	0.81	0.91	0.86	0.84	0.79	0.82	1.28	3.49	1.25
C.V. (%)	8.10	6.41	6.82	6.30	8.43	7.31	17.2	16.9	15.2

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