Original Research Article

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 at All India Coordinated Research Project on Soybean, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India. 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 T_3 (150 % RDF for cotton and soybean) and it was on par with T_2 (125 % RDF for cotton and soybean). It could be concluded that application of 125: 62.5: 62.5 kg N, P_2O and K_2O ha^{-1} in cotton and soybean intercropping system or 100:50:50 kg N, P_2O_5, K_2O 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 with 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(University of agricultural sciences, Dharwad), cotton and soybean intercropping (1:2 rows) is recommended with spacing of cotton 120 cm × 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 15^0 26' N latitude and 75^0 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 (Table 2, 3, 4, 5, 6 and 7). 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, P_2O_5 and K_2O_5 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.

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

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 $P = 0.05$. 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 ($P = 0.05$) [8].

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

Particulars	Value	Methods employed
1. Physical properties		
Particle size distribution		
Coarse sand (%)	6.25	
Fine sand (%)	14.32	
Silt (%)	27.14	International pipette method [5]
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_2O_5 (kg ha^{-1})	34	Olsen's method [6]
Available K_2O (kg ha^{-1})	312	Flame photometry method [6]

3. RESULTS AND DISCUSSION

3.1 Nutrient uptake by cotton

Nitrogen uptake differed significantly due to integrated nutrient management (INM) treatments during both the years and in pooled data (Table 2 and 3). Among the different treatments at 50 per cent flowering, T_3 (150 % RDF for cotton and soybean) recorded significantly higher nitrogen uptake and it was on par with T_2 (125 % RDF for cotton and soybean) compared to rest of the intercropping systems during both years and in pooled data. At harvest, T_3 (150 % RDF for cotton and soybean) recorded significantly higher nitrogen uptake and it was on par with T_2 (125 % RDF for cotton and soybean) during 2015-16 and in pooled data and also with T_{17} (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} + Pongamia 2.5 t ha^{-1}) during 2016-17. The release of organic acids and CO_2 in the process of decomposition occurs, which resulted in conversion of unavailable P into available form and release K into soil solution [9]. In addition to this population and diversity of beneficial microorganisms will be enhanced in the soil. Due to rapid growth, nitrogen fixation, greater biomass accumulation, nutrient conservation in their green tissue and mineralization of the nutrients allowing increase in the nutrient uptake by crops. During decomposition process organic acids like citric acid buteric acid acetic acid *etc* are produced as intermediatery products and these acids make unavailable form of P_2O_5 to available form of P_2O_5. Therefore, organic and green manures helped in proper mineralization of nutrients in the soil consequently increased the uptake of nutrients. In another study by [9] reported that application of organic manures, resulted in increase in available N, P_2O_5 and K_2O of soil.

Phosphorus uptake differed significantly due to INM treatments during both the years and in pooled data (Table 4 and 5). Among the different treatments at 50 per cent flowering, T_3 (150 % RDF for cotton and soybean) recorded the highest phosphorus uptake and it was on par with T_2 (125 % RDF for cotton and soybean), T_4 (100 % FYM and 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. At harvest, T_3 recorded significantly higher phosphorus uptake and it was on par with T_2 (125 % RDF for cotton and soybean) during both years and in pooled data and also with T_{17} and T_{18} (T_1 + Vermicompost 1.25 t ha^{-1} + Pongamia 2.5 t ha^{-1}) during 2016-17. Due to balanced supply of nutrients to the crops viz., FYM, vermicompost and green leaf manure undergo decomposition which results in series of nutrient transformation in soil. Slow release of nutrients during entire crop growth period ensures higher availability to the long durated crop like cotton.

Potassium uptake differed significantly due to INM treatments during both the years and in pooled data (Table 6 and 7). Among the different treatments, T_3 (150 % RDF for cotton and soybean) recorded higher potassium uptake and it was on par with T_2 (125 % RDF for cotton and soybean) compared to rest of the intercropping systems and sole cotton at 50 per cent flowering and at harvest during both years and in pooled data. The results suggested that addition of organics not only increased the availability of these nutrients in soil, but also favoured the release of nutrients from organic sources through mineralization by microorganisms and uptake by the crop. Higher uptake of nitrogen, phosphorus and potassium by cotton is due to higher yield in T_3 and T_2. The results are in agreement with the findings of [10], who observed that recycling ensures the return of major portion of nutrients recovered by the crop back to mother earth.

3.2 Nutrient uptake by soybean

Nitrogen uptake differed significantly due to INM treatments during both the years and in pooled data (Table 2 and 3). Among the different treatments at 50 per cent flowering, T_3 (150 % RDF for cotton and soybean) recorded significantly higher nitrogen uptake and it was on par with T_2 (125 % RDF for cotton and soybean) compared to rest of the intercropping systems during both years and in pooled data. At harvest, T_3 (150 % RDF for cotton and soybean) recorded significantly higher nitrogen uptake and it was on par with T_2 (125 % RDF for cotton and soybean) during 2015-16 and in pooled data and also with 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} (T_1 + Vermicompost 1.25 t ha^{-1} + Pongamia 2.5 t ha^{-1}) during 2016-17. Results are in agreement with the findings of [11], who also reported that integrated application of vermicompost + gliricidia equivalent to RDF recorded higher avialble N, P_2O_5 and K_2O over RDF + FYM (5 t ha^{-1}).

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

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

3.3 Total uptake by cotton + soybean

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

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

with T_{17} (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} + Pongamia 2.5 t ha^{-1}) during 2016-17.

Potassium uptake differed significantly due to INM treatments during both the years and in pooled data (Table 6 and 7). Among the different treatments at 50 per cent flowering, T_3 (150 % RDF for cotton and soybean) recorded significantly higher potassium uptake and it was on par with T_2 (125 % RDF for cotton and soybean) compared to rest of the intercropping systems during both years and in pooled data. At harvest, T_3 (150 % RDF for cotton and soybean) recorded significantly higher potassium uptake and it was on par with T_2 (125 % RDF for cotton and soybean) during 2015-16 and in pooled data and also with T_{17} (T_1 + Vermicompost 1.25 t ha^{-1} + Gliricidia 2.5 t ha^{-1}) during 2016-17. Use of organic manures along with recommended dose of fertilizers resulted in release of nutrients which are available to crop for longer period. Biodegradation of manures exerted favorable effect on the release of nutrients, which depended on type, quantity of residues and stage of decomposition [13].

4. CONCLUSIONS

Farmers can adopt a fertilizer dose of 125 : 62.5 : 62.5 kg N, P_2O and K_2O ha^{-1} in cotton and soybean intercropping system or 100 : 50 : 50 kg N, P_2O_5 and K_2O ha^{-1} along with Gliricidia + Pongamia 2.5 t ha^{-1} each for cotton and soybean intercropping for efficient 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. ±	**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. ±	**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