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Research Article

Response of cotton based cropping systems and nutrient management practices with bioinoculants on growth and yield of cotton in South India

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Abstract : A cropping system is to be efficient in resource use and ensure sustained production with no adverse effect on the bioecosytem. Nutrient management is considered to be an important technology for increasing the productivity of the crop plants. Application of nitrogen at the time of flowering leads to increase in seed cotton yield and quality in most of the crops. Phosphorus and potassium favour root growth, square, fruiting and seed development in cotton. Application of bioinoculants leads to induce the plant growth hormone and increased production of growth promoting substances, improved ACC deaminase activity (1-amino cyclo propane-1-carboxylate), siderophore production, phosphorus solubilization, indole acetic acid production and biological N fixation. A study was conducted with an objective to study the growth and yield of cotton under sole as well as intercropping systems with levels of NPK and bioinoculants. Field experiments were conducted in winter seasons during 2007 and 2008 on MCU 12 cotton at Tamil Nadu Agricultural University, Coimbatore, South India. The results proved that cotton + *dhaincha* recorded the highest seed cotton yield of 2010 and 1894 kg ha^{-1} with combined application of 100 per cent recommended NPK and bioinoculants recorded the seed cotton yield of 2227 and 1983 kg ha^{-1}, respectively during 2007 and 2008, respectively.

Key Words : *Gossypium hirsutum* (L.) Intercropping, Mineral nutrition, Bioinoculants, Seed cotton yield

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INTRODUCTION

Cotton (*Gossypium* sp.) is one of the most important commercial crops playing a key role in global agriculture. In south India, the crop is mostly cultivated during winter and there exits a wide gap between the potential yield and actual yield and this yield gap has to be narrowed down. Today, greater emphasis in cotton cultivation has been on the cost-cutting and low energy intensive farming with very low biotic pressure to harvest the better produce since improved crop management especially its nutrition has a key role on both yield and quality (Rajendran *et al*., 2011). The deterioration of the soil quality pertinent in the traditional cotton belt due to poor resource management. Similarly, imbalanced fertilization, soil erosion and exclusion of organic sources coupled with overuse of acid forming N fertilizers especially urea compels the cropping systems to exploit soils reserves for other nutrients, thereby creating multiple nutrient deficiencies. Therefore, there is an urgent need for appropriate crop nutrition, a key component for yield maximization and better quality, through integrated nutrient management (Praharaj *et al.,* 2006). However, the suitable intercrops and integrated use of organics and inorganic can restore and sustain soil fertility and productivity. The present study was undertaken with the objectives of economizing the use of mineral fertilizers through suitable intercropping and integrated nutrient management to formulate a sustainable production technology by integrating organic, inorganic and biological sources of nutrients for

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maximizing seed cotton yield.

EXPERIMENTAL METHODS

Field experiments were conducted during 2007 to 2008 at eastern block farm, Tamil Nadu Agricultural University, Coimbatore, India. The soils of the experimental field was sandy clay loam: clay 30.51 per cent, silt -23.17 per cent, course sand -29.13 per cent, fine sand -17.19 per cent, with available N-182.00 ; P_2O_5-11.46 and K_2O-453 kg ha^{-1} during 2007. The experiments were carried out in split-plot design with three replications. Treatments included four cropping systems, *i.e.*, M_1: Cotton alone, M_2: Cotton + *dhaincha* (*Sesbania aculeata*), M_3: Cotton+ greengram and M_4:Cotton+onion in main plot and five nutrient management practices *viz.*, S_1: *Azospirillum* + *Pseudomonas,* S_2:50 per cent recommended NPK, S_3:100 per cent recommended NPK, S_4: 50 per cent recommended NPK+ *Azospirillum* + *Pseudomonas* and S_5: 100 per cent recommended NPK+ *Azospirillum* + *Pseudomonas* in sub plots. Cotton var. MCU 12 was raised at a spacing of 75 x 30 cm @ two seeds per hill, on one side of the ridges. The seed rate was 7.5 kg of delinted seed ha^{-1}. For intercropping systems, dibbling of cotton seeds was done on one side of the ridge and in opposite side intercrops (*Dhaincha*: *Sesbania aculeata*, Greengram: *Vigna radiata* and Onion (aggregatum): (*Allium cepa*) were sown. The cotton seeds were sown after treating with *Azospirillum* and *Pseudomonas* as per treatments. The crops were raised under irrigated condition.

Farmyard manure @ 12.5 t ha^{-1} (which contain 0.5:0.21:0.46 % of N, P_2O_5 and K_2O, respectively) was applied as common dose for all the plots. Nitrogen, phosphorus and potassium were applied as urea (46%N), rock phosphate (18% P_2O_5) and muriate of potash (60% K_2O), respectively at recommended level of 80:40:40 kg N, P_2O_5 and K_2O ha^{-1}. For S_2 and S_3, 40:20:20 and 80:40:40 kg N, P_2O_5 and K_2O ha^{-1} were applied, respectively. For S_1, S_4 and S_5 *Azospirillum* and *Pseudomonas* were applied both as seed treatment and soil application @ 80 g and 10 g kg^{-1} of seed, respectively. For soil application, *Azospirillum* and *Pseudomonas* were mixed with 50 kg FYM and applied at 30 DAS @ 2 kg ha^{-1} and 2.5 kg ha^{-1}, respectively. Nitrogen was applied in three splits *viz.*, 50 per cent at 18 DAS, 25 per cent at 45 DAS and remaining 25 per cent at 60 DAS. Entire phosphorus was applied basally and potassium was applied in two equal splits *viz.*, 50 per cent at 18 DAS and remaining 50 per cent at 45 DAS as per the treatment schedule. The green manure *i.e. dhaincha* (containing 3.2:0.60:1.20 % of N, P_2O_5 and K_2O, respectively) was incorporated in the interspace of cotton at 45 DAS at the time of earthing up. The kapas was harvested in five pickings in net plot of 30 square metre. The experimental data were subjected to statistical scrutiny as per methods suggested by Gomez and Gomez (1984). Wherever the results were significant, critical differences were worked out at five per cent level. The non-significant treatment differences were denoted as NS. The cotton equivalent yield was calculated using the following formulae.

$$CEY = \frac{\text{Intercrop yield (kg ha}^{-1}\text{) x Price of intercrop (Rs. kg}^{-1}\text{)}}{\text{Price of cotton (Rs. kg}^{-1}\text{)}}$$

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study have been discussed in detail under following heads :

Biomass production and nitrogen (N) accumulation of *dhaincha* :

The highest biomass production and N accumulation by *dhaincha* was observed in *dhaincha* sole crop in both the years (Fig. 1 and 2). Under intercropping, the higher biomass production of *dhaincha* was 13.82 and 13.09 t ha^{-1} with the N accumulation of 97.67 and 90.49 kg ha^{-1} in 2007 and 2008 were registered by application of 100 per cent recommended dose of NPK along with bioinoculants (M_2S_5). This was followed by 100 per cent recommended NPK alone (M_2S_3). The least biomass production of *dhaincha* (10.23 and 9.04 t ha^{-1}) and N

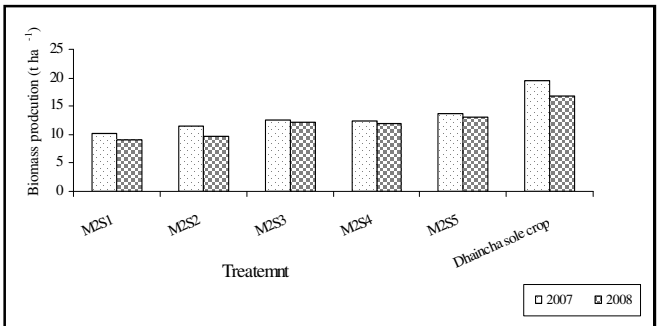

Fig. 1 : Biomass production of *dhaincha* in 2007-2008

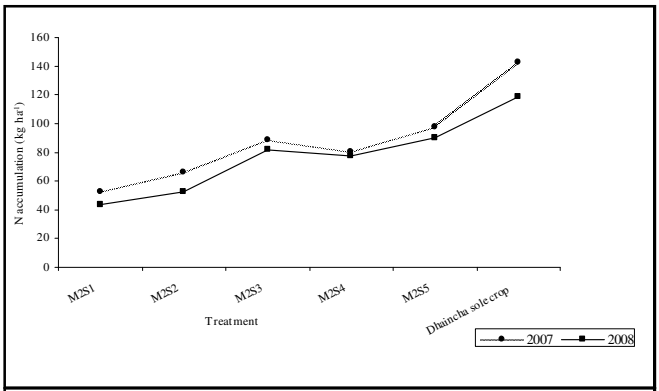

Fig. 2 : N accumulation due to *in situ* incorporation of *dhaincha* in 2007-2008

accumulations (52.40 and 43.82 kg ha^{-1}) were recorded due to application of bioinoculants alone (S_1) in 2007 and 2008, respectively.

Growth parameters:

The observations on the growth parameters were recorded at 40, 80 and 120 days after sowing (DAS). Cropping system did not have significant effect except on plant height at 40 DAS during 2007. The plant height of cotton was higher during 2007 as to 2008. There was a gradual increase in plant height upto 45 DAS in both years and later it increased steadily upto harvest. During 2007, at 40 DAS, sole crop of cotton (M_1) produced significantly higher plant height of 41.40 cm and Cotton + *dhaincha* recorded least plant height of 35.33 cm at 40 DAS. There was no significant variation in plant height due to cropping systems at 80 and 120 DAS (Table 1). At early stage, intercropping of *dhaincha* reduced the plant height of cotton compared to other systems. This may be due to the smothering effect of *dhaincha*, which have a tendency to grow faster compared to cotton and it also helped to restrict the early vegetative growth of cotton. But in the later stages, this system favourably influenced the growth and yield characters of cotton (Kumaresan and Rangasamy, 1997). The initial smothering effect by the *dhaincha* was compensated during subsequent growth stages by effective control of weeds and supplementation of N by *in situ* incorporation of *dhaincha*. Rapid and abundant release of CO_2 during decomposition of green manure which benefited the plants by enhanced photosynthetic activity (Ravisankar, 2002). Better weed smothering effect by *dhaincha* through its *in situ* incorporation. The mineralization of organic N and P from incorporated *dhaincha* might have also benefited the crop (Srinivasan and Palaniappan, 1994).

The integrated nutrient management practices had significant impact on plant height of cotton at all growth stages in both years. The 100 per cent recommended NPK with bioinoculants (S_5) registered maximum plant height of 127.25 and 112.08 cm during 2007 and 2008, respectively and was closely followed by application of 100 per cent NPK alone (118.33 and 103.67 cm, respectively) and combined application of 50 per cent recommended NPK and bioinoculants (110.17 and 98.17 cm, respectively). The least plant height was observed due to application of bioinoculants alone at 120 DAS in both years. Conjunctive use of inorganic and biological sources was more beneficial for better growth of cotton than individual application. The greater N supply and more availability of growth promoting substances like Indole acidic acid and Indole aceto nitrate might have resulted taller cotton plants (Bouche *et al*.,1997). The combined application of *Azospirillum* and *Pseudomonas* favourably influenced the plant height of cotton. The reason could be due to increased fixation and addition of nitrogen by *Azospirillum* and phosphorus by *Pseudomonas,* besides the growth promoting action of siderophores (microbial iron transport agents) produced by *Pseudomonas* which inturn reflected on leaf area (Manwar *et al*., 2000).

Kapas yield:

The cotton + *dhaincha* (M_2) recorded significantly higher

Table 1 : Effect of cropping systems and nutrient management practices on plant height, seed cotton yield and cotton equivalent yield (CEY)

Treatments	Plant height (cm)						Seed cotton yield (kg ha^{-1})	CEY (kg ha^{-1})	Seed cotton yield (kg ha^{-1})	CEY (kg ha^{-1})
	2007			2008			2007		2008	
DAS	40	80	120	40	80	120				
Main plot										
M_1	41.40	86.87	111.93	38.93	84.93	99.33	1841	-	1716	-
M_2	35.33	88.93	118.27	34.72	84.00	109.00	2010	2010	1894	1894
M_3	39.90	85.91	109.86	37.20	82.73	97.87	1651	1878	1542	1764
M_4	39.07	83.85	107.93	36.41	80.13	95.00	1583	2052	1479	1895
S.E.±	0.60	2.65	3.94	1.48	2.27	2.71	34	33	32	37
C.D. (P=0.05)	1.47	NS	NS	NS	NS	NS	83	82	79	90
Sub plot										
S_1	29.08	70.92	93.00	29.58	69.17	86.41	1208	1315	1171	1280
S_2	35.83	77.67	100.02	32.83	74.25	92.42	1634	1800	1569	1704
S_3	43.17	87.08	118.33	39.92	84.58	103.67	1965	2172	1840	2030
S_4	38.08	82.17	110.17	36.17	79.50	98.17	1806	1991	1718	1868
S_5	45.83	94.08	127.25	45.58	89.75	112.08	2227	2460	1983	2190
S.E.±	0.76	2.18	3.35	1.05	2.32	2.67	51	58	56	51
C.D. (P=0.05)	1.56	4.46	6.63	2.14	4.73	5.49	104	119	115	103

NS=Non-significant

kapas yield of 2010 and 1894 kg ha^{-1} during 2007 and 2008, respectively. It was followed by sole crop of cotton (M_1). The lowest seed cotton yield of 1583 and 1479 kg ha^{-1} were recorded under cotton + onion (M_4) during first and second years, respectively and it was on par with cotton + greengram (M_3) system (Table 1). Integrated use of 100 per cent recommended NPK with bioinoculants (S_5) recorded higher seed cotton yield of 2227 and 1983 kg ha^{-1} during 2007 and 2008, respectively followed by application of 100 per cent recommended NPK alone (S_3). Significantly higher seed cotton yield was obtained by application of 50 per cent recommended NPK along with bioinoculants (S_4) compared to 50 per cent NPK alone (S_2), but the magnitude of variation was non significant. Hence, it is possible to save 50 per cent of NPK due to integrated nutrient management. The lowest seed cotton yield of 1208 and 1171 kg ha^{-1} was recorded due to *Azospirillum* and *Pseudomonas* (S_1) during 2007 and 2008, respectively.

Cotton equivalent yield (CEY):

The maximum CEY of 2052 and 1895 kg ha^{-1} were recorded by cotton + onion system (M_4) and it was at par with cotton + *dhaincha* (M_2) in 2007 and 2008, respectively. This was followed by cotton + greengram system (M_3). The combined use of 100 per cent recommended NPK with bioinoculants recorded significantly higher CEY of 2460 and 2190 kg ha^{-1} during 2007 and 2008, respectively.

Intercropping of *dhaincha* with 100 per cent recommended NPK and bioinoculants recorded higher kapas yield by 24.8 and 18.2 per cent over sole crop of seed cotton during 2007 and 2008, respectively. This system registered higher yield attributes over other cropping systems. This might be due to better growth and production of more number of nodes plant^{-1}, which are the seating points for sympodial branches. Incorporation of green manure enhances the soil CO_2 concentration and the rate of photosynthesis and regulates the activity of Fe and Mn leading to better growth and development of crops (Singh *et al*., 1988). Green manuring increases the availability of P through mechanisms of reduction, chelation and favourable changes in soil pH and reduces the C: N and C: P ratios which ultimately increases the yield characters and yield of cotton (Singh *et al*.,1992). In the present investigation, green manuring with *dhaincha* not only increased the soil available nutrients but also favourably suppressed the weeds, pests and diseases incidence and enhanced the water holding capacity of the soil. This resulted in increased yield attributing characters and the kap as yield.

The combined application 100 per cent recommended NPK and *Azospirillum* and *Pseudomonas* had significant influence on the seed cotton yield of 13 and 8 per cent higher in 2007 and 2008, respectively than 100 per cent recommended NPK alone. The higher number of fruiting points with increased levels of NPK fertilizers might be due to the cumulative effect of increased leaf area index, drymatter production, sympodial branches as the result of higher nutrient uptake (Ogunwole *et al*., 2003). The increase in kapas yield due to phosphorus may be attributed due to its vital role in root proliferation, soil structure improvement and water use efficiency. It also counteracts excessive vegetative growth and hastens the maturity of the crop. The increase in the yield due to P fertilization was reported by Srinivasan (2003). The enhancement of kapas yield with application of K was due to the fact that K involves in early initiation of reproductive growth and increases the larger boll mass due to cumulative effect of seed and lint index (Pettigrew, 2003). Better growth of cotton as result of increased uptake of nutrients due to bioinoculants and increased production of growth promoting substances, improved ACC deaminase activity (1-amino cyclo propane-1-carboxylate), siderophore production, phosphorus solubilization, indole acetic acid production and biological N fixation might have influenced more number of sympodial branches, fruiting points, bolls plant^{-1} and seed cotton yield (Pal *et al.,* 2000) and Wankhade *et al*. (2001). The effect of manures and fertilizers on cotton proved that neither the chemical fertilizers alone nor exclusively the organic sources can achieve production sustainability of soil and cotton crop (Marimuthu *et al*., 2004).

Cotton + *aggregatum* onion intercropping system recorded higher CEY. It was followed by cotton + *dhaincha* system in both years. Raising onion as intercrop in cotton has resulted in higher CEY of 211 and 179 kg ha^{-1} during 2007 and 2008, respectively, which was followed by cotton + *dhaincha* system in both the years. The increased CEY is due to increased returns from onion compared to *dhaincha*. (Sivakumar, 2004).

Conclusion:

Intensive cultivation without addition of organic manures affects the productivity of soil. It is well realized that substantial quantities of inorganic fertilizers applied to the soil are not amenable to the plants of which a sizable portion is lost by various mechanisms operating in soil. In this study concluded that cotton + *dhaincha* recorded the highest seed cotton yield of 2010 and 1894 kg ha^{-1} with combined application of 100 per cent recommended NPK and bioinoculants recorded the seed cotton yield of 2227 and 1983 kg ha^{-1}, respectively during 2007 and 2008, respectively. The maximum CEY of 2052 and 1895 kg ha^{-1} were recorded by cotton + onion system (M_4) and it was at par with cotton + *dhaincha* (M_2) in 2010 and 1894 kg ha^{-1} in 2007 and 2008, respectively. The combined use of 100 per cent recommended NPK with bioinoculants recorded significantly higher CEY of 2460 and 2190 kg ha^{-1} during 2007 and 2008, respectively.

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