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Improving the Productivity of Cotton Based Intercropping System by Integrated Nutrient Management System (INMS) Under Irrigated Condition

Sangameshwari P[1*], Veeral DK[2], Krishnamoorthy R[2] and Kanchana D[3]

[1]Department of Agriculture, Annamalai University, Annamalai Nagar, Chidambaram, Tamilnadu, India

[2]Department of Agronomy, Annamalai University, Annamalai Nagar, Chidambaram, Tamilnadu, India

[3]Department of Agricultural Microbiology, Annamalai University, Annamalai Nagar, Chidambaram, Tamilnadu, India

Corresponding author: Sangameshwari P, Department of Agriculture, Annamalai University, Annamalai Nagar, Chidambaram, Tamilnadu, India.

sangameshwari.priya@gmail.com

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Abstract

Intercropping is the agronomic practice of simultaneously growing two or more crop species in the same field in close proximity for a considerable proportion of their growing season. The integrated nutrient management practices are designed and adopted to increase the quantity and quality of crop produce, decrease nutrient losses, increases the efficiency of applied and native nutrients, improve soil health, economic on fertilizer use, protect the environment and minimize the energy consumption in agriculture. Therefore the field experiments were conducted during (Aug 2019-Jan 2020). The experiment was laid out in Randomized Block Design (RBD) with three replications in order to evolve an appropriate INMS for cotton based intercropping system. T1-cotton alone, T2-cotton+cowpea+VC@2.5 t ha-1+BF+50% RDF+panchagavya@3% (2 sprayings), T3-cotton+blackgram+VC@2.5 t ha-1+BF+50% RDF+panchagavya@3% (2 sprayings), T4-cotton+cowpea+VC@ 2.5 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings), T5-cotton+blackgram+VC@2.5 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings), T6-cotton+cowpea+FYM@10 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayigs), T7-cotton+blackgram+FYM @10 t ha-1+BF+50% RDF+ Panchagavya @ 3% (2 sprayings), T8-cotton+cowpea+FYM@10 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings), T9-cotton+blackgram+FYM@10 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings). The intercrop cotton+cowpea along with VC@2.5 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings) (T2) generally increased the growth, yield attributes and yield of cotton. In conclusion, the intercrop cotton+cowpea along with combined application of Vermicompost@2.5 t ha-1+Bio fertilizer+50% RDF+Panchagavya spray@3% (2 sprayings) could be the economical approach to attain the higher seed cotton yield.

Keywords: Cotton; Intercrops; Organic manure; RDF; Bio-fertilizer; Foliar spray

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Introduction

CCotton (Gossypium spp.) is globally valuable, synthetic cash crop known for its natural fibers. Gossypium hirsutum is a commonly cultivated cotton species, accounting for 95% of world-wide cotton production owing to its high yielding capacity [1]. Cotton is the major fibre crop grown in India and plays a dominant role in agricultural and industrial sectors. Cotton contributes 70% of total fibre consumption in textile sector and 38% of the country's export, fetches over Rs. 42,000 crores.

Intercropping increase crop productivity from a unit area where available growth resources are efficiently utilized. In comparision with sole crop systems, intercropping improves crop diversification, increases crop yield and stability, especially under low-input conditions, and improves soil fertility and conservation as well as weed control [2].

Apriyani et al. noticed that long term application of organic matter such as FYM can gradually increase crop productivity while maintaining soil health [3]. The use of organic matter is very important because it contains various types of nutrients needed by plants including micronutrients, can improve soil physical, chemical properties and increased microbial activity.

Lousis et al. reported that vermicompost is an organic fertilizer obtained by the decomposition of degradable residues through the digestive tracts of earthworms. Waste is converted into

vermicompost which has a high-nutrient value that has been shown to contribute to an improvement in soil fertility and plant productivity. Vermicompost provides essential nutrients to the plants in a form they can readily utilize [4].

Kumar et al. revealed that beneficial micro-organisms in Panchagavya and their establishment in the soil have improved sustainability of agriculture as the microorganisms present in the rhizosphere environment i.e. around the roots, which influence the plant growth and crop yield was might be due to presence of growth accelerating enzymes in Panchagavya which favoured rapid cell division and multiplication [5].

Dasagavya are effective organic manures which are used as a growth stimulator, growth promoter and immunity booster. Beneficial microorganisms could have stimuli in plant growth and increased the production of growth regulators in plant system, it enhances the spatial distribution of soil microbial diversity.

Priyanka Saha et al. stated that bio-fertilizers containing living cells helps to restore the soil fertility and improves the plant growth and development. Bio-fertilizers produces hormones and enzymes that improve plant growth and it reduces soil nutrient depletion and provides long term sustainability to the farming system. It enhances nutrient use efficiency.

Islam et al. stated that an integrated approach involving organic manures, biological resources and chemical fertilizers can go a long way to improve crop productivity and to maintain soil fertility [6]. Crop growth, productivity can be well maintained through judicial use of fertilizers with proper combination of organic and inorganic sources.

Keeping all the views in mind an experiment was planned to find out the influence of INMS on growth and yield of cotton based intercropping system influenced by organic manures, inorganic fertilizers, bio-fertilizers and foliar spray along with intercropping system.

Materials and Methods

The field experiments were conducted at farmer's field, Bommanaickenpalayam village, Gobichettipalayam Taluk, Erode district during (Aug 2019 -Jan 2020). The variety Surabhi was chosen for this study. The experimental site is geographically situated at 10°74' N latitude and 77°15' E longitude with an altitude of about+213 m above Mean Sea Level (MSL). The mean maximum and minimum temperature are 36°C and 27°C respectively. The relative humidity range from 5%-63%. The experimental plots had assured irrigation facility coupled with uniform topography, good drainage and soil suitable for cotton cultivation. The soil of the experimental farm is classified as udic chrom (clay) according to FAO/UNESCO (1974). The soil is low in available nitrogen, medium in available phosphorous and high in available potassium. The experiment was laid out in randomized block design with three replications. The treatment comprised of nine treatments viz., T1-cotton alone, T2-cotton+ cowpea+VC @2.5 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings), T3-cotton+blackgram+VC@2.5 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings),T4-cotton+cowpea+VC@ 2.5 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings), T5-cotton+blackgram+VC@2.5 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings), T6-Cotton+ Cowpea + FYM @ 10 t ha-1+BF+50% RDF+Panchagavya @ 3% (2 sprayings), T7-cotton+blackgram+FYM@10 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings), T8-cotton+cowpea+FYM@10 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings), T9-cotton+blackgram+FYM@10 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings), in order to evolve an appropriate INMS for cotton based intercropping system. Spacing for cotton 120 cm x 60 cm. As per intercrops one row of intercrop blackgram with a plant to plant spacing of 30 cm × 10 cm were sown in between the cotton rows. One row of intercrop of cowpea with a plant to plant spacing of 10 cm × 15 cm were sown in between the cotton rows the seed rate adopted is 5 kg ha-1. FYM@10 t ha-1 and vermicompost@2.5 t/ha were incorporated uniformly at the time of last ploughing. Fertilizer was applied according to treatment schedule for cotton. For cotton, recommended dose of 80:40:40 kg ha-1 of N, P2O5 and K2O was applied. Nitrogen was applied in two equal splits viz., half the dose of N and full dose of P2O5 and K2O were applied at 20 DAS and remaining half dose N was applied at 40 DAS. The azotobacter and phosphobacteria were applied in soil @2 kg ha-1. The required quantity of each of the bacterial culture was mixed with 25 kg of sand and applied 3 days before sowing evenly over the respective plots as per the treatment schedule. The foliar spraying of Panchagavya, Dasagavya@3 per cent foliar spray was done as per treatment schedule at 45 DAS and 75 DAS using hand operated knapsack sprayer. Five plants in each treatment in the net plot area were selected at random and tagged for biometric observations. The plant height was measured from the basal point nearer to cotyledenary node to the opened leaf of the main shoot and expressed in cm. While taking observations, five plants from sampling rows were pulled off in each treatment plot for recording dry matter production. Leaf area index-The length and breadth of the third leaf from the top of the plant were measured and multiplied with number of leaves and the correction factor to arrive total leaf area plant-1 at flowering stage. Then the leaf area index was calculated using the following formula:

$$LAI = \frac{K(L \times W)(\text{Number of leaves plant}^{-1})}{\text{Area occupied by the plant}}$$

Where, L: Leaf length (cm)

W: Leaf width (cm)

K: Correction factor (0.75)

The number of monopodial branches arising from auxillary buds were counted at maturity. The reproductive sympodial branches arising from extra-axillary buds were counted at maturity. Total number of fruiting points were recorded at final harvest. Total number of bolls picked at each picking till the completion of harvest ware summed up. The weight of matured bolls picked from the tagged plants were recorded and expressed in g. The seed cotton obtained from the net plot area at each picking was

recorded, pooled and expressed in q ha-1. The intercrops were incorporated within the interspaces after picking of pods of intercrops. The observations recorded during the experiments were analyzed statistically using the procedure outlined by Gomez et al. [7]. Wherever the results were found significant, the critical differences were worked out at 0.05% probability level.

Results and Discussion

Growth attributes

The plant height at harvest stage, LAI at 70 DAS, DMP at harvest stage of cotton at various stages was significantly influenced by the intercrops and INMS. Among the treatments tested, when cotton+ cowpea grown with VC@2.5 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings) (T2) recorded the maximum height 187.23 cm at harvest stage, maximum LAI of 6.87 at 70 DAS and maximum DMP of 7723.54 kg ha-1 at harvest stage. This was closely followed by the treatment nourished with cotton+ cowpea is grown with VC@2.5 t ha-1+BF+50% RDF+Dasagavya@3% (2 sprayings) (T4)

This treatment was on par with the treatment, combination of VC@2.5 t ha-1+BF+50% RDF+Panchagavya @ 3% (2 sprayings) in cotton+blackgram intercropping system (T3). The descending trends on plant height at harvest stage, LAI at 70 DAS and DMP at harvest stage were as follows; T6, T8, T5, T7 and T9 in the rest of the treatments. The least plant height, LAI and DMP were recorded in control (T1).

Among the treatments, when cotton+cowpea nourished with VC@2.5 t ha-1 +BF+50% RDF+Panchagavya@3% (2 sprayings) (T2) recorded the highest growth attributes viz., plant height, LAI and DMP. This is in line with findings of Harisudan et al. stated that cotton intercropped with cowpea suppressed the weed growth and thereby the nutrient uptake by weeds is avoided which facilitated more availability and uptake of nutrients by cotton. Relatively weeds, pest and disease incidence was curtailed resulting in healthy and vigorous establishment of cotton. In addition legume has released nutrient at steady and balanced rate which was available to crop at later stages. Higher growth parameters might be due continuous supply of nutrients due to the synergistic effect of bio-fertilizer and release of nutrients from organics resulted in better translocation of photosynthates and Panchagavya includes coconut water (contains kinetin) increased cytokinin content in leaf, which in turn increased chlorophyll content and photosynthetic activity for longer period. Also, the easy transfer of nutrients to plant through foliar spray and the quantities of IAA and GA present in panchagavya, could have created the stimuli in the plant system and which in turn increased the production of growth regulators, in cell system and it enhances the biological efficiency of crop plants [8]. Hence, stimulated the necessary growth and development in plants, leading to better yield. These results are in conformity with the findings of Bavya et al.; Kulkarni et al.; Yoldas et al. reported that organic fertilizers have been widely used as alternative fertilizers for organically grown fields [9]. Organic manures can serve as alternative to mineral fertilizers. Decomposition of organic material would provide additional nutrients to the growing medium which may lead to higher uptake of nutrients by the crop and subsequently high yield. Besides, organic manures have positive effect on root growth by improving the root rhizosphere conditions and also plant growth is encouraged by increasing the population of microorganisms. This might be due to better availability of nutrients applied either through fertilizers or in combination with organic sources, organic sprays increased vegetative phase of the crop [10]. Azotobacter is reported to synthesize auxins, cytokinins and GA like substances that have been found to be directly associated with improved plant growth [11] (Table 1).

Table 1: Effect of different treatments on subsequent yield (kg) of Mukunuwenna

N=18	Growth attributes			Yield attributes					Yield
	Plant height at harvest (cm)	DMP at harvest (kg ha-1)	LAI at 70 DAS	Monopodial branches per plant	Sympodial branches per plant	No. of squares per plant	No. of bolls per plant	Boll weight (g)	Seed cotton yield (q ha-1)
T1	139.02	6724.39	5.66	3.18	29.26	52.14	31.84	3.53	2595.49
T2	187.23	7723.54	6.87	4.05	34.23	63.43	41.15	4.47	2990.65
T3	172.82	7393.64	6.48	3.77	32.47	59.68	38.06	4.18	2864.11
T4	184.85	7720.45	6.85	4.03	34.02	63.39	41.1	4.05	2986.25
T5	155.26	7057.26	6.07	3.48	29.9	55.92	36.95	3.95	2728.05
T6	170.65	7387.36	6.45	3.76	32.45	59.64	38.03	4.05	2862.91
T7	153.28	7053.17	6.04	3.47	28.68	55.89	35.92	3.83	2725.53
T8	158.42	7060.49	6.09	3.5	30.9	55.94	36.98	3.87	2739.33
T9	151.87	7051.54	6.02	3.45	20.58	55.85	34.89	3.81	2720.38
S.Ed	3.9	111.63	0.11	0.08	0.52	1.26	0.69	0.08	41.55
CD (p=0.05)	11.39	325.96	0.35	0.25	1.53	3.69	2.02	0.26	121.33

Yield attributes

The total number of monopodial branches plant-1 and Number of sympodial branches plant-1, number of squares plant-1, number of bolls plant-1, boll weight and seed cotton yield were significantly influenced by the intercropping system and INMS. The maximum number of monopodial branches plant-1 and number of sympodial branches plant-1 (4.05 and 34.23), number of squares plant-1 (63.43), Number of bolls plant-1 (41.15), boll weight (4.47 g) and seed cotton yield (2990.65 kg ha-1) were recorded by cotton+cowpea is grown with VC@2.5 t ha-1+BF+ 50% RDF+Panchagavya@3% (2 sprayings) (T2) .The other treatments viz., T4, T3, T6, T8, T5, T7 and T9 were next in

the order of lower magnitude. The least number of monopodial branches plant-1 and number of sympodial branches plant-1, Number of squares plant-1, Number of bolls plant-1, boll weight and seed cotton yield were observed under control (T1).

Cotton+cowpea along with VC@2.5 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings) (T2) recorded higher values of yield attributes viz., number of monopodial branches plant-1, sympodial branches plant-1, number of squares plant-1, number of bolls plant-1 and boll weight than other treatments. This might be due to reduced competition between cotton and cowpea is important in order to get maximum benefits from cotton-cowpea intercropping system. The percentage N2 fixation by cowpea was higher in intercrop treatment tan in sole crop indicating a higher productivity of cotton+cowpea intercropping system [12].

The above treatment gave the highest number of monopodial branches and sympodial branches. This might be due to the nutrient substitution of FYM or vermicompost in combination with 50%, 50% RDF due to slow release and continuous supply of nutrients in balance quantity throughout the various growth stages enables the plant to assimilate sufficient photosynthetic products and thus, increased the dry matter and source capacity, resulted in the production of increased number of branches with more number of capsules and higher test weight, seed and straw yield. The result collaborates with the findings of Vala et al.; Kumar et al. [13]. This might be due to the application of soil amendments, organic foliar spray and their combined applications. This might be due to availability and optimum supply of nutrients to plants favourably influenced the flowering. Higher yield attributing characters in aforesaid treatments is a consequence of increased rate of photosynthesis coupled with efficient translocation of photosynthates form source (leaf and stem) to sink (seeds) and this may be attributed to significant improvement in the sink size which could be due to increased number of branches per plant, which might have resulted in the development of more number of reproductive parts and there by increased the sink size to obtain higher seed yield. The results are in agreement with findings of Patil et al. Azotobacter has the ability to produce vitamins like thiamine and riboflavin and plant hormones viz., indole acetic acid, gibberllins, siderophores and cytokinins [14]. These plant growth promoting substances are released by Azotobacter and thus growth and productivity of the plant is improved [15]. Significantly higher seed cotton yield was mainly attributed to cow dung in Panchagavya act as a medium for the growth of beneficial microbes and cow urine provides nitrogen which is essential for crop growth.VC which supply micronutrients in the readily available form to the plants, react with the native soil nutrients in a way that enhance their availability to crops. [16]. Use of VC, FYM and BF resulted in increased availability of nutrients along with retention of high moisture in soil profile and moderation of soil temperature during summer which favoured better growth and yield of cotton.

Conclusion

It could be concluded that cotton+cowpea with VC@2.5 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings) (T2) registered maximum values for most of the parameters like growth attributes, yield attributes and yield of crops, without affecting the soil fertility and thereby sustaining the crop production. In nut shell, the results have proved sustainability in productivity and soil fertility in cotton with Integrated Nutrient Management System (INMS) practices using vermicompost, FYM and bio-fertilizer as organics. Cotton+cowpea along with VC@2.5 t ha-1+BF+50% RDF+Panchagavya@3% (2 sprayings) to cotton will hold an eco-friendly, agronomically sound and economically viable technique.

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