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Organic Nutrient Management in Colour Cotton in Vertisol Soil

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ABSTRACT

Nutrient management is one of the greatest challenge in obtaining sustainable yield of crop over a long period. The increasing food demands of a growing human population and the need for an environmentally friendly strategy for sustainable agricultural development require significant attention for enhancing crop productivity, hence the present experiment was conducted at Agriculture Research Station, Achalpur (Dr. PDKV, Akola) Maharashtra state of India with an aim to achieved sustainable productivity. Experiment was conducted in a Randomized Block Design with six treatments and four replications. The average rainfall and its distribution were found normal in all five years of the experimentation. The PCA of five year rainfall shows not much variation in the dimension. Seed treatment with beejamrut, azotobactor and PSB along with biological pest control was followed in all treatments. Five rows of sunhemp, one row of ambadi and two rows of Marigold were sown at the border of experimental plot. Five years of pooled results revealed that colour cotton + black gram in 2:1 proportion at 60 cm spacing (mulching of black gram after plucking of pods) + vermicompost @ 2.5 t ha-1 + jeevamrut 10% at 50 DAS recorded highest seed equivalent yield (1318 kg ha-1) with highest B:C ratio (1.92).

Keywords: *Organic, Nutrient, Colour Cotton, Vertisol Soil, Vermicompost and Sunhemp*

INTRODUCTION

Cotton is grown mostly for fibre used in the manufacture of cloths for mankind. In recent years, cotton apparels are being preferred to the synthetic ones due to the increasing the health consciousness among the people. Besides fibre, cotton is also valued for its oil (15-20 per cent) which is used as vegetable oil and cotton seed cake. Cotton seed cake used as cattle feed and can also be used as manure which contains 6.4, 2.9 and 2.2 per cent N, P and K, respectively also it is likely to play a pivotal role in paper, particle board and cardboard industries, With the advanced technology, short fibre or fuzz or lint can now be used to make excellent grade paper like currency paper, linoleum cellophane, rayons, photographic films, dynamic and moulded plastics. Cotton provides livelihood to more than 60 million people in India by the way of agriculture, processing and use of cotton in textile.

India is one of the largest producers of cotton in the world accounting for about 23.30 per cent of the world cotton production. The lint yield per hectare which is presently 510 kg ha^{-1} is still lower against the world average yield about 768 kg ha^{-1} which is 50.59 per cent higher than India average yield [3]. India is the second largest consumers of cotton i.e. about 23 per cent which is 5.8 million MT and world cotton consumption is 25.63 million MT [3].

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Conventional white cotton is the sought after in the world and most of countries in the world rely upon cotton for a significant per cent of GDP. However the production of white cotton has become increasingly associated with severe negative environmental impacts like reduce soil fertility, salinization etc. Cotton processing also takes another toxic toll, as the use of chlorine bleaching agents, formal-aldehydes and phenols is quite dangerous to all lives, fabrics dyes utilizing lead arsenic, cadmium, cobalt, zinc and chromium are skin irritants and children are especially sensitive to their effects. So, the demand for harmful dyes and pesticides free cotton is increasing in cotton industries. In this context, there is revival of interest in organic and natural colour cotton without recourse to dyeing using harmful and polluting chemicals.

Cotton with natural colour lint, other than white, is commonly referred as colour cotton. In nature, colour and white linted cottons are found from time immemorial. Colour cotton is being grown and used by mankind since 2500 B.C. In India, brown linted varieties of cotton (*Garboreum* L) namely Cocanada 1, Cocanada 2 and Red Northerns were under commercial cultivation mainly on black soils under rainfed condition in parts of Andhra Pradesh. Red linted types were predominant and high in demand for their better dyeing qualities and colour fastness. However, the situation has changed with the advancement and standardization of dyeing techniques. Cultivation of colour cotton was discouraged and almost abandoned in the latter half of this century. Colour linted varieties could not remain popular with growers, mainly because of low productivity per unit area, poor fibre characteristics and non-uniformity of colour.

In recent years organic colour cottons are receiving increasing importance in view of their eco- friendly character.

The awareness about the toxicity and pollution caused by synthetic dyes has revived the interest in cultivation of organic cotton. The urge for eco-friendly cotton can only be fulfilled preferably by organically grown colour cotton, dispensing harmful chemicals in dying and processing.

Naturally colour cotton totally eliminates the process of colouration as this cotton has a colour gene present in the lumen of the fibre that imparts natural colour to cotton as it grows and matures. The fabric has inherent anti-microbial, UV protective and better comfort properties farm to fabric conversion without chemical processing. The dyeing process adds to the cost of production of fabric. The dyeing process is omitted when naturally colour lint is used for manufacturing of the fabric. Thus, the cost of production of fabric can be reduced to some extent through the use of naturally colour cotton.

Organic agriculture is now developing rapidly and practiced in 191 countries of the world with 76.4 million hectares of area managed organically by at least 3.7 million farmers. Organic share of total agricultural land is 1.6 per cent. As per the available statistics, India's rank 6th in terms of World's Organic Agricultural land and 1st in terms of total number of producers as per 2021. Organic farming is one of the several approaches found to meet the objectives of sustainable agriculture. Many techniques used in organic farming like intercropping, mulching and integration of crops and livestock are not alien to various agriculture systems including the traditional agriculture practiced in old countries like India. Organic farming is one of the widely used methods, which are thought of as the best alternative to avoid the ill effects of chemical farming. In organic farming system nutrient management is one of the most important challenges as per the nutrient requirement of crop for those different organic sources including farmyard manure, vermicompost, *jeevamrut* and green manuring with legume crops are use in organic farming. Each organic source has its own importance for soil health and crop health. *jeevamrut* is low-cost liquid organic manure which is an excellent source of natural carbon, beneficial micro-organism such as nitrogen fixing and phosphate solubilizing bacteria, macro and micro-nutrients. *jeevamrut* is made from pure desi cow dung, desi cow urine, jaggery, pulse flour, and fertile soil. Thus, the use of *jeevamrut* is the best alternative organic source of nutrients instead of chemical fertilizer and better bio enhancer to improve the fertility status of soil and increase sustainable crop productivity, quality, profitability, nutrient use efficiency and resources use efficiency.

The beneficial effects of *jeevamrut* reported by [28], [44] and [17] were attributed to higher microbial load and growth hormones which might have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately resulted in better growth and yield of crops. *Jeevamrut* also rich in various microorganisms like *azospirillium*, PSM, *pseudomonas*, *trichoderma*, *yeast* and mould which promotes immense biological activity in soil and makes the nutrients available to crop [17].

Sunhemp (*Crotalaria juncea*) is a popular as green manure in many tropical and subtropical areas in the world as an organic nitrogen source sunhemp suppresses weeds, slows soil erosion, and reduces root- knot nematode populations. When ploughed under the early bloom stage, nitrogen recovery is highest. Under optimum growing conditions sunhemp can produce 134 to 147 lb acre^{-1} of nitrogen (N) and 3 tons acre^{-1} organic matter at 60 days of growth at 40 kg seed ha^{-1}. Cutting the crop down to 1 ft 100 days after planting and then letting the plant re-grow for a period of 70 days has been found to increase the N content of the biomass [1]. Green manuring with sunhemp is most economical and practically applicable method identified for enhancing the soil organic carbon. Addition of organic matter through green manures plays an important role in improving productivity of crop besides improvement in soil physico-chemical properties, which often deteriorate under intensive cropping involving inorganic fertilization [13]. The beneficial effects of the green manuring and intercropping have already been studied in various part of the world in different soils and diverse crops [14] and [12]. Green manure builds up considerable soil organic carbon due to the addition of phyto-mass and biomass [37]. It was observed that soil organic carbon content in different soil layer in plots with green manuring increased to the extent of 25 to 50 per cent as compared to no green manuring [38].

The use of vermicompost has long been recognized as an effective means of increasing crop yields through improved soil physical, chemical and biological properties [10]. Vermicompost is a nutritive 'organic fertilizer' with 2-3 per cent nitrogen, 1.55-2.25 per cent phosphorus and 1.85-2.25 per cent potassium besides micronutrients. It is reach in bacteria, *actinomycetes*, fungi and cellulose-degrading bacteria. Black gram (*Vigna mungo*) is one of the important pulse crop grown in the rainfed farming system throughout India. It has high nutritive value and consist high content of proteins, vitamins and minerals. Grain contains about 24 per cent protein, 60 per cent carbohydrate, 1.3 per cent fats and is the richest among the various pulses in phosphoric acid, being 5 to 10 time richer than others. Black gram is used as green manuring crop and it possesses deep root system which binds soil particles and thus prevents soil erosion. Black gram is used as nutritive fodder especially for milk cattle. Cowpea (*Vigna Unguiculata)* is a important pulse crop. The grains contain 25 per cent protein and several vitamins and minerals. The plant tolerates drought, performs well in a wide variety of soils, and being a legume replenishes low fertility soils when the roots are left to decay. It also grows and covers the ground quickly, preventing erosion. Application of bio fertilizers result in increased mineral and water uptake, role in development, vegetative growth and 15 to 30 per cent increase in crop yield [46].

Main aim of organic farming is conservation and optimum utilization of natural resources for reasonable profitability under the guiding factor of sustainability of the agriculture. Costly chemical fertilizers are creating economic problems to the small and marginal farmers. In the rainfed tract of central India, cotton is grown on large scale where the production is low due to poorly distributed rainfall, and eroded undulating nature of lands and low resources investment by farmers. Such soils require low-cost and low external input production system to minimize cost on fertilizer and pesticides for imparting stability in production. Cultivation of cotton crop with organic sources helped farmers to improve sustainable productivity.

METHODOLOGY

This experiment was conducted for total five years from 2019 to 2023 on the farm of Agriculture Research Station, Achalpur, Dist Amravati, 444805, comes under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola Maharashtra State of India. Achalpur is situated in the subtropical region at 21^{0}15'26$^{''}$ North latitude and 77^{0}30'31'' East longitude and at an altitude of 375 m above mean sea level. The soil of the experimental plot was clayey in texture having 15.6 % sand, 30.7 % silt and 53.7% clay by Bouyoucos hydrometer method [30]. Soil was slightly alkaline in reaction having pH 7.90.

Among nutrient status it ranged medium in organic carbon (0.42%), low in available nitrogen (174.3 kg ha^{-1} by alkaline $KMnO_4$ method [40], very low in available phosphorus (12.21 kg ha^{-1} by alkaline Olsen's method [27] and very high in available potassium (412.74 kg ha^{-1} by Flame photometric method [16]. This experiment was conducted for total five years from the year 2019 to 2023. In the present investigation, healthy and viable seeds of colour cotton (Vaidehi-95) variety having 160-170 days duration were used with six different treatments and four replications.

Treatment details:

T_1	Control
T_2	Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS.
T_3	Vermicompost @ 2.5 t ha^{-1} + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Jeevamrut 10% at 50 DAS.
T_4	Vermicompost @ 2.5 t ha^{-1} + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS).
T_5	Vermicompost @ 2.5 t ha^{-1} + Cowpea in 2:1 proportion at 60 cm spacing (Green manuring of cowpea at 40 DAS) + Jeevamrut 10% at 50 DAS.
T_6	Vermicompost @ 2.5 t ha^{-1} + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after picking of pods) + Jeevamrut 10% at 50 DAS.

Note :

1) Seed treatment with Beejamrut, Azotobactor and PSB along with Biological Pest control will be followed in all treatments.

2) Five rows of sunhemp and one row of ambadi were sown at border of the experimental plot.

Experiment was conducted with following objectives to study the effect of organics on growth, yield and quality of colour cotton and to develop package of practices for organics cultivation of colour cotton.

Typology Construction

Explored the differences in the treatment combination using typological analysis [4]. Typologies can be developed by using structural (Recourses) or functional (Yield) variables or both [43]. Rainfall is perhaps the most important variable in the phenomenon of monsoon. The amount of rainfall in a given week, month or season varies from year to year over a wide range. This raises the question: is there an identifiable pattern in these variations, or is the variability purely random. Variability may be defined as a tendency of rainfall to fluctuate around a long-term average (normal) value. Studied first step in the dimensionality of the rainfall pattern and identified primary patterns and variability by applying Principal Component Analysis (PCA) using R (R 3.1.1) [5]. The rainfall distribution was normal during the five years of experimentation. The four principle components (PCs) can explain more than 90 % of the total variances by the seasonality of rainfall.

RESULTS AND DISCUSSION

Different organic treatment plays an important role, five years pooled data in respect of plant height, number of sympodial branches, and number of picked boll per plant and boll weight. Treatment T_3 - Colour Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS showed significantly more plant height (149.81 cm), number of sympodial branches (16.36), number of picked boll per plant (22.16) and boll weight (2.74) over rest of the treatment. *In-situ* green manuring with sunhemp crop acts as field covers which suppresses the weeds through smothering effects and conserve soil moisture by reducing evaporation from the soil might be responsible for adequate moisture availability during the crop growth, which might have been resulted in optimum cell division and cell growth, which was ultimately enhanced the plant height. Similar findings were also reported by [46], [36], [31] and [21].

Application of vermicompost along with *in-situ* green manuring of sunhemp, cowpea and black gram might be resulted in to effective enhancement in root formation, elongation of stem and production of bio-mass. The dissemination of dry matter in different plant parts demonstrated that increment in dry matter accumulation with higher nitrogen availability and physical soil parameters with vermicompost and green manuring, sunhemp were helpful to supply macro and micro nutrients The increase in number of leaves, number of monopodial and sympodial branches and fruiting bodies might be identified with the increase in dry matter of leaf, stem and fruiting bodies with application these organic sources. Similar results were reported by [33],[25] and [24].

Five years pooled results showed that, significantly highest seed cotton yield (1340 kg ha^{-1}) was observed with the treatment T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10 % at 50 DAS over rest of the treatment, but found at par with treatment T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS (1276 kg ha^{-1}). Improvement in different growth and development credits expanded photosynthetic productivity of colour cotton which leads to higher assimilate production and their efficient partitioning to the economic sink. Increase in number of bolls might likewise be because of better environment that promoted number of bolls as well as lateral growth and induced number flower and bearing nodes. Similar type of results was reported by [33] and [26].

Organic sources provided balanced nutrients to plant for advancing growth and yield contributing characters. Further, impact of organic manures on physical properties of soil was also a significant factor which might support the reproductive development. The similar results were confirmed in response of vermicompost and *in-situ* green manuring by [34], [15], [26] and [39].

Five years pooled results of seed colour cotton yield data showed that, significantly positive correlation was observed within the treatment combinations.

Five years pooled results showed that, significantly highest straw yield (2768 kg ha^{-1}) was observed with the treatment T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10 % at 50 DAS over rest of the treatments. The increase with the addition of organic sources through organic treatments resulted significant increase in stalk yield over no organics might be due to better utilization of well decomposed organic nutrient sources supplied through balance nutrient to plant for boosting up growth and yield attributing characters which were responsible for maximum allocation of dry matter to vegetative parts. Similar results were quoted by [31] and [26].

Pooled results showed that, significantly highest seed cotton equivalent yield (1340 kg ha^{-1}) was observed with the treatment T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS over rest of the treatment but found at par with treatment T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha-1 + Jeevamrut 10% at 50 DAS (1318 kg ha^{-1}) and T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 %

at 50 DAS (1276.04 kg ha^{-1}). Use of sunhemp, cowpea and black gram as intercrop enhanced the fertility status of the soil particularly nitrogen and valuable in saving N Legume helped in utilization of atmospheric nitrogen as well as help in residual build up the soil. Cotton intercropped with black gram found higher seed equivalent yield similar result was found by [19].

Highest cost of cultivation ha^{-1} (Rs. 50593) was observed with the treatment T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS followed by the treatment T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS (Rs. 43969). Results showed that, significantly highest gross monetary return (87016 Rs ha^{-1}) was observed with the treatment T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS over rest of the treatment but found at par with treatment T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS (85809 Rs ha^{-1}) and T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10 % at 50 DAS (82989 Rs ha^{-1}).

The higher GMR ha^{-1} was obtained due to black gram was associated with higher MSP of black gram indicating good response in organic colour cotton and low input cost in maximizing colour cotton yield. These results are confirmatory by [32] and [19]. Significantly highest net monetary return (Rs. 45139 ha^{-1}) was observed with the treatment T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10% at 50 DAS. It was at par with treatment T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10 % at 50 DAS (Rs. 39020 ha^{-1}).

The higher NMR ha^{-1} was obtained due to black gram was associated with higher MSP of black gram indicating good response in organic colour cotton and low input cost in maximizing colour cotton yield. These results are confirmatory by [35] and [45]. Five years pooled results showed that, highest B:C ratio (2.11) was observed with the treatment T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10% at 50 DAS.

Five years pooled results showed that, significantly highest N uptake (51.12 kg), P uptake (10.09 kg) and K uptake (45.80 kg) was observed with the treatment T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10 % at 50 DAS over rest of the treatment. However it was at par with treatment T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10 % at 50 DAS (48.28 kg). Green manuring crops are known to fix atmospheric nitrogen, further develop soil structure and recycle the nutrients. The expanded uptake of nitrogen might be because of mineralization of N added by green manure crops and its quick decomposition after incorporation of green manuring crops. Higher dry matter accumulation and yield contribution resulted in increase in nitrogen uptake. These results are conformity with findings of [8], [6], [20] and [42]. Phosphorus supplied through organic manure along with biofertilizer (PSB) may play key role in conversion of insoluble soil P in to soluble form and produce plant growth substances in the soil. Similar results were found by [6], [20] and [23]. Expanded K uptake with organically treated plots might be due to the combine impact of organic/green manures on the decomposition related release of organic acids that solubilize local. These results are conformity with findings of [6], [20] and [42].

Five years pooled results showed that, significantly highest available N (196.72 kg ha-1), P (15.56 kg ha-1) and K (432.69 kg ha^{-1}) was observed with the treatment T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10 % at 50 DAS over rest of the treatment. The main improvement in availability of nitrogen under the treatment T_3 receiving balance fertilization might be expected due to increasing recommended dose of nutrient through vermicompost, *jeevamrut* 10% and green manuring of sunhemp as it is source of multiple nutrients. These results are in confirmatory with those reported by [9] and [22]. The use of PSB and vermicompost, being direct source of phosphorus and might have also solubilized the native phosphorus in the soil through the release of various organic acids which had the chelating effect that reduced phosphorus fixation. These results are in close conformity with these findings mentioned by [22]. The reduction of potassium fixation and release of more K due to the interaction of organic matter with clay, besides the direct K addition in the available K pool to the soil it might have increased the available K in the soils. This confirms the earlier reports of many workers [18] and [22].

Fig. 7 shows Principle Component Analysis of major insect pests of cotton was done. PCA of insect pest population was conducted and it is observed that the population was controlled below ETL for the respective pest. PCA graph of variable shows 44.06 % dimension.

CONCLUSION

Five years of pooled results revealed that the colour Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10% at 50 DAS recorded highest seed equivalent yield (1318 kg ha^{-1}) with highest B:C ratio (1.92). Higher uptake of nutrients (N, P, and K), available nutrients and microbial population observed with application of Vermicompost @ 2.5 t ha^{-1} + *Jeevamrut* 10% @ 500 L ha^{-1} at 50 DAS along with green manuring of *Sunhemp* at 40 DAS. So, it improved soil fertility.

Future scope of the study: Cultivation of cotton crop with organic sources help farmers to improve sustainable productivity.

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Conflicts of interest: The authors declare that they have no conflicts of interest relevant to this research study.

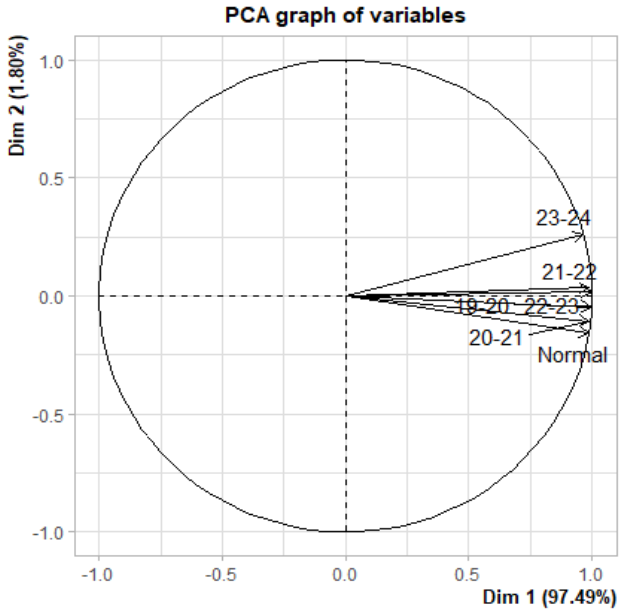

Fig 1: Principle Component Analysis of rainfall obtained during five years of the experimentation. PCA graph of variable shows 97.49 % similarity.

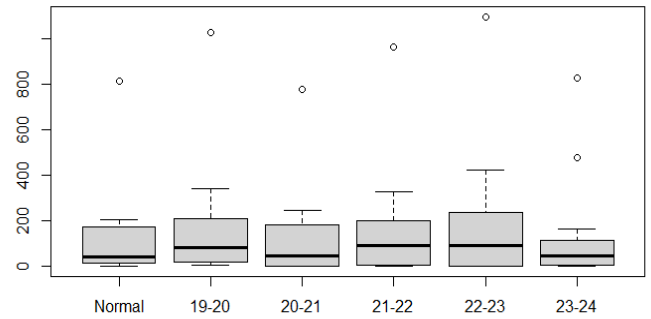

Fig 2 : Box plots of variables shows cluster means, median for five years rainfall data along with normal rainfall.

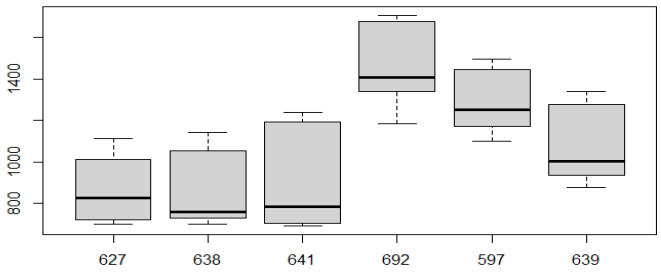

Fig 3: Box plot analysis showing result of highest colour seed cotton yield was harvested from treatment T3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha-1 + Jeevamrut 10 % at 50 DAS.

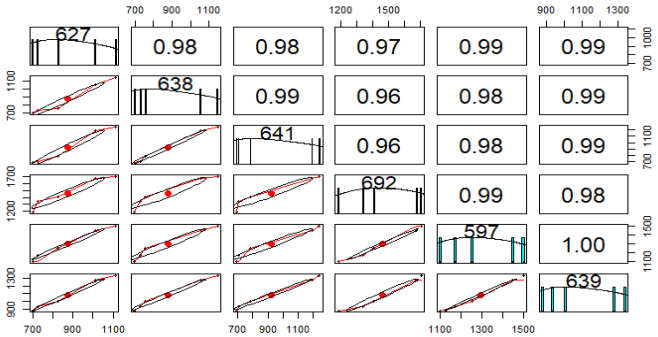

Fig 4: Ellipse analysis showing correlation with respect to the different treatment and clarify patterns of diversification.

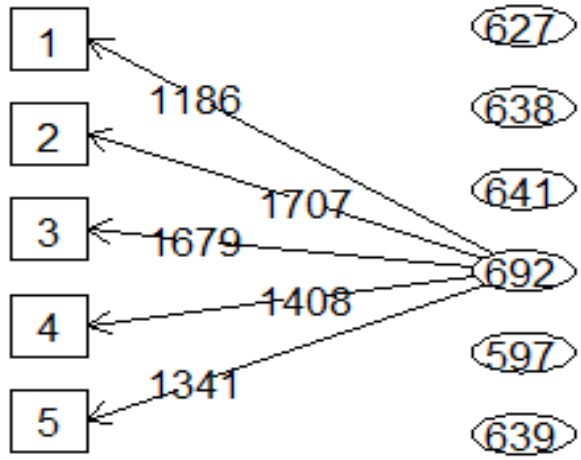

Fig 5: Structural model shows relation of treatment with respective seed cotton yield.

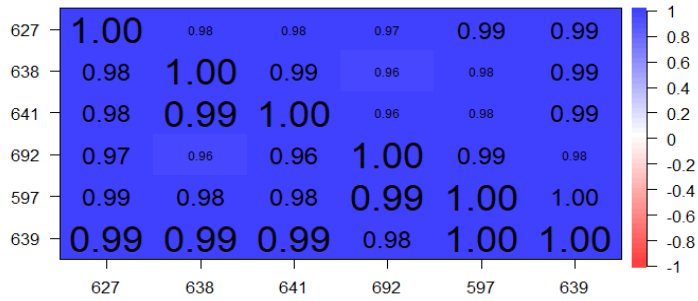

Fig 6: Correlation plot from the seed cotton yield data.

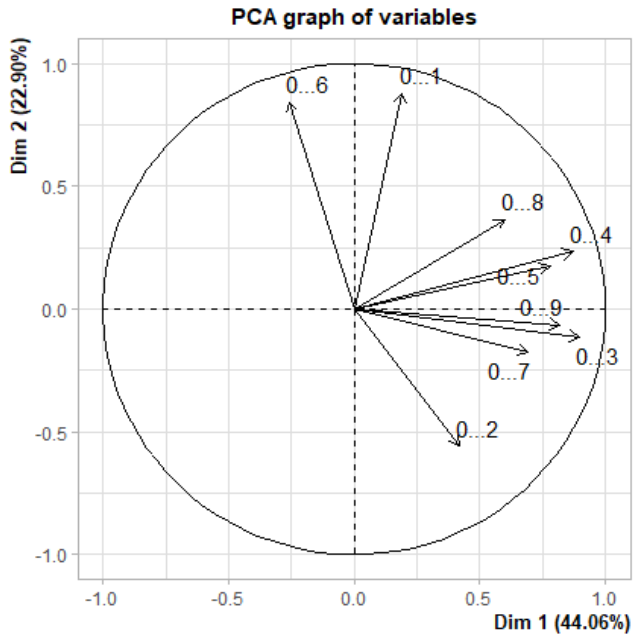

Fig 7: PCA graph of variable

Table 1: Growth and yield attributing character of colour cotton as influenced by different treatments (Pooled data – Five years).

Treatments	Plant height (cm)	No. of Monopodial branches	No. of Sympodial branches	No. of picked boll/ plant	Boll weight (g)
T_1 - Control	127.67	1.83	11.78	16.06	2.38
T_2 - Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	133.37	1.89	12.95	17.67	2.51
T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	149.81	2.03	16.36	22.16	2.74
T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1}.	146.91	2.00	15.60	21.64	2.67
T_5 - C. Cotton + Cowpea in 2:1 proportion at 60 cm spacing (Green manuring of cowpea at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	140.79	1.93	14.39	19.10	2.60
T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS.	138.22	1.91	13.94	18.56	2.56
SE (m)±	2.46	0.06	0.32	0.81	0.07
CD at 5 %	7.42	NS	0.98	2.43	0.20

Table 2: Seed cotton yield (Kg ha^{-1}) of colour cotton as influenced by different treatments.

Treatments	2019-20	2020-21	2021-22	2022-23	2023-24	Pooled
T_1 - Control	627	638	641	692	597	639
T_2 - Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	699	699	692	1186	1100	875
T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	1113	1144	1240	1707	1498	1340
T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1}.	1012	1052	1192	1679	1446	1276
T_5 - C. Cotton + Cowpea in 2:1 proportion at 60 cm spacing (Green manuring of cowpea at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	826	757	784	1408	1250	1004
T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS.	723	729	706	1341	1172	934
SE (m)±	101.7	33.7	84.0	60.2	45.5	38.5
CD at 5 %	306.7	101.6	253.3	181.4	137.2	116.1

Table 3: Straw yield (Kg ha^{-1}) of colour cotton as influenced by different treatments.

Treatments	2019-20	2020-21	2021-22	2022-23	2023-24	Pooled
T_1 - Control	1135	1258	1613	1325	1328	1332
T_2 - Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	1296	1373	1710	2254	2194	1765
T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	2149	2328	3392	3244	2727	2768
T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1}.	2063	2141	2950	3189	2643	2597
T_5 - C. Cotton + Cowpea in 2:1 proportion at 60 cm spacing (Green manuring of cowpea at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	1519	1569	1958	2676	2316	2008
T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) +Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS.	1403	1466	1770	2547	2289	1895
SE (m)±	69.0	63.8	185.1	51.5	112.7	59.3
CD at 5 %	207.9	192.4	557.9	155.3	339.7	178.9

Table 4: Seed cotton equivalent yield (Kg ha^{-1}) of colour cotton as influenced by different treatments.

Treatments	2019-20	2020-21	2021-22	2022-23	2023-24	Pooled
T_1 - Control	627	638	641	692	597	639
T_2 - Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	699	699	692	1186	1100	875
T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	1113	1144	1240	1707	1498	1340
T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1}.	1012	1052	1192	1679	1446	1276
T_5 - C. Cotton + Cowpea in 2:1 proportion at 60 cm spacing (Green manuring of cowpea at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	826	757	784	1408	1250	1004
T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS.	1081	1164	1146	1611	1592	1318
SE (m)±	101.7	33.7	84.0	60.2	45.5	38.5
CD at 5 %	306.7	101.6	253.3	181.4	137.2	116.1

Table 5: Cost of cultivation (Rs ha^{-1}) of colour cotton as influenced by different treatments.

Treatments	Seed Cotton Yield (Kg ha^{-1})	COC (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C ratio
T_1 - Control	639	29314	41033	11718	1.40
T_2 - Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	875	42424	57163	14738	1.32
T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	1340	50593	87016	36423	1.69
T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1}.	1276	43969	82989	39020	1.88
T_5 - C. Cotton + Cowpea in 2:1 proportion at 60 cm spacing (Green manuring of cowpea at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	1004	41098	65642	24544	1.56
T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS.	934	40670	85809	45139	2.11
SE (m)±	38.5	-	2481	2277	-
CD at 5 %	116.1	-	7477	6863	-

Table 6: N uptake (kg) by plant in colour cotton as influenced by different treatments.

Treatments	N	P	K	Av. N	Av. P	Av. K
Initial Status	-	-	-	170.42	11.28	404.35
T_1 - Control	24.59	4.88	22.12	168.06	10.86	411.45
T_2 - Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	32.52	6.46	29.24	173.31	12.26	416.78
T_3 - C. Cotton + Sunhemp at 60 cm spacing in 2:1 proportion (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	51.12	10.1	45.80	196.72	15.56	432.69
T_4 - C. Cotton + Sunhemp in 2:1 proportion at 60 cm spacing (Green manuring of Sunhemp at 40 DAS) + Vermicompost @ 2.5 t ha^{-1}.	48.28	9.49	42.86	188.04	14.97	428.09
T_5 - C. Cotton + Cowpea in 2:1 proportion at 60 cm spacing (Green manuring of cowpea at 40 DAS) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10 % at 50 DAS.	37.85	7.45	33.36	181.51	13.94	425.03
T_6 - C. Cotton + Black gram in 2:1 proportion at 60 cm spacing (Mulching of black gram after plucking of pods) + Vermicompost @ 2.5 t ha^{-1} + Jeevamrut 10% at 50 DAS.	35.28	6.94	31.28	175.05	12.82	423.91
SE (m)±	1.16	0.23	0.96	1.49	0.82	1.32
CD at 5 %	3.51	0.68	2.90	4.50	2.46	3.99

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