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Response of integrated nutrient management on growth and yield character of *Bt.* cotton-groundnut cropping sequence

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Abstract
A field experiment was carried out at Regional Research Station, Anand Agricultural University, Anand, Gujarat during the *kharif* and summer season of 2021-22 and 2022-23, to study the response of integrated nutrient management on *Bt.* cotton-groundnut cropping sequence. The experiment was laid out in a randomized block design in *Bt.* cotton with 5 treatments and 4 replications, while split plot design was laid out in summer groundnut with 10 treatments and 4 replications. Application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost along with Bio NPK consortium to *kharif* cotton significantly increased the plant height, monopodial branches per plant, sympodial branches per plant, seed cotton yield and stalk yield. In succeeding summer groundnut, residual effect of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost along with Bio NPK consortium and 100% RDF significantly increased plant height, number of branches per plant, pods per plant, pod yield and haulm yield.

Keywords: INM, *Bt.* cotton, groundnut, RDF, RDN

Introduction
Cotton, the king of fiber, is one of the momentous and an important cash crop exercising profound influence on economics and social affairs of the world. Any other fiber crop cannot compare with cotton particular for its fiber quality. It plays an important role in textile industries and is a means of livelihood for millions of farmers and those concerned with its trade, processing, manufacturing and other allied industries. It is used in the manufacturing of cloth for mankind. Cotton seed contains 15 to 20 percent oil and is used in vegetable purpose and soap industries. After extraction of oil, the left-over cake is very proteinous and is use as cattle feed. India remains the leading country in terms of area under cotton cultivation and raw cotton production in the world. As per Committee on Cotton Production and Consumption (COCPC) estimate, cotton production in India during 2022-23 was 341.91 lakh bales from 130.61 lakh hectares with a productivity of 447 kg lint/ha. During the year 2022-23, Gujarat, Maharashtra and Telangana were the major cotton growing states covering around 70.48% (83.18 lakh hectare) area and 65.90% (225.33 lakh bales) production of cotton in India. Gujarat produced 87.12 lakh bales from 25.49 lakh hectare and contributed 23.75% of the national output (AICRP on cotton, 2022-23).

Primarily integrated nutrient management refers to combine old and modern method of nutrient management into ecologically sound and economically optimal farming that uses the benefits from all possible sources of organic, inorganic and biologically components in a judicious, efficient and integrated manure. Organic fertilizers include compost (Village compost, town compost, water hyacinth compost and vermicompost), farmyard manure (Cattle manures, sheep penning and poultry manures), green manures (Leguminous plant and non-leguminous plant), biofertilizers (Algal biofertilizer, fungal biofertilizer, bacterial biofertilizer or plant growth–promoting rhizobacteria (PGPR), etc.). Organic fertilizers have long since been known to improve physical properties viz. declining sodicity, reducing bulk density, water infiltration rate, increased porosity and aeration, improved saline water leaching and chemical properties, that is, decreasing acidity. On increasing the humus content, there is a change in biological properties of soil that help in flourishing of beneficial macro- and microorganisms. Organic amendments increase soil carbon and nitrogen content, which results in enhanced soil fertility and crop productivity and it is also eco-friendly and cost-effective (Singh, *et al.*, 2020) [24]. INM is also important for marginal farmers who cannot afford to supply crop nutrients through costly chemical fertilizers.

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O. It improves the soil structure (aggregation), so that it holds more nutrients and water and helps in improving the fertility of the soil. It also encourages soil microbial activity, which promotes the soil trace mineral supply, improving plant nutrition. It also contains some nitrogen and other nutrients that assist the growth of plants.

Vermicompost is dropping of earthworms after the intestinal digestion of organic matter and has high nutritive value. It is well known that earthworm plays important role in improving physical and chemical properties of soil. Simultaneously, it increases aeration and water holding capacity of soil. The activities of earthworms increase the amount of water stable aggregates. A vast portion of non-available nitrogen present in organic matter is made available to the plant through the process of vermicomposting. Vermicompost is a nutrient rich organic fertilizer and soil conditioner. Nutrient content in vermicompost is 1.60% N, 2.50% P_2O_5 and 0.8% K_2O (Ashokan, 2008) [4].

Addition of organic matter through FYM or vermicompost plays an important role in improving the soil physical properties, which often gets deteriorated under intensive cropping system. Carbon present in organic matter is used as a source of energy for microbes, which improve the beneficial microbial activities and thereby leading to better root and shoot growth and thereby, increasing the yield of the crop. The use of biofertilizers with organic manures may prove viable option for sustainable crop production, since the biofertilizers are eco-friendly and cost effective and renewable source of plant nutrients, which help to maintain long term soil fertility and sustainability. Their use in crop production is found to improve soil health by rendering the adverse effects of excessive and imbalanced use of chemical fertilizers and augmenting the quality of crop produce by colonizing in the rhizosphere (Rugheim and Abdelgani, 2012) [27].

Plant parts left after crop harvesting called crop residues which are the good source of soil nutrients. It is not a waste whereas a good natural resource and it is the largest part of agricultural harvests which contains huge amount of carbon and other nutrients *viz.* nitrogen phosphorus, potassium, sulphur etc. These elements must be recycled for the sustainable development of agriculture. Crop residues are not waste but it is a provider of essential environmental services, assuring the perpetuation of productive agro-ecosystem. Crop residues can be a valuable resource for carbon sequestering and/or power generation. It is also as organic material remains left behind on fields after harvesting, such as corn stalks and husks. Often this bulk holds more carbon than the crop itself. During a growth season, crops store carbon from air, and then exhale it as the crop residues rot, giving no net change in atmospheric CO_2. Removal or burning of residue ensures farmers quick seedbed preparation and avoids the risk of reduced crop yields associated with incorporating wide C/N ratio residue that immobilizes N during decomposition. The benefits of sequestering soil organic C (SOC) to sustaining crop productivity by applying organic amendments and crop residue and including legumes in crop rotations have been well documented in the temperate regions.

Integration and incorporation of crop residues in the agricultural system helps to improve soil structure, soil microbial activity and soil moisture conservation and which in turn helps to stabilize the production and productivity of the crops. Incorporation of crop residues is also important management practices that supply crop nutrients to the succeeding crop for better crop growth.

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop belonging to family *fabaceae* (or *Leguminosae*). Groundnut is the king of oilseed crops and vegetable oil economy of country depends very much on it. It is mostly grown on for seeds and oil production in the world it is also known as peanut, monkeynut, earthnut, goobernut and manillaunt. It is native to South America (Brazil) and best grown in tropics and subtropics.

Cotton- summer groundnut cropping system is popular in many regions of Gujarat where irrigation facilities are adequate and mostly followed by farmers. Due to continuous adoption of the nutrient exhaustive crops and imbalanced use of fertilizers, production of the cropping system is either declining or remaining stable in the state. In order to enhance the productivity of the system, organic sources of nutrient along with inorganic fertilizer can be included in the system. Cotton stalks produced in the field are normally burnt and for efficient utilization of cotton stalk and residual effect of manures and fertilizers applied and nitrogen fix by legumes can considerably bring down the production cost if all the crops are considered instead of individual crops. In this context, cropping sequence approaches gaining importance.

Materials and Methods

A field experiment was carried out during the *kharif* seasons of the year 2021 and 2022 at Regional Research Station, Anand Agricultural University, Anand, Gujarat. The soil of experimental site was loamy sand in texture, having low in organic carbon (0.41%), available N (237.65 kg/ha), medium in available P_2O_5 (39.27 kg/ha) and available K_2O (318.52 kg/ha) with slightly alkaline condition (pH 8.21) and EC (0.25 dS/m). the soil was free from any kind of salinity and sodicity hazard. Cotton variety Gujarat Talod Hirsutum Hybrid-49 (BG-II) and groundnut variety Gujarat Groundnut 34 were used as a test crop in the study. The experiment was arranged in randomized block design with four replications in cotton, consisting of five treatments *viz*., C_1 (100% RDN through inorganic fertilizer), C_2 (75% RDN through inorganic fertilizer + 25% through FYM), C_3 (75% RDN through inorganic fertilizer + 25% through vermicompost), C_4 (75% RDN through inorganic fertilizer + 25% through FYM + Bio NPK consortium) and C_5 (75% RDN through inorganic fertilizer + 25% through vermicompost + Bio NPK consortium), while split plot design was carried out for groundnut crop with four replications and two treatments *viz*., G_1 (100% RDF through inorganic fertilizer) and G_2 (75% RDF through inorganic fertilizer + cotton residue). Application of Bio NPK consortium for cotton @ 1 l/ha at the time of sowing and 1 l/ha at 45 DAS.

Results and Discussion

Effect of integrated nutrient management on growth and yield cotton

The growth attributes *viz*., plant height, number of monopodial branches and sympodial branches was significantly influenced due to different INM treatments. The differences in plant height among different treatments did not exert their significant effect at 30 DAS during both the years of experimentation and in two-year pooled analysis. The differences in plant height among different treatments were significant at 60, 90 DAS and harvest stages of crop growth during both the years and in pooled analysis. At 60 DAS, significantly taller plants were observed in treatment C_5 (75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium), whereas it was at par with treatment C_4 (75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium) during both the years of experimentation and in pooled analysis. Similar trend was observed in case of 90 DAS and at harvesting stage. All the stages of crop growth exhibited significantly low values of plant height during both the years of investigation and in pooled data recorded in 100% RDN through inorganic fertilizer (C_1) at 60, 90 DAS and harvest. This might be due to combined effect of inorganic and organic nutrient which plays very important role due to their synergism effect. The nitrogen from fertilizer helped in promotion of growth during early stages and it is considered to be a vitally important plant nutrient. In addition to its role in formation of proteins, nitrogen is an integral part of chlorophyll which is primary absorber of light energy needed for photosynthesis. Further, an adequate supply of nutrients in the life cycle of plant through organic and bio fertilizer is important in laying down the primordia of its reproductive parts. Hence, increases initiation of both first and second order rootlets and their development. The extensive root system helps in exploiting the maximum nutrient and water from the soil while organic source of nutrients improved crop growth during later stages. The favourable effect of organic sources on growth might be attributed to presence of relatively readily available plant nutrients, growth enhancing substances and number of beneficial organisms like nitrogen fixing, phosphate solubilizing, cellulose decomposing and other beneficial microbes as well as antibiotics, vitamins and hormones etc. The enhanced growth with levels of fertilizer and organic source treatments was also endorsed by Lokhande *et al.,* (2020) [9] and Muthu and Rao (2023) [14].

Monopodial branches/plant were significantly influenced by different treatment at 60, 90 DAS and at harvest. At 60 DAS monopodial branches/plant were found higher with treatment C_5 (75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium), whereas it was at par with treatment C_4 (75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium) during both the years of experimentation and in pooled analysis. Treatment C_3 (75% RDN through inorganic fertilizer + 25% RDN through vermicompost) was found at par with treatment C_4 and C_5 during first year. Similar trend was observed in monopodial branches/plant at 60 DAS and at harvest. It could be attributed to the better availability of N, P and micronutrients due to integrated nutrient management practices resulted in higher accumulation, nutrient uptake and translocation owing to increase in the vegetative growth *i.e.* monopodial branches /plant. Analogous findings have been reported by Patel *et al*., (2016) [16] and Meena *et al.,* (2019) [12].

Number of sympodial branches/plant was also found significantly higher with treatment C_5 and treatment C_4 was found at par with it during both the years and on pooled basis except treatment C_3 which was found at par during both the years of experimentation. At all different developmental stages treatment C_1 was found significantly lower in case of both number of monopodial as well as sympodial branches. This may be mainly due to favourable effect of vermicompost that attributed to sustained availability of major and micronutrients with different growth hormones like gibberellins resulting from organic manures and bio fertilizers. Lesser response of cotton to inorganic fertilizers could be attributed to slow mineralization of and low population of beneficial microbes as compared to vermicompost, FYM and application of bio fertilizer. These results coincide with the work of Ramesh *et al.,* (2018) [19] and Parmar *et al.,* (2019) [15].

The data on influence of different treatments on days to 50 percent flowering of cotton during *kharif* season of the year 2021-22 and 2022-23 did not show any statistical differences.

The magnitude of expression of yield attributes like number of bolls/plant, harvest index, seed index. Ginning percentage, seed cotton yield and stalk yields were significantly influenced by INM treatments. Number of bolls/plant was found higher with treatment C_5 (75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium), whereas it was at par with treatment C_4 (75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium) during both the years of experimentation and in pooled analysis. Also, treatment C_3 was found at par with C_4 and C_5 during first year of experimentation. Treatment C_1 recorded significantly lower number of bolls/plant during both the years and on pooled basis. This might be due to increase in plant height and number of sympodial branches/plant that have reflected in increasing number of bolls/plant as evident from the data presented in respective tables. Further, appreciable availability of major and micro nutrients as well as improved soil microbial properties under theses treatment may also responsible for higher values of this yield attribute. Shivamurthy *et al*., (2015) [22] and Muthu and Rao (2023) [14] also reported similar findings.

While, harvest index, ginning percentage and seed index did not exert any significant difference among the different treatments but higher values were recorded with treatment C_5.

The results summarized different treatments had significant influence on seed cotton and stalk yield during both the years of experimentation and also in pooled analysis. Significantly higher seed cotton and stalk yield were recorded with an application 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5), but it was at par with 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4) during both years and in pooled data. Significantly lower value of seed cotton and stalk yield were recorded by 100% RDN through inorganic fertilizer (C_1) during first year, second year and in pooled analysis, respectively. Since, yield of crop is a function of several yield components, which are dependent on complementary interaction between vegetative and reproductive growth of the crop. It was noticed that a magnitude of variation in the seed cotton yield was proportional to variation in yield attributing parameters like sympodial branches/plant, number of bolls/plant and their variation was attributed to availability of nutrients in soil as indicated by significant and positive correlation observed between seed cotton yield and available nitrogen status in soil. Further, all those treatments which received nitrogen in integrated form recorded significantly higher seed cotton yield compared to inorganic fertilizer treatment.

An increase in seed cotton yield with FYM and vermicompost with bio fertilizer application along with N fertilizers might be due to the fact that added FYM or vermicompost served as store house of several macro and micro nutrients which were released during the process of mineralization. In addition to release of plant nutrients from organic matter, organic acids formed in decomposition process also release native nutrients in soil and increases their availability to plants through microorganism. Among the treatments, conjuctive use of organics with inorganic fertilizer recorded higher seed cotton and stalk yield compared to inorganic fertilizer probably because of optimum supply of nutrients at right time of crop requirement and cotton responds well to fertilizer application as a result of its well-developed root system, crop absorbed required nutrients from soil for effective dry matter production and translocation of photosynthates from leaves to the sink for better development of cotton seed. These results are supported by Thimmareddy *et al*., (2013) [26], Chavda and Rajawat (2015) [6], Ramesh *et al.,* (2018) [19] and Meena *et al.,* (2019) [12].

Residual effect of integrated nutrient management applied to preceding *kharif* cotton on succeeding summer groundnut

Residual effect of INM treatment applied to preceding *kharif* cotton crop was beneficial for increasing growth attributing characters of succeeding summer groundnut crop *viz*., plant height and number of branches. Plant height at 60 DAS and harvest, treatment receiving application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5) produced significantly taller plants at 60 DAS during both the years of study and in pooled analysis. But in case of harvest stage, it was at par with 75% RDN through inorganic fertilizer + 25% RDN through vermicompost (C_4) during both the year of study and in pooled analysis. While treatment C_4 was found at par during first and second year of experimentation. In case of harvest stage treatment C_5 was found significantly higher and at par with C_4 in both the years and in pooled analysis and treatment C_3 was at par with C_4 and C_5 during first and second year of study. Significantly lower plant height was found in 100% RDN through inorganic fertilizer treatment during both the years of study and in pooled analysis at all growth stages of groundnut. Significant increase in plant height with RDN along with FYM and vermicompost was probably due to cell and inter nodal elongation, plant metabolism, thereby promoting vegetative growth which is positively correlated to the productive potentiality of plant which corroborates with the results of Srinivasa *et al*., (2019) [25] and Makwana and Bhanvadia (2023) [11]. The increase in plant height with higher level of fertilizer application was result of enhanced activities of meristematic tissues of plant, increase in number and size of cell and efficient utilization of nutrients uptake. The similar result was also recorded by Dhandore *et al*., (2021) [7].

While significantly higher number of branches per plant was recorded with application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5) but it was at par with 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4) during both of the years and pooled analysis. Increased in number of branches per plant might be due to organic matter content improved by application of organic manure which modifies the soil environment led to hold more nutrients and water, good aeration, growth hormones, increased availability of nitrogen and balanced nutritional environment. Further organic, inorganic and biofertilizers, enhanced microbial activities, which promote the cell division and cell enlargement in axillary buds. These results corroborated the earlier findings obtained by Sindhi *et al*., (2016) [23] and Makwana and Bhanvadia (2023) [11]. The number of branches per plant increased with increasing level of fertilizer application. The inorganic fertilizer provides favourable condition for activation of meristematic cells and encourage emergence of branches. It is a result of activation of auxiliary bud which mainly dependent on moisture and nutrient availability. Similar results were reported by Bhosale and Pisal (2017) [5], Patil *et al*., (2017) [17] and Dhandore *et al*., (2021) [7].

Yield contributing characters of groundnut *viz*., number of pods per plant, pod yield and haulm yield per hectare as influenced by different treatments were significantly affected due to different treatments. Application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5) produced significantly higher number of pods per plant and number of kernels per pod, which was at par with 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4) during both the year of experimentation except pooled analysis. It might be due to integrated use of chemical fertilizers with organics *viz*., FYM, vermicompost might have added huge quantity of organic matter in soil that resulted in higher yield attributes. These results are similar with results obtained by Radhakumari and Reddy (2010) [18] and Srinivasa *et al*., (2019) [25]. The number of pods per plant of groundnut could be attributed to favourable changes in physical and chemical characteristics of the soil which may have enabled better pod formation. Similar results were also reported by Hossain and Hamid (2007) [8] and Meena and Yadav (2015) [13].

Significantly lower number of branches per plant was found in 100% RDN through inorganic fertilizer treatment (C_1) during both the years of study and pooled analysis. The INM to preceding *kharif* cotton crop did not exert any significant effect on kernels per pod and seed index of summer groundnut during both the years and in pooled analysis.

The residual effect of combination of organic and inorganic to preceding *kharif* cotton crop, application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5) produced significantly higher pod (3602, 3639 and 3620 kg/ha) and haulm yield (4665, 4710 and 4687 kg/ha) during 2021-22, 2022-23 and in pooled mean basis, respectively and at par with 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4). Application of 100% RDN through inorganic fertilizer treatment (C_1) resulted in significantly lower pod yield and haulm yield during both the years of study and pooled analysis. All growth and yield attributes were higher with treatment 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5) could be due to directly relation of yield attributes to pod yield. The combined effect of those yield attributes resulted in to higher yield. This might be due to balanced nutrient supply throughout growth period, efficient translocation of photosynthates and metabolites to reproductive parts and increased metabolism of plant. Further, biofertilizer application resulting in enhanced root functions that favours better growth and efficient absorption of moisture and nutrients resulting into higher pod yield. These findings are also in accordance with those of Radha kumari and Reddy (2010) [18] and Mahapatra *et al*., (2018) [10], The response may be due to efficient and greater partitioning of metabolites and adequate translocation and accumulation of photosynthesis to developing reproductive structure under adequate fertilization that might have resulted in increase of important growth and yield contributing characters *viz*., plant height, number of branches, number of pods and kernels and their weight which resulted in increased pod yield with proper level of fertilizer dose. Further, fertilizer application provided better conductive condition for higher uptake of nutrients. These above results are in conformity with the findings of Satpute *et al*., (2021) [21] and Reddy *et al*., (2022) [20].

Table 1: Effect of integrated nutrient management on plant population of cotton

Treatment	Plant population at 20 DAS			Plant population at harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
C_1	57.75	58.00	57.88	52.50	53.50	53.00
C_2	57.75	58.50	58.13	53.00	54.25	53.63
C_3	57.75	58.50	58.13	53.00	55.50	54.25
C_4	58.00	59.00	58.50	53.50	55.75	54.63
C_5	58.00	59.75	58.88	54.00	56.50	55.25
S.Em. ±	1.09	0.69	0.65	1.55	1.44	1.06
C.D. at 5 %	NS	NS	NS	NS	NS	NS
C.V. %	3.78	2.34	3.13	5.82	5.22	5.52
Interaction (Y X C)	-	-	NS	-	-	NS

Table 2: Effect of integrated nutrient management on plant height of cotton

Treatment	Plant height at 30 DAS (cm)			Plant height at 60 DAS (cm)			Plant height at 90 DAS (cm)			Plant height at harvest (cm)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
C_1	29.78	31.88	30.83	97.96	98.30	98.13	112.23	120.95	116.59	142.07	150.95	146.51
C_2	30.38	32.13	31.25	101.51	108.36	104.94	121.15	127.53	124.34	152.45	157.53	154.99
C_3	31.10	32.85	31.98	108.16	112.71	110.43	125.46	129.93	127.69	155.70	159.93	157.82
C_4	31.15	32.60	31.88	116.57	122.60	119.58	133.04	139.00	136.02	178.90	169.00	173.95
C_5	31.35	32.88	32.11	124.94	131.21	128.07	145.86	150.78	148.32	181.63	180.78	181.20
S.Em. ±	1.37	1.37	0.97	5.98	5.72	4.14	7.00	6.38	4.73	9.26	6.38	5.62
C.D. at 5%	NS	NS	NS	18.41	17.63	12.08	21.55	19.66	13.82	28.54	19.66	16.42
C.V. %	8.90	8.43	8.66	10.88	9.98	10.43	10.97	9.55	10.25	11.43	7.80	9.77
Interaction (YXC)	-	-	NS	-	-	NS	-	-	NS	-	-	NS

Table 3: Monopodial branches of cotton crop as influenced by integrated nutrient management

Treatment	Monopodial branches per plant								
	At 60 DAS			At 90 DAS			At harvest		
	2020-21	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
C_1	1.78	1.75	1.76	2.70	2.66	2.68	2.97	2.93	2.95
C_2	1.83	1.85	1.84	2.96	2.96	2.96	3.40	3.40	3.40
C_3	1.85	1.86	1.86	2.97	3.05	3.01	3.42	3.51	3.46
C_4	2.10	2.18	2.14	3.57	3.70	3.63	3.78	3.94	3.86
C_5	2.15	2.20	2.18	3.70	3.78	3.74	3.94	4.04	3.99
S.Em. ±	0.09	0.08	0.06	0.14	0.14	0.10	0.16	0.14	0.11
C.D. at 5%	0.29	0.24	0.18	0.45	0.43	0.29	0.50	0.44	0.32
C.V. %	9.72	7.81	8.80	9.09	8.59	8.84	9.36	8.02	8.70
Interaction (Y X C)	-	-	NS	-	-	NS	-	-	NS

Table 4: Sympodial branches of cotton crop as influenced by integrated nutrient management

Treatment	Monopodial branches per plant								
	At 60 DAS			At 90 DAS			At harvest		
	2020-21	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
C_1	5.94	6.01	5.97	14.78	15.62	15.20	20.40	20.56	20.48
C_2	6.81	6.86	6.83	15.95	16.00	15.98	22.13	22.30	22.22
C_3	6.83	7.02	6.93	16.05	16.56	16.31	22.18	22.69	22.44
C_4	7.59	7.88	7.73	17.00	17.69	17.35	23.84	24.51	24.18
C_5	7.90	8.09	7.99	18.59	19.09	18.84	26.34	26.61	26.48
S.Em. ±	0.35	0.37	0.26	0.79	0.78	0.55	1.24	1.11	0.83
C.D. at 5%	1.07	1.15	0.74	2.43	2.40	1.62	3.82	3.41	2.43
C.V. %	9.94	10.39	10.17	9.56	9.16	9.36	10.80	9.50	10.16
Interaction (Y X C)	-	-	NS	-	-	NS	-	-	NS

Table 5: Days to 50 percent flowering and number of bolls per plant of cotton crop as influenced by integrated nutrient management

Treatment	Days to 50 percent flowering			Number of bolls/plant		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
C_1	57	59	58	42.73	45.45	44.09
C_2	57	59	58	46.62	49.21	47.92
C_3	58	60	59	47.61	49.55	48.58
C_4	58	59	59	52.43	53.06	52.75
C_5	59	60	59	55.26	57.77	56.51
S.Em. ±	1.13	0.96	0.74	2.74	2.57	1.88
C.D. at 5%	NS	NS	NS	8.44	7.92	5.48
C.V. %	3.91	3.25	3.59	11.20	10.08	10.63
Interaction (Y X C)	-	-	NS	-	-	NS

Table 6: Seed cotton yield and stalk yield of cotton crop as influenced by integrated nutrient management

Treatment	Seed cotton yield (kg/ha)			Stalk yield (kg/ha)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
C_1	2849	2880	2864	6004	6140	6072
C_2	2920	2942	2931	6315	6517	6416
C_3	3009	3034	3022	6530	6602	6566
C_4	3201	3226	3214	7082	7256	7169
C_5	3458	3508	3483	7683	7872	7778
S.Em. ±	135	140	97	368	369	260
C.D. at 5%	417	432	284	1135	1137	761
C.V. %	8.78	9.01	8.89	10.96	10.73	10.85
Interaction (Y X C)	-	-	NS	-	-	NS

Table 7: Plant population of summer groundnut after *kharif* cotton as influenced by different treatments

Treatment Details	Plant population (per meter length)					
	At 30 DAS			At harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
I) Main plot (*Kharif* cotton): C						
C_1	8.00	8.13	8.06	7.00	7.25	7.13
C_2	8.13	8.25	8.19	7.38	7.25	7.31
C_3	8.25	8.25	8.25	7.38	7.38	7.38
C_4	8.25	8.38	8.31	7.50	7.63	7.56
C_5	8.38	8.38	8.38	7.63	7.75	7.69
S.Em. ±	0.21	0.33	0.19	0.27	0.32	0.21
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V. %	7.17	11.17	9.403	10.39	11.97	11.22
II) Sub plot (Summer groundnut): G						
G_1	8.35	8.35	8.35	7.50	7.60	7.55
G_2	8.05	8.20	8.13	7.25	7.30	7.28
S.Em. ±	0.13	0.14	0.10	0.16	0.14	0.11
C.D. at 5%	NS	NS	NS	NS	NS	NS
Interaction (C × G)						
C × G	NS	NS	NS	NS	NS	NS
Y × C	-	-	NS	-	-	NS
Y × G	-	-	NS	-	-	NS
Y × C × G	-	-	NS	-	-	NS
C.V.%	6.86	7.72	7.31	9.98	8.31	9.17

Table 8: Plant height of summer groundnut after *kharif* cotton as influenced by different treatments

Treatment Details	Plant height (cm)								
	At 30 DAS			At 60 DAS			At harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
I) Main plot (*Kharif* cotton): C									
C_1	8.40	8.40	8.40	17.78	17.39	17.58	39.65	39.73	39.69
C_2	8.55	8.70	8.62	18.56	18.71	18.64	41.81	42.36	42.09
C_3	8.76	9.08	8.92	18.61	18.92	18.77	42.99	43.44	43.21
C_4	8.83	9.10	8.96	19.25	19.52	19.38	44.42	44.87	44.64
C_5	9.21	9.30	9.25	20.97	21.33	21.15	46.89	47.34	47.12
S.Em. ±	0.33	0.42	0.27	0.67	0.77	0.51	1.39	1.57	1.05
C.D. at 5%	NS	NS	NS	2.05	2.37	1.49	4.27	4.84	3.06
C.V. %	10.80	13.20	12.08	9.88	11.37	10.66	9.09	10.20	9.66
II) Sub plot (Summer groundnut): G									
G_1	9.10	9.30	9.20	19.76	19.92	19.84	44.53	44.95	44.74
G_2	8.40	8.53	8.46	18.31	18.43	18.37	41.78	42.15	41.96
S.Em. ±	0.23	0.25	0.17	0.37	0.42	0.28	0.81	0.87	0.59
C.D. at 5%	0.69	0.76	0.48	1.11	1.27	0.81	2.45	2.63	1.72
Interaction (C × G)									
C × G	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y × C	-	-	NS	-	-	NS	-	-	NS
Y × G	-	-	NS	-	-	NS	-	-	NS
Y × C × G	-	-	NS	-	-	NS	-	-	NS
C.V.%	11.66	12.61	12.15	8.66	9.85	9.28	8.44	8.95	8.69

Table 9: Branches per plant, pods per plant and kernels per pod of summer groundnut after *kharif* cotton as influenced by different treatments

Treatment Details	Branches per plant			Pods per plant			Kernels per pod		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
I) Main plot (*Kharif* cotton): C									
C_1	4.99	5.17	5.08	17.66	17.51	17.59	1.90	1.93	1.92
C_2	5.23	5.33	5.28	18.35	18.83	18.59	1.93	1.96	1.95
C_3	5.31	5.41	5.36	18.65	19.04	18.85	1.96	1.96	1.96
C_4	5.55	5.67	5.61	19.08	19.64	19.36	1.96	1.99	1.98
C_5	5.86	5.96	5.91	21.09	21.45	21.27	1.99	1.99	1.99
S.Em. ±	0.17	0.17	0.12	0.66	0.77	0.51	0.05	0.08	0.05
C.D. at 5%	0.52	0.51	0.35	2.04	2.37	1.48	NS	NS	NS
C.V. %	8.90	8.57	8.73	9.89	11.30	10.63	7.17	11.17	9.40
II) Sub plot (Summer groundnut): G									
G_1	5.55	5.68	5.62	19.71	20.04	19.87	1.99	1.99	1.99
G_2	5.22	5.34	5.28	18.22	18.55	18.39	1.92	1.95	1.93
S.Em. ±	0.10	0.10	0.07	0.41	0.42	0.29	0.03	0.03	0.02
C.D. at 5%	0.30	0.31	0.20	1.24	1.27	0.85	NS	NS	NS
Interaction (C × G)									
C × G	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y × C	-	-	NS	-	-	NS	-	-	NS
Y × G	-	-	NS	-	-	NS	-	-	NS
Y × C × G	-	-	NS	-	-	NS	-	-	NS
C.V.%	8.28	8.31	8.29	9.68	9.79	9.74	6.86	7.72	7.31

Table 10: Pod yield and haulm yield of summer groundnut after *kharif* cotton as influenced by different treatments

Treatment Details	Pod yield (kg/ha)			Haulm yield (kg/ha)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
I) Main plot (*Kharif* cotton): C						
C_1	3022	3088	3055	3952	3992	3972
C_2	3195	3207	3201	4152	4209	4180
C_3	3239	3252	3245	4201	4246	4224
C_4	3403	3421	3412	4385	4446	4416
C_5	3602	3639	3620	4665	4710	4687
S.Em. ±	109	117	80	147	146	103
C.D. at 5%	336	363	234	454	450	303
C.V. %	9.37	10.04	9.72	9.77	9.57	9.67
II) Sub plot (Summer groundnut): G						
G_1	3412	3459	3436	4379	4426	4402
G_2	3172	3183	3178	4163	4215	4189
S.Em. ±	64.29	68.08	46.82	55.19	54.16	38.03
C.D. at 5%	193	205	135	166	163	111
Interaction (C × G)						
C × G	NS	NS	NS	NS	NS	NS
Y × C	-	-	NS	-	-	NS
Y × G	-	-	NS	-	-	NS
Y × C × G	-	-	NS	-	-	NS
C.V.%	8.73	9.17	8.95	5.78	5.61	5.69

Conclusion
On the basis of two-years of experiment, it can be concluded that for getting higher yield of cotton-groundnut cropping sequence, net returns and maintenance of soil fertility, kharif cotton should be fertilized with 180 kg N through inorganic fertilizer, 60 kg N through vermicompost along with application of bio NPK consortium at the time of sowing and at 45 DAS with 1 L/ha and 100% RDF through inorganic fertilizers in succeeding summer groundnut.

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