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Economics of *Bt.* cotton-groundnut cropping sequence as influenced by integrated nutrient management

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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 increased the net return of of ₹ 111955/ha, while application of 100% RDN through inorganic fertilizer recorded maximum BCR of 5.26, followed by 2.41 in 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5). In succeeding summer groundnut, residual effect of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost along with Bio NPK consortium and 100% RDF recorded maximum return of of ₹ 157619 per hectare with BCR of 4.05.

Keywords: INM, *Bt.* cotton, groundnut, BCR, net return

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).
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].

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.

Result and Discussion

Effect of integrated nutrient management on economics of cotton

The regional adaptability of any agronomic practices in the yield of any crop is completely based on the highest economic value of a treatment. Therefore, it is necessary to work out the economics of different treatments for valid comparison of agronomics practices and sound recommendation.

The economic aspect of the treatments is the basic consideration in their application. Hence, economics of different treatment was worked out only based on the mean of two years (Table 4.22). Maximum net returns of ₹ 111955/ha were recorded with the treatment receiving 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5), followed by 100% RDN through inorganic fertilizer (₹ 95982/ha), 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (₹ 94701/ha), and 75% RDN through inorganic fertilizer + 25% RDN through vermicompost (₹ 87503/ha). However, 75% RDN through inorganic fertilizer + 25% RDN through FYM (C_2) treatment recorded minimum net monetary returns (₹ 80039/ha).

Application of 100% RDN through inorganic fertilizer recorded maximum BCR of 2.56, followed by 2.41 in 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5). Whereas, 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4) and 75% RDN through inorganic fertilizer + 25% RDN through vermicompost (C_3) were third and fourth in the order i.e. 2.15 and 2.11, respectively in average value of both the years. The lowest BCR (1.99) was registered by 75% RDN through inorganic fertilizer + 25% RDN through FYM treatment.

Effect of integrated nutrient management on economics of groundnut

Effect of main plot treatment (*kharif* cotton)

The data presented in Table 2 revealed that the highest net returns of ₹ 172186 per hectare and BCR of 4.56 were realized with application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5), followed by 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4) with net returns of ₹ 15507 per hectare and BCR of 4.29, ₹ 149366 per hectare and BCR of 4.08 with 75% RDN through inorganic fertilizer + 25% RDN through vermicompost (C_3), ₹ 146704 per hectare and BCR of 4.03 with 75% RDN through inorganic fertilizer + 25% RDN through FYM (C_2). The lowest net returns of ₹ 137778 per hectare and BCR of 3.85 were realized under 100% RDN through inorganic fertilizer (C_1).

Higher level of biomass accrual and efficient translocation to reproductive parts due to supply of adequate nutrients through integrated nutrient management for different cotton treatment might be responsible for the production of elevated yield attributes, yield which resulted in higher net returns and BCR. Similar results were also reported by Radha Kumar and Reddy (2010) [10], Shanwad *et al*., (2010) [13], Mahapatra *et al*., (2018) [17], Sathiya *et al*., (2020) [11] and Makwana and Bhanvadia (2023) [8].

Effect of sub plot treatment (summer groundnut)

The data in Table 2 indicated that the highest net returns of ₹ 157619 per hectare with BCR of 4.03 were observed under the treatment 100% RDF (G_1). The lowest net realization of ₹ 139671 per hectare and BCR of 3.58 were noted under 75% RDF + cotton residue (G_2).

Similar results reported by Chavan *et al*., 2014) [6], Bala and Nath (2015) [5], Meena and Yadav (2015) [9], Vaghasia *et al*., (2016) [15], Waghmode *et al*., (2017) [16], Singh *et al*., (2019) [14] and Satpute *et al*., (2021) [21].

Economics of cropping sequence

Effect of main plot treatment (*Kharif* cotton)

It is revealed from the average of 2021-22 and 2022-23 (Table 3) that, the highest net returns of ₹ 283915 per hectare and BCR of 3.22 were realized with 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5), followed by 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4) with net returns of ₹ 253956 per hectare and BCR of 2.95.

Effect of sub plot treatment (Summer groundnut)

Perusal of data depicted in Table 3 revealed that the highest net returns of ₹ 251394 per hectare with BCR of 2.96 were observed under the treatment 100% RDF (G_1). The lowest net realization of ₹ 233477 per hectare and BCR of 2.79 was noted with treatment 75% RDF + cotton residue (G_2).

Table 1: Economics of cotton crop as influenced by integrated nutrient management (Mean of two years)

Treatment	Seed Cotton yield (kg/ha)	Stalk yield (kg/ha)	Gross realization (₹)	Total cost of production (₹)	Net realization (₹)	BCR
C_1	2864	6072	157520	61538	95982	2.56
C_2	2931	6416	161205	81166	80039	1.99
C_3	3022	6566	166210	78707	87503	2.11
C_4	3214	7169	176770	82069	94701	2.15
C_5	3483	7778	191565	79610	111955	2.41

Selling price: Seed Cotton: ₹ 55/kg

Table 2: Economics of summer groundnut after *kharif* cotton as influenced by different treatments (Average of two years)

Treatment Details	Pod Yield (kg/ha)	Haulm Yield (kg/ha)	Gross returns (Rs)	Total cost of cultivation (Rs)	Net Returns (Rs)	BCR
I) Main plot (*Kharif* cotton): C						
C_1	3055	3972	186203	48425	137778	3.85
C_2	3201	4180	195129	48425	146704	4.03
C_3	3245	4224	197791	48425	149366	4.08
C_4	3412	4416	207932	48425	159507	4.29
C_5	3620	4687	220611	48425	172186	4.56
II) Sub plot (Summer groundnut): G						
G_1	3432	4402	209327	51708	157619	4.05
G_2	3178	4189	193786	54115	139671	3.58

Selling price: groundnut pod: 59 Rs/kg, groundnut haulm: 1.5 Rs/kg

Table 3: Economics of cotton – groundnut cropping sequence as influenced by different integrated nutrient management treatments (Average of two years)

Treatment Details	Cotton equivalent yield (kg/ha)	Cost of cultivation (₹)	Gross monetary returns (₹)	Net monetary returns (₹)	B:C ratio
I) Main plot (*Kharif* cotton): C					
C_1	6246	109963	343530	233567	3.12
C_2	6475	129591	356125	226534	2.75
C_3	6614	127132	363770	236638	2.86
C_4	6990	130494	384450	253956	2.95
C_5	7490	128035	411950	283915	3.22
II) Sub plot (Summer groundnut): G					
G_1	6904	128326	379720	251394	2.96
G_2	6622	130733	364210	233477	2.79

Selling price: Seed cotton: ₹ 55/kg

Conclusion

The maximum net returns of ₹ 283915 per hectare and BCR of 3.22 of cropping sequence were recorded with 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + Bio NPK consortium (C_5), followed by 75% RDN through inorganic fertilizer + 25% RDN through FYM + Bio NPK consortium (C_4). The maximum net returns of ₹ 253956 per hectare with BCR of 2.95 were observed under the treatment 100% RDF to groundnut on basis of average of two-year study.

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