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Effect of *Bt* cotton based cropping system and nutrient management to *rabi* crops on yield and economics of *Bt* cotton

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Abstract

A field experiment was conducted at Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra (India) to study the effect of *Bt* cotton based cropping system and nutrient management to *rabi* crops on yield and economics of *Bt* cotton during *kharif* and *rabi* season of 2020-21 and 2021-22. The soil of the experimental field was medium black, clayey in texture and slightly alkaline in reaction. The soil was low in organic carbon, available nitrogen and phosphorous and fairly rich in potassium. Total rainfall received during 2020-21 was 771.6 mm and 1085 mm during 2021-22 concentrated in June, July, August and September. The experiment was laid out in split plot design with five main plot treatments comprising of crop sequences viz. sole mid-late duration *Bt* cotton (C_1), *Bt*-cotton (Early duration)-Wheat (C_2), *Bt*-cotton (Early duration)-Chickpea (C_3), *Bt*-cotton (Early duration)-Linseed (C_4), *Bt*-cotton (Early duration) -Onion (C_5) and sub plot consisting of nutrient management treatments i.e. 75% RDF (N_1) and 100% RDF (N_2) to *rabi* crops replicated thrice. The results revealed that the treatment C_1 i.e. sole *Bt* cotton (mid-late) recorded significantly highest seed cotton yield (2058, 2110 and 2084 kg ha⁻¹), lint yield (724, 743 and 734 kg ha⁻¹), stalk yield (3327, 3481 and 3404 kg ha⁻¹), biological yield (5385, 5591 and 5488 kg ha⁻¹) and harvest index (38.31, 38.84 and 38.87) as well as gross monetary returns (113508, 127107 and 120308 Rs ha⁻¹) net monetary returns (67189, 79047 and 73118 Rs ha⁻¹) as compared to all other cropping systems during both the years of experimentation and under pooled results. However, all the cropping system treatments were found significantly at par with each other in respect of seed cotton yield, lint yield, stalk yield and biological yield (kg ha⁻¹), harvest index, GMR, NMR during 2020-21 and 2021-22 and pooled analysis. The higher benefit cost ratio was obtained under C_1 -sole mid-late *Bt* cotton i.e. 2.45, 2.64 and 2.55 during 2020-21, 2021-22 and pooled data, respectively than all the other cropping systems. Nutrient management to *rabi* crops showed non-significant influence on seed cotton yield, lint yield, stalk yield and biological yield (kg ha⁻¹) during first year. Where as, during second year of study, residual effect of application of 100% RDF to *rabi* crops recorded significantly highest seed cotton yield (1928 kg ha⁻¹), lint yield (703 kg ha⁻¹), stalk yield (3100 kg ha⁻¹) and biological yield (5028 kg ha⁻¹) as well as GMR (116182 Rs ha⁻¹) and NMR (72238 Rs ha⁻¹) of cotton over 75% RDF application to *rabi* crops. As regards BC ratio of cotton, residual effect of application of 100% RDF (N_2) to *rabi* crops showed higher benefit cost ratio of 2.35, 2.64 and 2.50 during 2020-21, 2021-22 and in pooled data, respectively than application of 75% RDF to *rabi* crops.

Keywords: *Bt* cotton (mid-late), *Bt* cotton (early duration) cropping system, nutrient management, *rabi*, residual effect.

Introduction

Cotton (*Gossypium hirsutum* L.) is a long duration crop hence double cropping can't be possible, however availability of early *Bt* cotton in the market, permits for growing of crops in sequence immediate after harvest of early *Bt* cotton. By cultivating the early *Bt* cotton hybrid, it becomes possible to harvest cotton early and permits for timely sowing of *rabi* crops. Studies from different areas in India showed that diversified cotton production systems can surpass cotton monocropping systems in profitability (Saravanakumar, 2022) ^[1] and not only diversify risks but also increase productivity. Out of the of the total geographical area (328.7 m ha), nearly half is arable (159.7 m ha) and only 42.6% (about 140 m ha) is actually cultivated, that has

remained static over decades, indicating no scope for horizontal expansion. Hence, in order to fulfil the demand of India's growing population from limited resources, an increase in crop productivity is imperative (Gulati *et al.* 2023)^[2]. An ideal cotton based cropping system should aim at higher yield and net profits per unit area, bring stability into the production system and ensure optimal utilization of the available resources. Research indicates that under cotton based cropping system there is efficient use of resources, resulting into high productivity. As such, cotton which is an exhaustive crop followed by wheat, chickpea, linseed and onion will be very useful for exploring the productivity and profitability of cotton based crop sequence under nutrient management levels to *rabi* crops for gaining extra economic returns.

Materials and Methods

A field experiment was carried out at Department of Agronomy, Dr. PDKV, Akola during 2020-21 and 2021-22 to study the various *Bt* cotton based cropping system with different fertilizers levels to *rabi* crops during both the years. The soil of the experimental field was medium black cotton belonging to vertisols, clayey in texture and slightly alkaline in reaction. The soil was low in organic carbon, low in available nitrogen and phosphorous and fairly rich in potassium. Total rainfall received during 2020-21 season was 771.6 mm (June to Dec 2020) and during the cropping season of 2021-22 was 1085 mm mainly concentrated in June, July, August and September. The experiment was laid out in split plot design with five main plot treatment comprising of crop sequence viz. sole *Bt* cotton, mid-late duration (C_1), *Bt*-cotton (early duration)-Wheat (C_2), *Bt*-cotton (early duration)-Chickpea (C_3), *Bt*-cotton (early duration)-Linseed (C_4), *Bt*-cotton (early duration) -Onion (C_5), and sub plot treatments of nutrient management practices i.e. 75% RDF(N_1) and 100% RDF(N_2) to *rabi* crops replicated thrice. Cotton (*Gossypium hirsutum* L.) variety used for early duration was ACH-5 BG-II *Bt* (140-150 days) and medium duration was PDKV-JKAL 116 BG-II *Bt* (160-170 days). The recommended dose of fertilizers were applied to cotton and as per treatment to *rabi* crops. All the recommended practices and appropriate plant protection measures were adopted. Observations on seed cotton yield, lint yield, stalk yield, biological yield (kg ha^{-1}) and harvest index (%) were recorded, from which gross monetary returns, net monetary returns (Rs. ha^{-1}) and B:C ratio was calculated. Further analysis was carried out as per the procedure described by Panse and Sukhtame (1985)^[3].

Results and Discussion

Cotton yield (Table 1 and 2)

Cropping system

The treatment C_1 , sole *Bt* cotton (mid-late) recorded significantly higher seed cotton yield (2058, 2110 and 2084 kg ha^{-1}), lint yield (724, 743 and 734 kg ha^{-1}), stalk yield (3327, 3481 and 3404 kg ha^{-1}) and biological yield (5385, 5591 and 5488 kg ha^{-1}) over all other treatments during both the years of experimentation and under pooled results. However, all the cropping system treatments were found significantly at par with each other in respect of seed cotton yield, lint yield, stalk yield and biological yield (kg ha^{-1}) during 2020-21 and 2021-22. The increase in seed cotton yield (kg ha^{-1}), lint yield, stalk yield and biological yield (kg ha^{-1}) of C_1 , sole *Bt* cotton (mid-late) was due to more duration of variety up to January end, which leads more number of bolls picked plant⁻¹ that helps in increased seed cotton yield plant⁻¹ as well as ha^{-1} . However, all the cropping systems were at

par with each other as the single variety was used for all the systems and were harvested at same time leading to no significant difference in seed cotton yield ha^{-1} . The results are in close agreement with the findings of Charjan and Gaikwad (2001)^[4], Gudadhe *et al.* (2015)^[5], Turkhede *et al.* (2017)^[6], Kumar *et al.* (2022)^[7] and Latkar *et al.* (2024)^[8]. The mean harvest index of cotton for the year 2020-21 and 2021-22 was 38.63 and 38.44 per cent, respectively, while the pooled mean of harvest index was over two years was 38.53 per cent. The treatment C_1 , sole *Bt* cotton (mid-late) recorded higher harvest index of 38.91, 38.84 and 38.87 during 2020-21, 2021-22 and under pooled results over all other treatments. The increase in harvest index of sole *Bt* cotton (mid-late) was due to longer duration of crop up to January end which increased the number of picking and seed cotton yield. The harvest index was recorded maximum during second year of study than first year of study. Where as all the cropping system treatments were found to be nearly equal in respect of harvest index during 2020-2021 and 2021-2022.

Nutrient Management

Nutrient management to *rabi* crops showed non-significant influence on seed cotton yield, lint yield, stalk yield and biological yield (kg ha^{-1}) during 2020-21. Where as, during second year of study, residual effect of application of 100% RDF to *rabi* crops recorded significantly highest seed cotton yield (1928 kg ha^{-1}), lint yield (703 kg ha^{-1}), stalk yield (3100 kg ha^{-1}) and biological yield (5028 kg ha^{-1}) over 75% RDF application to *rabi* crops. Nutrient management to *rabi* crops had marked and favorable influence on growth and yield parameters. These favorable influence might be attributed to sustain release of nutrients in the soil through mineralization of organic matter that have facilitated better crop growth. That resulted on highest seed cotton yield and significantly highest lint yield and other parameters also. Similar results were reported by Kumbhar *et al.* (2008)^[9], Das *et al.* (2004)^[10], Mahavishnan *et al.* (2005)^[11], Senthivelu *et al.* (2009)^[12], Ramesh *et al.* (2017)^[13], Chaudhari *et al.* (2022)^[14], Sanjivkumar *et al.* (2022)^[15] and Latkar *et al.* (2024)^[8]. Residual effect of application of 100% RDF to *rabi* crops recorded marginal increase in harvest index over 75% RDF application to *rabi* crops during both the years of experimentation. Similar results were reported by Mahavishnan *et al.* (2005)^[11] and Sanjivkumar *et al.* (2022)^[15].

Economics

Cropping system (Table 3)

The gross monetary returns and net monetary returns of cotton were significantly influenced by different cropping systems during both the years and pooled analysis. Treatment C_1 - Sole *Bt* cotton mid-late recorded significantly higher gross monetary returns (113508, 127107 and 120308 Rs ha^{-1}) and net monetary returns (67189, 79047 and 73118 Rs ha^{-1}) as compared all other cropping systems during both the years of experimentation and pooled data. Where as, all the cropping systems treatments were at par with each other in respect of GMR, NMR during 2020-21 and 2021-22 and pooled analysis. The higher benefit cost ratio was obtained under C_1 -sole mid-late *Bt* cotton i.e. 2.45, 2.64 and 2.55 during 2020-21, 2021-22 and pooled data, respectively than all the other cropping systems. The increase in the GMR, NMR of (mid-late) cotton (C_1) and higher benefit cost ratio was due to higher yield of mid-late cotton than other *Bt* cotton in cropping systems. All the cropping systems were at par with each other as single variety was used in all the cropping systems. Similar

results were reported by Turkhede *et al.* (2017)^[6], Muhammad *et al.* (2023)^[16] and Latkar *et al.* (2024)^[8].

Nutrient management

Nutrient management to *rabi* crops showed non-significant differences on GMR, NMR during 2020-21. During the year 2021-22 residual effect of application of 100% RDF to *rabi* crops recorded significantly higher GMR (116182 Rs ha⁻¹) and NMR (72238 Rs ha⁻¹) of cotton over 75% RDF application. This might be due to residual effect of N and P applied to preceding *rabi* crops as well as nutrients available from crop residue which accounted for significant improvement in growth and yield of cotton crop. The results are in conformity with the findings of Charjan and Gaikwad (2001)^[4] and Mahala (2019)^[17]. As regards BC ratio of cotton, residual effect of application of

100% RDF (N₂) to *rabi* crops showed higher benefit cost ratio of 2.35, 2.64 and 2.50 during 2020-21, 2021-22 and in pooled data, respectively as compared to application of 75% RDF to *rabi* crops which recorded lower BC ratio during both the years and pooled data. This might be due to higher net monetary returns received due to maximum yield produced under 100% RDF than lower level of fertilizer. Similar results are reported by Charjan and Gaikwad (2001)^[4] and Mahala (2019)^[17].

The interaction effect between cropping system and nutrient management to *rabi* crops were not significant in respect of seed cotton yield, lint yield, stalk yield and biological yield' gross monetary returns, net monetary returns and BC ratio than all other cropping systems during both the years of experimentation and under pooled results over all other treatments.

Table 1: Seed cotton yield, lint yield, stalk yield (kg ha⁻¹) as influenced by different treatments in cotton during 2020-21 and 2021-22

Treatments	Seed cotton yield (kg ha ⁻¹)			Lint yield (kg ha ⁻¹)			Stalk yield (kg ha ⁻¹)		
	20-21	21-22	Pooled	20-21	21-22	Pooled	2020-21	2021-22	Pooled
Main plot – Cropping System									
C ₁ Sole Bt Cotton (mid-late)	2058	2110	2084	724	743	734	3327	3481	3404
C ₂ Bt-Cotton (Early)- Wheat	1728	1748	1738	631	643	637	2713	2772	2743
C ₃ Bt-Cotton (Early)- Chickpea	1774	1836	1805	650	676	663	2839	2947	2893
C ₄ Bt-Cotton (Early)- Linseed	1760	1765	1762	644	649	647	2798	2815	2807
C ₅ Bt-Cotton (Early)- Onion	1741	1724	1733	637	633	635	2751	2716	2733
SE(m)±	33	35	28	13.24	15.30	12.68	66	56	38
CD at 5%	108	114	92	43.16	49.89	41.36	214	182	124
Sub plot-Nutrient Management (Rabi crops)									
N ₁ 75% RDF	1801	1745	1773	652	635	643	2854	2792	2823
N ₂ 100% RDF	1824	1928	1876	662	703	683	2918	3100	3009
SE(m)±	17	18	16	6.41	5.44	4.96	59	29	36
CD at 5%	NS	57	51	NS	17.14	12.47	NS	93	113
Interaction effect between cropping system and nutrient management (rabi crops) (CxN)									
SE(m)±	37	41	18	14.33	12.16	9	131	66	80
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	1812	1837	1824	657	669	663	2886	2946	2916

Table 2: Biological yield (kg ha⁻¹) and harvest index (%) of cotton as influenced by different treatments in cotton during 2020-21 and 2021-22

Treatments	Biological yield (kg ha ⁻¹)			Harvest index (%)		
	20-21	21-22	Pooled	20-21	21-22	Pooled
Main plot – Cropping System						
C ₁ Sole Bt Cotton (mid-late)	5385	5591	5488	38.91	38.84	38.87
C ₂ Bt-Cotton (Early)- Wheat	4442	4520	4481	38.40	38.39	38.39
C ₃ Bt-Cotton (Early)- Chickpea	4613	4783	4698	38.76	38.68	38.72
C ₄ Bt-Cotton (Early)- Linseed	4558	4580	4569	38.61	38.54	38.57
C ₅ Bt-Cotton (Early)- Onion	4492	4440	4466	38.46	37.74	38.10
SE(m)±	73	91	57	-	-	-
CD at 5%	237	296	186	-	-	-
Sub plot-Nutrient Management (Rabi crops)						
N ₁ 75% RDF	4655	4537	4596	38.50	38.38	38.44
N ₂ 100% RDF	4741	5028	4885	38.76	38.50	38.63
SE(m)±	67	48	42	-	-	-
CD at 5%	NS	150	133	-	-	-
Interaction effect between cropping system and nutrient management (rabi crops) (CxN)						
SE(m)±	150	107	95	-	-	-
CD at 5%	NS	NS	NS	-	-	-
GM	4698	4783	4740	38.63	38.44	38.53

Table 3: Gross monetary returns, net monetary returns (Rs ha⁻¹) and B:C ratio of cotton as influenced by different treatments during 2020-21 and 2021-22 and pooled analysis of two years

Treatments	Gross monetary returns (Rs. ha ⁻¹)			Net monetary returns (Rs. ha ⁻¹)			B:C ratio		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Main plot – Cropping System									
C ₁ Sole Bt Cotton (mid-late)	113508	127107	120308	67189	79047	73118	2.45	2.64	2.55
C ₂ Bt-Cotton (Early)- Wheat	95318	105337	100327	53574	62422	57998	2.28	2.45	2.37
C ₃ Bt-Cotton (Early)- Chickpea	97854	110619	104237	56110	67704	61907	2.34	2.58	2.46
C ₄ Bt-Cotton (Early)- Linseed	97064	106331	101698	55320	63416	59368	2.33	2.48	2.40
C ₅ Bt-Cotton (Early)- Onion	96016	103881	99949	54272	60966	57619	2.30	2.42	2.36
SE(m)±	1823	2098	1624	1823	2098	1624	-	-	-
CD at 5%	5944	6843	5298	5944	6843	5298	-	-	-
Sub plot-Nutrient Management (Rabi crops)									
N ₁ 75% RDF	99329	105128	102229	56670	61184	58927	2.33	2.39	2.36
N ₂ 100% RDF	100575	116182	108379	57916	72238	65077	2.35	2.64	2.50
SE(m)±	918	1098	472	918	1098	472	-	-	-
CD at 5%	NS	3461	1488	NS	3461	1488	-	-	-
Interaction effect between cropping system and nutrient management (rabi crops) (CxN)									
SE(m)±	2052	2456	1056	2052	2456	1056	-	-	-
CD at 5%	NS	NS	NS	NS	NS	NS	-	-	-
GM	99952	110655	105304	57293	66711	62002	2.34	2.52	2.43

Conclusion

Sole Bt cotton (mid-late) recorded significantly highest seed cotton yield, lint yield, stalk yield, biological yield and harvest index as well as GMR, NMR as compared to all other cropping systems during both the years and under pooled results. However, all the cropping systems were found significantly at par with each other in respect of above parameters. The higher BC ratio was obtained under sole mid-late Bt cotton. Nutrient management to rabi crops showed non-significant influence on above mentioned parameters during 2020-21. Residual effect of application of 100% RDF to rabi crops recorded significantly highest seed cotton, lint, stalk and biological yield GMR, NMR and higher benefit cost ratio of 2.35 and 2.64 of cotton over 75% RDF application to rabi crops.

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