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Effect of *Bt* cotton based cropping system and nutrient management to *rabi* crops on growth and yield attributes 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 evaluate different *Bt* cotton-based cropping systems under varying fertilizer levels applied to *rabi* crops during *kharif* and *rabi* season of 2020-21 and 2021-22. The soil of the experimental field was medium black belonging to vertisols and 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 this season was 771.6 mm (June to Dec 2020) where as it was 1085 mm during 2021-22 concentrated in June, July, August and September. The experiment was laid out in split plot design with five main treatment containing crop sequence of sole mid-late duration *Bt* cotton (C₁), *Bt*-cotton (Early duration)-Wheat (C₂), *Bt*-cotton (Early duration)-Chickpea (C₃), *Bt*-cotton (Early duration)-Linseed (C₄), *Bt*-cotton (Early duration)-Onion (C₅), was compared with sub plot treatment of nutrient management practices containing 75% RDF (N₁) and 100% RDF (N₂) to *rabi* crops replicated thrice. The results revealed that the treatment (C₁) sole *Bt* cotton (mid-late) recorded significantly higher growth attributes of cotton viz. plant height (126.43 and 139.63), leaf area index (1.705 and 1.838), number of sympodial branches plant⁻¹ (22.70 and 25.05), dry matter accumulation plant⁻¹ of cotton (385.59 and 394.17 g) and yield attributes viz. number of bolls picked plant⁻¹ (26.12 and 28.12), average boll weight (4.78 and 4.96 g), seed cotton yield plant⁻¹ (126.54 and 130.78 g) and significantly higher seed cotton yield (2058 and 2110 kg ha⁻¹) were recorded significantly higher over all other treatments during both the years of experimentation. However, all the cropping system treatments were found at par with each other in respect of all the growth attributes, yield attributes and seed cotton yield ha⁻¹ of cotton during both the years. Nutrient management to *rabi* crops showed non-significant differences on growth attributes of cotton at all the growth stages during 2020-21. Where as, during the year 2021-22 residual effect of application of 100% RDF (N₂) to *rabi* crops recorded significantly higher plant height (126.86 cm), leaf area index (1.721), number of sympodial branches plant⁻¹ (21.68) and total dry matter accumulation plant⁻¹ (391.50g) and yield attributes viz. highest number of bolls picked plant⁻¹ (26.98), seed cotton yield plant⁻¹ (117.83 g) and seed cotton yield (1928 kg ha⁻¹) over 75% RDF application to *rabi* crops. Nutrient management to *rabi* crops showed non-significant influence on boll weight as this is genetical character which recorded average boll weight of 4.56 and 4.73 g during both the years.

Keywords: *Bt* cotton (mid-late duration), *Bt* cotton (early duration), cropping system, nutrient management, RDF

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most important cash as well as fibre crop and a play vital role in the economy of Indian farmers. Cotton is also known as 'King of Fibre Crops' due to its global and industrial importance, commonly known as 'White Gold' in farming community. Cotton industry is also the second-largest employer in the country after agriculture, providing employment to over 51 million people directly and 68 million people indirectly, including unskilled women (Berwal, 2020) [1]. The unsuitability and the low productivity of cotton in rainfed regions is only related, especially the long duration hybrids that suffer moisture stress at boll formation stage, due to poor water retention of shallow soils. Selection of suitable cropping system for conservation of resources has prime importance now a days.

Nutrient management in any crop is one of the most important practise. Over use of chemical fertilizers is degrading soil health and also increase cost of inputs. Therefore, it is important to suggest farmers proper recommended dose of fertilizers under cropping system. Cotton is cultivated in India on 130.49 lakh hectares and accounts around 21% of the total global production. Indian cotton occupies highest area under cotton i.e. 40% of global cotton growing area and is the second largest producer and third largest exporter in the world. However, more than 80% of the cotton produced is consumed domestically (DAFW, 2023) [2]. The earliness associated with *Bt* hybrid could be exploited to design more efficient cotton based cropping systems. A horizontal expansion of area is an impractical task and hence, alternative option need to be explored. Sequence cropping is one such practice and involving crop rotation by which, productivity can be improved, along with increase in cropping area. Due to availability of short duration or early *Bt* cotton in the market there is a vast scope of growing other crops in sequence immediate after harvest of early *Bt* or short duration cotton. The main reason for low productivity of cotton based cropping sequence is its cultivation in marginal and sub marginal lands under poor management and input starved rainfed conditions. Late harvesting of cotton is the major time conflict in the rotation, resulting in late sowing of sequence crops particularly wheat, chickpea, linseed and onion resulting in low potential yields.

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 with same site and same randomization. The soil of the experimental field was medium black belonging to vertisols and 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 this season was 771.6 mm (June to Dec 2020). The amount of rainfall received in the year 2021-22 during the cropping season was 1085 mm in 54 rainy days and was mainly concentrated in June, July, August and September. Germination of cotton was satisfactory due to sufficient and well distributed rainfall during both the years. The experiment was laid out in split plot design with five main treatment containing crop sequence of 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), was compared with sub plot treatment of nutrient management practices containing 75% RDF(N_1) and 100% RDF(N_2) to *rabi* crops replicated thrice. Cotton (*Gossypium hirsutum* L.) variety of early duration, ACH-5 BG-II *Bt* (140-150 days) and medium duration PDKV-JKAL 116 BG-II *Bt* (160-170 days). The recommended dose of fertilizers were applied to cotton and *rabi* crops as per treatments. All the recommended practices and appropriate plant protection measures were adopted bear all crops of the cotton based cropping system. Observations on growth attributes viz., leaf area index (LAI) recorded at 90 DAS, dry matter accumulation plant^{-1} at 120 DAS, mean plant height and number of sympodial branches plant^{-1} at harvest. Similarly, yield attributes viz. number of bolls

picked plant^{-1} , average boll weight (g), seed cotton yield plant^{-1} (g) were recorded at harvest. Further analysis was carried out by procedure described by Panse and Sukhtame, 1985 [3].

Results and Discussion

Growth attributes (Table 1)

Cropping system

The data on mean plant height at harvest, leaf area index (LAI) at 90 DAS, number of sympodial branches plant^{-1} at harvest, dry matter accumulation plant^{-1} of cotton at 120 DAS revealed that, the effect of different treatments on growth attributes of cotton was significant during 2020-21 and 2021-22. The treatment C_1 i.e. Sole *Bt* cotton (mid-late) recorded significantly higher plant height (126.43 and 139.63 cm), leaf area index of 1.705 and 1.838, sympodial branches (22.70 and 25.05), total dry matter accumulation (385.59 and 394.17 g plant^{-1}) at 120 DAS over all other treatments during both the years of experimentation. However, all the cropping system treatments were found at par with each other in respect of growth attributes of cotton at all the growth stages during both the years i.e. 2020-21 and 2021-22. The increase in all the growth attributes of sole *Bt* cotton (mid-late) was due to varietal character whereas the cropping systems didn't show any significant difference in growth attributes of cotton as the same variety was used i.e. early *Bt* cotton in all the cotton based cropping systems. In general leaf area index increased in all treatments up to 90 DAS, and reached to its maximum of 1.705 and 1.838 respectively in 2020-21 and 2021-22, thereafter a declining trend was observed towards maturity due to leaf senescence. The results are in close conformity with the findings of Turkhede *et al.* (2017) [4] and Kumar *et al.* (2022) [5]. Number of sympodial branches was more in second year than first year of study. It is revealed that total dry matter per plant increased gradually at every stage of crop growth up to maturity during both the years of investigation. The rate of increase was initially slow up to 30 DAS and picked up to 120 DAS and attained maximum of 385.59 and 394.17 g plant^{-1} at 120 DAS during 2020-21 and 2021-22, respectively. Decline in dry matter after 120 DAS onwards might be because of leaf senescence and termination of vegetative development in the reproductive parts. It was maximum during 2021-22 as compared to 2020-21 due to favorable weather condition and residual or carryover effect of nutrients which were applied to *rabi* crops and their organic residues, due to higher number of monopodial and sympodial branches, leaf area and more photosynthetic activity due to longer duration of crop variety which utilizes more nutrients thereby increases dry matter accumulation. The various cropping systems didn't show any significant difference in dry matter accumulation as the same variety was used in all the cotton based cropping systems. Similar results were reported by Turkhede *et al.* (2017) [4] and Kumar *et al.* (2022) [5].

Nutrient management

Nutrient management to *rabi* crops showed non-significant differences on growth attributes of cotton at all the growth stages during 2020-21. During the year 2021-22 residual effect of application of 100% RDF to *rabi* crops recorded significantly higher plant height at harvest (126.86 cm), leaf area index (LAI) (1.721) at 90DAS, number of sympodial branches plant^{-1} at harvest (21.68) and total dry matter

accumulation plant⁻¹ of (391.50) of cotton at 120 DAS over 75% RDF application to *rabi* crops. This increase in growth attributes such as plant height, LAI, sympodial branches and dry matter may be attributed to increased addition of organic matter due to leaf shedding. Which on mineralization increased nutrient availability to succeeding cotton crop. Also growing of legume crop increased N fixation as well as P applied to legume crop increased residual carry over to next succeeding crop, which ultimately increased the growth of cotton. The results are in conformity with the findings of Kumbhar *et al.* (2008) [6],

Rawal *et al.* (2015) [7], Chaudhari *et al.* (2022) [8], Sanjivkumar *et al.* (2022) [9], Das *et al.* (2004) [10] and Gudadhe (2008) [11].

Interaction effect of cropping systems and nutrient management to *rabi* crops

Interaction effect on plant height, leaf area index, number of sympodial branches and total dry matter accumulation were found to be non-significant at all the growth stages during both the years of experimentation.

Table 1: Growth attributes of cotton as influenced by different cropping systems and nutrient management treatments to *rabi* crops (2020-21 & 2021-22)

Treatments	Plant height (cm) at harvest		Leaf Area Index (LAI) at 90 DAS		Number of sympodial branches plant ⁻¹ at harvest		Total dry matter accumulation plant ⁻¹ (g) at 120 DAS	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Main plot treatments: Cropping System (C)								
C ₁ Sole <i>Bt</i> Cotton (mid-late)	126.43	139.63	1.705	1.838	22.70	25.05	385.59	394.17
C ₂ <i>Bt</i> -Cotton (Early)-Wheat	115.84	121.76	1.459	1.644	18.00	19.26	375.42	383.68
C ₃ <i>Bt</i> -Cotton (Early)-Chickpea	117.50	123.19	1.520	1.690	20.19	20.58	378.32	387.85
C ₄ <i>Bt</i> -Cotton (Early)-Linseed	117.10	122.68	1.491	1.664	19.91	19.77	376.50	384.50
C ₅ <i>Bt</i> -Cotton (Early)-Onion	116.57	120.99	1.467	1.632	18.75	18.83	375.63	382.77
SE(m)±	1.02	1.04	0.019	0.018	0.70	0.71	2.12	1.76
CD at 5%	3.32	3.39	0.062	0.059	2.29	2.32	6.91	5.72
Sub-plot treatments: Nutrient Management (<i>Rabi</i> crops)								
N ₁ 75% RDF	118.38	124.44	1.496	1.666	19.62	19.71	375.62	381.68
N ₂ 100% RDF	118.99	126.86	1.561	1.721	20.20	21.68	380.97	391.50
SE(m)±	0.86	0.38	0.021	0.015	0.58	0.35	2.36	1.81
CD at 5%	NS	1.19	NS	0.047	NS	1.09	NS	5.70
Interaction effect between cropping system and nutrient management (<i>rabi</i> crops) (CxN)								
SE(m)±	1.92	0.85	0.048	0.033	1.30	0.77	5.27	4.04
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
GM	118.69	125.65	1.528	1.694	19.91	20.70	378.29	386.59

Yield attributes and yield (Table 2)

Cropping system

The data on number of bolls picked plant⁻¹ mean boll weight (g) and seed cotton yield plant⁻¹, seed cotton yield (kg ha⁻¹) are presented in Table 2. The data revealed that the treatment C₁, sole *Bt* cotton(mid-late) recorded significantly higher number of bolls picked plant⁻¹ (26.12 and 28.12), higher seed cotton yield plant⁻¹ (126.54 and 130.78 g plant⁻¹) and significantly higher seed cotton yield (2058 and 2110 kg ha⁻¹) as compared to rest of the treatments during both the years of experimentation. This might be due to longer duration of mid-late sole *Bt* cotton which favours higher uptake of nutrients that are responsible for increased growth which ultimately reflected in yield attributes. All the

cropping system treatments were found at par with each other in respect of number of bolls picked plant⁻¹ and seed cotton yield plant⁻¹ and seed cotton yield (kg ha⁻¹) during both the years which might be due to same variety of early *Bt* hybrid was used in cropping sequence, during both the years. The number of bolls picked plant⁻¹ was higher during 2021-22, might be due to favorable weather conditions which favors vegetative growth that contributed to more photosynthates towards sink i.e. boll development. The results are close agreement with the findings of Charjan and Gaikwad (2001) [13], Mahavishnan *et al.* (2005) [13], Turkhede *et al.* (2017) [4], Kumar *et al.* (2022) [14], and Latkar *et al.* (2024) [15].

Table 2: Yield and yield attributes of cotton as influenced by different cropping systems and nutrient management treatments to *rabi* crops (2020-21 & 2021-22)

Treatments	No. boll picked plant ⁻¹		Average boll weight (g)		Seed cotton yield plant ⁻¹ (g)		Seed cotton yield (kg ha ⁻¹)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	20-21	21-22
Main plot-Cropping System								
C ₁ Sole <i>Bt</i> Cotton (mid-late)	26.12	28.12	4.78	4.96	126.54	130.78	2058	2110
C ₂ <i>Bt</i> -Cotton (Early)-Wheat	24.30	25.38	4.42	4.60	102.18	108.91	1728	1748
C ₃ <i>Bt</i> -Cotton (Early)-Chickpea	25.07	26.36	4.50	4.70	107.18	110.51	1774	1836
C ₄ <i>Bt</i> -Cotton (Early)-Linseed	24.98	26.00	4.47	4.62	104.82	109.55	1760	1765
C ₅ <i>Bt</i> -Cotton (Early)-Onion	24.47	25.22	4.46	4.57	103.88	107.98	1741	1724
SE(m)±	0.28	0.38	0.04	0.07	1.74	0.79	33	35
CD at 5%	0.91	1.25	0.14	0.22	5.67	2.56	108	114
Sub plot-Nutrient Management (<i>Rabi</i> crops)								
N ₁ 75% RDF	24.42	25.45	4.49	4.65	104.35	109.27	1801	1745
N ₂ 100% RDF	25.55	26.98	4.56	4.73	113.48	117.83	1824	1928
SE(m)±	0.39	0.20	0.03	0.03	3.04	0.77	17	18
CD at 5%	NS	0.62	NS	NS	NS	2.43	NS	57
Interaction effect between cropping system and nutrient management (<i>rabi</i> crops) (C×N)								
SE(m)±	0.88	0.44	0.06	0.07	6.81	1.73	37	41
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
GM	24.99	26.22	4.53	4.69	108.92	113.55	1812	1837

Nutrient management

Nutrient management to *rabi* crops showed non-significant influence on number of bolls picked plant⁻¹, seed cotton yield plant⁻¹ and seed cotton yield (kg ha⁻¹) during 2020-2021. However, during the year 2021-2022, significant difference was recorded due to application of different levels of nutrients to *rabi* crops on number of bolls picked plant⁻¹, seed cotton yield plant⁻¹ and seed cotton yield (kg ha⁻¹). Residual effect of application of 100% RDF to *rabi* crops recorded significantly highest number of bolls picked plant⁻¹ (26.98) and recorded significantly highest seed cotton yield plant⁻¹ (117.83 g plant⁻¹) and over application of 75% RDF application to *rabi* crops. Also 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) over 75% RDF application to *rabi* crops. This might be due to increased addition of organic matter to the soil by *rabi* crops at higher levels of nutrient management. Which reflected in the increased availability of nutrients to succeeding cotton crop which ultimately increased the growth of cotton that favours increase in photosynthetic activity and greater translocation of photosynthates from source to sink. The cumulative effect of these finally improved the number of bolls picked plant⁻¹. Similar results were reported earlier by Das *et al.* (2004) [10], Mahavishnan *et al.* (2005) [14], Kumbhar *et al.* (2008) [6], Rawal *et al.* (2015) [7], Gudadhe *et al.* (2015) [15], Chaudhari *et al.* (2022) [8], Sanjivkumar *et al.* (2022) [12] and Latkar *et al.* (2024) [16]. Nutrient management to *rabi* crops did not show any significant influence on average boll weight during both the years of experimentation. This might be due to genetical character of the *Bt* variety, therefore nutrient management treatments to *rabi* crops could not attain the level of significance in respect of boll weight of cotton. Similar results were noted by Sanjivkumar *et al.* (2022) [9].

Interaction effects of cropping systems and nutrient management to *rabi* crops

Interaction effect on number of bolls picked plant⁻¹, seed cotton yield plant⁻¹, average boll weight and seed cotton yield (kg ha⁻¹) were found non-significant at all the growth stages during both the years.

Conclusion

Based on the results of the study it is concluded that, significantly maximum growth and yield attributes of cotton were recorded by mid-late sole *Bt* Hybrid as compared to early *Bt* hybrid. Also nutrient management to *rabi* crops showed that, residual effect of application of 100% RDF recorded significantly higher growth, yield attributes and yield of cotton over application of 75% RDF to *rabi* crops.

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