International Journal of Plant & Soil Science

34(10): 150-158, 2022; Article no.IJPSS.85012
ISSN: 2320-7035

Studies on Earliness of *Bt* Cotton Influenced by Moisture Conservation and Fertilizer Levels under Rainfed Condition

A. D. Pandagale [a*], B. V. Asewar [b], K. S. Baig [a], I. A. B. Mirza [b] and S. S. Rathod [a]

[a] Cotton Research Station, Nanded (VNMKV, Parbhani), India.
[b] Department of Agronomy, College of Agriculture, VNMKV, Parbhani, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i1030931

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/85012

Original Research Article

Received 12 January 2022
Accepted 19 March 2022
Published 25 March 2022

ABSTRACT

A field experiment was conducted at Cotton Research Station, Nanded (M.S.) India during *kharif* season of 2019 and 2020 to study effect of moisture conservation practices and fertilizer levels on earliness of *Bt* cotton under rainfed condition. The trial was conducted with *Bt* cotton hybrid NHH 44 (BG II) in split plot design and was replicated thrice. Four moisture conservation treatments (M_1- flat bed, M_2- opening of furrow at 60 DAS, M_3- application of superabsorbent @ 12.5 kg ha^{-1} and M_4- broad bed and furrow) were evaluated in main plot along with four NPK levels (F_1- 80:40:40 kg ha^{-1}, F_2 - 100:50:50 kg ha^{-1}, F_3 -120:60:60 kg ha^{-1} and F_4 - 140:70:70 kg ha^{-1}) in sub plot. The broad bed and furrow (BBF) practice of moisture conservation was found to have significantly higher seed cotton yield (1369 kg ha^{-1}) and per cent share to the total seed cotton yield was 58.58 per cent in first picking over control. However, opening of furrow recorded more seed cotton yield (1125 kg ha^{-1}) and its share to total yield was 47.97 per cent at second picking. Seed cotton yield in second picking was significantly increased in moisture conservation practices. The BBF was found to have earliness with respect to various indices (Bartlett's index, combined picking and day index, fraction of first picking index, mean maturity date index and production rate index) followed by other moisture conservation practices over flat bed.

**Corresponding author: E-mail: arvindpandagale@yahoo.co.in;*

Fertilizer levels didn't affect seed cotton yield in first picking. Higher fertilizer levels of F_3 and F_4 being significant over lower levels for seed cotton yield in second picking; showed delayed crop maturity based on various earliness indices.

Keywords: Seed cotton yield; moisture conservation practice; fertilizer levels; picking wise yield; earliness index; Bartlett's index; NHH 44 Bt.

1. INTRODUCTION

Cotton is one of the most important fiber and cash crop of India. India ranks first in area with 12.95 million ha which is about 40 per cent of the global during 2020-21 season with production of 371 lakh bales [1]. The crop provides direct livelihood to 6 million farmers in the country. The global average productivity of cotton is 766 kg lint ha^{-1} whereas Indian productivity is only 487 kg lint ha^{-1}. Maharashtra state contributes to highest area in the country with acreage of 41.84 lakh ha productivity of merely 349 kg lint ha^{-1}. The productivity of crop is declined after last five years owing to infestation of pink bollworm.

Major reasons for low productivity in India and Maharashtra in particular are rainfed cultivation, non-adoption of good agronomic practices and increasing incidence of pests. Management is often important for the maturity of a given crop. Maintaining optimum moisture and nutrient levels will support rapid early season growth, avoid premature shedding and ensure a yield-limiting deficiency does not develop. Saving moisture through better management practices may provide dire relief to the farmers not only in terms of increasing yields but also by reducing risk of crop failure. Adoption of *in-situ* moisture conservation practices is the only option in rainfed agriculture to support soil moisture in critical period. The research revealed that Broad bed and furrow (BBF) system induced greater root development, better drainage, good nodulation, better crop growth, better pod filling and early maturity in groundnut in comparison to flat bed system, besides considerable saving of time and cost of cultivation [2]. Ridges and furrow, raised beds, opening of furrow are some of the promising crop management technologies for improved infiltration and water use efficiency. *In-situ* rain water conservation practices reduce run off, increase ground water recharge and increase nutrient status [3]. Early crop harvest is the option to avoid moisture stress during boll development stage.

The optimum requirement of NPK nutrients for achieving the maximum yield of *Bt* cotton varies from location to location in consideration with soil moisture, temperature, cropping pattern followed by crop cultivars. However, increased moisture availability and higher fertilizer levels extend the duration of crop. Earliness of the crop maturity is important to avoid frost damage, insect and disease build up (especially pink bollworm), soil moisture depletion and weathering of the open cotton. Earliness also has other advantages, such as allowing rotation with a winter crop or extending the season for harvesting and ginning operations. Comparison of cotton in the inappropriate condition of growth like different soil moisture, soil fertility level, pest pressure, temperature and cloudy weather can affect earliness [4]. Short duration in cotton may be more profitable as it will reduce the critical growth window for drought, heat and insect pests [5]. It will likely to help farmers to manage those problems for short period of time. Early crop has less incidence of pink bollworm as compared to longer duration. Therefore, greater emphasis on earliness is needed in order to increase production efficiencies by decreasing input of fertilizer, water, crop protection consideration. Hence, the field trial was conducted to study effect of moisture conservation practices and fertilizer levels on earliness of *Bt* cotton under rainfed condition.

2. MATERIALS AND METHODS

2.1 Experimental Details

A field study was conducted at Cotton Research Station, Nanded, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S.) India during *kharif* season of 2019-20 and 2020-21 under rainfed condition. The experimental site was situated in assured rainfall zone of Maharashtra state at 19.13^{o} N latitude and 77.34^{o} E longitude with an altitude of 362 m above mean sea level. The soil was having pH 8.1, low in available nitrogen (148.74 kg ha^{-1}), medium P_2O_5 (11.92 kg ha^{-1}) and high K_2O content (403.18 kg ha^{-1}). Field trial was laid out in split plot design with three replications. Four moisture conservation treatments (M_1 - control; M_2 - opening of furrow at 60 DAS; M_3 - application of super absorbent

@ 12.5 kg ha^{-1} and M_4 - broad bed and furrow) were evaluated in main plot along with response of four fertilizer levels (F_1 - 80:40:40 NPK kg ha^{-1}; F_2 - 100:50:50 NPK kg ha^{-1}; F_3 - 120:60:60 NPK kg ha^{-1} and F_4 - 140:70:70 NPK kg ha^{-1}) were checked in sub plots. Site of the experiment was clay loam. *Bt* cotton hybrid NHH 44 (BG II) was sown at 120 x 45 cm spacing on 12th July, 2019 and 18th June, 2020 after receipt of sufficient monsoon rains. Nitrogen was applied in three splits (40% as basal, 30% each at 30 DAS and 60 DAS), complete dose of P and K were applied as basal. All other cultivation practices were adopted as per university recommendation. First picking of cotton was done on 19th Dec., 2020 and 7th Dec., 2021 during first and second year, respectively. Second picking was done as per treatment wise crop maturity in 2 MW and 3 MW of the respective season. Excess rainfall (1150 mm and 977 mm, respectively) was received during both the seasons over station average of 900 mm received in 57 and 53 rainy days (average 44). Dry spell was observed during 2019-20 season immediately after sowing. Late rains received during 2019-20 season resulted in dropping of reproductive parts initially, however was beneficial for second flush of cotton. The mean temperature was more than normal during vegetative growth to flowering period in second season.

2.2 Days to Reproductive Stages

Days required to attain different reproductive stage *viz.*, 50% square formation, 50% flowering, 50% boll formation and 50% boll bursting were noted. Picking wise seed cotton yield data was analysed. Picking wise per cent share of seed cotton was calculated to total seed cotton yield to know the earliness of crop. Different earliness indices were calculated based on picking wise seed cotton yield, picking wise days to harvest and mean maturity days as per formulae as below.

2.3 Earliness Index

2.3.1 Bartlett's earliness index

The Bartlett's earliness index suggests the earliness of the crop. Greater the value of Bartlett's index denotes more is the earliness of crop. The Bartlett's earliness index values were calculated with the formula as below [6].

$$\text{Bartlett's index} = \frac{P1 + (P1 + P2) + (P1 + P2 + \ldots. + Pn)}{n\,(P1 + P2 + \ldots. + Pn)}$$

Where P_1 = seed cotton yield in first picking; P_2 = seed cotton yield in second picking; P_n = seed cotton yield in nth picking and N = number of pickings.

2.3.2 Combined picking and day index (CPD)

Combined picking and day (CPD) earliness index is calculated considering combination of both days to picking and weight of seed cotton in picking as weighted earliness index. It is calculated by formula as below [4].

$$\text{Combined picking and duration index for earliness} = \frac{P1}{P1 + P2 + \ldots + Pn} \times \frac{\text{Number of days to last picking}}{\text{Number of days to first picking}}$$

Where (P_1, P_2, … P_n) being the weight of seed cotton yield in first, second and nth picking and n is the total number of pickings.

2.3.3 Fraction of first picking (FFP) index

The fraction of first picking index is calculated by dividing seed cotton in first picking by the total seed cotton yield in the season. Higher the seed cotton yield in first picking denotes higher values of fraction of first picking (FFP) earliness index of crop.

2.3.4 Mean maturity days (MMD) index

The procedure to determine the mean maturity date (days) is generalized as follows [7].

$$\text{Mean maturity date (MMD)} = \frac{(W1 \times H1) + (W2 \times H2) + \ldots\ldots\ldots + (Wn \times Hn)}{W1 + W2 + \ldots\ldots + Wn}$$

Where W = Weight of seed cotton; H = Number of days from planting to harvest and 1, 2…n = Consecutive periodic harvest number

2.3.5 Production rate index (PRI)

Production rate index (kg day^{-1}) was calculated from total seed cotton weight divided by the mean maturity days [8].

3. RESULTS AND DISCUSSION

3.1 Seed Cotton Yield (kg ha^{-1})

Earliness of cotton crop in terms of days to attain various stages may be deceptive because of the fact that the cotton plant flowers and sets bolls over a long period of time. Hence, picking wise seed cotton yield was statistically analysed to study the effect of treatments on early harvest of cotton. It was significantly influenced by moisture conservation practices and fertilizer levels (Table 1).

3.1.1 First picking

The yield of seed cotton harvested at first picking was 1389 kg ha^{-1} and 1088 kg ha^{-1} during 2019-20 and 2020-21, respectively with pooled mean of 1239 kg ha^{-1} (Table 1). The seed cotton yield at first picking in year 2020-21 was low due to dropping of reproductive parts during 43 MW to 47 MW (September to October) associated with increased rainy days and relative humidity.

The broad bed and furrow (M_4) method of moisture conservation had produced significantly more seed cotton yield in first picking during both the seasons and in pooled mean (1369 kg ha^{-1}). It was at par with opening of furrow at 60 DAS treatment (M_2) during second year of study. Availability of sufficient moisture and nutrients, better crop growth might have resulted in early bearing and development of reproductive parts in broad bed and furrow treatment. Sufficient moisture during square formation to flowering and boll development period results in development of first flush. Greater crop yield in first picking was previously reported with adoption of moisture conservation measures [9]. Moisture conservation exerts decisive role in earliness and seed cotton yield [10].

The seed cotton yield in first picking was not influenced due to fertilizer levels. However, fertilizer level of 140:70:70 NPK kg ha^{-1} (F_4) recorded highest numerical values of seed cotton yield in first picking during both the seasons and in pooled mean (1281 kg ha^{-1}).

3.1.2 Second picking

The second picking had 729 kg ha^{-1} and 1271 kg ha^{-1} seed cotton yield during 2019-20 and 2020-21, respectively whereas 1001 kg ha^{-1} in pooled mean. Seed cotton yield at second picking in 2020-21 was greater due to dropping of reproductive parts prior to first picking and development of a greater number of squares, flowers and bolls supported by available soil moisture due to late rains.

All the moisture conservation methods produced significantly higher seed cotton yield during second picking over control *i.e.*, flat bed (M_1) during 2020-21 and in pooled mean. It was due to conversion of greater number of squares in to bolls which might have supported by increased in soil moisture in these treatments. The opening of furrow at 60 DAS (M_2) treatment was the highest for seed cotton yield in second picking during both the seasons and in pooled mean (1125 kg ha^{-1}).

Fertilizer level of 120:60:60 NPK kg ha^{-1} (F_3) recorded highest seed cotton yield during 2019-20 (852 kg ha^{-1}) and in pooled mean (1092 kg ha^{-1}) whereas fertilizer level of 140:70:70 NPK kg ha^{-1} (F_4) had higher seed cotton yield at second picking during 2020-21 season (1387 kg ha^{-1}). This might be due to increase in available nutrients with higher fertilizer levels which had supported for better growth and development of crop.

3.1.3 Interaction effect of M x F for seed cotton yield (kg ha^{-1}) in second picking

Pooled mean interaction effect of M_2F_3 (opening of furrow at 60 DAS along with fertilizer level of 120:60:60 NPK kg ha^{-1}) recorded highest seed cotton yield (Table 2) at second picking (1267 kg ha^{-1}) and was at par with M_2F_4 (1218 kg ha^{-1}). On par yield with fertilizer 100:50:50 NPK kg ha^{-1} (F_2) and higher levels was observed in application of super absorbent @ 12.5 kg ha^{-1} (M_3). However, other treatments had statistically similar seed cotton yield in fertilizer levels of 120:60:60 NPK kg ha^{-1} and 140:70:70 NPK kg ha^{-1}. Increased soil moisture availability in BBF and opening of furrow treatments might have increased availability of nutrients for longer period resulting significant increase in seed cotton yield in higher fertilizer levels.

3.2 Picking Wise Share in Total Seed Cotton Yield (%)

Earliness index (percent first-pick) is most frequently used to estimate earliness in cotton [11]. The per cent share of seed cotton yield in first and second picking in total seed cotton yield was varying and is presented in Table 1.

3.2.1 First picking

Greater mean seed cotton yield in broad bed and furrow practice has increased its share (58.58 per cent) at first picking to total seed cotton yield. Application of superabsorbent @ 12.5 kg ha^{-1} (M_3 - 56.71 per cent) was on par with broad bed and furrow for per cent share in first picking. This shows the earliness of these treatments in total seed cotton yield. Early crop maturity with broad bed and furrow practice of moisture conservation was previously reported in groundnut [2].

Increasing fertilizer levels had reduced the share of first picking in total seed cotton yield and lowest fertilizer level of 80:40:40 NPK kg ha^{-1} (F_1) had significantly more share in mean per cent share seed cotton (59.14 per cent). It means that lower fertilizer levels have earliness for seed cotton yield.

3.2.2 Second picking

The second picking shared 44.18 per cent to total seed cotton yield in pooled mean. Opening of furrow at 60 DAS (M_2) had significantly greater share over all the moisture conservation treatments in pooled mean (47.97 per cent). Broad bed and furrow (M_4) had lowest share in total seed cotton yield at second picking in pooled mean which denotes the earliness of the treatment. Greater share of opening of furrow at second picking proves delay in maturity which might be due to greater availability of moisture for longer duration in this treatment.

Greater share of fertilizer level of 140:70:70 NPK kg ha^{-1} (F_4) in seed cotton yield at first picking has reduced its yield in second picking on pooled mean basis.

3.3 Earliness

The number of days required for 50% plants to attain square formation, flowering, boll formation and boll bursting are presented in Table 3. The average number of days to attain these stages was more in 2019 season in comparison with 2020. This might due to dry spell observed after sowing in first season which delayed crop since vegetative period and higher temperature more than normal during 2020 season. Cotton growth and development relates with the amount of heat to which the plant is exposed [12]. During 2020 season, days to 50% square and 50% flower appearance were less than 2019; this might be due to high temperature and more accumulation of heat units in the in the months of July-August and October - December.

In the present study, days to various reproductive stages were not significantly affected by moisture conservation and fertilizer levels in either year. However, number of days for 50% flowering and days for 50% boll appearance were reduced marginally with moisture conservation measures *viz*., application of superabsorbent and sowing broad bed and furrow. The number of days to appear reproductive stages was increased with increase in fertilizer levels. These results substantiated previously reported findings [13]. These results corroborate the earlier findings that increased nitrogenous fertilizer levels delay cotton maturity [14]. Increase in soil moisture during boll development and boll bursting period might have delayed the 50% boll bursting by 1.90 days in broad bed and furrow over control.

3.4 Earliness Index

Various earliness indices were studied based on picking wise seed cotton yield and duration of picking and those are presented in Table 4. Each earliness index has its own benefits. CPD index shows effect of both weight and time despite of time only in FFP index.

3.4.1 Moisture conservation practices

Earliness index (percent first-pick) is most frequently used to estimate earliness in cotton [11]. The broad bed and furrow (M_4) showed higher values of Bartlett's index (0.845 and 0.741), combined picking and day index (0.83 and 0.60), fraction of first picking index (0.69 and 0.48) during 2019-20 and 2020-21, respectively suggesting the earliness of crop with respect to seed cotton yield in proportion to number pickings. Opening of furrow recorded lower values of Bartlett's index (0.789 and 0.731) among moisture conservation methods showing delayed harvest in comparison with broad bed and furrow. It was due to lower share of seed cotton in first picking. Broad bed and furrow (M_4) was found to be earliest treatment with lowest

Table 1. Picking wise seed cotton yield (kg ha^{-1}) of *Bt* cotton hybrid NHH 44 (BG II) as influenced by different treatments

Treatments	First picking SCY (kg ha^{-1})			Second picking SCY (kg ha^{-1})			Mean share (%) in total SCY (pooled mean)	
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	FP	SP
Main plot : Moisture conservation methods								
M_1 : Control (Flat bed)	1379	912	1146	644	1185	915	55.96	44.04
M_2 : Opening of furrow at 60 DAS	1254	1150	1202	916	1333	1125	52.03	47.97
M_3 : Superabsorbent application @ 12.5 kg ha^{-1}	1398	1076	1237	671	1273	972	56.71	43.29
M_4 : Broad bed and furrow	1523	1215	1369	687	1295	991	58.58	41.42
SE±	52.57	32.85	31.62	17.59	27.50	18.10	0.85	0.85
CD (P = 0.05)	N.S.	95.74	92.15	51.27	80.15	52.75	2.47	2.47
Sub plot : Fertilizer levels (4)								
F_1 : 80 : 40 : 40 NPK kg ha^{-1}	1350	1025	1188	551	1131	841	59.14	40.86
F_2 : 100 : 50 : 50 NPK kg ha^{-1}	1376	1068	1222	743	1239	991	55.39	44.61
F_3 : 120 : 60 : 60 NPK kg ha^{-1}	1397	1129	1263	852	1330	1092	53.84	46.16
F_4 : 140 : 70 : 70 NPK kg ha^{-1}	1431	1131	1281	771	1387	1079	54.91	45.09
SE±	55.67	41.98	37.15	22.30	20.89	16.53	0.92	0.92
CD (P = 0.05)	N.S.	N.S.	N.S.	64.99	60.89	48.16	2.68	2.68
Interaction M x F								
SE±	111.35	83.95	74.29	44.60	41.78	30.05	1.84	1.84
CD (P = 0.05)	N.S.	N.S.	N.S.	129.97	N.S.	96.32	N.S.	N.S.
CV (%)	13.88	13.36	10.39	10.59	5.69	7.72	6.71	7.22
GM	1389	1088	1239	729	1271	1001	55.82	44.18

SCY : Seed cotton yield, FP : first picking, SP : second picking

Table 2. Interaction effect of M x F for seed cotton yield (kg ha^{-1}) in second picking of *Bt* cotton hybrid NHH 44 on pooled analysis

Moisture conservation methods	Fertilizer levels (NPK kg ha^{-1})			
	F_1 : 80:40:40	F_2 : 100:50:50	F_3 : 120:60:60	F_4 : 140:70:70
M_1 : Control (Flat bed)	734	922	1010	994
M_2 : Opening of furrow at 60 DAS	957	1057	**1267**	1218
M_3 : Superabsorbent application	824	1063	986	1015
M_4 : Broad bed and furrow	850	922	1102	1089
SE±	33.05			
CD (P = 0.05)	96.32			

Table 3. Number of days to attain reproductive stages to *Bt* cotton hybrid NHH 44 (BG II) as influenced by different treatments

Treatments	Days to 50% square			Days to 50% flowering			Days to 50% boll appearance			Days to 50% boll bursting		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
Main plot : Moisture conservation methods												
M_1 : Control (Flat bed)	45.58	41.42	43.50	62.25	59.33	60.79	71.92	69.92	70.92	114.42	112.83	113.63
M_2 : Opening of furrow at 60 DAS	45.67	41.75	43.71	62.17	59.42	60.79	71.17	69.58	70.38	116.42	113.83	115.13
M_3 : Superabsorbent appl. @ 12.5 kg ha^{-1}	45.50	41.42	43.46	61.58	58.25	59.92	70.58	68.25	69.42	116.25	113.42	114.83
M_4 : Broad bed and furrow	45.58	41.33	43.46	62.33	57.42	59.88	71.33	67.42	69.38	116.58	114.08	115.33
SE±	0.21	0.26	-	0.71	0.47	-	0.83	0.51	-	1.78	0.87	-
CD (P = 0.05)	N.S.	N.S.	-	N.S.	N.S.	-	N.S.	N.S.	-	N.S.	N.S.	-
Sub plot : Fertilizer levels												
F_1 : 80 : 40 : 40 NPK kg ha^{-1}	45.67	41.42	43.54	62.33	59.42	60.88	71.50	70.00	70.75	114.67	112.75	113.71
F_2 : 100 : 50 : 50 NPK kg ha^{-1}	45.58	41.75	43.67	62.33	58.58	60.46	71.50	69.08	70.29	115.33	113.50	114.42
F_3 : 120 : 60 : 60 NPK kg ha^{-1}	45.67	41.42	43.54	61.83	58.42	60.13	71.00	68.42	69.71	116.25	113.67	114.96
F_4 : 140 : 70 : 70 NPK kg ha^{-1}	45.42	41.33	43.38	61.83	58.00	59.92	71.00	67.67	69.33	117.42	114.25	115.83
SE±	0.48	0.37	-	0.46	0.92	-	0.46	0.83	-	0.97	0.83	-
CD (P = 0.05)	N.S.	N.S.	-	N.S.	N.S.	-	N.S.	N.S.	-	N.S.	N.S.	-
Interaction M x F												
SE±	0.95	0.74	-	0.93	1.83	-	0.93	1.67	-	1.94	1.66	-
CD (P = 0.05)	N.S.	N.S.	-	N.S.	N.S.	-	N.S.	N.S.	-	N.S.	N.S.	-
GM	45.58	41.48	43.53	62.08	58.60	60.34	71.25	68.79	70.02	115.92	113.54	114.73

Table 4. Earliness indices of *Bt* cotton as influenced by different treatments

Treatments	BI		CPDI		FFPI		MMDI		PRI	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Main plot : Moisture conservation methods										
M_1 : Control (Flat bed)	0.843	0.717	0.83	0.54	0.69	0.43	170.39	180.50	10.72	10.69
M_2 : Opening of furrow at 60 DAS	0.789	0.731	0.70	0.57	0.58	0.46	173.92	179.43	11.37	12.50
M_3 : Superabsorbent application @ 12.5 kg ha^{-1}	0.838	0.729	0.82	0.57	0.68	0.46	170.69	179.59	10.87	11.95
M_4 : Broad bed and furrow	0.845	0.741	0.83	0.60	0.69	0.48	170.24	178.68	11.58	12.62
Sub plot : Fertilizer levels										
F_1 : 80 : 40 : 40 NPK kg ha^{-1}	0.855	0.737	0.86	0.59	0.71	0.47	169.60	179.00	10.11	11.06
F_2 : 100 : 50 : 50 NPK kg ha^{-1}	0.824	0.730	0.78	0.57	0.65	0.46	171.63	179.51	11.20	11.71
F_3 : 120 : 60 : 60 NPK kg ha^{-1}	0.810	0.728	0.75	0.57	0.62	0.46	172.52	179.67	11.79	12.39
F_4 : 140 : 70 : 70 NPK kg ha^{-1}	0.826	0.723	0.79	0.55	0.65	0.45	171.50	180.03	11.44	12.60
GM	**0.829**	**0.730**	**0.79**	**0.57**	**0.66**	**0.46**	**171.31**	**179.55**	**11.14**	**11.94**

BI : Bartlett's index, CPDI : Combined picking and day index, FFPI : Fraction of first picking index, MMDI : Mean maturity date index, PRI : Production rate index

mean maturity days index of 170.24 and 178.68 during 2019-20 and 2020-21, respectively. Production rate index was highest in broad bed and furrow (M_4 - 11.58 and 12.62) followed by opening of furrow at 60 DAS (M_2 - 11.37 and 12.50) during 2019-20 and 2020-21. Higher values of Bartlett's index, CPD index, FFP index, PRI and lower values of MMD index in moisture conservation practices shows earliness in those treatments as compared to flat bed. Greater availability of moisture which has influenced better growth and development of crop along with reproductive parts has reduced the harvesting time in moisture conservation treatments as compared to control.

3.4.2 Fertilizer levels

Increasing fertilizer level has resulted in reduction in values of Bartlett's index and combined picking and day index which suggests that delay in crop maturity with increasing fertilizer levels. Higher fertilizer levels had lower seed cotton yield in first picking resulting in lower fraction of first picking index than fertilizer level of 80:40:40 NPK kg ha^{-1} (F_1 - 0.70 and 0.47, respectively) during 2019-20 and 2020-21. It suggests delay in crop harvest with increase in fertilizer level. The MMD index values are increased with increase in fertilizer level denotes the increase in crop duration. Delay in cotton crop maturity with increase in fertilizer level based on Bartlett's index and CPD index were earlier reported [15]. Higher percentage of opened bolls in cotton with no nitrogenous fertilizer was given compared to which nitrogen was applied resulting in decreased earliness index [16-17]. Increased seed cotton yield with comparatively very few increased mean maturity days has resulted in increased production rate index in higher fertilizer levels. Fertilizer level of F_2 (fertilizer level of 100:50:50 NPK kg ha^{-1}) and F_3 (120:60:60 NPK kg ha^{-1}) had highest values of production rate index whereas, lowest fertilizer level of 80:40:40 NPK kg ha^{-1} (F_1 - 10.11 and 11.06) was the lowest during 2019-20 and 2020-21, respectively. Decrease in earliness index with increase in N fertilizer suggests that nitrogen delay crop maturity [13, 18-19].

Thus, with respect to greater crop harvest in first picking, lower fertilizer levels had earliness. However, considering the total seed cotton yield with respect to maturity days, higher fertilizer level is desirable.

4. CONCLUSION

Among the moisture conservation practices evaluated, early crop of *Bt* cotton hybrid can be harvested with broad bed and furrow sowing in comparison with flat bed. Increasing fertilizer levels has found to increase crop duration based on earliness index. Hence, judicious dose of nutrient is found necessary.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. AICRP on Cotton. Annual Report of All India Coordinated Research Project on Cotton 2020-21. Coimbatore: Central Institute for Cotton Research, Regional Station, Coimbatore; 2022.
2. Yadav AL, Goswami B, Aggarwal P, Arya M. Few important soil management technologies for sustainable crop production - A review. Agri. Rev. 2003;24(3): 211-16.
3. Nuti RC, Lamb MC, Sorensen RB, Truman CC. Agronomic and economic response to furrow diking tillage in irrigated and non-irrigated cotton (*Gossypium hirsutum* L.). Agricultural water management. 2009; 96(7): 1078-84.
4. Hosseini G. New earliness index and integration of earliness additive genes in the new genotype of cotton (*Gossypium hirsutum L.*). Int. J. Life. Sci. Scienti. Res. 2017; 3(3):1016-19.
5. Iqbal M, Khan M, Shafqat W. Developing short-season cotton genotypes with high harvest index might be an advantageous option under late duration plantings. Plant Genetic Resources: Characterization and Utilization. 2020;18(3):190-95.
6. Bartlett MS Some examples of statistical methods of research in Agriculture and applied Botany. In. J. Roy. Statist. Soc. B. 1973; 4; 37-70.
7. Christidis BG, Harrison GJ. Cotton Growing Problems. McGraw-Hill Book Company, New York, 16; 1955.
8. Saleem MF, Shakeel A, Bilal MF, Shahid MQ, Anjum SA. Effect of different phosphorus levels on earliness and yield of cotton cultivars. Soil & Environ. 2010;29(2): 128-35.

9. Khan NU, Khakwani AA, Ullah S, Ullah N, Rauf A, Ullah I. Response of upland cotton (*Gossypium hirsutum* L.) to tillage and nitrogen in wheat-based cropping system. Sarhad Journal of Agriculture. 2017; 34(1): 70-78.
10. Singh K, Dhillon BS, Limba V. Effect of mulching on growth and productivity of *Bt* cotton (*Gossypium hirsutum* L.). Int. J. Curr. Microbiol. App. Sci. 2021;10(01):2610-2615. DOI:https://doi.org/10.20546/ijcmas.2021.1001.304
11. Bourland FM, Benson NR, Vories ED, Tugwell NP, Danforth DM. Measuring maturity of cotton using nodes above white flower. J. Cotton Sci. 2001;5:1-8.
12. Clay PA, Young KM, Taylor. Effect of heat unit accumulation on cotton defoliation, lint yield and fiber quality. Arizona Cotton Report, Coop. Ext., Univ. Arizona, Tucson, USA. 2006;245-50.
13. Munir MK, Tahir M, Saleem MF, Yaseen M. Growth, yield and earliness response of cotton to row spacing and nitrogen management. J. Anim. Plant Sci. 2015;25(3):729-38.
14. Brown HB. Cotton history, species, varieties, morphology, breeding. culture, diseases, marketing and uses. Secind ed. Biotech books, New Delhi. 2002; 592.
15. Ghule PL, Palve DK, Jadhav JD, Dahiphale VV. Plant geometry and nutrient levels effect on productivity of *Bt* cotton. Internat. J. agric. Sci. 2013;9(2):486-94.
16. Tang X, Tian C, Lu Z. Relationship between the spread quantity of nitrogenous fertilizer and the accumulated sunshine requirement of cotton in its growing stages. Arid Zone Res. 2003;20: 226-29.
17. Reddy KR, Koti S, Davidonis GH, Reddy VR. Interactive effects of carbon dioxide and nitrogen nutrition on cotton growth, development, yield and fiber quality. *Agron. J.* 2004; 96: 1148-57.
18. Amal S. Abdel-Aal1, M.A. Emara1 and Hamada M. Maha. Effect of Different N-fertilizer Levels and Fertilizers Splitting on Growth and Productivity of Giza 94 Cotton Cultivar. East African Scholars J Agri Life Sci. 2019; 6(2):323-329.
19. Raphael JP, Echer F, Rosolem C. Shading and nitrogen effects on cotton earliness assessed by boll yield distribution. Crop Science. 2019; 59(2): 697-707.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/85012