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MOISTURE CONSERVATION AND OPTIMUM FERTILIZER LEVELS FOR *BT* COTTON (*GOSSYPIUM HIRSUTUM* L.) HYBRID UNDER RAINFED CONDITION

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ABSTRACT:
A three-year investigation (2019-20 to 2021-22) was conducted at the Cotton Research Station, Nanded, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra, India). The study aimed to evaluate the response of *Bt* cotton hybrids to moisture conservation practices and to optimize fertilizer levels in a rainfed environment. The experiment was arranged in a split-plot design with three replications. Four moisture conservation practices [M1 - Control *i.e.* flat bed, M2 - opening of every furrow at 60 DAS, M3 - application of super absorbent @ 12.5 kg ha^{-1} and M4 - broad bed and furrow] in main plot and four fertilizer levels [F1 - 80:40:40 NPK kg ha^{-1}, F2 - 100:50:50 NPK kg ha^{-1}, F3 - 120:60:60 NPK kg ha^{-1} and F4 - 140:70:70 NPK kg ha^{-1}] were accessed in sub plots.
Moisture conservation practices, broad bed and furrow (BBF) method and opening every furrow at 60 days after sowing (DAS) had improved several aspects of *Bt*-cotton growth. Specifically, these practices led to increased plant height, a greater number of monopodial and sympodial branches, and enhanced nutrient uptake compared to the control (flat bed). Sowing cotton on a broad bed and furrow (BBF) system and opening furrows at 60 days after sowing (DAS) significantly improved soil moisture content compared to flat bed sowing. This improved moisture retention led to an increase in yield-contributing characteristics, seed cotton yield, and lint yield of *Bt* cotton hybrid NHH 44. The highest harvest index was observed in the furrow-opening treatment. The BBF method resulted in the highest Gross Monetary Return (GMR) of ₹1,52,137 per hectare. However, the furrow-opening treatment proved to be the most profitable, yielding the highest Net Monetary Return (NMR) of ₹80,281 per hectare and the best Benefit-Cost (B:C) ratio of 2.15. These moisture conservation techniques did not affect the fiber properties of the *Bt* cotton.
An NPK fertilizer application rate of 140:70:70 kg ha^{-1} resulted in superior growth compared to the lower rate of 80:40:40 kg ha^{-1}. The 140:70:70 kg/ha NPK level significantly increased seed cotton yield (2330 kg ha^{-1}), Gross Monetary Return (GMR) (₹1,54,707 ha^{-1}), Net Monetary Return (NMR) (₹81,210 ha^{-1}), and the Benefit-Cost (B:C) ratio (2.10) compared to the 100:50:50 kg ha^{-1} level. These results were comparable to the 120:60:60 kg ha^{-1} NPK level in terms of seed cotton yield and overall profitability. The harvest index increased with NPK levels up to 120:60:60 kg ha^{-1}, while the lint yield at this same level was significantly higher than the control group. Higher fertilizer levels also notably improved the uniformity index compared to the lowest application rate (F1). Furthermore, the overall uptake of nitrogen, phosphorus, and potassium by the crop increased significantly as the fertilizer level was raised.

KEYWORDS: Cotton, moisture conservation, fertilizer level, BBF, opening of furrow, superabsorbent, nutrient uptake,

INTRODUCTION

Cotton is crucial to India's agricultural and industrial sectors. It is cultivated in over 80 countries with India being dominant in terms of area cultivated, with 129.5 lakh hectares, accounting for 40% of worldwide cotton acreage. Despite this, India produced 371 lakh bales of cotton, accounting for a considerable share of global production at a productivity of 437 kg lint per hectare. This crop provides 85 percent of the raw materials used by India's textile industries and provides employment to 70 million people. Rainfed farming, which accounts for 66% of total area, is a major contributor to the low yield of cotton in India.
India's low cotton yield is primarily due to the effects of rainfed cultivation, dry spells during the growing season, and moisture stress during critical stages of growth. Adequate moisture is required for successful cotton cultivation in rainfed areas. Moisture stress during flowering and boll formation reduces the growth and retention of reproductive organs, resulting in declined yields. Adoption of efficient moisture conservation techniques is critical for improving water infiltration and extended moisture availability, especially in rainfed areas. Soil and water conservation techniques can help to reduce the adverse effects of dry spells and protect crops from moisture stress (Nyamadzawo et al., 2013). In-situ moisture conservation is critical to withstand dry spells and increasing the production of rainfed crops,

particularly those planted on small sized farms. The most efficient and economical method of saving rainfall is to store it in-situ. The principle behind in-situ moisture-conservation practices is to increase infiltration by minimizing the rate of runoff, temporarily impounding water on the soil surface to increase the opportunity time for infiltration, and modifying the land configuration for inter-plot water harvesting (Muthamilselvan et al., 2006).

The ideal NPK nutrient requirements for maximizing the yield of *Bt* cotton differ based on location, taking into account factors such as soil moisture, temperature, cropping patterns, and the specific cultivars used. Effective nutrient management is a critical component of improved agronomic practices aimed at increasing cotton productivity. The nutritional needs during different growth stages of hybrid cotton play a crucial role in determining seed cotton yield. Effective and appropriate fertilizer management not only protects farmers' investments in costly inputs, but also increases production by optimizing input use. Therefore, it is essential to focus on agronomic management, particularly in terms of moisture conservation and fertilizer application in rainfed conditions, to optimize economic returns and maintain high levels of productivity.

The current study entitled 'Moisture conservation and optimum fertilizer levels for *Bt* cotton (*Gossypium hirsutum* L.) hybrid under rainfed condition' was conducted with the aim of examining how moisture conservation techniques influence the growth, yield, and economic viability of the *Bt* cotton hybrid in rainfed environments. Additionally, the research seeks to determine the optimal nutrient requirements for *Bt* cotton in these conditions.

MATERIALS AND METHODS

The field experiment was conducted at Cotton Research Station in Nanded (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani) over the Kharif seasons from 2019-20 to 2021-22. This experimental location is positioned in a subtropical area at a latitude of 19°13′72″ North and a longitude of 77°34′81″ East, with an elevation of 362 meters above mean sea level. The site experiences hot summers, with an average maximum temperature reaching 42.1°C, while average winter temperatures can drop to as low as 11.8°C in December.

During the whole cropping period, total 1150.3 mm, 976.9 mm and 1090.2 mm rainfall was received in a span of 57, 52 and 50 rainy days during 2019-20, 2020-21 and 2021-22, respectively as against normal rainfall of 913.8 mm. Thus 25.9 per cent, 6.9 per cent and 11.3 per cent higher than normal rainfall was received during the respective season. The topography of the field was reasonably uniform and level. The soil was medium black cotton belonging to Vertisols. The soil of experimental site was neutral to alkaline (8.06) with organic carbon content 0.46 per cent, electrical conductivity was 0.28 dSm-1and CaCO3 content was 3.8 %. The available nitrogen was 157.85 kg ha^{-1}, available P2O5 and K2O were 12.44 kg ha^{-1} and 486.47 kg ha^{-1}, respectively.

The experiment was laid out in Split Plot Design (SPD) with four main and four sub plot treatments. All the treatments were replicated thrice. Each net plot was sized 3.6 × 4.5 m2. The main plot treatments were; M1: Control *i.e.* flat bed, M2: opening of furrows at 60 days after sowing (DAS), M3: Superabsorbent application @ 12.5 kg ha^{-1} and M4: Broad bed furrow (BBF). Four fertilizer levels were evaluated in sub plot as F1: 80 : 40 : 40 NPK kg ha^{-1}, F2: 100 : 50 : 50 NPK kg ha^{-1}, F3: 120 : 60 : 60 NPK kg ha^{-1} and F4: 140 : 70 : 70 NPK kg ha^{-1}. The *Bt* cotton hybrid NHH 44 BG-II was been used for experimentation with spacing of 120 cm × 45 cm. Sowing was done by dibbling method during 27 SMW, 24 SMW and 26 SMW during 2019, 2020 and 2021, respectively on receipt of sufficient monsoon rains. The trial was conducted under rainfed condition. Fertilizer doses were applied in three splits; 40% nitrogen, complete dose of P2O5 and K2O were applied as basal by drilling and remaining dose of nitrogen was applied in two splits of 30% each at 30 DAS and 60 DAS by ring method. Opening of furrows was done at 60 DAS by running tied harrow between every row. Superabsorbent material in 'Starch-g-poly' form (Zeba) was applied by mixing with basal dose of fertilizers in main plot treatment (M3). One row was stacked on broad bed and furrow (BBF) for evaluation of response to BBF in cotton (M4). Soil moisture content was studied by gravimetric method from 30 DAS at every month interval. Nutrient uptake by the crop was analysed. Ginning out turn *i.e.* percentage of fibre from the seed cotton was calculated by ginning samples with hand gin machine and lint yield ha^{-1} was calculated from the ginning efficiency. The fibre qualities were evaluated on HVI mode. Pooled analysis of three years data was worked out as per procedure suggested by Panse and Sukhatme (1957).

RESULTS AND DISCUSSION:

Soil moisture content :

Moisture conservation practices: The moisture conservation practices had significant effect on soil moisture content (cm) in 0-45 cm depth at different stages of observation (Fig. 1). Highest soil moisture (cm) was recorded in broad bed and furrow (M4) treatment at all the observations. The pooled mean (2019-20 to 2021-22) moisture content in broad bed and furrow was significant over other moisture conservation measures at 30 DAS and at 150 DAS. The opening of furrow at 60 DAS (M2) was on par with broad bed and furrow for moisture content at 90 DAS, 120 DAS and at harvest stage. Flat bed recorded lowest mean soil moisture content at all the observation. Singh et al. (2011) and Veeranna et al. (2017) also reported benefit of ridges and furrow on soil moisture improvement as compared to flat bed sowing at various stages. The results of improvement in soil moisture content in broad bed and furrow method over flat bed are in conformity with Gnanasoundari and Balusamy (2015). Increased moisture storage in soil might be due to improvement in moisture content in upper layers by increased chance to infiltrate moisture in broad bed and furrow and opening of furrow treatments. These results are in line with Ambika et al. (2017) and Veeranna et al. (2017).

Fertilizer levels: The effect of fertilizer levels was not evident on soil moisture content in soil (0-45 cm depth) during every year and on pooled analysis.

Nutrient uptake

Moisture conservation practices: Uptake of nitrogen, phosphorus and potassium was improved in broad bed and furrow sowing treatments over flat bed and application of super absorbent on pooled analysis of nutrient uptake data (Table 1). Sowing of cotton on broad bed and furrow was on par with opening of furrow in cotton at 60 DAS for pooled mean uptake of nutrients. The flat bed recorded least mean nutrient uptake. This might be due to increased availability of nutrients for longer period due to sufficient and extended moisture availability, greater root length effective in harvesting of nutrients coupled with favorable microclimate as well as increased plant growth in broad bed and furrow (M4) and opening of furrow at 60 DAS (M2) treatments. These results are in close conformity with Jaybhay et al., (2015), Veeranna et al., (2017) and Khargkharate et al., (2017).

Fertilizer levels: Increase in fertilizer levels has increased nitrogen, phosphorus and potassium uptake by *Bt* cotton crop. The pooled mean nutrient uptake data showed significant increase in uptake of nitrogen (103.78 kg ha^{-1}), phosphorus (29.15 kg ha^{-1}) and potassium (89.17 kg ha^{-1}) in fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) over lower levels. Lowest level of fertilizer 80:40:40 NPK kg ha^{-1} (F1) was the lowest for nutrient uptake. Increase in nitrogen uptake in higher levels may be ascribed to efficient utilization and assimilation of macronutrients and increase in dry matter accumulation of plant. Mehta et al. (2009) also reported similar findings. Gadhiya et al. (2009) and Jyothi and Hebsur (2017) reported increased phosphorus content in stalk and leaves resulting greater uptake with increased fertilizer levels. Das and Reddy (2009) and Modhvadia et al. (2012) reported that higher nitrogen level improves the vegetative growth in turn increases uptake of phosphorus which necessitates the balanced nutrition to *Bt* cotton crop. Khalifa et al (2012) concluded that increase in either nitrogen or potassium levels has resulted to increase in nutrient uptake of another nutrient by plant.

Plant growth characters

Data regarding pooled mean plant growth characters as influenced by moisture conservation practices and fertilizer levels of *Bt* cotton hybrid are presented in Table 2.

Moisture conservation practices: The pooled mean plant height (149.04 cm) and number of monopodia (1.96) as well as sypmodia (21.16) plant^{-1} were highest in sowing on broad bed and furrow. The sufficient moisture enhances cell division and resulting increased plant height. It is congenial for development of auxiliary buds and which ultimately increase number of monopodial branches plant^{-1}. Broad bed and furrow (M4) was on par with opening of furrow at 60 DAS for plant growth. Sowing on flat bed recorded lowest values of plant growth characters. Devaranavadagi and Santhana (2017), Pragathi Kumari et al., (2019) has earlier reported significant effect of soil moisture conservation practices on cotton growth and development.

Fertilizer levels: The effect of incremental levels of fertilizers was significant on plant growth characters. The highest fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) recorded highest pooled mean plant height (149.64 cm), number of monopodia (2.00), sympodia plant^{-1} (21.03). Nitrogen has role in cell division and cell elongation whereas, potassium has role in photosynthesis, helping in transportation of photosynthates. Hence, increasing levels of fertilizers might have resulted in increasing plant growth. Pragathi Kumari et al. (2019) also reported significant increase in plant height due to incremental fertilizer level.

Yield contributing characters and seed cotton yield ha^{-1}

Data regarding pooled mean yield contributing characters, year wise and pooled mean seed cotton yield (kg ha^{-1}) as influenced by moisture conservation practices and fertilizer levels of *Bt* cotton hybrid are presented in Table 1.

Moisture conservation practices: Sowing on BBF has significantly increased yield plant^{-1} (126.71 g) and number of bolls plant^{-1} (44.57) over flat bed sowing and application of superabsorbent on pooled mean basis. Significantly highest pooled mean boll weight (2.94 g) was observed in broad bed and furrow treatment. Broad bed and furrow (M4) was on par with opening of furrow at 60 DAS for plant growth and yield contributing characters. Sowing on flat bed recorded lowest values of plant growth characters and yield attributes. The increased soil moisture and interception of solar radiation in moisture conservation practices was efficiently utilized at the flowering and boll development period of crop. It has benefited in increasing number of bolls m-2 and seed cotton yield plant ha^{-1}. Devaranavadagi and Santhana (2017), Pragathi Kumari et al., (2019) has earlier reported significant effect of soil moisture conservation practices on cotton growth and development. Advantages of broad bed and furrow increasing yield attributes were earlier reported by Gnanasoundari and Balusamy (2015), Aslam et al. (2018) and Ashraf et al. (2020). Similarly, Pandagale et al., (2018a) reported increase in number bolls m-2 on raised beds and opening of furrow.

Increase in plant growth and yield contributing characters has resulted in increased seed cotton yield in Broad bed and furrow (M4), during individual years and in pooled analysis. During individual years as well as on pooled analysis, broad bed and furrow (M4 - 2283 kg ha^{-1}) was significantly superior over control *i.e.*, flat bed (M1 - 2068 kg ha^{-1}) and application of superabsorbent @ 12.5 kg ha^{-1} (M3 - 2150 kg ha^{-1}). Broad bed and furrow (M4) was at par with opening of furrow at 60 DAS (M2 - 2248 kg ha^{-1}). Moisture conservation practices *viz.*, opening of furrow at 60 DAS (M2), application of superabsorbent @ 12.5 kg ha^{-1} (M3) and broad bed and furrow (M4) has increased mean seed cotton yield by 8.70 per cent, 3.97 per cent and 10.40 per cent over control *i.e.*, flat bed (M1), respectively. Broad bed and furrow (BBF) planting system increased seed cotton yield primarily by improving soil water conservation, aeration and nutrient uptake. Dhillon et al (2019) reported increased length, girth and dry weight of roots of cotton planted on BBF. These systems also reduce soil compaction and improve drainage, particularly in areas prone to waterlogging. Effective moisture conservation causes more uptake of the plant nutrients and moisture content from the soil which enhanced the plant growth and development which leads to more synthesis of photosynthates and their translocation to the sink. These results are in line with Pragathi Kumari et al. (2019) and More et al. (2021) who reported increase in seed cotton yield due to broad bed and furrow followed by furrow opening.

Fertilizer levels: Yield attributes and seed cotton yield of *Bt* cotton hybrid ha^{-1} were influenced significantly due to the effect of fertilizer levels in *Bt* cotton. Highest yield attributes *viz.*, yield $plant^{-1}$ (128.40 g), number of bolls $plant^{-1}$ (44.62) and boll weight (2.95 g) were recorded in fertilizer level of 140:70:70 NPK kg ha^{-1} (F4). It was at par with fertilizer level of 120:60:60 NPK kg ha^{-1} (F3). Greater availability of nutrients in increased fertilizer level along with improved number of fruiting sites might have resulted to increased number of bolls and yield $plant^{-1}$. Similarly, enhanced photosynthesis in increased fertilizer level might have resulted to translocation of photosynthates from source to sink leading to increased boll weight.

Increase in number of picked bolls $plant^{-1}$ due to application of fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) was associated with the increase in various growth attributes *viz.*, plant height, number of sympodial branches. Shao et al. (2024) found significant positive correlation was found between yield and boll weight and boll number, with the correlation coefficient being higher for boll number. Macro nutrients particularly phosphorus and potassium increase the efficiency of plant in reproductive stage and are involved in translocation of photosynthates towards boll formation site (Khan et al, 2023 and Gunasekhar et al., 2022). The cumulative effect of this finally improved number of picked bolls $plant^{-1}$. Similar results of increase in number of picked bolls $plant^{-1}$ with higher fertilizer level was reported by Bharathi et al. (2016), Veeraputhiran and Gunaseasekaran (2018), Pragathi Kumari et al. (2019) and Solanki et al. (2020).

The fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) recorded highest seed cotton yield, 2291 kg ha^{-1}, 2572 kg ha^{-1}, 2128 kg ha^{-1} and 2330 kg ha^{-1} during 2019-20, 2020-21, 2021-22 and on pooled analysis, respectively. Application of fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) was significantly superior over fertilizer levels of 80:40:40 NPK kg ha kg ha^{-1} (F1) and 100:50:50 NPK kg ha^{-1} (F2) during all the years of experimentation. On pooled analysis of seed cotton yield data, every higher level of fertilizers was significantly superior over lower levels on pooled mean basis. On an average of the three seasons, additional seed cotton yield of 16.04 per cent, 13.00 per cent and 6.67 per cent was received due to application of 140:70:70 NPK kg ha^{-1} (F4), 120:60:60 NPK kg ha^{-1} (F3) and 100:50:50 NPK kg ha^{-1} (F2) over 80:40:40 NPK kg ha^{-1} (F1) over lowest level of 80:40:40 NPK kg ha^{-1} (F1). The significant increase in seed cotton yield with higher level over its lower level up to F3 was the result of increase in various growth and yield attributes *viz.*, plant height, number of branches, number of picked bolls $plant^{-1}$, boll weight and seed cotton yield $plant^{-1}$. The results of increase in seed cotton yield with higher fertilizer dose over lower are in conformity with the findings of Asewar et al., (2013) Deepa and Aladakatti (2016), Honappa et al. (2019) and Solanki et al. (2020).

Economics

Moisture conservation practices: The gross as well as net monetary returns and B:C ratio as influenced by moisture conservation practices and fertilizer levels are presented in Table 3. The highest gross monetary returns were recorded from sowing on broad bed and furrow (M4) treatment during all the years and on pooled analysis (Rs. 1,52,136 ha^{-1}). Opening of furrow at 60 DAS (M2 - Rs. 1,49,783 ha^{-1}) was on par with broad bed and furrow for GMR during every year and on pooled mean basis. Both these treatments were significantly superior over control *i.e.*, flat bed (M1) and application of superabsorbent @ 12.5 kg ha^{-1} (M3) for pooled mean GMR. However, increased cost of broad bed and furrow preparation and additional weed management cost as interculture was not possible due to BBF, has lowered the net monetary returns in broad bed and furrow treatment. Thus, highest NMR were recorded in opening of furrow at 60 DAS (M2) treatment during 2019-20, 2020-21 and on pooled analysis (Rs. 80,281 ha^{-1}). Broad bed and furrow (M4 - Rs. 79,159 ha^{-1}) was on par with opening of furrow at 60 DAS for pooled mean NMR. Control *i.e.*, flat bed (M1) was the lowest for monetary returns during all the years and pooled mean. Opening of furrow at 60 DAS (M2) recorded highest individual seasonal as well as mean B:C ratio (2.15) followed by broad bed and furrow (2.08). Thus, opening of furrow at 60 DAS (M2) was economically more profitable than control *i.e.*, flat bed sowing (M1) and application of superabsorbent @ 12.5 kg ha^{-1} (M3). Higher seed cotton yield with moisture conservation practices of opening of furrow 60 DAS (M2) and broad bed and furrow (M4) by supplying the optimum moisture to crop that led to greater net monetary returns. Greater net monetary returns received in opening of furrow treatment over flat bed was earlier reported by Khargkharate et al. (2017) whereas Pragathi Kumari et al. (2018) reported greater NMR in ridges and furrow.

Fertilizer levels: The highest fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) was significantly superior over 80:40:40 NPK kg ha^{-1} (F1) and 100:50:50 NPK kg ha^{-1} (F2) during all the three years. However, on pooled analysis the fertilizer level of 140:70:70 NPK kg ha^{-1} was significantly superior over all the lower levels for pooled mean GMR (Rs.1,54,707 ha^{-1}). Highest net monetary returns during every year and pooled mean NMR (Rs. 82,210 ha^{-1}) were from fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) and was at par with fertilizer level of 120:60:60 NPK kg ha^{-1} (F3). The fertilizer level of 120:60:60 NPK kg ha^{-1} (F3) was significantly superior over other lower levels. Highest mean B:C ratio was recorded in fertilizer level of 140:70:70 NPK kg ha^{-1} (2.10) followed by 120:60:60 NPK kg ha^{-1} (F3 - 2.09). From present results, it is clear that fertilizer level of 120:60:60 NPK kg ha^{-1} (F3) is economically viable and cost effective in comparison with lower levels. Asewar et al. (2013) observed response *Bt* cotton to 150% RDF with respect to gross monetary returns. These results are in line with Veeraputhiran and Gunasekaran (2018) and Solanki et al. (2020). Similarly, 150% RDF to *Bt* cotton hybrid was reported to be profitable by Ranjith et al. (2015).

Fibre quality parameters

Moisture conservation practices: The ginning outturn (GOT) influenced due the moisture conservation practices and fertilizer levels and is presented in Table 4. Moisture conservation practices did not affect GOT and showed greater values than control. By virtue of greater yield and higher GOT, broad bed and furrow (M4) recorded highest lint yield on pooled mean basis (773 kg ha^{-1}). It was at par with opening of furrow at 60 DAS (M2 - 759 kg ha^{-1}) and significantly superior over rest of treatments. Dhillon et al (2019) also reported numerically higher GOT lint yield and lint index in bed maker *Bt* cotton sowing followed by ridge sowing. Fiber properties of *Bt* cotton were not found to be influenced due to moisture conservation practices. Non-significant influence of moisture conservation practices on fiber length was also reported by Ehsanullah et al. (2017) and Pragathi Kumari et al., (2018).

Fertilizer levels: The highest fertilizer level of 140:70:70 NPK kg ha^{-1} (F4) was the highest for seasonal as well as pooled mean lint yield (789 kg ha^{-1}). It was at par with fertilizer level of 120:60:60 NPK kg ha^{-1} (F3 - 766 kg ha^{-1}). Fertilizer levels except uniformity index which was increased in highest fertilizer level over lowest. Raju and Thakare (2012) reported that improvement in uniformity index due to higher fertilizer level might be due to uniform development of cotton fibres with incremental nutrition levels. Fiber quality traits *viz.*, length, micronaire and strength are governed by genetic makeup of the plant and hence are not influenced by fertilizer levels. Similar results were also published by Pragathi Kumari et al. (2018), Solanki et al. (2020)

Harvest index: The stalk yield and harvest index data of *Bt* cotton hybrid is presented in Fig. 2 and Fig. 3, respectively. The highest stalk yield was observed in broad bed and furrow treatments during all the seasons and in pooled mean (3814 kg ha^{-1}). It was at par with opening of furrow at 60 DAS (3751 kg ha^{-1}). However, harvest index had non-significant differences. Opening of furrow at 60 DAS recorded highest harvest index (37.55 per cent). Increased seed cotton yield due to moisture conservation practices in comparison with comparatively low increase in stalk yield was resulted to numerically increased values of harvest index in these treatments. Non-significant increase in harvest index was previously observed by Pandagale et al, (2018). Increase in plant biomass which was result of increased plant height and number of branches under moisture conservation might have led the harvest index to have non-significant differences.

Increase in fertilizer level has increased stalk yield. The fertilizer level of 140:70:70 NPK kg ha^{-1} recorded highest stalk yield during every season and on pooled mean (3875 kg ha^{-1}). It was at par with fertilizer level of 120:60:60 NPK kg ha^{-1} (3769 kg ha^{-1}). The concurrent fertilizer level has improved harvest index numerically over its preceding lower level. These results are in corroboration with Khatua et al. (2021).

CONCLUSION

Sowing of *Bt* cotton hybrid on Broad bed and furrow has increased soil moisture content, plant growth characters, yield attributes, seed cotton yield ha^{-1}, and lint yield over control. Opening of furrow in *Bt* cotton crop at 60 DAS was profitable in terms of higher NMR and B:C ratio. The fertilizer dose of 120:60:60 NPK kg ha^{-1} was found remunerative as it was on par with higher level for monetary returns.

Fig. 1: Soil moisture content (cm) in 0-45 cm depth of *Bt* cotton crop as influenced by moisture conservation techniques (pooled mean)

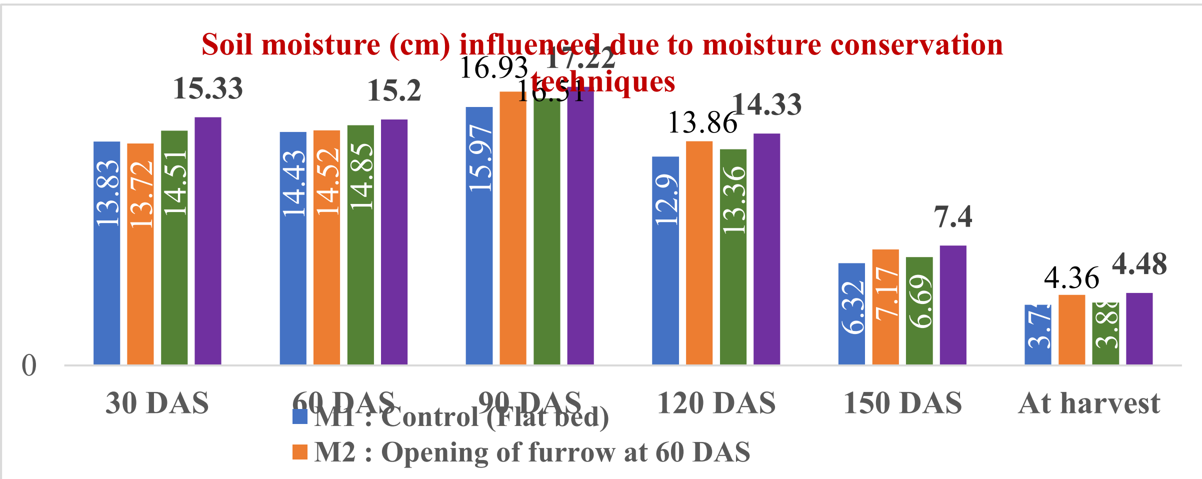
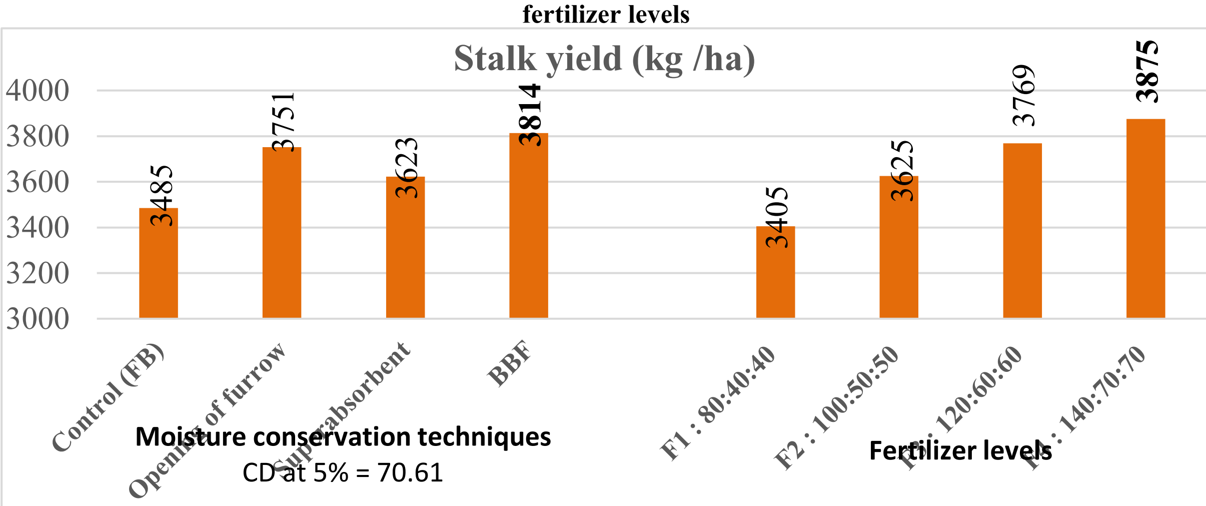


Fig. 2: Pooled mean stalk yield (kg ha^{-1}) *Bt* cotton crop as influenced by moisture conservation techniques and fertilizer levels



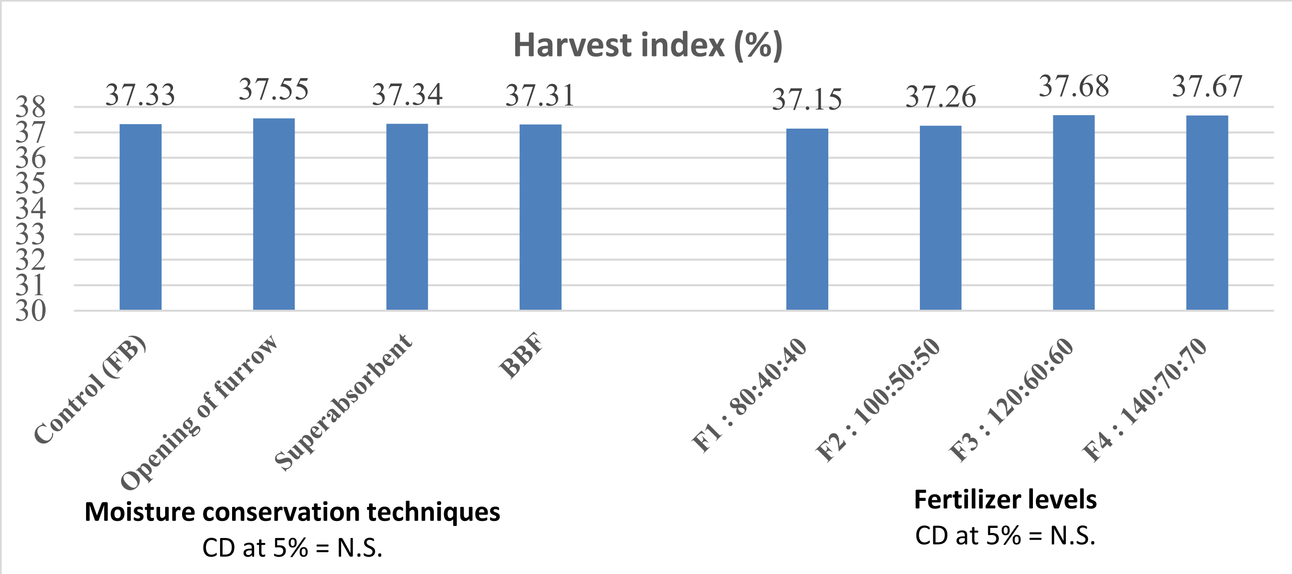


Fig. 3: Pooled mean harvest index (%) *Bt* cotton crop as influenced by moisture conservation techniques and fertilizer levels

Table 1: Nutrient uptake by *Bt* cotton hybrid crop and fiber quality as influenced by different treatments (pooled mean)

Treatments	**Nitrogen uptake (kg ha^{-1})**	**Phosphorus uptake (kg ha^{-1})**	**Potassium uptake (kg ha^{-1})**
Main plot : Moisture conservation practices			
M1 : Control (Flat bed)	91.08	25.30	77.74
M2 : Opening of furrow at 60 DAS	99.12	27.81	84.71
M3 : Superabsorbent application @ 12.5 kg ha^{-1}	94.47	26.33	80.85
M4 : Broad bed and furrow	101.47	28.69	86.42
SE+	1.11	0.40	0.86
CD at 5%	3.25	1.17	2.51
Sub plot : Fertilizer levels (4)			
F1 : 80 : 40 : 40 NPK kg ha^{-1}	87.74	24.41	74.18
F2 : 100 : 50 : 50 NPK kg ha^{-1}	94.26	26.40	80.49
F3 : 120 : 60 : 60 NPK kg ha^{-1}	100.37	28.18	85.89
F4 : 140 : 70 : 70 NPK kg ha^{-1}	103.78	29.15	89.17
SE+	1.04	0.33	0.96
CD at 5%	3.03	0.95	2.81
Interaction M x F			
SE+	2.08	0.65	1.93
CD at 5%	N.S.	N.S.	N.S.
CV (%)	5.73	5.17	5.05
GM	96.54	27.03	82.43

Table 2: Plant growth, yield contributing characters (pooled mean) and seed cotton yield (kg ha^{-1}) of *Bt* cotton hybrid as influenced by different treatments

Treatments	Plant height (cm)	Monopodia $plant^{-1}$	Sympodia $plant^{-1}$	No. of picked bolls $plant^{-1}$	Boll weight (g)	Yield $plant^{-1}$ (g)	Seed cotton yield (kg ha^{-1})			
							2019-20	2020-21	2021-22	Pooled mean
Main plot : Moisture conservation practices										
M1 : Control (Flat bed)	141.01	1.75	19.00	40.81	2.76	113.08	2027	2277	1902	2068
M2 : Opening of furrow at 60 DAS	147.87	1.89	20.59	44.39	2.86	124.86	2175	2483	2089	2248
M3 : Superabsorbent application @ 12.5 kg ha^{-1}	144.53	1.93	19.79	41.94	2.82	118.02	2073	2389	1988	2150
M4 : Broad bed and furrow	149.04	1.96	21.16	44.57	2.94	126.71	2214	2510	2125	2283
SE+	1.63	0.02	0.24	0.41	0.02	1.24	38.42	32.97	44.25	22.20
CD at 5%	4.74	0.06	0.71	1.20	0.63	3.62	111.96	96.11	128.95	64.70
Sub plot : Fertilizer levels (4)										
F1 : 80 : 40 : 40 NPK kg ha^{-1}	140.19	1.73	19.14	40.55	2.73	111.38	1918	2211	1896	2008
F2 : 100 : 50 : 50 NPK kg ha^{-1}	144.97	1.86	19.85	42.35	2.82	118.63	2066	2362	2000	2143
F3 : 120 : 60 : 60 NPK kg ha^{-1}	147.65	1.95	20.50	44.21	2.89	124.26	2213	2514	2081	2269
F4 : 140 : 70 : 70 NPK kg ha^{-1}	149.64	2.00	21.03	44.62	2.95	128.40	2291	2572	2128	2330
SE+	1.26	0.02	0.20	0.60	0.02	1.68	43.38	42.67	34.42	20.65
CD at 5%	3.66	0.06	0.58	1.75	0.06	4.89	126.44	124.36	100.32	60.19
Interaction M x F										
SE+	2.51	0.04	0.40	1.20	0.04	3.35	86.77	85.34	68.84	41.30
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CV (%)	4.99	4.83	4.45	5.86	4.50	5.81	7.08	6.12	6.88	8.27
GM	145.61	1.89	20.14	42.93	2.85	120.67	2122	2415	2026	2188

Table 3. Economics *Bt* cotton hybrid as influenced by different treatments

Treatments	GMR (`ha^{-1})				NMR (`ha^{-1})				B:C ratio			
	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean
Main plot : Moisture conservation practices												
M1 : Control (Flat bed)	108422	125021	179136	137526	42962	55767	113164	70631	1.65	1.80	2.71	2.05
M2 : Opening of furrow at 60 DAS	116336	136330	196684	149783	48592	64228	128023	80281	1.71	1.89	2.86	2.15
M3 : Superabsorbent application @ 12.5 kg ha^{-1}	110884	131167	187237	143096	38855	54817	113952	69208	1.54	1.72	2.55	1.94
M4 : Broad bed and furrow	118437	137790	200182	152136	48414	62840	126222	79159	1.69	1.84	2.70	2.08
SE+	2055	1810	4167	1605	1748	1546	3817	1437	-	-	-	-
CD at 5%	5989	5275	12143	4678	5093	4507	N.S.	4189	-	-	-	-
Sub plot : Fertilizer levels (4)												
F1 : 80 : 40 : 40 NPK kg ha^{-1}	102591	121394	178581	134189	36464	51691	110895	66350	1.55	1.74	2.64	1.98
F2 : 100 : 50 : 50 NPK kg ha^{-1}	110553	129665	188333	142850	42535	57535	118654	72908	1.63	1.80	2.70	2.04
F3 : 120 : 60 : 60 NPK kg ha^{-1}	118393	138028	195968	150796	48493	63459	124480	78811	1.69	1.85	2.74	2.09
F4 : 140 : 70 : 70 NPK kg ha^{-1}	122542	141221	200357	154707	51331	64966	127332	81210	1.72	1.85	2.74	2.10
SE+	2321	2343	3242	1335	1974	2001	2966	1181	-	-	-	-
CD at 5%	6764	6828	9447	3893	5752	5833	8645	3441	-	-	-	-
Interaction M x F												
SE+	4642	4685	6483	2671	3948	4003	5932	2362	-	-	-	-
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	-	-	-	-
CV (%)	7.08	6.21	6.88	4.17	15.29	11.67	8.53	5.46	-	-	-	-
GM	113520	132577	190810	145636	44706	59413	120340	74820	1.65	1.81	2.71	2.06

Table 4: Mean Ginning out turn (%), lint yield (kg ha^{-1}) and harvest index as influenced by different treatments

Treatments	GOT (%)	Lint yield (kg/ha)	UHML (mm)	Micronaire (µg/inch)	Uniformity index (%)	Tenacity (g tex-1)	Elongation (%)
Main plot : Moisture conservation practices							
M1 : Control (Flat bed)	33.45	692	25.41	4.61	82.33	24.54	5.55
M2 : Opening of furrow at 60 DAS	33.77	759	25.53	4.64	82.50	24.79	5.58
M3 : Superabsorbent application @ 12.5 kg ha^{-1}	33.63	723	25.55	4.63	82.46	24.65	5.56
M4 : Broad bed and furrow	33.83	773	25.58	4.64	82.58	24.74	5.58
SE+	0.39	4.73	0.09	0.05	0.36	0.09	0.03
CD at 5%	N.S.	13.79	N.S.	N.S.	N.S.	N.S.	N.S.
Sub plot : Fertilizer levels (4)							

F1 : 80 : 40 : 40 NPK kg ha^{-1}	33.49	672	25.21	4.63	81.83	24.39	5.54
F2 : 100 : 50 : 50 NPK kg ha^{-1}	33.59	720	25.44	4.64	82.29	24.65	5.56
F3 : 120 : 60 : 60 NPK kg ha^{-1}	33.74	766	25.67	4.62	82.75	24.79	5.57
F4 : 140 : 70 : 70 NPK kg ha^{-1}	33.86	789	25.76	4.63	83.00	24.88	5.59
SE+	0.30	8.04	0.13	0.02	0.28	0.13	0.02
CD at 5%	N.S.	23.44	N.S.	N.S.	0.80	N.S.	N.S.
Interaction M x F							
SE+	0.58	16.08	0.26	0.04	0.55	0.26	0.05
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CV (%)	4.53	5.78	2.74	1.47	2.16	1.81	1.44
GM	33.67	737	25.52	4.63	82.47	24.68	5.57

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