Growth and Yield of Bt Cotton Influence by Land Configuration and Nutrient Levels Under Rainfed Situation

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ABSTRACT

A field experiment was conducted at main agriculture research station, Raichur (Karnataka, India) during *Kharif* 2016 to enhance the yield of Bt cotton and improve the economy of farmers under the rainfed situation. The experiment was laid out in split plot design with three land configuration practices as main plots and four different combinations of an organic and inorganic source of nutrients as subplots replicated thrice. The results showed that, significantly higher seed cotton yield (2834 kg ha^{-1}) were recorded with land configuration practice of Ridges and Furrow method in conjunction with application of 90:45:45 NPK kg ha^{-1} (50% N through organic) when compared to Broad Bed and Furrow method and Flat Bed methods and their respective combination with different source of nutrients. This trend was also reflected in dry matter accumulation in various plant parts (leaves, stem and reproductive organs). The combined effect of Ridges and Furrow method and application of 90:45:45 NPK kg ha^{-1} (50% N through organic) also resulted in recording higher gross (Rs.1,53,018 ha^{-1}) and net returns (Rs.1,07,67 ha^{-1}) when compared to other treatment combinations. Therefore it was concluded that, land configuration practice of Ridges and Furrow method in combination with the application of 90:45:45 NPK kg ha^{-1} (50% N through organic) was found to be the best option to realise higher seed cotton yield and more economical.

Keywords: Bt cotton, land configurations, Ridges and furrows, Broad bed and grooves and flatbed, Nutrient levels, organic and inorganic

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an essential fibre crop of India and cotton is often called as white gold. Commercial crop extensively grown in India and Karnataka and it is backbone of textile industries mainly because of its lint. India contributes 85 percent of raw material to the textile industry, and it earns about 33 percent of total foreign exchange (Anonymous, 2016). In India, cotton was cultivated in an area of 11.88 m ha with a production of 35.2 million bales of seed cotton during 2015-16. Average productivity of cotton in India is 504 kg lint ha^{-1}, which is lower when compared to the world average of 725 kg lint ha^{-1}. Cotton is grown in 7.8 m ha in 296 districts of which 5.1 m ha is rainfed in sixteen states of the country and about 85 percent of the rainfed cotton is grown in 30 districts (4.1 m ha). Karnataka ranks the fifth in area with 6.12 lakh ha and the fourth in production with 20 lakh bales of lint and fifth in productivity with an average lint productivity of 556 kg per ha [1]. Rainfed regions are not only thirsty but also, hungry because these characterized by low and erratic behaviour of rainfall with uneven periodicity and distribution, high temperature, eroded and degraded soils with low available water, multi-nutrient deficiencies and weak base of the farmers which are main constraint resulting in small and unstable crop performance. There is an urgent need for more efficient rainwater harvesting and its maximum utilization for higher farm productivity. Besides, economics, cropping on these low fertile and multi-nutrient deficient soils must be addressed through selection and optimization of appropriate nutrient management strategies coupled with soil health improvement.

2. MATERIAL AND METHODS

A Field experiment was conducted during the *Kharif* 2016 at Main agriculture research station, University of Agricultural Sciences, Raichur, Karnataka situated at $16^0 12^1$ N latitude, $77^0 20^1$ E longitude and 389 meters above mean sea level and is located in North Eastern Dry Zone of Karnataka. The experiment was laid out in split plot design with three main plots includes different *in-situ* moisture conservation practices (**M_1**:Broad bed and furrows, M_2: ridges and furrows and M_3: flatbed) and four sub plots with different source of nutrient levels (S_1: 60:30:30 NPK kg ha^{-1}, S_2: 90:45:45 NPK kg ha^{-1}, S_3: 60:30:30 NPK kg ha^{-1} (50% N through organic), S_4: 90:45:45 NPK kg ha^{-1} (50% N through organic)). The hybrid KCH14K59 BG-II (Jaadoo) was used in the study. The soil of the experimental site was deep black and clay in texture with the available nitrogen (192 kg ha^{-1}), phosphorus (30.20 kg ha^{-1}), potassium (207.42 kg ha^{-1}), organic carbon content (0.50 %). Land was ploughed once with mould board plough and then harrowed twice to bring the soil into fine tilth followed by , three land configurations such as broad bed and furrows, flat bed and ridges and furrows was laid out as per the treatments. Four levels of fertilizer dose namely 60:30:30 NPK kg ha^{-1}, 90:45:45 NPK kg ha^{-1}, 60:30:30 NPK kg ha^{-1} (50% N through organic) and 90:45:45 NPK kg ha^{-1} (50% N through organic) were applied to the plots as per the treatments. The entire dose of nitrogen, phosphorous and potassium in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively were band placed at 4-5 cm deep and 5 cm away from the seed. The entire dose of fertilizers applied as basal .. The 50% of nitrogen was applied through FYM before sowing of cotton as per treatments. Sowing was done by dibbling with spacing of 90×60 cm on 20th July, 2016 and each plot size 7.2×4.8m. Two pickings were made on 8th and 21st January, 2017, respectively. At each picking, the numbers of good and bad opened bolls from the tagged plants were counted. Fisher's method of analysis of variance was applied for analysis and interpretation of the data. The level of significance used in 'F' test was at 5% ($P = 0.05$). Critical difference values were calculated wherever 'F' was significant.

3. RESULTS AND DISCUSSION

EFFECT OF LAND CONFIGURATION AND EFFECT OF NUTRIENT LEVELS

DRYMATTER ACCUMULATION

Dry matter accumulation and its partitioning is one of the most important parameters that have a marked influence on final realization of crop. In the present study, distribution of drymatter into different parts revealed significant difference with land configurations (Table 1). Ridges and furrow had significant effect on drymatter accumulation in leaves, stem and reproductive parts (110.31, 136.38 and 127.86 g $plant^{-1}$, respectively) compared to flatbed (99.26, 126.35 and 117.15 g $plant^{-1}$, respectively) at harvest. Higher drymatter accumulation in leaves, stem and reproductive parts was due to better soil moisture availability to the crop under ridge and furrow method at all growth stages [2].

In the present investigation revealed the positive effect on integration of nutrients and organics on yield maximization. Dry matter accumulation in leaves, stem and reproductive part was significantly higher with application of 90:45:45 NPK kg ha^{-1} (50% N through organic) (109.33, 135.16 and 126.91 g, respectively). Lower dry matter production and accumulation in leaves, stem and reproductive part were recorded with application of 60:30:30 NPK kg ha^{-1} (100.17, 127.57 and 117.98 g, respectively) (Table 1). The beneficial effect of organic manures in increasing dry matter accumulation is well documented by [5] and [6].

YIELD PARAMETERS

Seed cotton yield was significantly influenced by the *in-situ* moisture conservation practises wherein significantly higher seed cotton was recorded with ridges and furrows (2403 kg ha^{-1}) over broad bed and furrow (2222 kg ha^{-1}) and flat bed (conventional method) (1743 kg ha^{-1}) (Table 2). These results are in conformity with findings of [3], [4] and [2]. Seed cotton yield in turn is governed by several factors, which have a direct or indirect bearing on yield. The factors which have much influence on seed cotton yield are yield components like number of good bolls per plant, bad bolls per plant and boll weight (Table 2). Significantly higher number of good bolls per plant and boll weight (g) were recorded with ridges and furrows (30.30 and 5.48, respectively) while significantly lower number of good bolls per plant and boll weight (g) were recorded with the conventional flatbed method (25.21 and 4.12 respectively). Lower bad opened significantly lower with ridges and furrows (5.18) and it was on par with broad bed and furrow (5.34) and higher bad bolls were recorded with flat bed (6.40). Improvement in growth and yield with ridges and furrow method of land configuration could be attributed to conservation of in-field run-off of water during the season and enhanced entry of rain water into the soil profile for crop use. The resulting improved soil moisture status in the rooting profile helps crop growth, and the method suits especially for Vertisols [9].

Significantly higher seed cotton yield was recorded with 90:45:45 NPK kg ha^{-1} (50% N through organic - 2308 kg ha^{-1}) compared to 90:45:45 NPK kg ha^{-1}- 2148 kg ha^{-1}, 60:30:30 NPK kg ha^{-1} (50% N through organic) (2097 kg ha^{-1}) and 60:30:30 NPK kg ha^{-1} (1937 kg ha^{-1}). The increase in seed cotton yield over inorganic alone was 13 to 45 per cent [5], [7] and [8]. This may be ascribed to its rapid mineralization and release of nutrients for crop plants. Apart from this, abundant supply of nutrients through organic and inorganic might have increased the protoplasmic constituents and accelerated the process of cell division and elongation. This in turn might have increased the values of growth and yield contributing attributes, which is reflected in seed cotton yield. Seed cotton yield per hectare was mainly influenced by growth factors like good opened bolls per plant, bad number of bolls per plant and boll weight (Table 2). Application of 90:45:45 NPK kg ha^{-1} (50% N through organic) recorded significantly higher good opened bolls per plant and boll weight and lower bad opened bolls per plant (30.12, 5.50 g and 5.31, respectively), lower number of good opened bolls per plant and boll weight and higher number of bad opened bolls were recorded with application of 60:30:30 NPK kg ha^{-1} (26.21, 4.80 g and 6.26 respectively). All the growth parameters had positive impact on yield and yield components. All the growth attributing characters were higher during all the stages of crop growth due to the combined application of 50% N through organic as compared to NPK alone.

INTRACTION EFFECT OF LAND CONFIGURATION AND NUTRIENT LEVELS

Cotton being long duration crop needs moisture and balanced nutrients for longer periods especially in rainfed areas to express its potential. There is a linear relation between moisture and availability of nutrients and, therefore, availability of nutrients for has to be enhanced through *in-situ* moisture conservation practices in addition to integrated nutrient management using optimum levels of fertilizers. Dry matter accumulation in leaves, stem and reproductive parts significantly influenced by different land configuration practices with nutrient levels (Table 1). Ridges and furrows with application of 90:45:45 NPK kg ha^{-1} (50% N through organic) were recorded significantly higher dry matter accumulation in leaves, stem and reproductive parts (116.64, 141.44 and 136.50 g plant^{-1}, respectively) (Table 1). Flatbed with application of 60:30:30 NPK kg ha^{-1} recorded significantly lower accumulation in leaves, stem and reproductive parts (98.53, 124.23 and 114.85 g plant^{-1}, respectively). Land configuration involving ridges and furrows along with application of 90:45:45 NPK kg ha^{-1} (50% inorganic and 50% organics) recorded significantly higher good opened bolls and seed cotton yield (31.90 and 2834 kg ha^{-1}), while lower good opened bolls and seed cotton yield were recorded with conventional flat bed system along with application of 60:30:30 NPK kg ha^{-1} (22.53 and 1694 kg ha^{-1}) (Table 2). Farm yard manure served both as slow releasing nutritional source and as moisture retainer attributed to organic matter directly and indirectly through improvement in soil structure which is so critical in deep black soils. Ridges and furrow reduces the runoff and provide more opportunity time for infiltration. Increase in moisture with the former treatments could be ascribed to effectiveness of ridges and furrow system of moisture conservation and applied FYM [9].

ECONOMICS

Economics is the ultimate criteria for acceptance and wider adoption of any technology. Among different indicators of economic efficiency in any production system, where the net return has a greater impact on the practical utility and acceptance of the technology by the farmers. In all the treatments same cultural practices and plant protection measures were applied except the cost of the technology about which the investigation was intended to carry out.

The economic analysis of different treatments in the study indicated that the total gross returns, net returns and B:C recorded were significantly higher in treatment with ridges and furrows (□ 129740 ha^{-1}, □ 88082 ha^{-1} and 3.10, respectively) followed by broad bed furrows (□ 119979 ha^{-1}, □ 78321 ha^{-1} and 2.88) and significantly lower values were recorded with flatbed (□ 94140 ha^{-1}, □ 54983 ha^{-1} and 2.41). Similar findings were reported earlier by [5] and [6] (Figure 1).

Among different nutrient levels gross and net return was significantly higher in the treatment with application of 90:45:45 NPK kg ha^{-1} (50% N through organic) (□ 124658 and 104577 ha^{-1}, respectively) while lower return was recorded with application of 60:30:30 NPK kg ha^{-1} (□ 104577 and 66640 ha^{-1}, respectively).
Combination of ridges and furrow along with application of 90:45:45 NPK kg ha^{-1} (50% N through organic) was recorded significantly higher gross and net returns (□ 1,53,018 ha^{-1} and □ 1,07,674 ha^{-1}, respectively), while lower gross returns was recorded in flatbed with 60:30:30 NPK kg ha^{-1} (□ 91478 ha^{-1} and 52556 ha^{-1}).

Table 1. Dry matter accumulation in leaves, stem and reproductive parts (g plant^{-1}) of *Bt* cotton at different growth stages as influenced by land configuration and nutrient levels

Treatment	Dry matter accumulation in different parts of plant											
	Dry matter accumulation in leaves (g plant^{-1})				Dry matter accumulation in stem (g plant^{-1})				Dry matter accumulation in reproductive parts (g plant^{-1})			
	Main plot											
Sub plot	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	100.30	101.68	98.53	100.17	128.47	130.02	124.23	127.57	119.50	119.57	114.85	117.98
S_2	107.91	113.21	99.48	106.87	134.35	138.89	127.21	133.48	124.24	129.97	118.20	124.13
S_3	101.87	109.69	99.09	103.55	134.03	135.18	126.23	131.81	120.93	125.40	117.27	121.20
S_4	111.40	116.64	99.94	109.33	136.29	141.44	127.74	135.16	125.93	136.50	118.30	126.91
Mean	105.37	110.31	99.26		133.29	136.38	126.35		122.65	127.86	117.15	
Source of variance	S. Em.±		C.D. at 5%		S. Em.±		C.D. at 5%		S. Em.±		C.D. at 5%	
M	0.30		1.17		0.63		2.46		1.03		4.06	
S	1.13		3.37		0.56		1.66		1.06		3.16	
S at same level of M	1.96		5.84		0.97		2.88		1.84		5.47	
M at same or different level of S	1.73		5.13		1.05		3.11		1.90		5.65	

NOTE: NS - Not significant DAS: Days after sowing

Main plots: *In-situ* moisture conservation practices (M)

M_1: Broad bed and furrows (BBF)

M_2: Ridges and furrows (R&F)

M_3: Flatbed

Sub plots: Nutrient management (S)

S_1: 60:30:30 NPK kg ha^{-1}

S_2: 90:45:45 NPK kg ha^{-1}

S_3: 60:30:30 NPK kg ha^{-1} (50% N through organic)

S_4: 90:45:45 NPK kg ha^{-1} (50% N through organic)

Table 2. Yield parameters of *Bt* cotton as influenced by land configuration and nutrient levels

Treatment	Yield parameters															
	Good opened bolls per plant				**Bad opened bolls per plant**				**Boll weight (g plant^{-1})**				**Seed cotton yield (kg ha^{-1})**			
	Main plot															
Sub plot	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	28.00	28.09	22.53	26.21	5.49	5.46	7.83	6.26	4.80	5.48	4.12	4.80	2046	2070	1694	1937
S_2	30.20	30.96	26.91	29.36	5.26	5.03	5.98	5.43	5.53	5.78	4.33	5.22	2287	2395	1763	2148
S_3	28.14	30.26	23.81	27.40	5.48	5.20	6.00	5.56	5.46	5.56	4.32	5.11	2230	2312	1750	2097
S_4	30.85	31.90	27.60	30.12	5.12	5.01	5.79	5.31	5.60	6.50	4.40	5.50	2325	2834	1767	2308
Mean	29.30	30.30	25.21		5.34	5.18	6.40		4.80	5.48	4.12		2222	2403	1743	
Source of variance	S. Em.±		C.D. at 5%		S. Em.±		C.D. at 5%		S. Em.±		C.D. at 5%		S.Em±		C.D. at 5%	
M	0.87		3.41		0.20		0.79		0.121		0.477		39.43		154.9	
S	0.22		0.67		0.18		0.53		0.109		0.323		53.78		159.8	
S at same level of M	0.39		1.16		0.31		NS		0.19		NS		93.16		276.8	
M at same or different level of S	0.93		2.77		0.33		NS		0.20		NS		89.80		266.8	

NOTE: NS - Not significant

Main plots: *In-situ* moisture conservation practices (M)

M_1: Broad bed and furrows (BBF)

M_2: Ridges and furrows (R&F)

M_3: Flatbed

Sub plots: Nutrient management (S)

S_1: 60:30:30 NPK kg ha^{-1}

S_2: 90:45:45 NPK kg ha^{-1}

S_3: 60:30:30 NPK kg ha^{-1} (50% N through organic)

S_4: 90:45:45 NPK kg ha^{-1} (50% N through organic)

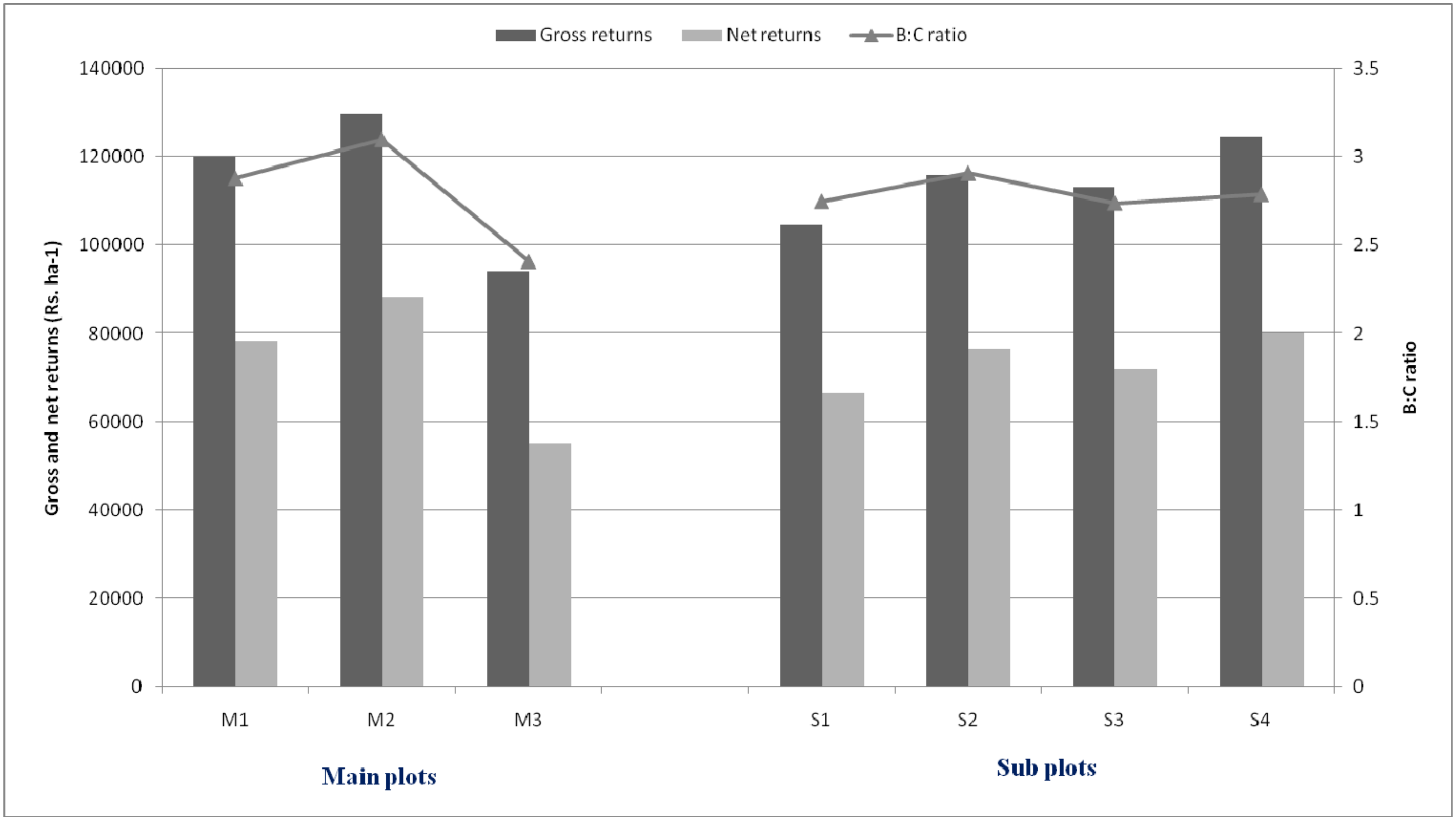

Fig. 1. Economics of *Bt* cotton as influenced by land configuration and nutrient levels

4. CONCLUSION

Ridges and furrows, application of 90:45:45 NPK kg ha^{-1} (50% N through organic) and there interaction effect recorded better growth, yield and economic parameters over the broad bed and furrow and flat bed.

COMPETING INTERESTS

"Authors have declared that no competing interests exist."

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