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Effect of different plant geometry and canopy management practices on dry matter distribution and NPK uptake of *Bt* cotton under drip irrigation

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Abstract
The present study was carried out during *kharif* season of 2024-2025 at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharastra to investigate the effect of different plant geometry and canopy management practices on NPK uptake of *Bt* cotton under drip irrigation. The experiment was laid out in a Factorial Randomized Block Design (RBD) having 3 replications with 12 different treatment combinations. These treatments included three different plant geometry viz., 90 cm x 15 cm (S_1), 90 cm x 30 cm (S_2), and 90 cm x 45 cm (S_3). For canopy management, there were four treatments: Control (C_1), monopodial removal at 45-50 DAS and detopping at 100 cm plant height (C_2), monopodial removal at 45-50 DAS and one spray of mepiquat chloride @ 25 g a.i. at 60-65 DAS (C_3), and two sprays of mepiquat chloride @ 25 g a.i. at 45-50 DAS and 60-65 DAS (C_4) and recommended dose of fertilizer (RDF) @ 120:60:60 N:P_2O_5:K_2O kg/ha. The results showed that plant geometry of 90 cm x 15 cm was recorded highest dry matter distribution in leaves, stem and fruiting body (35.13 g, 138.79 g, 125.69 g) and NPK uptake (119.74 kg ha^{-1}, 37.37 kg ha^{-1} and 88.88 kg ha^{-1}) over 90 cm x 30 cm, and 90 cm x 45 cm plant spacing. Among different canopy management practices treatment C_2 (as monopodia removal at 45-50 DAS and detopping at 100 cm plant height) recorded significantly highest dry matter distribution in leaves, stem and fruiting body (53.06 g, 180.10 g 150.95 g) and NPK uptake (119.20 kg ha^{-1}, 37.37 kg ha^{-1} and 87.97 kg ha^{-1}) over other canopy management practices and lowest dry matter distribution in leaves stem and fruiting body (42.75 g, 160.30 g, 118.90 g) and NPK uptake (89.95 kg ha^{-1}, 27.10 kg ha^{-1} and 68.79 kg ha^{-1}) observed in C_1 treatment.

Keywords: Plant geometry, canopy management, drip irrigation, detopping, mepiquat chloride (MC), monopodia removal

Introduction
Cotton (*Gossypium* spp.) popularly known as white gold and is an important crop for the rural economy of India and livelihood of the Indian farming community. Presently India ranks first in area and second in production of cotton in the world (Anonymous, 2024). Cotton is an important cash crop of India occupying an area of 31.1 million ha with a production of 117.40 million bales, each weighing 217.72 kg (ICAC, COCPC meeting Report, 2024). The production and productivity of cotton can be increased by the introduction of high yielding varities coupled with optimum plant geometry and suitable canopy management practices like detopping and removal of monopodia and spraying of growth retardant like mepiquat chloride (Thokale *et al.*, 2004) [24]. In addition to this, role of plant growth regulators is very important in maintaining proper ratio of vegetative and reproductive structures under excessive vegetative growth situations to obtain higher fruiting bodies contributing the higher dry matter per plant.
Highest dry matter accumulation in plant observed in fruiting bodies might be attributed to the improvement in the assimilation of photosynthates under monopodia removal at 45-50 DAS and detopping at 100 cm plant height because of resources benefit compared to other treatments. This might be due to efficient utilization of moisture, nutrients and sunshine by cotton crop with proper aeration in the root zone, which enabled crop plants to explore their maximum potential in the absence of monopodial branches (i.e vegetative branches) as well as due to detopping practice, that enhance availability and uptake of nutrients to enhance

photosynthesis and translocation of nutrients to reproductive parts thus increasing dry matter accumulation per plant. Similar results were recorded by Shwetha *et al.* (2009) [20], Hallikeri *et al.* (2010) [11], Kataria and Valu (2018) [15], Chaudhari *et al.* (2021) [8].

Agriculture is by far the largest (81%) water consumer in India (WRI, 2007) [25] and hence more efficient use of water in agriculture needs to be the top most priority. Water input per unit irrigated area will have to be reduced in response to water scarcity and environmental concerns (INCID, 2006) [13].

Materials and Methods

The present experiment was carried out in growing season *kharif* 2024-25 at Cotton research Unit Dr. Panjabrao Deshmukh Krushi Vidyapeeth, Akola, Maharashtra. The experimental site was located at 20.7039246 N and 77.0655831 E. The soil of experimental site was slightly saline in texture with pH (8.10), available nitrogen (214 kg ha^{-1}), available phosphorus (16.80 kg ha^{-1}) and available potassium (308 kg ha^{-1}) during experimental study. The present experiment was laid out in Factorial Randomized Block Design with 12 treatment combination replicated thrice. The treatment detail was, factor I is different plant geometry viz., 90 cm x 15 cm (S_1), 90 cm x 30 cm (S_2) and 90 cm x 45 cm (S_3) and factor II is four canopy management treatment is used namely, Control (C_1), Monopodia removal of at 45-50 DAS and detopping at 100 cm plant height, Monopodia removal at 45-50 DAS and one spray of mepiquat chloride @ 25 g a.i. at 60-65 DAS (C_3) and Two spray of mepiquat chloride 25 g a.i. at 45-50 DAS and 60-65 DAS.

Effect of plant geometry

The plant geometry of 90 cm x 45 cm plant spacing recorded significantly higher dry matter distribution to different plant parts as well as total dry matter accumulation $plant^{-1}$ over 90 cm x 15 cm and 90 cm x30 cm, at all the crop growth stages.

Difference in dry matter production $plant^{-1}$ among plant geometry, might be due to dry matter accumulation and distribution in different plant parts depend on photosynthetic ability of plant which in turn dependence on dry matter accumulation in leaves, stem, and reproductive parts, leaf area and leaf area index, Similar results were reported by Shwetha *et al.* (2009) [20], Hallikeri *et al.* (2010) [11], Kataria and Valu (2018) [15], Dodiya *et al.* (2018) [10] and Chaudhari *et al.* (2021) [8].

Result and Discussion

The results and discussion of the present study have been summarized under following heads:

A. Dry matter distribution per plant

Table 1(a): Dry matter partitioning $plant^{-1}$ (g) of as influenced by different plant geometry and canopy management practices under drip irrigation.

Treatments	30 DAS			60 DAS				90 DAS			
	Leaves	Stem	Total dry matter	Leaves	Stem	Fruiting bodies	Total dry matter	Leaves	Stem	Fruiting bodies	Total dry matter
I. Plant geometry											
S_1 : 90 cm x 15 cm	8.35	4.38	12.73	50.04	45.35	13.45	108.84	87.14	66.60	130.43	284.17
S_2 : 90 cm x 30 cm	8.86	4.56	13.42	54.64	46.77	15.80	117.21	94.00	75.50	136.34	305.84
S_3 : 90 cm x 45 cm	9.63	5.43	15.06	57.10	49.81	19.54	126.45	95.31	76.30	144.48	316.09
SE (m) ±	0.20	0.16	0.39	1.92	1.21	0.70	2.86	2.30	2.72	1.87	4.50
CD at 5%	0.58	0.45	1.15	5.64	3.54	2.05	8.38	6.76	8.00	5.49	13.20
II. Canopy management practices											
C_1 : Control	9.06	4.96	14.02	61.80	53.77	15.48	131.05	101.41	88.57	129.04	319.02
C_2 : Monopodia removal at 45-50 DAS and detopping at 100 cm plant height	8.74	4.88	13.62	57.60	49.60	18.64	125.84	84.50	71.52	148.03	304.04
C_3 : Monopodia removal at 45-50 DAS and spraying of mepiquat chloride @ 25 g a.i. at 60-65 DAS	9.01	4.84	13.85	50.12	45.45	14.72	110.29	97.03	67.35	133.44	297.82
C_4 : Two sprays of mepiquat chloride @ 25 g a.i. at 45-50 DAS and 60-65 DAS	8.98	4.61	13.59	46.19	40.41	16.20	102.80	85.67	63.74	137.83	287.24
SE (m) ±	0.23	0.18	0.45	2.22	1.39	0.81	3.30	2.66	3.15	2.16	5.20
CD at 5%	NS	NS	NS	6.51	4.09	2.37	9.68	7.80	9.24	6.34	15.25
Interaction(SXC)											
SE (m) ±	0.40	0.31	0.78	3.85	2.41	1.40	5.72	4.61	5.46	3.74	9.00
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	8.95	4.82	13.77	53.93	47.31	16.26	117.46	92.15	72.80	137.08	302.03

Table 1 (b): Dry matter partitioning plant^{-1} (g) of as influenced by different plant geometry and canopy management practices under drip irrigation.

Treatments	120 DAS				At harvest			
	Leaves	Stem	Fruiting bodies	Total dry matter	Leaves	Stem	Fruiting bodies	Total dry matter
I. Plant geometry								
S_1 : 90 cm x 15 cm	57.47	98.33	212.40	368.20	35.13	138.79	125.69	299.60
S_2 : 90 cm x 30 cm	65.16	110.20	225.26	400.62	49.15	179.80	136.27	365.23
S_3 : 90 cm x 45 cm	71.65	118.41	233.64	423.70	54.64	194.43	142.97	395.03
SE (m) ±	2.01	2.39	4.28	5.17	1.84	3.06	3.68	5.54
CD	5.89	7.02	12.55	15.16	5.40	8.99	10.80	16.24
II. Canopy management practices								
C_1 : Control	59.14	103.84	210.01	372.99	42.75	160.30	118.90	321.95
C_2 : Monopodia removal at 45-50 DAS and detopping at 100 cm plant height	68.87	115.43	239.95	424.25	53.06	180.10	150.95	386.20
C_3 : Monopodia removal at 45-50 DAS and spraying of mepiquat chloride @ 25 g a.i. at 60-65 DAS	66.37	110.51	221.08	397.96	45.57	174.72	131.95	354.46
C_4 : Two spray of mepiquat chloride @ 25 g a.i. at 45-50 DAS and 60-65 DAS	64.66	106.14	224.02	394.82	43.85	168.91	138.11	350.54
SE (m) ±	2.32	2.76	4.94	5.97	2.12	3.54	4.25	6.39
CD	6.80	8.11	14.49	17.50	6.23	10.38	12.47	18.75
Interaction (S X C)								
SE (m) ±	4.01	4.79	8.56	10.34	3.68	6.13	7.36	11.07
CD	NS	NS	NS	NS	NS	NS	NS	NS
GM	64.76	108.98	223.77	397.51	46.31	171.01	134.98	353.29

Effect of canopy management practices

Accumulation of dry matter in different plant parts was significantly influenced by canopy management practices at all the dates of observations except, at 30 DAS for leaf, stem and fruiting bodies dry matter.

At 60, 90 DAS, control treatment (C_1) recorded significantly higher dry matter accumulation of leaves (61.80 g and 101.41 g) and stem dry matter (53.77 and 88.57 g) over all the other treatments. However, treatment C_2 (Monopodia removal at 45-50 DAS and detopping at 100 cm plant height) showed significantly higher dry matter in terms of fruiting bodies (18.64 g and 148.03 g) over other treatments, which was followed by C_4 treatment (two spray of mepiquat chloride @ 25 g a.i. at 45-50 DAS and 60-65 DAS).

At 120 DAS and at harvest, control treatment (C_1) showed superior over all the treatments in accumulation of highest dry matter of leaves and stem. However, among the other canopy management practices, treatment C_2 and C_3 shows significantly minimum dry matter of leaf and stem. This might be due to removal of monopodial branches at 60 DAS, which reduced the number of functional leaves well as stem compared to other treatments.

Among the other treatments, C_2 (monopodia removal at 45-50 DAS and detopping at 100 cm plant height) recorded significantly highest dry matter of fruiting bodies, which was followed by treatment C_4 (two spray of mepiquat chloride @ 25 g a.i. at 45-50 DAS and 60-65 DAS) at 120 DAS and at harvest.

Highest dry matter accumulation in fruiting bodies might be attributed to the improvement in the assimilation of photosynthates under monopodia removal at 45-50 DAS and detopping at 100 cm plant height because of resources benefit compared to other treatments. This might be due to efficient utilization of moisture, nutrients and sunshine by cotton crop with proper aeration in the root zone, which enabled crop plants to explore their maximum potential in the absence of monopodial branches (i.e vegetative branches) as well as due to detopping practice, that enhance availability and uptake of nutrients to enhance photosynthesis and translocation of nutrients to reproductive parts thus increasing dry matter accumulation per plant. Similar results were recorded by Shwetha *et al.* (2009) [20], Hallikeri *et al.* (2010) [11], Kataria and Valu (2018) [15], Chaudhari *et al.* (2021) [8].

Interaction

The data on dry matter distribution to different parts plant^{-1} of *Bt.* cotton was not influenced significantly due to the interaction effect between different plant geometry and different canopy management practices.

Nutrient Uptake

Nitrogen uptake

Nitrogen uptake The data revealed that, the different plant gerometry on nitrogen uptake was influenced significantly among the treatments. The plant grometry 90 cm x 15 cm recorded highest nitrogen uptake (119.74 N kg ha^{-1}), which was followed by 90 cm x 30 cm and 90 cm x 45 cm (104.09 and 93.39 N kg ha^{-1}) it might be due to higher plant population in closer spacing. Among different canopy management practices, the maximum uptake of nitrogen recorded in C_2 treatment i.e. monopodia removal at 45-50 DAS and detopping at 100 cm plant height (119.20 N kg ha^{-1}), followed by C_4 and C_2, where biological yield was maximum. Minimum uptake of nitrogen (89.95 kg ha^{-1}) by crop was recorded with control treatment (C_1), where no canopy management practices were done during experiment. It might be due high dry matter production and yield. Similar finding was reported by Norton *et al.* (2005) [17].

Phosphorous uptake

Phosphorus uptake in different plant geometry was strongly influenced by Bt. Cotton hybrid. The highest phosphorus uptake (37.37 P kg ha^{-1}) was reported in closer plant spacing of 90 cm x 15 cm (S_1) followed by wider plant spacing of 90 cm x 30 cm (S_2) and 90 cm x 45 cm (S_3) (31.62 and 28.28 P kg ha^{-1}). It might be due to maximum plant population obtained in closer plant spacing. The phosphorus uptake by

plant was influenced significantly due to different canopy management practices. The phosphorus by plant was significantly higher (37.37 P kg ha^{-1}) under monopodia removal at 45-50 DAS and detopping at 100 cm plant height (C_2) than rest of treatments. However, which was followed by C_4 and C_3 treatment (Norton *et al.*, 2005) [17].

Potassium uptake

Among the different plant geometry, potassium uptake by plant was influenced significantly among the treatments. Significantly maximum potassium uptake by plant was recorded in closer plant spacing of 90 cm x 15 cm (88.88 K kg ha^{-1}), as compared to wider plant spacing of 90 cm x 30 cm and 90 cm x 45 cm (77.26 and 71.23 K kg ha^{-1}). The maximum uptake of potassium (87.97 K kg ha^{-1}) by Bt cotton was found with treatment monopodia removal at 45-50 DAS and detopping at 100 cm plant height (C_2) over all the other treatments, which is followed by C_4 and C_3 treatment (83.72 and 76.02 K kg ha^{-1}). Minimum uptake of potassium by crop (68.79 K kg ha^{-1}) was recorded with control treatment, where no canopy management practices (Norton *et al.*, 2005) [17].

Table 2: Uptake of NPK (kg ha^{-1}) by cotton crop as influenced by different plant geometry and canopy management practices under drip irrigation.

Treatment	Seed (kg ha^{-1})	Stalk (kg ha^{-1})	Total N uptake (kg ha^{-1})	Seed (kg ha^{-1})	Stalk (kg ha^{-1})	Total P uptake (kg ha^{-1})	Seed (kg ha^{-1})	Stalk (kg ha^{-1})	Total K uptake (kg ha^{-1})
I. Plant geometry									
S_1 :90 cm x 15 cm	83.80	35.94	119.74	22.65	14.72	37.37	31.94	56.93	88.88
S_2 : 90 cm x 30 cm	72.47	31.55	104.02	19.25	12.37	31.62	27.43	49.83	77.26
S_3 : 90 cm x 45 cm	62.94	30.45	93.39	16.77	11.51	28.28	23.54	47.69	71.23
SE (m) ±	1.68	1.21	2.50	0.54	0.58	1.05	0.62	1.81	2.13
CD at 5%	4.92	3.55	7.34	1.57	1.71	3.08	1.83	5.32	6.26
II. Canopy management practice									
C_1 : Control	61.10	28.85	89.95	16.06	11.05	27.10	22.78	46.00	68.79
C_2 : Monopodia removal at 45-50 DAS detopping at 100 cm plant height	83.50	35.70	119.20	22.75	14.52	37.27	31.97	56.00	87.97
C_3 : Monopodia removal at 45-50 DAS and one spray of mepiquat chloride @ 25 g a.i. at 60-65 DAS	69.74	31.88	101.62	18.37	12.12	30.49	26.17	49.84	76.02
C_4 : Two spray of mepiquat chloride @ 25 g a.i. at 45-50 DAS and 60-65 DAS	77.95	34.15	112.10	21.04	13.78	34.82	29.63	54.10	83.72
SE (m) ±	1.94	1.40	2.89	0.62	0.67	1.21	0.72	2.09	2.47
CD at 5%	5.68	4.10	8.47	1.81	1.98	3.56	2.12	6.14	7.23
Interaction (S X C)									
SE(m) ±	3.36	2.42	5.00	1.07	1.17	2.10	1.25	3.63	4.27
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	73.00	32.65	105.72	19.55	12.87	32.42	27.64	51.48	79.12

Conclusion

Based on above data, it could be concluded that plant spacing 90 cm x 15 cm had better dry matter production than 90 cm x 30 cm and 90 cm 45 c. under drip irrigation. As well as canopy management practices like monopodial removal at 45-50 DAS detopping at 100 cm plant height had advantage to produce higher dry matter than no or other canopy management practices. In case of NPK uptake of plant 90 cm x 15 cm plant spacing observed higher NPK uptake than 90 cm x 30 cm and 90 cm x 45 cm. In canopy management practices monopodia removal at 45-50 DAS and detopping at 100 cm plant height (C_2) observed significantly highest available NPK than other canopy management practices.

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