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Response of nutrients in *Bt* cotton as influenced by SSNM, methods of crop establishment and dates of sowing

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Abstract
A field experiment was conducted at Agronomy Farm, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka with the objective to know the uptake pattern of NPK with respect to methods of establishment and varied dates of sowing in *Bt* cotton in the TBP irrigation command. Uptake of N, P and K was significantly higher in transplanting method (191, 49.6 and 201 kg/ha, respectively) compared to dibbling method of sowing (181, 46.8 and 190 kg/ha, respectively). Among the varied dates of sowing, significantly higher N, P and K uptake was observed with crop sown on 1st fortnight of June (238, 51.8 and 211 kg/ha, respectively) when compared with crop sown in 1st fortnight of August (123, 43.6 and 171 kg/ha, respectively). As a result of this, significantly higher seed cotton yield was observed with transplanting method in the early days of June month. From these results, we can conclude that early transplanting in the month of June leads *Bt* cotton to uptake higher amount of NPK that results ultimately to higher seed cotton yield especially in irrigation command area.

Keywords: *Bt* cotton, nutrient uptake, SSNM, crop establishment methods and sowing windows

Introduction
Karnataka, in India ranks fifth in area, fourth in production and fifth in productivity among the cotton growing states. *Bt* cotton is intensively cultivated in the North Eastern Dry Zone and Northern Dry Zone of the state (Zone 2 and 3) covering partly the Tungabhadra and Upper Krishna (TBP and UKP) irrigation Commands on black soil. The area under this crop in these commands has been increasing distinctly over the past decade. The average yields which hovered around 4.0 to 5.0 t ha^{-1} initially with the advent of *Bt* cultivars of late are either remaining stagnant of declining which is a deterrent to the farmers due to squeezing returns and hence needs special attention.

In the Northern Karnataka region, there are several reasons for the low yields in cotton such as imbalanced fertilizers application, late planting, and improper pest management etc. where the rainy season starts probably during second fortnight of June to as late as August. Therefore, there is very large yield gap between the average productivity of the country and of the region under the study. In this context, there is need for efforts to achieve higher nutrient uptake for achieving yield targets with balanced fertilization and appropriate method of planting maintaining the sustainability of the crop land.

Nutrient uptake is related to yield. Of all the elements, N, P and K are removed in greatest amounts. Site Specific Nutrient Management (SSNM) improved the plant uptake of N, P and K. Cotton particularly the hybrids are soil exhaustive crops and therefore, require heavy nutrient supplementation. Nutrient uptake, however, varies with cultivars, growing conditions and management practices. Halevy *et al*. (1987) [3] reported that the uptake by cotton was 267 and 332 N kg, 46 and 44 P_2O_5 kg, 208 and 251 K_2O kg per hectare at 120 and 180 N kg per hectare applications, respectively. Hence, with these ideas in view, the present study was undertaken to exploit the yield potentiality of *Bt* cotton by following important agro-technique such as method of crop establishment and varied dates of planting in TBP command.

Materials and Methods
On-station field study was conducted during *kharif* 2015 at Agronomy Farm, University of Agricultural Sciences, Raichur, Karnataka, India.

The soils are alkaline (p^H 8.2 by p^H meter, Piper, 1966) [6], non-saline (EC 0.24 dS/m by conductivity bridge, Jackson, 1967) [4], medium in organic Carbon (0.62% by wet oxidation method, Jackson, 1967) [4], low in available N (220 kg ha^{-1} by Alkaline potassium permanganate method, Subbaiah and Asija, 1956) [10], medium in P_2O_5 (31 kg ha^{-1} by Olsen's method, Jackson, 1967) [4] and high in K_2O (283 kg ha^{-1} by Flame photometry method, Jackson, 1967) [4]. Fertilizer N, P and K requirements were calculated by accounting the indigenous nutrient supply for a yield target of 5 t ha^{-1} (400:140:142.5 N:P_2O_5:K_2O kg ha^{-1}) and nutrient demand per ton of cotton lint yield as per set procedures of International Plant Nutrition Institute.

Ten treatment combinations consisted of transplanting and dibbling of cv. Jaadhu at five dates of planting viz., 1st and 2nd fortnights of June and July and 1st fortnight of August were laid out using Split plot design with three replications with a gross plot of 9 m x 6 m and spacing of 90 cm x 60 cm. 25 days old healthy seedlings were selected for transplanting in the experimental plot. The different nurseries were done for different dates of planting in such way that at the particular date of planting should coincide with 25 days old seedlings for the treatments having transplanting method and in case of seeding, two seeds per hill were dibbled by maintaining 60 cm space between two hills in a row to ensure even stand Gap filling was done 7 days after planting, and per hill one plant was retained after thinning at 15 DAS. Inter-cultivation was done with the help of blade hoe and twice manual hand weeding was carried out during the crop growth to keep the fields weed free. The plots were irrigated whenever the soil moisture fell below the optimum. Entire phosphorus and 50 per cent N and K were applied basally. Remaining N and K were applied twice at 45 and 75 days after planting. Prophylactic plant protection measures were taken up as and when pest and disease crossed ETL. Growth and yield attributes were recorded, analyzed and interpreted.

Results and Discussion

The year 2015 being dry year and due to outbreak of American pink bollworm in spite of prophylactic measures neither with planting technique nor with time of planting target yield was achieved. seed cotton yield/plant (272.67 g and 238.33 g with transplanting and dibbling, respectively), seed cotton yield/ha (4426 kg and 4376 kg with transplanting and dibbling, respectively) in early sown cotton crop in 1st fortnight of June were significantly higher compared to seed cotton yield/plant (116.67 g and 87.67 g with transplanting and dibbling, respectively), seed cotton yield/ha (1906 kg and 1640 kg with transplanting and dibbling, respectively) in late sown cotton crop in 1st fortnight of August. This variation in the yield between method of crop establishment and varied dates sowing are may be because of higher boll weight (5.71 g and 5.19 g with transplanting and dibbling, respectively), number of good opened bolls/ plant (44.93 and 43.50 with transplanting and dibbling, respectively) in early sown cotton crop in 1st fortnight of June compared to boll weight (4.70 g and 4.07 g with transplanting and dibbling, respectively), number of good opened bolls/ plant (30.73 and 28.87 with transplanting and dibbling, respectively) in late sown cotton crop in 1st fortnight of August (table 2). Results are in line with Manjunatha *et al.* (2014) [5] and Kumar *et al.* (2014) [9].

Among the two methods of crop establishment, significantly higher uptake of nitrogen (191 kg/ha), phosphorus (49.6 kg/ha) and potassium (201 kg/ha) was noticed in cotton crop that was transplanted when compared to uptake of nitrogen (181 kg/ha), phosphorus (46.8 kg/ha) and potassium (190 kg/ha) when the cotton crop is established with dibbling method. When comparing the nutrient uptake among the varied dates of planting, significantly higher uptake of nitrogen (238 kg/ha), phosphorus (51.8 kg/ha) and potassium (211 kg/ha) was observed in case of the crop planted on 1st fortnight of June when compared with delayed planting i.e., next four consecutive fortnights and the lowest uptake of nitrogen (123 kg/ha), phosphorus (43.6 kg/ha) and potassium (171 kg/ha) was observed in case of the crop planted on 1st fortnight of August (Table 1). Results are in line with Gomase and Patil (1987) [2], Doberman (1999) [1]. Superior performance of early crop in the present study could also be substantiated with nutrient uptake data.

Major nutrients, viz., nitrogen (228.17-243.45 with transplanting and 219.41-232.42 kg/ha dibbling), phosphorus (51.66-53.44 and 49.51-50.51, respectively with transplanting and dibbling during June) and potassium (208.71-213.03 and 202.86-208.99, respectively with transplanting and dibbling during June) uptake were higher with early/ normal planting compared to delayed planting (128.92, 45.59 and 180.54 kg/ha with transplanting and 118.04, 41.65 and 162.09 kg/ha NPK with dibbling, respectively during August). This was mainly due to dry matter accumulation in reproductive parts (310.31 g/plant with transplanting and 295.36 g/plant with dibbling, respectively), total dry matter production (525.52 g/plant with transplanting and 520.00 g/plant with dibbling, respectively) were higher in case of early planting (1st fortnight of June) compared to delayed planting in August in which dry matter accumulation in reproductive parts (279.16 g/plant with transplanting and 269.18 g/plant with dibbling, respectively), total dry matter production (470.62 g/plant with transplanting and 458.29 g/plant with dibbling, respectively).

Table 1: Uptake of nitrogen, phosphorus and potassium by *Bt*-cotton as influenced by method and date of planting.

Treatments	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Seed cotton yield (g/plant)	Seed cotton yield (kg/ha)
Method of planting					
Dibbling	181	46.8	190	178.40	3280
Transplanting	191	49.6	201	205.11	3457
C. D. @ 5%	8	NS	3	16.63	128.41
Dates of planting					
1st FN of June	238	51.8	211	255.50	4401
2nd FN of June	224	50.6	206	232.28	4277
1st FN of July	185	48.8	199	210.50	3698
2nd FN of July	161	46.4	188	158.33	2693
1st FN of August	123	43.6	171	102.17	1773
C. D. @ 5%	7	1.5	4	12.07	124
Interaction between method and dates of planting					
Dibbbling – 1st FN of June	232	50.5	209	238.33	4376

Dibbling – 2nd FN of June	219	49.5	203	220.67	4198
Dibbling – 1st FN of July	180	47.5	195	199.33	3576
Dibbling – 2nd FN of July	155	45.0	181	146.00	2609
Dibbling – 1st FN of August	118	41.6	162	87.67	1640
Transplanting - 1st FN of June	243	53.0	213	272.67	4426
Transplanting – 2nd FN of June	228	51.7	208	243.90	4356
Transplanting – 1st FN of July	191	50.2	203	221.67	3819
Transplanting – 2nd FN of July	166	47.8	196	170.67	2777
Transplanting – 1st FN of August	129	45.6	180	116.67	1906
C. D. @ 5%	NS	NS	6	NS	197

NS- not significant, FN- fortnight

Table 2: Dry matter accumulation in reproductive parts, total dry production, boll weight (g) and good opened bolls per plant in *Bt* cotton as influenced by method of crop establishment and varied dates of sowing.

Treatments	DM accumulation in reproductive parts (g/plant)	Total dry matter production (kg/ha)	Boll weight (g)	Good opened boll per plant
Crop establishment (M)				
Dibbling	285.13	491.45	4.62	36.85
Transplanting	298.00	505.02	5.09	39.88
C. D. @ 5%	2.91	6.24	0.42	1.27
Time of planting (D)				
1st FN of June	302.84	522.76	5.45	44.37
2nd FN of June	300.58	515.69	5.14	43.10
1st FN of July	297.07	504.16	4.80	38.87
2nd FN of July	283.18	484.12	4.50	35.70
1st FN of August	274.17	464.45	4.38	29.80
C. D. @ 5%	3.03	4.06	0.24	1.04
Interaction between method and dates of planting				
Dibbbling – 1st FN of June	295.36	520.00	5.19	43.80
Dibbling – 2nd FN of June	292.72	511.09	5.00	42.27
Dibbling – 1st FN of July	291.90	497.03	4.59	36.07
Dibbling – 2nd FN of July	276.49	470.85	4.24	33.27
Dibbling – 1st FN of August	269.18	458.29	4.07	28.87
Transplanting - 1st FN of June	310.31	525.52	5.71	44.93
Transplanting – 2nd FN of June	308.43	520.30	5.28	43.93
Transplanting – 1st FN of July	302.24	511.29	5.01	41.67
Transplanting – 2nd FN of July	289.86	497.39	4.76	38.13
Transplanting – 1st FN of August	279.16	470.62	4.70	30.73
C. D. @ 5%	NS	7.52	NS	1.72

NS- not significant, FN- fortnight

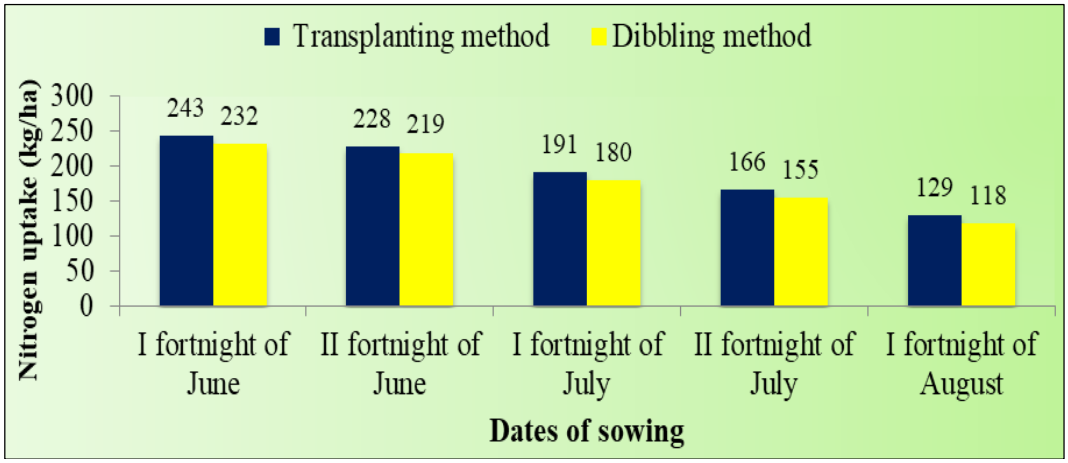

Fig 1(A)

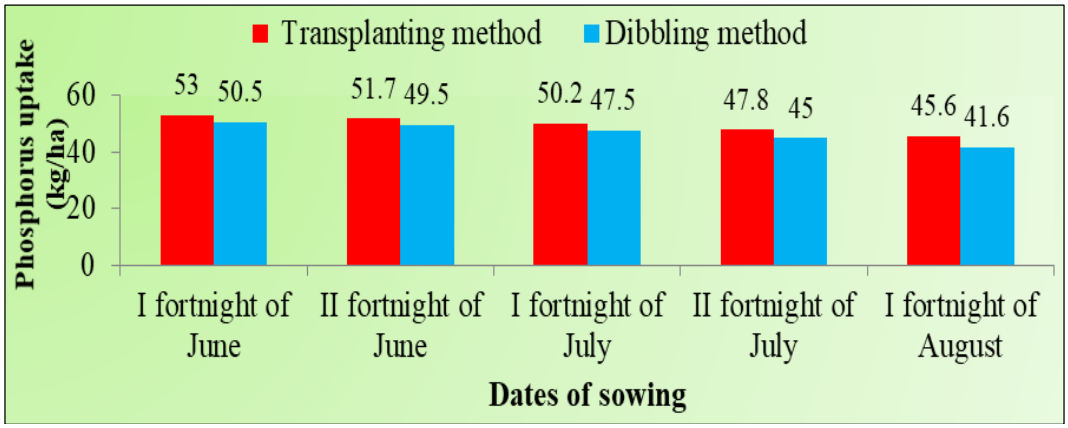

Fig 1(B)

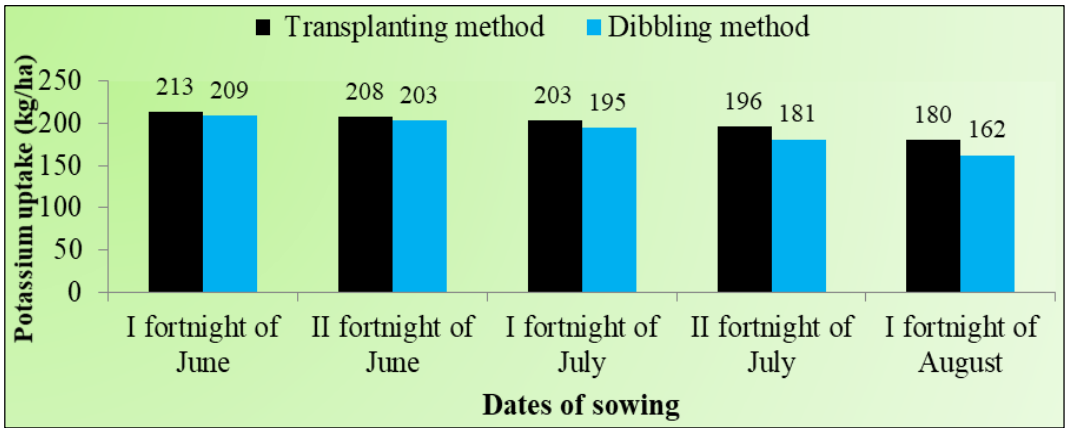

Fig 1(A, B, C): Uptake of nitrogen, phosphorus and potassium in *Bt* cotton as influenced by SSNM with crop establishment and varied dates of sowing.

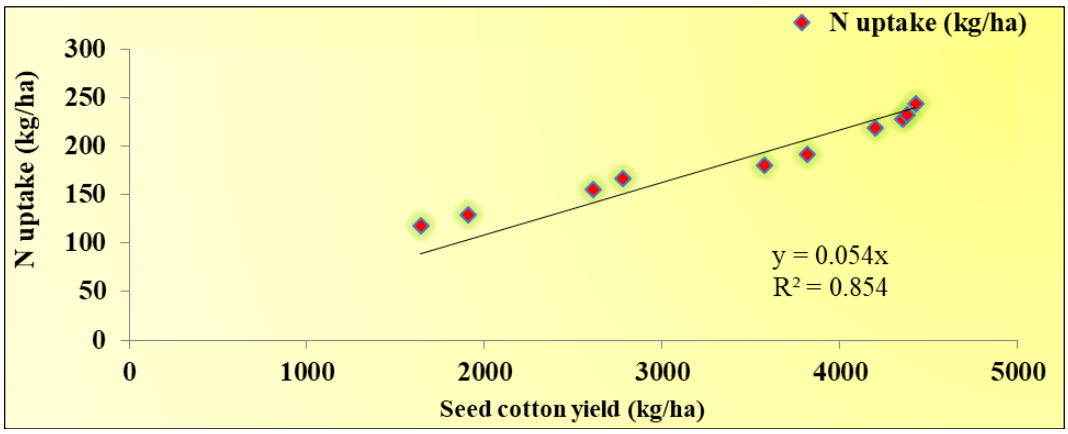

Fig 2(A)

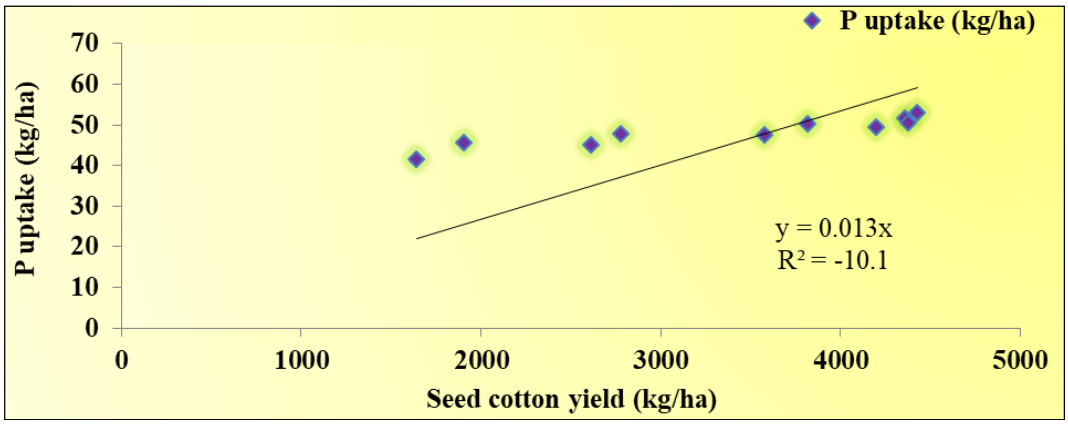

Fig 2(B)

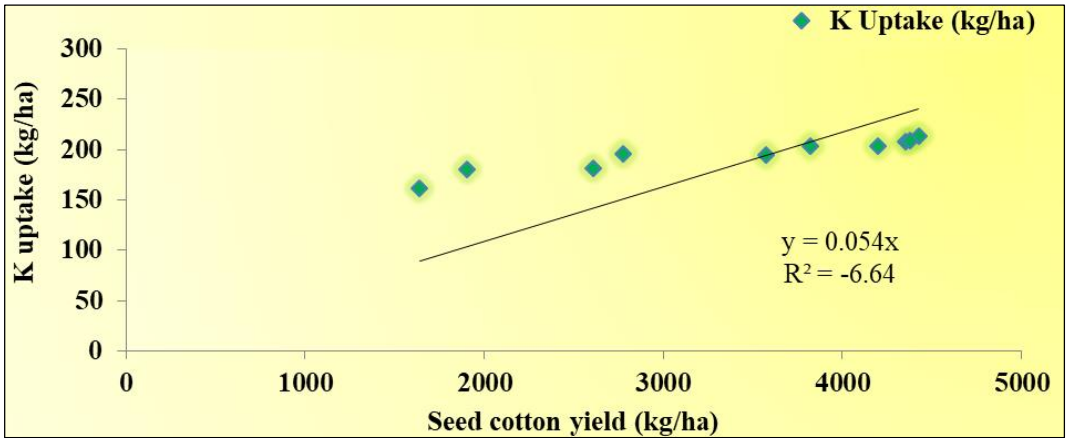

Fig 2: Relationship between seed cotton yield per ha and NPK uptake (kg/ha) in *Bt* cotton with methods of establishment and varied dates of sowing during *Kharif* 2015.

Fig 3: Cotton seedlings in nursery for transplanting

Conclusion

Transplanting method of establishment done in the 1st fortnight of June in *Bt* cotton results in higher uptake of nitrogen, phosphorus and potassium in crop plant resulting in higher accumulation of dry matter, total dry matter production, boll weight, good number of bolls per plant that collectively results in higher seed cotton yield in *Bt* cotton. Thus, the study revealed advantage of early planting in June, transplanting and site specific nutrient management to realize target yields (≥ 5.0 t ha^{-1}).

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