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Response of *Deshi* cotton variety *Phule dhanwantary* to high density planting system

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Abstract
A field experiment was conducted during *Kharif* season of 2016-17, 2017-18 and 2018-19 to find out the optimum spacing for growth, yield and to study economics of *arborium* cotton in clayey textured soil at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, (Maharashtra). The experiment was laid out in randomized block design with nine treatments *viz*., 45 x 15 cm^2, 45 x 30 cm^2, 45 x 45 cm^2, 60 x 15 cm^2, 60 x 30 cm^2, 60 x 45 cm^2, 90 x 15 cm^2, 90 x 30 cm^2 and 90 x 45 cm^2 in three replications. The pooled result of experiment indicated that the spacing 45 cm x 15 cm^2 observed significantly maximum plant height (120.74 cm) than other spacing's. However it was at par with spacing 60 x 15 cm^2 (117.68 cm) at harvest. The spacing 90 x 15 cm^2 recorded significantly higher number of bolls $plant^{-1}$ (24.37) and average boll weight (4.60 g) than rest of spacing's. Whereas, the spacing 45 x 15 cm^2 recorded significantly higher seed cotton yield (18.30 q ha^{-1}) than rest of all other spacing's and also observed 24% higher seed cotton yield than normal spacing of 45 x 30 cm^2. The spacing 45 cm x 15 cm^2 recorded highest gross monetary returns (Rs.93557 ha^{-1}), net monetary returns (Rs. 39297 ha^{-1}) and B:C ratio (1.71) than rest of spacing.

Keywords: Desi cotton, HDPS, Yield and Economics

Introduction
Cotton (*Gossypium* spp.), the queen of fiber or white gold, is one of the most important commercial crop of India. It is one of the most important cash crop next to food grains that play a vital role in Indian national economy (Patel *et al.*, 2016) [9]. Cotton production in India is considered to have a wide reaching impact not only on the livelihood of farmers and economy of the country but also on international trade. Cotton productivity depends on various factors among them selection of potential genotypes along with plant densities play a vital role in increasing the productivity of cotton. The *desi* cotton are known to tolerant and resistant to diseases, pests and adverse environmental condition than American cotton varieties. New desi cotton genotype *viz*., *Phule Dhanwantary* have been released by MPKV, Rahuri. The maximum exploitation of these genotypes can be achieved only after determining their optimum planting densities in comparison to recommended cotton varieties. In general, it was observed that lower plant densities produces high values of growth and yield attributes per plant, but yield per unit area was higher with higher plant densities (Dhoble *et al.*, 1992 and Sharma *et al*., 2001) [2, 10]. However, it may happen that moderate increase in plant densities may not increase the yield but decrease due to competition between plants for nutrients, water, space and light (Nehra and Kumawat, 2003) [8]. Adoption of High density Planting System (HDPS) and newly released desi cotton varieties offer an alternate to sustainable production and decrease production cost. In view of the above, present research work carried out with the objective to find out the optimum spacing for growth, yield and to study economics of of *desi* cotton.

Materials and Methods
The field experiment was conducted at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra), during *kharif* season of 2016-17, 2017-18 and 2018-19. The experiment was laid out in randomized block design with nine treatments *viz*., 45 x 15 cm^2, 45 x 30 cm^2, 45 x 45 cm^2, 60 x 15 cm^2, 60 x 30 cm^2, 60 x 45 cm^2, 90 x 15 cm^2, 90 x 30 cm^2 and 90 x 45 cm^2 in three replications. The topography of the experimental field was uniform and levelled. The soils of the experimental field was well drained and clayey in texture. Geographically MPKV, Rahuri lies between 19° 48' N and 19^O 57' N latitude and 74° 32' E and 74°19' E longitude. The altitude varies from 495 to 569 meter above mean sea level.

The recommended dose of fertilizer i.e., 80 kg nitrogen, 40 kg phosphorus and 40 kg potash per hectare were applied through urea, single super phosphate and muriate of potash, respectively. The average annual rainfall at Rahuri is 520 mm. Out of total rainfall, about 80 per cent rainfall is received from South –West monsoon (June to September), while the rest of the rainfall receives from North-East monsoon (October and November). Rainfall received during the *kharif* seasons was 840 mm, 642 mm and 308 mm during 2016-17, 2017-18 and 2018-19, respectively.

Results and Discussion

Growth and yield contributing characters

The spacing 45 x 15 cm^2 observed significantly maximum plant height at harvest during the year 2016-17, 2017-18, 2018-19 and also at the pooled results i.e., 125.64 cm, 112.43 cm, 124.13 cm and 120.74 cm, respectively than all other spacings. At pooled results, 45 x 15 cm^2 spacing was at par (120.74 cm) with spacing 60 x 15 cm^2 (117.68 cm) at harvest. The more number of plants per unit area resulted more height per plant which may be due to the increased competition for sunlight and CO_2. Similar type of results was reported by Narayana *et al.*, (2007) [6], Sisodia and Khamparia (2007) [11].

The spacing 90 x 45 cm^2 recorded significantly higher number of bolls $plant^{-1}$ as well as average boll weight during the year 2016-17, 2017-18, 2018-19 and also at the pooled results in both the parameters. Regarding the seed cotton yield $plant^{-1}$, the spacing 90 x 45 cm^2 also recorded significantly maximum during the all experimental years and also at the pooled results (111.12 g) than rest of the other spacings (Table 1). It might be due to better development of individual plant in wider plant spacing crop. The widely spaced plant received optimum microclimate and the beneficial influence on plant development. Similar results were observed by Nehra and Chandra (2001) [7].

Yield and economics

The sowing of cotton at 45 x 15 cm^2 (1,48,148 plants ha^{-1}) plant spacing produced considerably highest seed cotton yield during the year 2016-17, 2017-18, 2018-19 and also at the pooled results i.e., 17.94, 17.85, 19.10 and 18.30 q ha^{-1}, respectively than all other wider spacings (Table 2). The pooled results observed 24% higher seed cotton yield than normal spacing of 45 cm x 30 cm (74,074 plants ha^{-1}). The highest seed cotton yield in narrow row spacing might be due to more number of picked bolls per unit area and also higher plant density utilized all natural resources like solar radiation, moisture, nutrients and space. Maximum LAI increased photosynthesis and utilized for boll development, which ultimately improved the seed cotton yield. Comparatively at wider spacings yield was decreased because the reduction in yield per plant might be due to both inter-plant and intra-plant competition for resources, was more than compensated by increase in the number of plants per unit area. These above are in accordance with those obtained by Narayana and Aparna (2011) [5]. Mohapatra (2011) [4] and Paslawar *et al.*, (2015) [1].

The spacing 45 x 15 cm^2 obtained significantly highest gross monetary returns and net monetary returns during the year 2016-17, 2017-18 and 2018-19 than all other spacings. At pooled results, 45 x 15 cm^2 spacing recorded significantly highest gross monetary returns (Rs.93557 ha^{-1}), net monetary returns (Rs. 39297 ha^{-1}) than rest of spacing (Table 2). The B:C ratio (1.71) was also maximum with 45 x 15 cm^2 spacing than all other spacings.

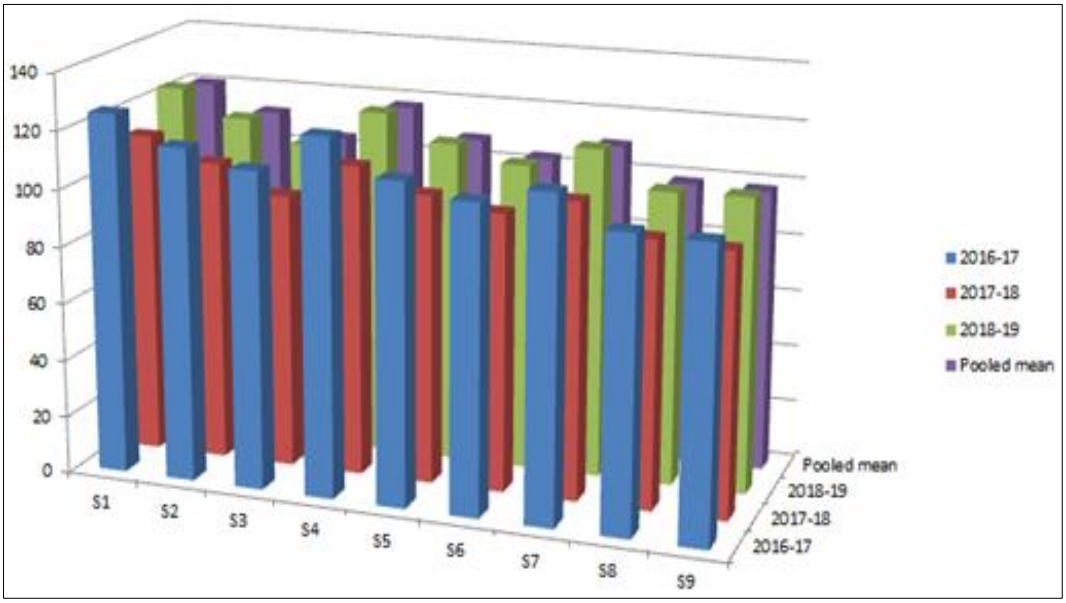

Fig 1: Plant height harvest (Spacings at X-axus and plant height in cm at Y-axis

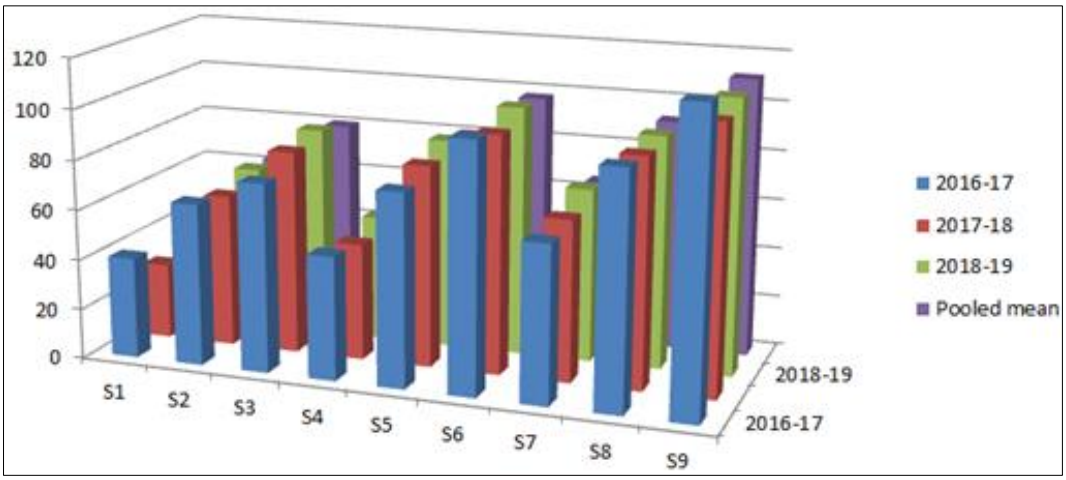

Fig 2: Seed cotton yield per plant (Spacing at X-axis and yield in g at Y-axis

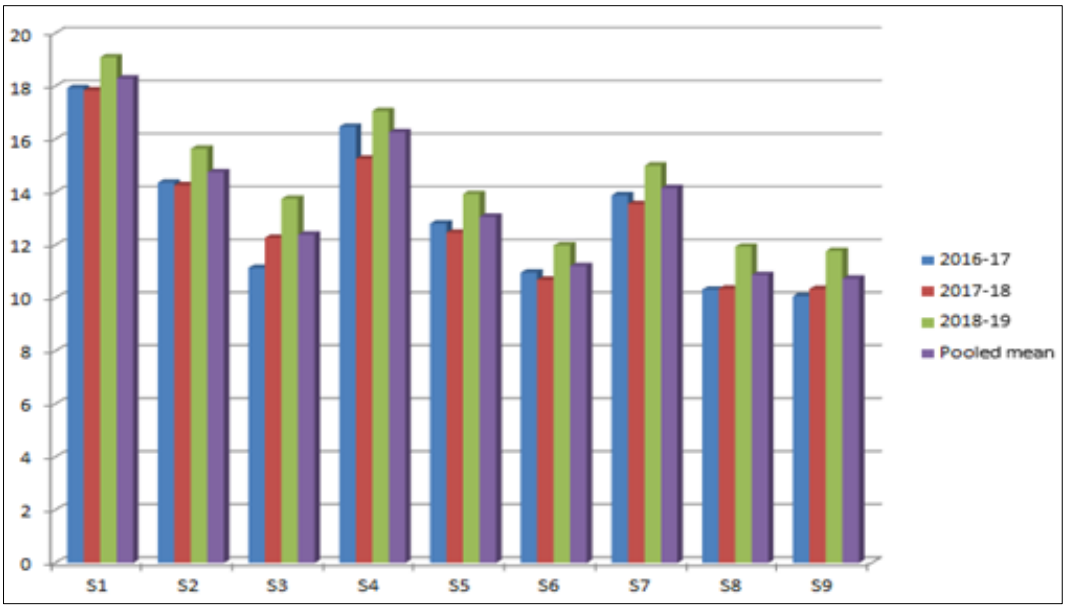

Fig 3: Seed cotton yield in qha^{-1} (Spacing X-axis and yield in quintal at Y-axis

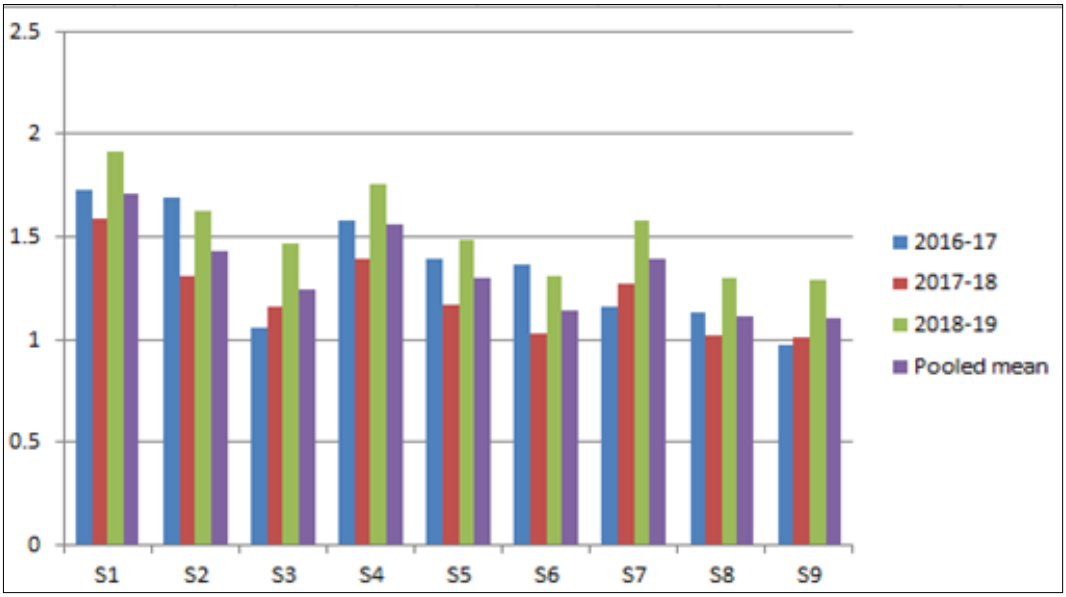

Fig 4: Benefit cost ratio (Spacing at X-axis and B: C ratio at Y-axis

Table 1: Plant height number of bolls, average boll weight and seed cotton yield per plant as influenced by different treatments at harvest

Treatments	Plant height (cm)				Number of bolls plant^{-1}				Average boll weight (cm)				Seed cotton yield plant^{-1} (g)			
	2016-17	2017-18	2018-19	Pooled mean	2016-17	2017-18	2018-19	Pooled mean	2016-17	2017-18	2018-19	Pooled mean	2016-17	2017-18	2018-19	Pooled mean
S1: 45 x 15 cm^2	125.64	112.43	124.13	120.74	13.64	11.56	13.54	12.91	3.10	2.63	2.73	2.82	40.37	30.17	33.57	34.70
S2: 45 x 30 cm^2	116.02	104.78	115.11	111.97	18.79	18.04	20.27	19.03	3.43	3.37	3.45	3.42	64.68	61.00	65.75	63.81
S3: 45 x 45 cm^2	110.42	95.56	107.68	104.55	19.70	19.24	20.99	19.98	3.83	4.22	4.31	4.12	75.24	81.28	84.22	80.25
S4: 60 x 15 cm^2	123.94	108.11	121.00	117.68	16.42	15.48	17.59	16.50	3.17	3.07	3.16	3.13	49.31	46.59	50.32	48.74
S5: 60 x 30 cm^2	111.41	100.48	112.18	108.02	21.48	20.51	22.39	21.46	3.77	3.88	3.98	3.87	76.75	80.30	84.20	80.42
S6: 60 x 45 cm^2	106.61	96.51	106.77	103.30	23.97	22.19	23.70	23.29	4.10	4.27	4.35	4.24	98.76	94.72	99.53	97.67
S7: 90 x 15 cm^2	112.05	102.91	114.54	109.84	17.96	17.26	19.59	18.27	3.63	3.71	3.79	3.71	62.52	64.31	69.32	65.39
S8: 90 x 30 cm^2	101.36	92.67	102.00	98.68	22.29	21.08	23.08	22.15	4.37	4.33	4.37	4.36	92.97	91.03	92.59	92.20
S9: 90 x 45 cm^2	100.78	91.40	102.57	98.25	25.22	23.29	24.59	24.37	4.70	4.53	4.57	4.60	118.26	105.80	109.30	111.12
S.E. ±	7.26	6.25	4.47	3.04	3.23	1.34	1.66	0.99	0.45	0.30	0.27	0.18	9.49	8.27	8.54	4.51
C.D.at 5%	20.57	17.70	12.66	8.69	9.15	3.82	4.72	2.01	1.29	0.85	0.78	0.51	26.89	23.45	23.20	12.74

Table 2: Seed cotton yield, gross monetary returns, net monetary returns and B:C ratio

Treatments	Seed cotton yield (q ha^{-1})				Gross monetary returns ha^{-1} (Rs)				Net monetary returns ha^{-1} (Rs)				B:C ratio			
	2016-17	2017-18	2018-19	Pooled mean	2016-17	2017-18	2018-19	Pooled mean	2016-17	2017-18	2018-19	Pooled mean	2016-17	2017-18	2018-19	Pooled mean
S1: 45 x 15 cm^2	17.94	17.85	19.10	18.30	86128	85692	108851	93557	33558	31944	52389	39297	1.73	1.59	1.92	1.71
S2: 45 x 30 cm^2	14.37	14.27	15.65	14.76	68992	68514	89186	75564	18493	16417	34725	23212	1.69	1.31	1.63	1.43
S3: 45 x 45 cm^2	11.15	12.29	13.76	12.40	53504	58992	78432	63642	4876	8113	25065	12685	1.06	1.16	1.47	1.24
S4: 60 x 15 cm^2	16.48	15.27	17.07	16.27	79088	73280	97318	83228	27369	20573	42029	29991	1.58	1.39	1.76	1.56
S5: 60 x 30 cm^2	12.82	12.48	13.94	13.08	61552	59920	79458	66976	11952	8922	25987	15620	1.39	1.17	1.49	1.30
S6: 60 x 45 cm^2	10.97	10.70	12.00	11.22	52672	51344	68400	57472	4145	1443	16054	7214	1.37	1.03	1.31	1.14
S7: 90 x 15 cm^2	13.89	13.56	15.01	14.16	66688	65104	85557	72449	16467	13928	31465	20620	1.16	1.27	1.58	1.39
S8: 90 x 30 cm^2	10.33	10.36	11.95	10.88	49584	49712	68134	55810	1430	850	15815	6032	1.13	1.02	1.30	1.11
S9: 90 x 45 cm^2	10.08	10.35	11.79	10.74	48384	49664	67184	55077	375	584	14962	5307	0.97	1.01	1.29	1.10
S.E. ±	1.50	1.28	1.17	0.67	7236	6167	6680	3570	6362	5577	6000	3040	--	--	--	--
C.D.at 5%	4.27	3.63	3.31	1.89	20496	17468	18921	10088	18019	15796	16996	8590	--	--	--	--

Conclusion

It is concluded that Phule Dhanwantary *deshi* cotton variety planted at distance 45 x 15 cm^2 recorded significantly higher seed cotton yield with maximum gross monetary returns, net monetary returns and obtained higher B: C ratio than all other spacing's.

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