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Planting Date and Plant Density Effects on the Performance of Contemporary Asiatic Diploid Cotton (*Gossypium arboretum* L.) Genotypes on Rainfed Vertisol and Vertic Inceptisol Soils

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ABSTRACT

The Asiatic diploid, *Gossypium arboreum* L., faced challenges in adoption due to its long duration, poor productivity, and inferior fiber quality. However, in recent decades, new genotypes were developed with medium duration and better fiber quality. To enhance the yield of these contemporary genotypes, agronomic interventions, such as selecting suitable soil-site combinations, choosing appropriate cultivars, and optimizing planting times and plant densities are required. This field experiment was conducted to evaluate the productivity potential of contemporary *G. arboreum* genotypes under rainfed conditions on two dominant soil types: Vertisol and Vertic Inceptisol. The study involved seven G. arboreum genotypes (DLSa-17, PA-528, PA-402, PA-812, PA-760, CNA-1041, and Phule Dhanwantary) planted across two plant densities (normal density: 55,555 plants/ha and high density: 111,111 plants/ha) on two sowing dates (timely: with onset of monsoon and late: 14 days delay). Analysis of pooled data (over years) indicated that planting date and plant density significantly influenced various parameters such as boll density, seed cotton yield, plant height, and days to first flower. The seed cotton yield of *G. arboreum* cotton was 2,516 kg/ha on Vertic Inceptisol compared to 2,151 kg/ha on Vertisol. A delay in sowing by 14 days significantly reduced seed cotton yield on Vertic Inceptisol and Vertisol. Planting in a high-density system provided a yield advantage over normal density. Genotype PA-812 had the highest fiber length, whereas Phule Dhanwantary was short stapled with coarse fiber. The study emphasizes the need for tailored agronomic practices based on both environmental conditions and genotype characteristics.

The Asiatic diploid, *Gossypium arboreum* L., originated in the Indian subcontinent and was the dominant cotton species in India during the pre-Independence period (Santhanam and Sundaram, 1997). Post-Independence, concerted research efforts led to the development and adoption of tetraploid *Gossypium hirsutum* L. varieties and hybrids. Consequently, the area under *G. arboreum* steadily declined from 97% of the total cotton area in 1950 to less than 2% today. Despite having a higher ginning outturn, resistance to abiotic stresses (drought and salinity), tolerance to insect pests (leaf hoppers), and resistance to diseases (leaf reddening and leaf curl virus), *G. arboreum* cotton is not favored by farmers and the textile industry. Lanky plant architecture; long duration; poor productivity; small boll size with poor locule retention; and poor fiber quality with short staple, weak, and coarse fibers (Manivannan, 2015) are attributed as the reasons. However, over the last three decades, several of these drawbacks have been overcome by cotton breeders. Introgression of fiber traits from *G. hirsutum* and selection from the segregating generations of backcrosses (Deshpande et al., 1992; Kulkarni and Khadi, 1998) have yielded new *G. arboreum* genotypes with fiber traits on par with *G. hirsutum* counterparts (Chandra and Srinivasan, 2011; Chinchane et al., 2018). These improved long-linted *G. arboreum* genotypes possess abiotic stress resistance and tolerance to sucking pests (Kulkarni and Khadi, 1998) and have higher productivity under rainfed conditions (Pradeep et al., 2005). A long-term study at the Indian Council of Agricultural Research (ICAR)-Central Institute for Cotton Research, Nagpur, India conclusively proved the superiority of *G. arboreum* over *G. hirsutum* cotton during years experiencing normal or below normal rainfall (Venugopalan and

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Pundarikakshudu, 1999). In the present era of climate change characterized by recurring drought, extreme weather events, and high temperatures (Roxy et al., 2017), the new *G. arboreum* genotypes could provide a sustainable alternative to *G. hirsutum* in drought-prone areas of Central India (Venugopalan and Prasad, 2022).

Low adoption rate of *G. arboreum* by farmers is attributed also to its poor productivity (Giri and Gore, 2006), and hence, appropriate site-specific agronomic interventions are imperative to improve its productivity. Selection of suitable soil-site, choice of appropriate cultivar, and planting at the most appropriate time with the optimum plant density are some commonly recommended interventions to increase productivity of *G. arboreum* (Sankaranarayanan et al., 2021; Venugopalan et al., 2016). Against this backdrop, the present investigation was undertaken to evaluate the productivity potential of the contemporary *G. arboreum* genotypes for growth, yield, earliness, and fiber traits under rainfed condition of Central India on two dominant cotton growing soils of the region by optimizing planting dates and plant density.

MATERIALS AND METHODS

A field experiment was conducted during the Kharif (monsoon) season of 2017-18 and 2018-19 at the research farm of ICAR-Central Institute for Cotton Research, Nagpur, Maharashtra, India (21˚ 04´N, 79˚ 04´E, 306 m above mean sea level) under rainfed conditions. The location is a representative of Agro Eco Sub Region 10.2 and is characterized by a hot, dry subhumid bioclimate.

Separate trials were laid out on two dominant soil types of the region: Vertisol and Vertic Inceptisol under rainfed conditions. The two fields were located 250 m apart. On each soil, seven contemporary *G. arboreum* genotypes, developed under diverse agro-ecological regions were evaluated across two plant densities and two dates of sowing in a factorial randomized block design with three replications. Factor A comprised two sowing dates: timely sowing with the onset of monsoon (22 June 2017 and 21 June 2018) and late sowing 2 wk after the first date (7 July 2017 and 5 July 2018). These dates correspond to the beginning and end of the sowing window for rainfed cotton in the region. Factor B comprised two plant densities: normal density (55,555 plants ha^{-1}) and high density (111,111 plants ha^{-1}). The plant population was maintained by planting the crop at 60 x 30 cm and 60 x 15 cm spacing, respectively. Factor C comprised seven genotypes: DLSa-17, PA-528, PA-402, PA-812, PA-760, CNA-1041 and Phule Dhanwantary.

The crop was cultivated following recommended practices. The recommended dose of phosphorus (30 kg P_2O_5 ha^{-1}) was applied at sowing through single super phosphate and potassium (30 kg K_2O ha^{-1}) through muriate of potash along with one-third dose of nitrogen (20 kg ha^{-1}) through urea; the remaining nitrogen through urea was side dressed in two equal splits of 20 kg N ha^{-1} at squaring (45 d after sowing, DAS) and flowering (65 DAS). Six representative plants from each plot were tagged to generate data on days to first flower, plant height at 100 DAS, boll number, and boll weight. The last date on which three of the six tagged plants had at least one flower was considered onset of flowering, and number of days from planting to that date was calculated to obtain days to the first flower. Similarly, the last date on which three of the six tagged plants had at least one open boll was used to calculate the date of first open boll. After recording plant height data, de-topping was done by mechanically clipping the top 10 cm when the crop was 100 d old to prevent apical dominance and reduce rank vegetative growth.

Seed cotton from the experimental plots was handpicked three times. At each picking, the total number of fully open bolls from the tagged plants were counted and averaged to give boll number per plant expressed as boll density in bolls m^{-2}. Seed cotton from these open bolls from six tagged plants was weighed and divided by the number of bolls to obtain boll weight. Composite lint samples from the first pick were analyzed for fiber quality parameters using High Volume Instrument.

The data were pooled for both years and statistically analyzed using ANOVA technique (Gomez and Gomez, 1984). Wherever F-test was significant, t-test was performed, and the critical difference (CD) value ($p = 0.05$) was used to determine the significance of the difference between treatment means.

RESULTS AND DISCUSSION

Soil and Weather Characteristics. The experiments were conducted on two soils: Vertic Inceptisol and Vertisol. The Vertic Inceptisol was clayey in texture, moderately alkaline, moderately shallow (60 cm) in depth (Table 1), and classified as a clayey, smectitic, hyperthermic family of Vertic Haplustepts.

Table 1. Important physical and chemical properties of the soil pedon of the experimental site: Vertic Inceptisol

Horizon	Depth	Clay	Bulk Density	sHC[z]	pH	Org. C[z]	$CaCO_3$	Water Retention 33 kPa	Water Retention 1500 kPa	AWC[z]
	(cm)	(%)	(Mg m^{-3})	(cmh^{-1})	(1:2)	(g kg^{-1})	(%)	(%)	(%)	
Ap	0–10	63.8	1.32	1.11	7.9	6.1	2.20	30.86	14.80	16.06
Bw1	10–20	66.4	1.44	0.54	7.9	6.1	5.38	32.68	16.10	16.58
Bw2	20–40	68.6	1.74	0.23	7.9	4.3	7.05	35.11	15.10	20.01
BC	40–60	68.6	-	1.79	7.9	3.5	25.99	32.98	14.30	18.68

[z]sHC: saturated hydraulic conductivity; Organic C: organic carbon; AWC: available water capacity

It was underlain with a layer of weathered basalt. The surface soil (AP horizon) had a bulk density of 1.3 mg m^{-3}, saturated hydraulic conductivity of 1.1 cm h^{-1} (well drained), organic C content of 6.1 g/kg, $CaCO_3$ content of 2.2%, and available water capacity of 16.06%. The Vertisol was clayey in texture, moderately alkaline, very deep (> 150 cm), and classified as a very fine, smectitic, hyperthermic Typic Haplusterts (Table 2). The surface soil had a bulk density of 1.61 mg m^{-3}, saturated hydraulic conductivity of 0.53 cm h^{-1} (moderately drained), organic C content of 5.8 g/kg, $CaCO_3$ content of 4.25%, and available water capacity of 12.82%. In both the soils, the clay content, bulk density, and calcareousness increased with depth, whereas organic C content decreased with depth.

During the 2017-18 crop season, 768 mm rainfall was received, and was well distributed over 52 rainy days (Table 3). During both the years of experimentation, temperatures were normal. During the 2018-19 crop season, 942 mm rainfall was received but the distribution was skewed over 32 rainy days. Rainfall during 2017-18 and 2018-19 was lower by 23.4 and 6.0% respectively, compared to normal rainfall of 1,002.2 mm. However, this deficit in rainfall did not adversely affect the performance of G. arboreum cultivars in either year. Long-term experiments under subhumid bioclimatic conditions in Central India by Venugopalan and Pundarikakshudu (1999) concluded that *G. arboreum* cotton performed well in years experiencing subnormal or normal rainfall.

Growth, Yield Attributes, and Cotton Yield on Vertic Inceptisol. Sowing time had a significant effect on boll density and seed cotton yield, but the effect on other parameters such as plant height, days to first flower, days to first open boll, and boll weight was not significant (Table 4). Averaged over genotypes and plant densities, timely sowing with the onset of monsoon increased boll density by 22.2 bolls m^{-2} and seed cotton yield by 747 kg/ha over late sowing (14 d delay). Plant density significantly influenced boll weight, boll density, and seed cotton yield. Averaged over sowing dates and genotypes, planting in a high-density system (111,111 plants/ha) provided a yield advantage of 326 kg/ha over normal density (55,555 plants/ha). This was manifested through an increase in boll density by 28.6 boll m^{-2} and heavier bolls (2.58 g) as compared to planting in normal density.

The genotype effect was significant for plant height, days to first flower, days to first open boll, boll weight, boll density, and seed cotton yield. The

Table 2. Important physical and chemical properties of the soil pedon of the experimental site: Vertisol

Horizon	Depth	Clay	Bulk Density	sHC[z]	pH	Org. C[z]	$CaCO_3$	Water Retention 33 kPa	Water Retention 1500 kPa	AWC[z]
	(cm)	(%)	(Mg m^{-3})	(cmh^{-1})	(1:2)	(g kg^{-1})	(%)	(%)	(%)	
Ap	0–15	68.07	1.61	0.53	8.27	5.8	4.25	36.44	23.62	12.82
Bw	15–31	67.81	1.66	0.98	8.34	4.2	4.70	40.07	24.35	15.72
Bss1	31–56	67.46	1.84	0.64	8.40	3.4	4.37	39.43	24.77	14.66
Bss2	56–78	74.10	1.85	0.49	8.37	2.7	5.00	40.40	23.77	16.63
Bss3	78–110	73.90	1.79	0.45	8.36	1.2	5.06	44.50	24.94	19.56
Bss4	110–150	70.81	1.91	0.46	8.30	0.9	5.14	44.31	26.55	17.76

[z]sHC: saturated hydraulic conductivity; Organic C: organic carbon; AWC: available water capacity

Table 3. Monthly average maximum, minimum temperature, and total rainfall during the crop growing season (2019) vis-a-vis normal (1969-2010)

Parameter	Year	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Max. Temp. (℃)	2017	36.9	30.9	31.4	32.6	33.6	30.7	28.9	
	2018	36.3	30.2	30.1	31.1	34.0	31.7	26.7	
	Normal	37.8	31.7	30.6	32.2	33.6	30.9	28.8	
Min Temp. (℃)	2017	26.3	24.3	24.5	23.9	20.2	14.5	10.3	
	2018	25.4	24.4	24.5	23.2	19.3	15.1	10.8	
	Normal	26.4	24.2	23.7	23.1	20.0	15.8	12.6	
Monthly rainfall (mm)	2017	132	246	276	99	15	0	0	768
	2018	217	480	171	74	0	0	0	942
	Normal	163.4	304.0	275.0	170.1	61.2	16.8	11.7	1002
Rainy days (number)	2017	7	19	11	9	6	0	0	52
	2018	10	11	8	3	0	0	0	32
	Normal	8.7	13.7	13.2	8.3	3.1	1.0	0.8	49

Table 4. Effect of sowing date, plant density (plants/ha), and genotype on growth, yield attributes, and seed cotton yield on Vertic Inceptisol

Vertic Inceptisol	Seed Cotton Yield	Height at 100 DAS[z]	Days to 1st Flower	Days to 1st Open Boll	Boll Weight	Boll Density
	(kg/ha)	(cm)			(g/boll)	(bolls m^{-2})
Dates of sowing						
Timely sowing	2889.3	119.3	71.0	114.2	2.61	123.4
Late sowing	2142.4	116.2	69.9	114.9	2.47	101.2
SeM±[z]	20.32	1.16	0.39	0.92	0.024	0.99
CD[z] ($p = 0.05$)	125.38	N/A	N/A	N/A	N/A	6.08
Plant density (*plant* ha^{-1})						
55,555	2352.7	118.3	70.8	114.6	2.58	98.0
111,111	2678.9	117.3	70.0	114.5	2.51	126.6
SeM±	42.71	0.79	0.30	0.30	0.013	1.22
CD ($p = 0.05$)	166.75	N/A	N/A	N/A	0.050	4.78
Genotypes						
DLSa-17	2516.6	121.7	69.0	114.2	2.25	115.4
PA-528	2585.2	128.6	70.5	116.7	2.56	112.7
PA-402	2511.9	125.9	71.1	114.9	2.61	110.3
PA-812	2672.4	122.8	69.8	116.6	2.58	117.8
PA-760	2591.8	119.5	69.1	115.4	2.56	113.7
CNA-1041	2773.3	120.2	70.8	113.8	2.54	120.6
Phule Dhanwantary	1959.5	85.8	72.5	110.3	2.69	95.5
SeM±	59.30	1.94	0.42	0.65	0.033	2.24
CD ($p = 0.05$)	168.66	5.50	1.19	1.85	0.094	6.37

[z]SeM±: Standard error mean; DAS: days after sowing; CD: Critical Difference

boll period (number of days required for a cotton boll to mature and crack open, calculated as the duration between flowering and boll opening) ranged from 37.8 d in Phule Dhanwantary to 46.8 d in PA-812. The genotype Phule Dhanwantary had the shortest plants (85.8 cm) and longest time for days to first flower (72.5 d) but had the shortest boll period (37.8 d), heaviest bolls (2.69 g), and lowest boll density (95.2 boll m^{-2}). Its seed cotton yield (1,960 kg/ha) was also significantly lower than all other genotypes. PA-528 was the tallest (128.6 cm at 100 DAS) and took the longest time for boll opening (116.7 d). The genotypes of CNA-1041 (2,773 kg/ha) and PA-812 (2,672 kg/ha) were the highest yielders and the difference in seed cotton yield among them was not significantly different.

The interaction between date of sowing and genotype was significant for boll density and seed cotton yield in Vertic Inceptisol (Table 5). A delay in sowing by 2 wk significantly decreased seed cotton yield of genotypes DLSa-17, PA-528, PA-402, PA-812, PA-760, and CNA-1041, but not in the early maturing, compact genotype Phule Dhanwantary. Similarly, the boll density of all other genotypes was significantly lower in DLSa-17, PA-528, PA-402, PA-812, PA-760, and CNA-1041 under late-sown conditions, but not in Phule Dhanwantary.

Growth, Yield Attributes, and Yields on Vertisol. Although delayed sowing reduced seed cotton yield by 248 kg/ha over timely sowing, this effect was not significant on Vertisol (Table 6). Time of sowing also did not significantly influence other parameters including height, days to first flower, days to first open boll, boll weight, and boll density.

Plant density had a significant influence on seed cotton yield, plant height, boll weight, and boll density, but not on parameters measuring earliness (date to first open flower and date to first open boll). Although the plants were significantly taller and had heavier bolls at normal spacing (55,555 plants/ha), planting in high density system (111,111 plants/ha) resulted in an additional yield of 239 kg/ha and this effect was significant. The yield improvement was mainly due to an increase in boll density by 16.3 bolls m^{-2}.

The genotype effect was significant for all parameters except days to first flower. Seed cotton yield realized by PA-528 (2,429 kg/ha) and CNA-1041 (2,403 kg/ha) was significantly higher than all other genotypes. The yield of Phule Dhanwantary (1,779 kg/ha) was significantly lower than other genotypes. The genotype Phule Dhanwantary was the shortest (81.5 cm), earliest in terms of boll opening (111.7 d), and had the heaviest bolls (2.51 g) but lowest boll

Table 5. Interaction effect between date of sowing and genotype on Vertic Inceptisol

Sowing Date	Genotype	Seed Cotton Yield (kg/ha)	Boll Density (bolls m^{-2})
Timely Sowing	DLSa-17	2,922	128.5
	PA-528	3,126	128.5
	PA-402	2,919	123.7
	PA-812	3,129	129.2
	PA-760	3,081	129.1
	CNA-1041	3,113	129.8
	Phule Dhanwantary	1,935	95.0
Late Sowing	DLSa-17	2,111	102.4
	PA-528	2,045	97.0
	PA-402	2,105	96.9
	PA-812	2,216	106.4
	PA-760	2,102	98.4
	CNA-1041	2,434	111.5
	Phule Dhanwantary	1,984	96.1
CD[z] (p = 0.05)		238.5	9.00

[z]CD: Critical Difference

Table 6. Effect of sowing date, plant density (plants/ha), and genotype on growth, yield attributes, and seed cotton yield on Vertisol

Vertisol	Seed Cotton Yield	Height at 100 DAS[z]	Days to 1st Flower	Days to 1st Open Boll	Boll Weight	Boll Density
	(kg/ha)	(cm)			(g/boll)	(bolls m^{-2})
Dates of sowing						
Timely sowing	2274.7	111.6	73.1	115.5	2.46	104.6
Late sowing	2027.7	118.1	74.2	117.9	2.39	90.0
SeM±[z]	41.02	2.51	0.34	0.59	0.018	2.41
CD[z] (p = 0.05)	N/A	N/A	N/A	N/A	N/A	N/A
Plant density (plant ha^{-1})						
55,555	2031.6	118.3	74.1	117.1	2.47	89.1
111,111	2270.8	111.5	73.3	116.3	2.39	105.4
SeM±	33.10	1.04	0.25	0.32	0.009	1.71
CD (p = 0.05)	129.22	4.06	N/A	N/A	0.036	6.67
Genotypes						
DLSa-17	1951.7	110.5	72.7	116.0	2.21	95.3
PA-528	2428.6	126.0	74.7	118.6	2.43	107.9
PA-402	2126.8	128.1	74.3	118.0	2.52	97.9
PA-812	2151.3	112.6	74.3	118.2	2.47	99.4
PA-760	2218.4	123.1	72.3	118.0	2.47	94.1
CNA-1041	2402.9	122.3	73.7	116.4	2.39	105.3
Phule Dhanwantary	1778.5	81.5	73.8	111.7	2.51	81.2
SeM±	53.46	2.78	0.65	0.66	0.030	2.14
CD (p = 0.05)	152.04	7.90	N/A	1.87	0.084	6.07

[z]SeM±: Standard error mean; DAS: days after sowing; CD: Critical Difference

density (81.2 bolls m^{-2}). The boll period ranged from 37.9 d in Phule Dhanwantary to 45.7 d in PA-760.

The interaction effect between date of sowing and genotype was significant for boll density and seed cotton yield in Vertisol (Table 7). A delay in sowing by 14 d significantly reduced the yield of genotypes DLSa-17, PA-508, PA-812, PA-760, and CNA-1041, but this reduction was not significant in PA-402 and Phule Dhanwantary. Similarly, the boll density in the genotype Phule Dhanwantary was not significantly different among the sowing dates, but in all other genotypes, the boll density was significantly different in delayed sowing as compared to normal sowing.

Planting under high-density (111,111plants/ha) significantly benefited *G. arboreum* on both soils compared to planting at normal density, and this was attributed to an increase in boll density at higher plant density. Earlier studies by Venugopalan et al. (2018) indicated that certain *G. arboreum* genotypes yielded best at high planting density and this effect was more pronounced in a year of low rainfall (Venugopalan et al., 2013), whereas the effect was not significant in a year of above normal rainfall (Venugopalan et al., 2021).

The genotypes differed significantly in plant height, phenology, yield attributes, and yield on both the soils. Among them, the early maturing genotype, Phule Dhanwantary, had the shortest boll period on both the soils, whereas the boll period was longest in the long-linted genotype, PA-812, on Vertic Inceptisol and PA-760 on Vertisol. Earlier, Jackson and Arkin (1986) reported significant differences in boll period among cotton cultivars and concluded that boll period was the main reason for differences in earliness among cultivars.

On both soils, the early maturing, compact genotype Phule Dhanwantary was the lowest yielder possibly due to suboptimal plant density. Blaise et al. (2020) concluded that optimum plant density was 221,000 plants/ha, which was double the highest density evaluated in this study. Under rainfed con-

Table 7. Interaction effect between date of sowing and genotype on Vertisol

Sowing Date	Genotype	Seed Cotton Yield	Boll Density
		(kg/ha)	(bolls m^{-2})
Timely Sowing	DLSa-17	2,096	102.0
	PA-528	2,590	116.2
	PA-402	2,215	102.3
	PA-812	2,332	109.9
	PA-760	2,393	100.8
	CNA-1041	2,601	117.6
	Phule Dhanwantary	1,861	83.1
Late Sowing	DLSa-17	1,807	88.7
	PA-528	2,267	99.5
	PA-402	2,039	93.5
	PA-812	1,970	89.0
	PA-760	2,043	87.3
	CNA-1041	2,205	93.1
	Phule Dhanwantary	1,696	79.3
CD[z] (p = 0.05)		215.0	8.59

[z]CD: Critical Difference

ditions, significant differences among *G. arboreum* genotypes were reported by Blaise et al. (2022), Pradeep et al. (2005), and Venugopalan et al. (2018).

The interaction between genotypes and date of sowing was significant on both soils, except for the yield of Phule Dhanwantary, which remained similar on both planting dates. Significant genotype and environment interaction was reported earlier by Jamwal et al. (2016) for G. arboreum cultivars from India and for G. barbadense L. cultivars in Egypt by Mahdy et al. (2017).

Effect of Soil Type. Under identical climatic conditions averaged over years, sowing dates, planting densities, and genotypes, seed cotton yield of *G. arboreum* was 2,516 kg/ha on Vertic Inceptisol compared to 2,151 kg/ha on Vertisol. Further, a delay in sowing by 14 d reduced seed cotton yield from 2,889 to 2,142 kg/ha on Vertic Inceptisol, but this reduction was lower, from 2,275 to 2028 kg/ha on Vertisol (Fig. 1). The magnitude of yield increase due to high density planting system was higher in Vertic Inceptisol as compared to Vertisol. The magnitude of yield difference of the genotypes among the two soils was higher in DLSa-17, PA-402, PA-812, PA-760, and CNA-1041 as compared to Phule Dhanwantary and PA-528.

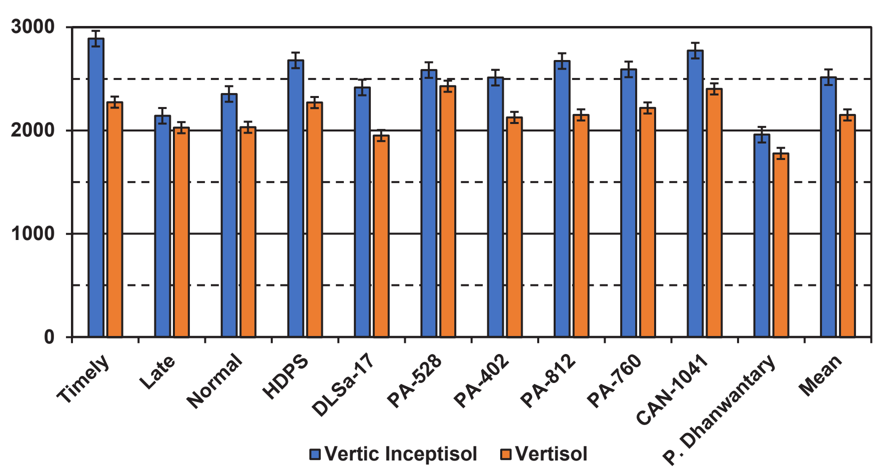

Figure 1. Paired comparison of seed cotton yield (kg/ha) on Vertic Inceptisol and Vertisol under different main, sub-plot, and sub-sub plot treatments.

Among the two soils, Vertisol and Vertic Inceptisol, the mean seed cotton yield of *G. arboreum* cultivars was higher by 365 kg/ha in the latter (Fig. 1). The surface layer of Vertic Inceptisol had a lower bulk density, lower clay content, and higher saturated hydraulic conductivity compared to Vertisol (Tables 1 and 2). These factors helped in better internal drainage, prevented accumulation of excess moisture following heavy rainfall, favored better root proliferation, and ultimately produced higher yields. Excess soil moisture was retained for a longer period in Vertisol that was moderately drained following rainfall events and could be a reason for lower yield. Wang et al. (2017) reported that excess moisture for 2 d or more decreased cotton yield significantly, and appropriate surface and subsurface drainage was essential for high cotton yield. Previous studies under similar dry subhumid bioclimatic conditions by Mandal et al. (2005) also indicated that Vertic Inceptisol are better suited than Vertisol for cotton, and in the latter soil, management practices like broad-bed furrow or ridge furrow could be needed to improve drainage and increase productivity of cotton. Vertisol was deeper than Vertic Inceptisol and had a higher quantum of stored moisture; these factors helped cotton perform better under late-sown conditions.

Fiber Quality Parameters. Fiber quality parameters of the seven genotypes averaged across years, soils, sowing date, and plant density are presented in Table 8. For fiber length, micronaire, strength, and uniformity index, the genotypes PA-812 and PA-760 were superior to the rest. Both genotypes can be classified as long-linted *G. arboreum*. On the other hand, Phule Dhanwantary is a short stapled, coarse (micronaire 7.0) fiber, but had the highest elongation index. In the present investigation, the yield of long-linted genotypes (PA-812 and PA-760) were not significantly lower than that of medium-long genotypes (PA-402 and CNA-1041). The genotypes PA-812 and PA-760 had the best fiber quality parameters and the values reported in this study are in agreement with the earlier reports by Chinchane and Baig (2018).

CONCLUSIONS

Timely sowing with the onset of monsoon and high planting density (111,111 plants/ha) had positive effects on boll density and seed cotton yield of contemporary *G. arboreum* genotypes. The productivity of *G. arboreum* cotton was higher on Vertic Inceptisol as compared to Vertisol soils. A delay in sowing by 14 days significantly reduced the yield of *G. arboreum* cultivars on both soils, but the magnitude was higher on Vertic Inceptisol. Among the seven *G. arboreum* cotton genotypes evaluated, CAN-1041, PA-528, and PA-812 performed well in terms of yield under rainfed conditions. Genotypes PA-812 and PA-760 were superior in terms of fiber quality traits. Significant interaction between plant density and genotypes necessitates that the genotypes must be evaluated at appropriate plant densities to maximize their productivity.

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Table 8. Fiber properties of *G. arboreum* genotypes (averaged over soils, sowing dates, spacings, and years)

Genotypes	UHML[z]	UI[z]	MIC[z]	Bundle Strength[y]	EI[z]
	(mm)	(%)	(µg/inch)	(g/tex)	(%)
DLSa-17	27.3	81.1	4.9	28.3	5.9
PA-528	27.0	81.0	5.2	28.5	5.9
PA-402	25.3	79.8	5.2	27.9	6.1
PA-812	29.1	82.3	4.8	30.8	5.8
PA-760	28.9	82.7	4.7	30.2	5.9
CNA-1041	25.1	79.3	5.6	28.6	6.2
Phule Dhanwantary	15.6	69.6	7.0	21.2	6.8

[z]UHML: Upper half mean length; UI: uniformity index; MIC: micronaire; EI: Elongation Index

[y]Tenacity at 3.2mm gauge

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