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OPTIMUM SOWING DATES FOR COTTON VARIETIES IN THE GUINEA SAVANNA AGROECOLOGICAL ZONE OF GHANA

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ABSTRACT

Cotton *(Gossypium hirsutum)* is a cash crop commonly grown in the savanna zone of Ghana. The objective of this study was to determine the optimum sowing dates for different cotton varieties in Ghana. The study was conducted at the Savanna Agricultural Research Institute (SARI), Tamale, Ghana during 2016-2018 wet seasons. Treatments consisted of sowing dates at four levels, namely mid to late June (PD1), early to mid- July (PD2), mid to late July (PD3) and early August (PD4); and cotton varieties at three levels, i.e. FK37, SARCOT1 and SARCOT5. Treatments were laid out in a splitplot design, with sowing date as the main plot and variety as the subplot factor. Results showed that earlier sown cotton maximised seed cotton yield, number of bolls and opened bolls, seed weight, boll weight, plant height, as well as ginning out-turn. Cotton sown early at PD1 produced the highest average (1570 kg ha^{-1}) seed cotton yield, with 10 number of bolls and 9 opened bolls plant^{-1}. SARCOT5 cotton variety produced the highest (1223 kg ha^{-1}) seed cotton yield; while FK37 gave the lowest (861 kg ha^{-1}) yield. The interaction between PD1 and SARCOT5 produced the highest (1777 kg ha^{-1}) seed cotton yield and could be recommended for viable cotton production in the Guinea savanna agroecology of Ghana.

Key Words: *Gossypium hirsutum*, open bolls, seed cotton

RÉSUMÉ

Le coton (*Gossypium hirsutum*) est une culture de rente couramment cultivée dans la zone de savane du Ghana. L'objectif de cette étude était de déterminer les dates de semis optimales pour différentes variétés de coton au Ghana. L'étude a été menée à l'Institut de recherche agricole de la savane (SARI), à Tamale, au Ghana, pendant les saisons humides 2016-2018. Les traitements consistaient en des dates de semis à quatre niveaux, à savoir mi à fin Juin (PD1), début à mi-Juillet (PD2), mi à fin Juillet (PD3) et début Août (PD4); et des variétés de coton à trois niveaux, à savoir FK37, SARCOT1 et SARCOT5. Les traitements ont été disposés selon une conception en parcelles divisées, avec la date de semis comme parcelle principale et la variété comme facteur de sous-parcelle. Les résultats ont montré que le coton semé plus tôt maximisait le rendements en coton-graine, le nombre de capsules et de capsules ouvertes, le poids des grains. Le coton semé tôt à PD1 a produit le rendements en coton-graine moyen le plus élevé (1570 kg ha^{-1}), avec 10 nombres de capsules et 9 capsules ouvertes $plant^{-1}$. Variété de coton SARCOT5 a produit le rendements en coton-graine le plus élevé (1223 kg ha^{-1}) tandis que FK37 a donné le rendements en coton-graine le plus faible (861 kg ha^{-1}). L'interaction entre PD1 et SARCOT5 a produit le rendements en coton-graine le plus élevé (1777 kg ha^{-1}) et pourrait être recommandé pour une production de coton viable dans l'agroécologie de la savane guinéenne du Ghana.

Mots Clés : *Gossypium hirsutum*, capsules ouvertes, coton-graine

INTRODUCTION

Cotton *(Gossypium hirsutum)* is a cash crop commonly grown in the savanna zone of Ghana. The potential area for cotton production in Ghana is huge with an estimated market value of about US$200 million (Salifu *et al.,* 1999). Despite the high potential, average seed cotton yield remains very low (800 kg ha^{-1}) compared to elsewhere in West Africa (FAOSTAT, 2010).

The cotton production belt of Ghana is challenged with poor and erratic rainfall pattern that affects cotton yield; which otherwise requires adequate soil moisture for effective physiological processes. The region experiences a marked decline in annual precipitation, owing largely to shortened rainy season, due to climate change and variability. Cotton farmers are unable to predict the onset of rains and thus cannot make proper decisions on sowing dates.

Sowing too early frequently results in poor stands and lint quality; yet sowing late reduces the number of bolls that open at maturity, due to insect pest damage and moisture stresses; leading to yield reduction (Gormus and Yucel, 2002; Ali *et al.,* 2009). Optimum sowing date for a variety in a region is considered to be the most important manageable factor in cotton crop (Bozbek *et al.,* 2006; Hakoomat *et al.,* 2012). Iqbal *et al.* (2012) reported that early sown cotton contributes more towards vegetative growth rather than yield. According to Elayan *et al.* (2015), cotton yield and quality are affected by unfavourable environmental conditions and short growth periods. Cotton is sensitive to water deficit during both flowering and boll development (Loka, 2012; Loka and Oosterhuis, 2012; Zonta *et al.,* 2017) and these correlate positively with seed cotton yield. Plaut *et al.* (1992) reported that limited supply of water during boll development results in significantly lower cotton yields. Moreover, Krieg (2000) concluded that if water-deficit stress occurs after flowering, young fruits are more likely to abort due to decreased carbon and nitrogen supply; as well as perturbations in hormone metabolism.

The selection of suitable varieties for agroecologies is equally an important contributing factor to yield and quality attributes of a cotton crop (Deho *et al.,* 2012). Optimum sowing time for different varieties varies with agroecologies, depending on environmental conditions of the area. Therefore, the interaction of sowing dates and varieties will help arrive at optimum sowing time for varieties to establish the optimum combination of high yielding and lint quality potential. The objective of this study was to determine the optimum sowing dates for different cotton varieties within the cotton growing environment in Ghana.

MATERIALS AND METHODS

Study area. A field study was conducted during the 2016 - 2018 wet cropping seasons, at the Savanna Agricultural Research Institute (SARI), Nyankpala, in the Northern region of Ghana. The institute is located at N $09^{0}23.301'$, W $01^{0}00.215'$ and at 183 meters above sea level. The trial site was with a sandy loam textural soil (Kombiok *et al.,* 2015). The soils of the zone are generally well drained sandy loam with fairly flat topography.

The vegetative cover is basically Guinea savanna with short drought resistant trees and grassland. Also, the climate is warm and semi-arid, with unimodal annual rainfall of 800 - 1300 mm (Kombiok *et al.,* 2005). In a normal year, the rainy season starts from May and ends in October, giving way to onset of the dry season. However, due to climate change variability, the onset of rains has shifted towards June although generally unpredictable in nature.

The remaining prolonged period (November - April) defines the dry season within which irrigation is fully practiced in the agro-ecology. Temperature is consistently high; with an annual range of 29 to 39 ^{0}C and an estimated reference evapotranspiration (ET_o) above 1,600 mm yr^{-1} (Abdul-Ganiyu *et al.* 2018). The cropping season is challenged by intermittent drought spells, affecting soil moisture availability and crop yields.

Experimental details. The experimental design was splitplot. Treatments consisted of sowing dates as mainplot factor and cotton varieties as subplot factor. The sowing dates were considered at four levels, namely mid to late June, early to mid- July, mid to late July and early August (Table 1); while the cotton varieties were considered at three levels, namely FK37, SARCOT1 and SARCOT5.

Cotton variety FK37 is widely cultivated by farmers in Ghana and the SARCOTs 1 and 5 varieties were released by CSIR-SARI in 2004 based on their high yielding and early maturity traits.

The experiment was conducted under rainfed conditions and sowing dates varied slightly among seasons due to differences in seasonal onset of rains; but stayed within the defined interval dates. Plot sizes consisted of four rows of 10 m in length with inter-and intra-row spacing of 0.9 x 0.3 m, respectively.

The land was disc harrowed (once) and hand leveled with hand-hoes to prevent water logging. Fuzzy cotton seeds were sown at four to five seeds per stand using the dibbling and burying method. A pre-emergence herbicide, Stomp SC (Pendimenthaline 400 g l^{-1}), was applied immediately after sowing at the rate of 3.5 l ha^{-1}, using a Matabi Knapsack Sprayer.

The seedlings were thinned to two per stand, a week after seedling emergence (WAE). A basal fertiliser, compound Actyva (23N-10P-5K+3S+2MgO+0.3Zn), was applied at a rate of 200 kg ha^{-1}, at 2 WAE; and top dressed with Sulfan fertiliser (24N + 6S + l B) at the rate of 100 kg ha^{-1} at 5 WAE. Fertiliser applications were done by the dibbling and burying method under optimum soil water conditions (18.2%v/v). Insect pests were

TABLE 1. Sowing date as treatments for cotton grown in the 2016 - 2018 cropping seasons, in the Guinea savanna agroecological zone of Ghana

Sowing date	Actual sowing date for cropping seasons		
	2016	2017	2018
PD1; Mid to Late June	21 June	29 June	27 June
PD2; Early to Mid-July	5 July	13 July	12 July
PD3; Mid to Late July	17 July	24 July	27 July
PD4; Early August	6 August	7 August	8 August

PD = planting/sowing date

controlled starting from 30 days after seedling emergence and subsequently whenever they were spotted during monitoring. The early season pests including aphids, were controlled using Tihan (Spirotetramat 75 g l^{-1} and Flubendiamide 100 g l^{-1}) applied at the rate of 200 ml ha^{-1}. Mid to late season, insect pests including the bollworm complex were controlled usingThunder (Imidacloprid 100 g l^{-1} and Betacyfluthrin 45 g l^{-1}) insecticide applied at the rate of 200 ml ha^{-1}.

Data collection. Data were recorded on number of bolls and opened bolls $plant^{-1}$ at maturity, single boll weight, plant height at maturity, seed cotton yield, 100 seed weight and ginning out turn (GOT, %). A sample of 20 representative plants was randomly selected and tagged per plot for recording data. Plant height was taken by measuring from the base of the stem to the terminal bud at maturity. The number of bolls $plant^{-1}$ and opened bolls $plant^{-1}$ were recorded by counting bolls from the selected twenty plants at maturity and converting to average number of bolls and open bolls $plant^{-1}$.

Single boll weight was determined from 20 bolls randomly selected from the 20 tagged plants per plot. Seed cotton yield was determined from the harvest of the net plots. Seed cotton samples were sun dried and the ginning out turn (GOT, %) was calculated by applying the formula according to Xian *et al.* (2014) as follows:

$$GOT\ (\%) = \frac{\text{Lint yield}}{\text{Seed cotton yield}} \times 100 \quad \text{... Equation 1}$$

Statistical analysis. Data collected were subjected to analysis of variance (ANOVA) of GenStat 12 edition software, following the factorial treatment arrangement in a randomised complete block design. Treatments means were separated using the least significant difference (LSD) test at 95% confidence level.

RESULTS AND DISCUSSION

Boll weight per plant (g). The interaction effect of sowing dates and variety was non-significant (P>0.05). However, boll weight per plant was significantly affected (P<0.01) by sowing dates and cotton varieties (Tables 2 - 4). Cotton variety FK37 outperformed the SARCOTs 1&5 and produced the highest mean boll weight (Tables 2 - 4). The superiority of SARCOT5 variety is more expressed in its higher boll formation and retention due to its genetic makeup.

The early sown cotton produced significantly higher boll weight than the late sown cotton possibly due to proper boll development. The cotton bolls of early planted (PD1) and late planted (PD2) weighed 6.09 g and 6.16 g, respectively (Table 2). However, weight of the cotton bolls from the different planting dates (PD1, PD2 and PD3), across cotton varieties were not significantly different (P>0.05) (Table 2). The late sown cotton (PD4) yielded significantly (P<0.01) inferior boll weights than the early sown cotton (Tables 2 - 4).

Several authors (Chen *et al.,* 2014; Liu *et al.,* 2015) have shown that late planting can greatly induce low boll weight due to delayed physiological maturity and carbohydrate deficiency. Research by Mahmood-ul-Hassan *et al.* (2003) on the effect of sowing dates on two cotton cultivars under Multan conditions found that, early sown cotton (between 1st May to 15th June) produced greater boll weight that ranged from 3.07 g to 3.13 g compared to the range of 2.4 g to 2.8 g boll weight produced by the late sown cotton (1st - 15th July). Kakar *et al*. (2012) and Mostafa *et al*. (2022) in the Multan district reported similar boll yield trends against planting dates on boll weight of cotton. These authors reported that boll weight variation was due to the favourable temperature experienced during the fruiting stage of crop development for the early sown cotton. Schrader *et al.* (2004) found that high

TABLE 2. Effect of sowing dates and varieties on cotton boll characteristics, ginning out turn (GOT, %), plant growth characteristics and cotton yield in the 2016 cropping season of the Guinea savanna agroecological zone of Ghana

Sowing date (S)	BW (g)	GOT (%)	BP^{-1}	OBP^{-1}	PH (cm)	SCY (kg ha^{-1})	100 SW (g)
PD1	6.09	47.20	6.90	5.91	105.40	1806.00	8.68
PD2	6.16	41.80	7.80	6.09	108.20	1871.00	9.09
PD3	5.83	41.10	8.15	5.96	101.50	1393.00	8.99
PD4	5.77	40.60	3.04	2.25	104.40	584.00	9.04
GM	5.96	42.68	6.47	5.05	104.88	1413.50	8.95
$LSD_{0.05}$	0.27**	NS	0.93*	0.76*	NS	290.20*	NS
Variety (V)							
FK 37	6.04	43.20	5.62	4.31	105.90	1298.00	8.81
SARCOT1	6.03	23.70	6.27	5.07	103.00	1246.00	8.88
SARCOT5	5.81	41.10	7.53	5.73	105.60	1696.00	9.16
GM	5.96	36.00	6.47	5.04	104.83	1413.33	8.95
$LSD_{0.05}$	NS	NS	0.80*	0.66*	NS	251.40*	NS
Interaction effect							
S × V	NS	NS	NS	NS	NS	NS	NS

BW = Boll weight $plant^{-1}$, GOT = Ginning out turn, BP^{-1} = Bolls per plant, OBP^{-1} = Opened bolls per plant, PH = Plant height at maturity, SCY = Seed cotton yield, 100SW = 100 seed weight. *, ** = significant at 5 and 1% level of probability, respectively. NS = Not significantly different ($P<0.05$), S = Sowing dates, V = Varieties. Means followed by similar letters do not differ significantly at 5% level of probability

ambient temperatures can contribute to inhibition of photosynthesis in plants.

Another dimension is that, drought conditions can cause male sterility and lead to fruit drop (Tariq *et al.,* 2017). Therefore, results of the present study is relevant in identifying optimum sowing dates thus; not later than mid-July for the cotton growing environment of Ghana.

Number of bolls per plant. The interaction effect of sowing date and cotton variety was significant ($P<0.05$) in terms of number of bolls $plant^{-1}$ (Tables 3 and 4). The interaction revealed that SARCOT5 cotton sown early (PD1) maximised bolls $plant^{-1}$ (Figs. 1 and 2). The interaction of PD1 and SARCOT5 produced the highest number (11) of bolls $plant^{-1}$; followed by PD1 and SARCOT1 with 10 bolls $plant^{-1}$ (Fig. 1). In contrast, late sown cotton varieties (PD4) produced fewer bolls (Fig. 2). The lower boll production of cotton varieties when planted late could be attributed to reproductive phase of late sown cotton coinciding with high ambient temperature and soil water stresses, which probably resulted in abortions of flowers and young bolls; leading to lower boll retention per plant (Loka and Oosterhuis, 2012; Zonta *et al.,* 2017).

The retention of fruits in cotton is associated with prevailing soil moisture, which can be affected under excess or deficient supply

TABLE 3. Effect of sowing dates and cotton varieties on boll characteristics, ginning out turn (GOT, %), plant growth characteristics and yield growth in the 2017 growing season of the Guinea savanna agroecological zone of Ghana

Sowing date (S)	BW (g)	GOT (%)	BP^{-1}	OBP^{-1}	PH (cm)	SCY (kg ha^{-1})	100 SW (g)
PD1	6.05	41.26	10.06	7.81	105.30	959.00	9.66
PD2	6.09	40.80	5.47	4.20	107.20	585.00	9.52
PD3	5.73	40.89	2.91	1.65	100.20	307.00	9.80
PD4	2.49	34.97	0.39	0.11	91.90	94.00	5.57
GM	5.09	39.48	4.71	3.44	101.15	486.25	8.64
$LSD_{0.05}$	0.36**	3.05**	1.05**	1.05**	8.50*	160.20*	0.79**
Variety (V)							
FK 37	5.21	38.07	3.91	2.89	100.10	382.00	8.29
SARCOT1	5.05	40.13	4.89	3.47	104.00	533.00	8.79
SARCOT5	5.02	40.23	5.33	3.97	99.30	544.00	8.82
GM	5.09	39.48	4.71	3.44	101.13	486.33	8.63
$LSD_{0.05}$	NS	NS	0.91*	0.91	NS	138.80**	NS
Interaction effect							
S × V	NS	NS	*	*	NS	**	NS

BW = Boll weight plant^{-1}, GOT = Ginning out turn, BP^{-1} = Bolls per plant, OBP^{-1} = Opened bolls per plant, PH = Plant height at maturity, SCY = Seed cotton yield, 100SW = 100 seed weight. *, ** = significant at 5% and 1% level of probability, respectively. NS = Not significantly different at 5%, S = Sowing dates, V = Varieties. Means followed by similar letters do not differ significantly at 5% level of probability

(Tariq *et al.,* 2017). Loka (2012) and Sawan (2018) noted that the severity of moisture stress can result in plants shedding leaves prematurely, causing drastic reduction in yields. Leaf senescence due to soil water stress condition reduces stomatal conductance and results in low transpiration rate (Pask *et al.,* 2012). This increases the temperature of plant structures such as leaves and affects certain physiological processes in the plant system (Parkash and Singh, 2020).

On the other hand, early sown cotton had favourable temperature and precipitation throughout the growing season, which positively affected translocation and mobilisation of photosynthates; and resulted in the production of large number of bolls as reported by Ali *et al.* (2009). Shah *et al.* (2017) stated that early planted cotton exploits rainfall, temperature and sunlight levels that occur in spring and summer, and start growth and reproduction stages earlier, thereby producing more blooms and setting more bolls. In contrast, late planting greatly reduces lint yield and induce low boll weight due to delayed physiological maturity and carbohydrate deficiency (Chen *et al.,* 2014; Liu *et al.,* 2015).

Opened bolls per plant. There was significant ($P<0.05$) interaction effect of sowing date by cotton variety in terms of number of open bolls plant^{-1} (Figs. 3 and 4). The interaction effect revealed that the three cotton varieties

TABLE 4. Effect of sowing dates and cotton varieties on boll characteristics, ginning out turn (GOT, %), plant growth and yield in the 2018 cropping season of the Guinea savanna agroecological of Ghana

Sowing date (S)	BW (g)	GOT (%)	BP^{-1}	OBP^{-1}	PH (cm)	SCY (kg ha^{-1})	100 SW (g)
PD1	6.02	40.99	13.72	12.02	84.40	1945.00	9.00
PD2	5.81	40.39	8.75	6.98	72.10	1249.00	8.87
PD3	6.07	39.99	9.90	6.09	79.10	877.00	9.57
PD4	5.29	37.54	6.96	2.08	77.60	438.00	7.97
GM	5.80	39.73	9.83	6.79	78.30	1127.25	8.85
$LSD_{0.05}$	0.34**	2.49*	1.40**	1.06**	7.20*	180.60**	0.82*
Variety (V)							
FK 37	6.06a	40.48	10.17	6.19	79.70	903.00	8.82
SARCOT1	5.59	39.62	7.73	5.82	76.80	1051.00	8.66
SARCOT5	5.74	39.08	11.59	8.35	78.40	1428.00	9.06
GM	5.80	39.73	9.83	6.79	78.30	1127.33	8.85
$LSD_{0.05}$	0.30*	NS	1.21**	0.92**	NS	156.40**	NS
Interaction effect							
S × V	NS	NS	*	*	NS	*	NS

BW = Boll weight $plant^{-1}$, GOT = Ginning out turn, BP^{-1} = Bolls per plant, OBP^{-1} = Opened bolls per plant, PH = Plant height at maturity, SCY = Seed cotton yield, 100SW = 100 seed weight. *, ** = significant at 5% and 1% level of probability respectively. NS = Not significantly different at 5%, S = Sowing dates, V = Varieties. Means followed by similar letters do not differ significantly at 5% level of probability

when sown early (PD1) would maximise the number of opened bolls $plant^{-1}$, followed by the next suitable date, that is PD2 (Figs. 3 and 4). The interaction of PD1 and SARCOT5 produced 9 opened bolls $plant^{-1}$, followed by PD1 and SARCOT1 with 8 opened bolls $plant^{-1}$ (Fig. 3). Also the interaction of PD1 and SARCOT5 produced 15 opened bolls $plant^{-1}$, followed by PD1 and FK37 with mean of 11 opened bolls $plant^{-1}$ (Fig. 4).

Generally, the late sown cotton (PD4) and cotton varieties (FK37, SARCOTs 1&5) produced significantly fewer opened bolls $plant^{-1}$ (Figs. 3 and 4). The late sown cotton coincided with high temperature stress that likely resulted in abortions of young bolls and led to the lower yields. Cetin and Basbag (2010) also noted that environmental factors, such as air temperature, rainfall and wind can significantly influence yield components and qualitative characteristics of the cotton fiber. The assertion is further supported by findings of Barbour and Farquhar (2000), while evaluating cotton in a controlled environment under relative humidity of 43 and 76%. They found that, plants produced under lower relative humidity conditions resulted in higher transpiration rates and decrease in leaf temperature.

Further, sowing too late resulted in poor boll opening due to the increased vulnerability of bolls to insect pests and bad weather as

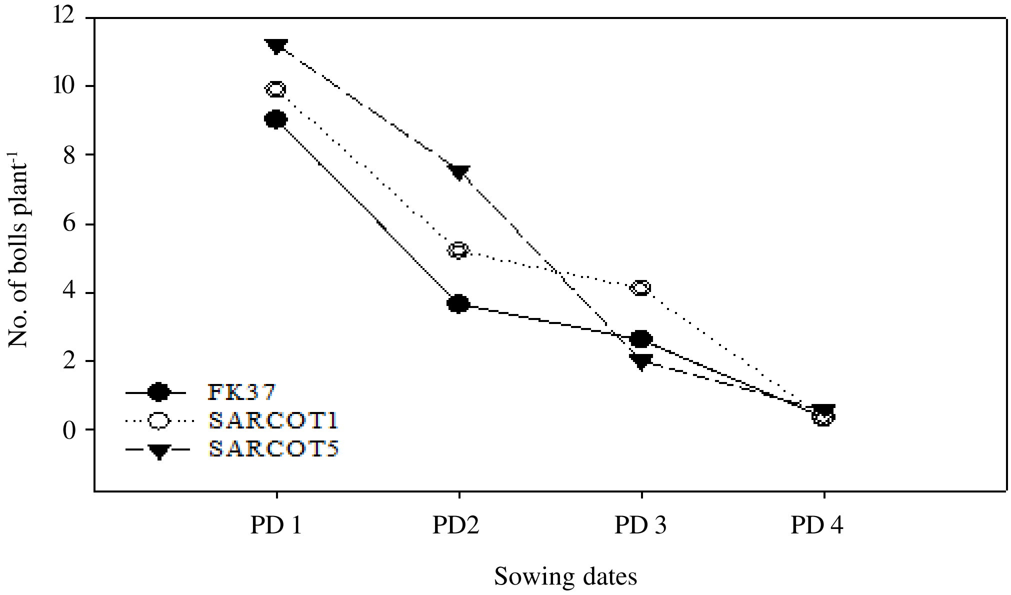

Figure 1. Effect of sowing dates and varieties on number of bolls plant^{-1} in the 2017 growing season.

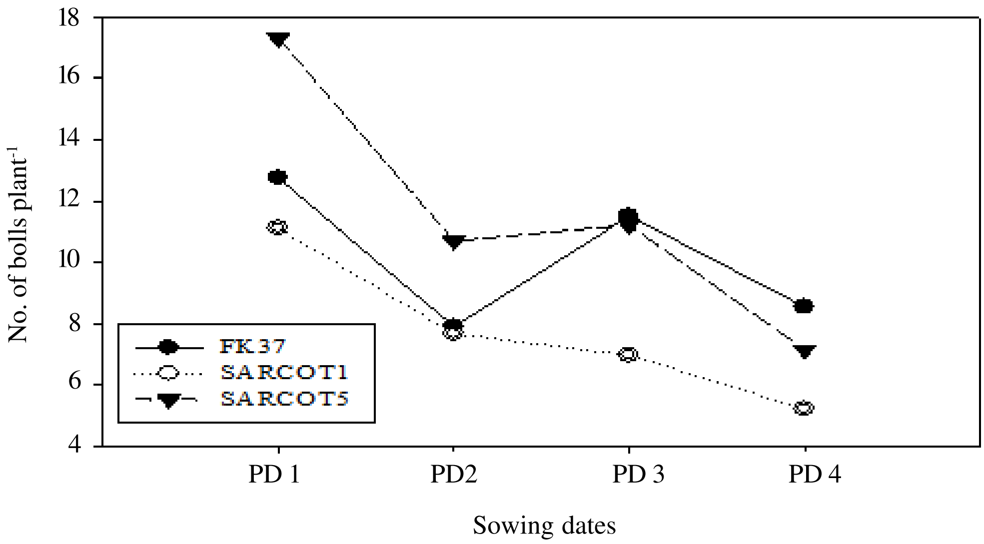

Figure 2. Effect of sowing dates and varieties on bolls plant^{-1} in the 2018 growing season.

some studies reported (Gormus and Yucel, 2002; Pedigo, 2004; Ali *et al.*, 2009). Karavina *et al.* (2012) also reported that change in sowing date did not only affect cotton yield and quality but also affected insect pest management due to the different cycles.

Plant height. There was a significant effect of sowing dates (P<0.05) in terms of plant height (Tables 3 and 4). Early sown cotton (PD1) produced higher plant height when compared to late sown dates due to the optimum soil water conditions. The PD1 and

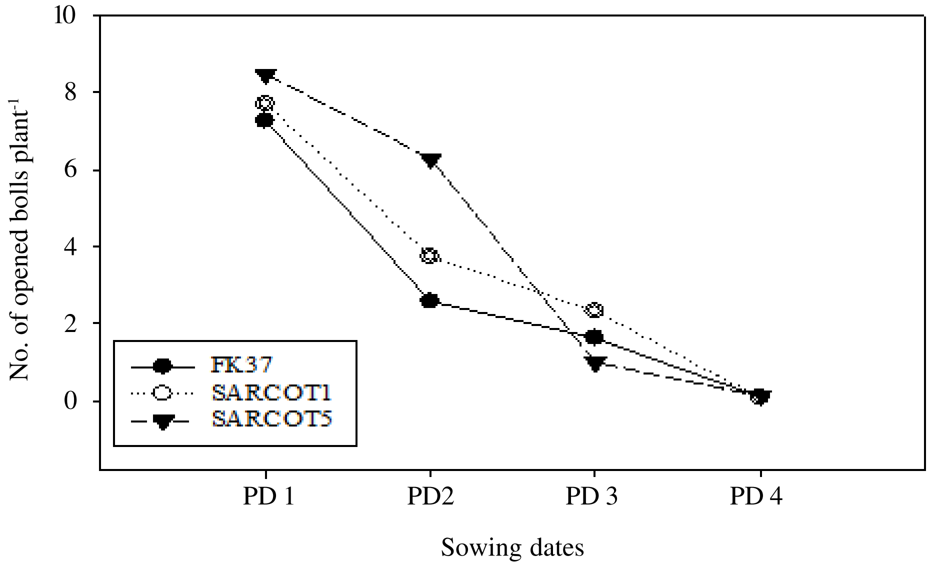

Figure 3. Combined effect of sowing dates and varieties on number of opened bolls plant^{-1} in the 2017 growing season.

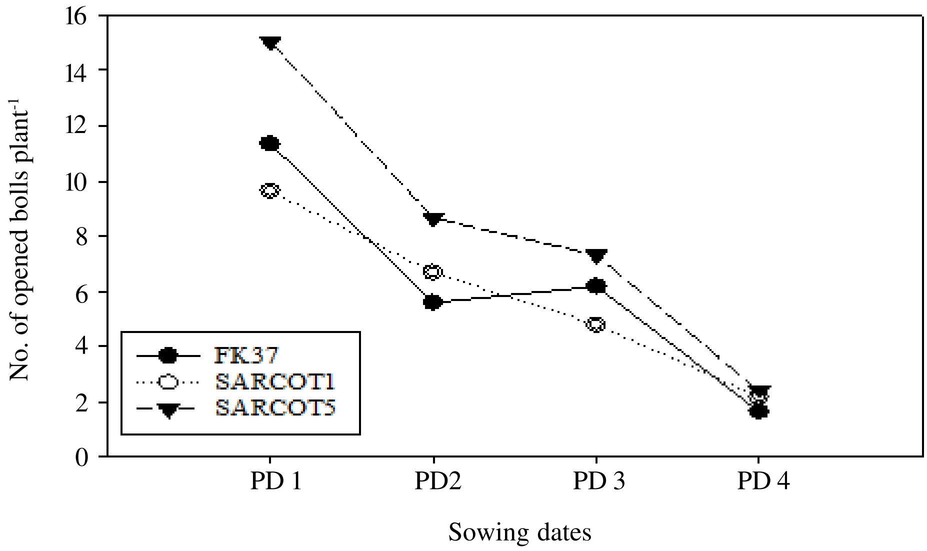

Figure 4. Combined effect of sowing dates and varieties on number of opened bolls plant^{-1} in the 2018 growing season.

PD2 produced plants with average height of 105.30 cm and 107.20 cm, respectively (Table 3). However, PD3 recorded the lowest plant height of 91.90 cm (Table 3). Again, cotton plants of PD1 obtained highest average height of 84.40 cm while PD3 gave 79.10 cm. PD2 emerged with the lowest average plant height of 72.10 cm (Table 4). The differences in plant heights may be attributed to the genetic makeup of the varieties as reported by Hussain *et al.* (2007), and shortened rainfall and extreme weather conditions of high temperatures and drought, especially during the prolonged vegetative phase that led to soil water stress conditions under later sown cotton. The crop's sensitivity to water stress conditions varies by growth stage and is also crop-dependent (Saini and Westgate, 2000). Therefore, it is necessary to observe early sowing of cotton to take advantage of the optimum soil and weather conditions.

Seed cotton yield (SCY). The interaction effect of S x V on seed cotton yield was significant (P<0.01) (Tables 3 and 4). The interaction of PD1 and SARCOT5 produced highest mean seed cotton yield of 1026 kg ha^{-1}, followed by PD1 and SARCOT1 with mean yield of 958 kg ha^{-1} (Fig. 5). However, late sown cotton (PD4) and FK37 produced lowest seed cotton yield of 87 kg ha^{-1} (Fig. 5). Also, the interaction of early sown cotton thus PD1 and SARCOT5 yielded highest seed cotton yield of 2528 kg ha^{-1}, followed by PD1 and SARCOT1 with a yield of 1819 kg ha^{-1} (Fig. 6). In addition, all three cotton varieties sown at PD2 produced seed cotton yield above 1 t ha^{-1}, making it the next suitable sowing date for cotton. However, the late sown cotton produced lower seed cotton yield for the varieties. The interaction of PD4 and FK34 produced the lowest seed cotton yield of 300 kg ha^{-1} (Fig. 6).

The general trend of higher seed cotton yields in early sown (PD1 and PD2) cotton varieties was probably due to favourable environmental and soil conditions that influenced physiological processes than all other sowing dates as reported by Rauf and Sadaqat (2007). Late sown cotton resulted in poor seed cotton yield due to soil water stresses and shorter growth period as reported by Elayan *et al.* (2015). Bange *et al.* (2008) reported that higher seed cotton yield ascribed to early sowing was mainly attributed to more bolls and seed index. Mahmood-ul-Hassan *et al.* (2003) worked on the effect of sowing dates on two cotton cultivars under Multan conditions and reported that cotton sown early produced highest seed cotton yield of 3514 kg ha^{-1} and 3511 kg ha^{-1} for cultivars MNH552 and MNH554, respectively; whereas cotton

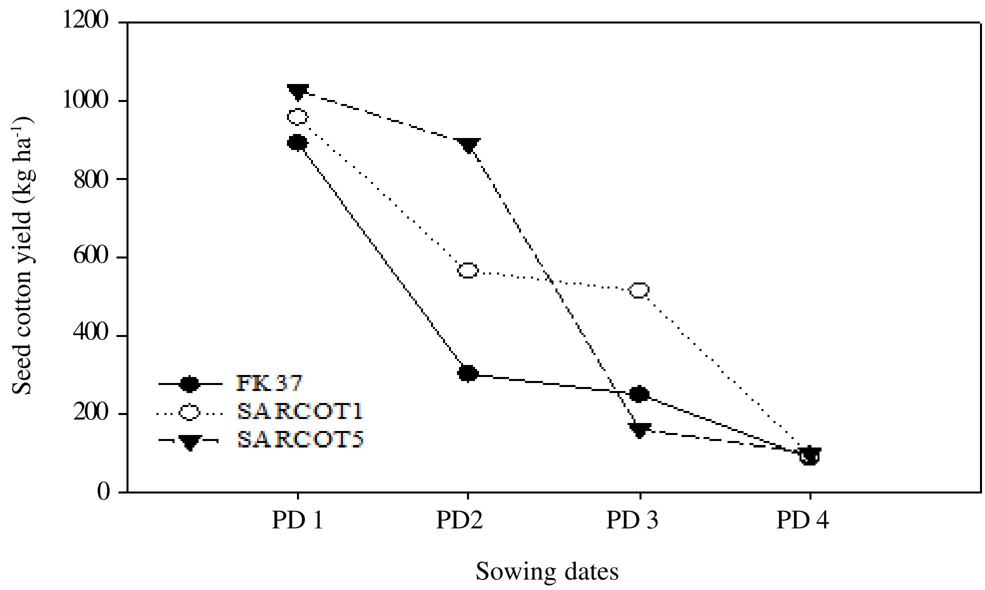

Figure 5. Combined effect of sowing dates and varieties on seed cotton yield (kg ha^{-1}) in the 2017 growing season.

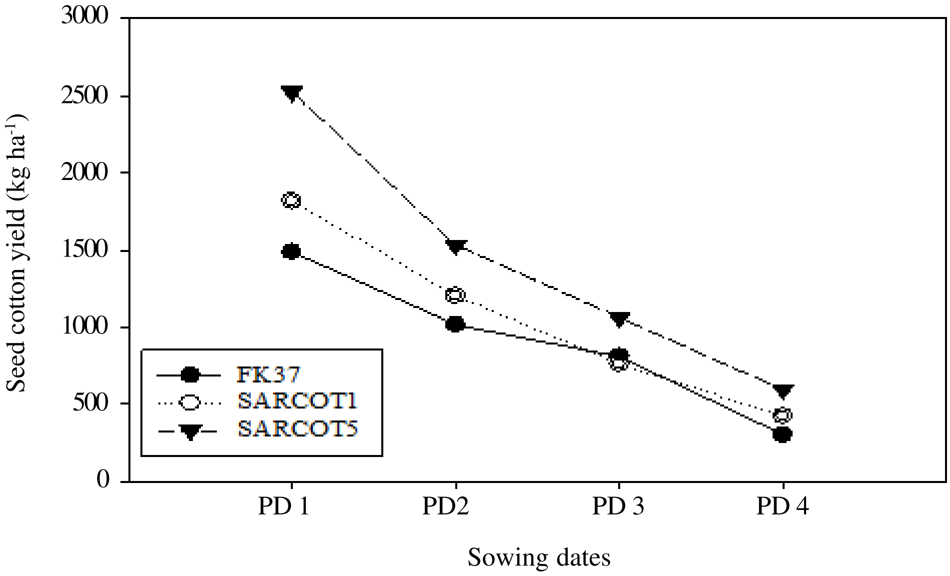

Figure 6. Combined effect of sowing dates and varieties on seed cotton yield (kg ha^{-1}) in the 2018 growing season.

sown late produced lowest seed cotton yield of 235 kg ha^{-1} and 241 kg ha^{-1} for MNH552 and MNH554, respectively. The results of the present study suggest that the SARCOT cotton varieties exhibited superiority over the popular FK37 variety, and would help farmers improve their seed cotton yields above the national average of 800 kg ha^{-1}. Therefore, efforts should be made by cotton companies operating in the zone to promote seed of the SARCOT varieties to cotton farmers to increase productivity of the crop.

100 seed weight. The interaction between sowing date and cotton variety was not significant (P>0.05) for 100 seed weight of cotton. Nevertheless, sowing dates significantly affected 100 seed weight of cotton varieties (Tables 2 - 4). Generally, early sown cotton yielded greater 100 seed weight than late sown cotton. Cotton sown early on PD1, PD2 and PD3 produced higher, yet significantly (P>0.05) similar 100 seed weight of 9.66, 9.52 and 9.80 g, respectively (Table 3). Again PD1, PD2 and PD3 produced higher but statistically similar 100 seed weight of 9.0, 8.87 and 7.97 g, respectively (Table 4). However, PD4 produced significantly lower 100 seed weight even below the recorded grand means. The findings agree with research by Deho *et al.* (2014), on the impact of sowing dates and picking stages on yield and seed maturity of cotton in Sindh, Pakistan. The authors evaluated four sowing dates against four picking stages of cotton and found that, the greatest seed index of 7.7 g was produced by cotton sown early. According to Bange *et al.* (2008), higher seed cotton yield due to early sowing can be attributed to higher boll number and seed index. Therefore, cotton varieties with desirable properties such as higher seed weight coupled with optimum planting date strategies would increase the crop's productivity and whole cotton industry of Ghana.

Ginning out turn (GOT, %). There was no significant (P>0.05) interaction effect of sowing date and cotton varieties on GOT. Similarly there was no significant effect of cotton varieties on GOT. Ginning out turn was significantly affected by sowing dates (Tables 3 and 4). Mean values of GOT for sowing dates revealed that the highest of 41.3% (Table 3) and 41.0% (Table 4) was produced by plants sown early at PD1. The late sown cotton (PD4) produced plants with lowest GOT of 35.0% (Table 3) and 37.5% (Table 4). In contrast, early sown cotton varieties are presumed to have had favourable environmental conditions that contributed towards boll development and resulted in higher lint yield as reported by Yeates *et al.* (2010). Harvesting of early sown cotton was done at a time when all the opened bolls still had cotton lint intact without shedding that usually results from heavy winds associated to late sown cotton. Also, the lower values of GOT for late sown cotton were probably due to the shortened fruiting period and delayed maturity compared to early sowing (Bauer *et al.,* 2000; Bange *et al.,* 2004). The textile industry depends on cotton varieties with good lint quality properties such as ginning out-turn. The results of the present study suggest that, the desired lint quality with market demand can be achieved when cotton is early sown in the region.

CONCLUSION

Late sowing of cotton varieties in the Guinea Savanna Agroecological zone of Ghana are unsuitable for most cotton varieties owing to unfavourable weather conditions that pertain later in the growing season. Generally, plant growth, ginning out turn, and yields are severely affected by late sowing thus resulting in poor performance of virtually all varieties. On the contrary, early sown cotton between mid to late June in study years produces the highest yield presumably due to favourable temperature and precipitation. Sowing between early to mid- July (PD2) is the second suitable sowing period for cotton in the zone. It is recommended from the present study to sow cotton not later than June 30, with SARCOT5 variety which has a comparative yield potential over the other two varieties in the Guinea savanna agroecology. Early sowing (PD1) and SARCOT5 variety may be evaluated further in other Savanna agroecological zones for wider recommendation and practice.

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