

Effects of sowing dates on grain yield and yield attributes of sorghum (*Sorghum bicolor* Moench) cultivar ICSV111 (Kapaala) in northern Ghana

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ABSTRACT

Lack of a suitable sowing date has often been identified as the main constraint to sorghum (*Sorghum bicolor* Moench) cv. ICSV111 (Kapaala) production in Ghana. Field experiments were, therefore, used on-station at the Manga Agricultural Research Station to evaluate the effects of five sowing dates on yield and yield components of 'Kapaala' in northern Ghana. Sowing dates significantly ($P<0.05$) influenced grain and straw yields and yield components of 'Kapaala'. The first two sowing dates (May 25 to June 12) significantly ($P<0.05$) out-yielded the later ones. Sorghum plant population at 14 days after sowing and at harvest, number of heads harvested, plant height, percent threshing, 1000-kernel weight, and grain and straw yields per plant and per hectare were superior with early sowings compared to their lately sown counterparts. However, late-sowed plants matured significantly ($P<0.05$) earlier than early-sowed plants, and had significantly fewer mouldy heads than their early-sowed counterparts. Mean increase in sorghum grain yield when 'Kapaala' was sown on May 25, the earliest sowing date, over the late-sowing date June 24 was 125 per cent. Mean increase in sorghum straw yield when sowed earliest compared to their lately sowed counterparts was 173 per cent. The grain and straw yields and other yield attributes recorded for 'Kapaala' in northern Ghana indicated that the first two sowing dates (end of May to mid June) performed better than the last three sowing dates. It could, therefore, be concluded that the most suitable sowing dates for 'Kapaala' in northern Ghana is from end of May to mid June.

RÉSUMÉ

KANTON, R. A. L., ATOKPLE, I. D. K., DOGBE, W. & KASEI, C. N.: Rendement de grain et les attributs de grain (*Sorghum bicolor Moench*) de la variété ICSV111 (Kapaala) comme influencé par les dates de semilles dans le nord du Ghana. Le manque de date de semilles appropriée a été souvent indiqué comme la principale entrave à la production de sorgho (*Sorghum bicolor* Moench) var. ICSV111 (Kapaala) au Ghana. Des expériences sur le terrain étaient donc entreprises sur place au Centre de Recherche Agricole de Manga pour évaluer les effets de cinq dates de semilles sur le rendement et les éléments de rendement de 'Kapaala' dans le nord du Ghana. Les dates de semilles influençaient considérablement ($P<0.05$) les rendements de grain et de paille ainsi que les éléments de rendement de 'Kapaala'. Les deux premières dates de semilles (25 Mai à 12 Juin) considérablement ($P<0.05$) dépassaient en rendement les dates tardives. Le nombre de plante de sorgho après 14 jours de semilles et pendant la moisson, le nombre de têtes moissonnées, la taille de plante, le pourcentage (%) de battage, le poids de 1000 grain et les rendements de grains et de paille par plante et ha⁻¹ étaient de qualité supérieure avec les semilles tôt comparées aux contreparties de semilles tardives. Les plantes semées tard, toutefois arrivaient à la maturité considérablement ($P<0.05$) plus tôt que les plantes semées tôt et puis elles avaient considérablement plus moins de tête moisie que leurs contreparties de semilles tardives. L'augmentation moyenne de rendement de grain de sorgho lorsque 'Kapaala' étaient semées le 25 Mai, le plus tôt de date de semille, par rapport à la date de semille tardive de 24 Juin, était 125%. L'augmentation moyenne de rendement de paille de sorgho lorsque semé le plus tôt possible comparée à leurs contreparties semées dernièrement était 173%. Les rendements de grain et de paille et d'autres attributs de rendement obtenus pour 'Kapaala' dans le nord du Ghana indiquaient que les deux premières dates de semilles (de fin Mai à mi Juin) rendaient mieux que les trois dernières dates de semilles. Donc, la conclusion pourrait être tiré que les dates de

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semailles appropriées pour 'Kapaala' dans le nord du Ghana est de la fin de Mai à mi Juin.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops grown in northern Ghana, considering area of cultivation and consumption. The grain is used to prepare several meals such as tuo zaafi, porridge, and a local beer called pito. It also has a potential use in the brewery industry. The straw of sorghum is equally important because it is used to roof local houses, for fencing dry season gardens, and also as fuelwood.

Grain yields of sorghum in farmers' fields are very low because of numerous production constraints. Low plant population densities, which are often observed on farmers' fields (Ntare, 1992), may partly be due to the low seeding rate adopted by farmers and poor seedling emergence which lead to low grain yields. If seedlings are established as desired by using good quality seed, along with other agronomic practices, plant population could be optimum in a particular cropping system for increased production of sorghum.

Planting at different dates may result in differences in grain yield, infection by disease pathogens, and percentage germination (Assiedu, Owusu-Akyaw & Fenteng, 1989). For example, in soybean, inappropriate planting date and variety maturity caused seeds to be exposed to poor weather (rainy or warm and humid climate) during maturation, leading to a high incidence of etched (physiologically cracked) seeds (Burchett *et al.*, 1985) as well as to high levels of infection by *Phomosis* species which resulted in low germination percentages (Tekrony *et al.*, 1984).

The sorghum cultivars being grown now by farmers in northern Ghana are the landraces. These landraces are characterised by low yields, are susceptible to pests and diseases, and are also late in maturing, ranging between 5 and 6 months.

One of the major constraints to sorghum production is unreliable rainfall and lack of suitably improved and early-maturing sorghum varieties. The seasonal characteristics of the West Coast moon, which transport moisture over the area, have been reported (Hamilton & Archbold, 1945; Adejokun, 1966). In northern Ghana, rainfall is erratic in on-set and distribution; therefore, strategies need to be developed for optimal use of periods of moisture availability for enhanced crop production.

Farmers participating in the pre-season annual planning sessions organised by the Research and Extension Linkage Committee (RELC) of the Upper East and Upper West regions have always identified lack of improved crop varieties as one of the most important constraints to agriculture. Breeders have, therefore, been breeding for early-maturing, pest and disease-resistant or tolerant, and high-yielding crop varieties. This has brought in its wake the improved and early-maturing sorghum variety 'Kapaala'.

Though 'Kapaala' has been tested across the major agro-ecologies of northern Ghana, its agronomy has not been studied much. It was, therefore, not surprising when farmers in the Upper regions complained of the optimal date of sowing 'Kapaala' after its release in 1994.

The objective of this study was to evaluate various sowing dates of 'Kapaala' and to determine the optimal date for increased and sustainable 'Kapaala' production.

Materials and methods

The sorghum cultivar 'Kapaala' was used in field experiments at the Savanna Agricultural Research Institute, Manga Station near Bawku in northern Ghana (11° 01'N, 00°-16'W, 249 m above sea level) during the period 1997-1998. The climate of the region is Sudan Savanna, with a mean annual rainfall of 908 mm of which 80 per cent is received

from June to September. The experiment was laid out in a randomised complete block design with five replications in 4.5 m × 10 m plots. Data were, however, taken from the middle four rows measuring 3.0 m × 10 m. The sowing date treatments in 1997 were 25/5, 8/6, 22/6, 6/7 and 20/7; and in 1998, they were 29/5, 12/6, 26/6, 10/7 and 24/7 (Table 1). The land was prepared by tractor-harrowing and ridged using bullocks. The crop was sown in 75-cm rows on the above dates for both seasons using four to six seeds per hole. The plant spacing of 30 cm within the rows was

TABLE 1

Sowing Dates Evaluated with Sorghum cv. 'Kapaala' at Manga (1997-1998)

Sowing date code	Month	Sowing date	
		1997	1998
1	May	25	29
2	June	8	12
3	June	22	26
4	July	6	10
5	July	20	24

maintained by thinning to two plants per hill at 14 days after sowing (DAS). Effective rains during both growing seasons amounted to 946.0 and 979.2 mm, respectively (Table 2).

Compound fertilizer 15-15-15 was applied at the rate of 40 kg N ha⁻¹, 40 kg P ha⁻¹, and 40 kg K ha⁻¹ at 14 DAS; and sulphate of ammonia (S/A) was applied at the rate of 20 kg N ha⁻¹ as a top-dress at exactly 28 DAS. Weeding was done at 14 and 28 DAS before each fertilizer was applied. Ridges were reshaped by bullock at 70 DAS. Data were taken on stand establishment 14 DAS, plant height at flowering, plant population and number of heads at harvest, number of mouldy heads and grain and straw yields at harvest. The data were then subjected to statistical analysis using STATISTIX General Linear Models (GLM). Means were separated using LSD test at the 5 per cent probability level.

For detecting differences in germination associated with different sowing dates, seeds were not rigidly sorted to discard the bad ones. Harvested seeds were subjected to laboratory tests. Four replicates of 50 seeds were germinated between moist paper towels (25 cm × 40 cm), with two paper towels beneath and above. Five seeds were arranged on the short side of the paper towel and 10 on the long side. The paper towels were moistened, rolled, and placed in a germinator at alternating temperatures of 25 and 35 °C every 12 h at 100 per cent relative humidity for 7 days. The first germination was counted on the 4th day; seedlings that were observed to be normal were counted and removed. Seeds that were dead were also counted, recorded and removed. Seeds which did not show clear evidence of germination were still kept until the end of the germination period, which was 7 days.

On the 7th day, normal seeds were counted as germinated and added to those counted on the 4th day for the total germination. Percentage germination was then determined. Seedlings that were considered normal were those that had vigorous primary roots, usually with adventitious roots present; or no primary roots, but at least two vigorous adventitious roots with vigorous green leaves not badly split, extending over half-way into the coleoptile (AOSA, 1983).

Seed moisture content was determined using the oven-dry weight method. Twenty grammes of seeds were weighed before and after drying at 105 °C for 24 h. Seed moisture content was then determined as a percentage of fresh (air-dry) weight.

$$\text{Seed moisture content (\%)} = \frac{\text{Fresh weight of seed} - \text{oven-dry weight of seed}}{\text{Fresh weight}} \times 100$$

Thousand-seed weight was determined by counting and weighing 1000 seeds on Metler balance at room temperature (27-30 °C).

TABLE 2

Rainfall (mm) in 10 Days' Interval Distribution During the Experimental Period at Manga (1997-1998)

Month	Year	Week 1	Week 2	Week 3	Week 4
May	1997	24.7	6.2	2.3	71.8
	1998	36.1	1.2	30.0	15.5
June	1997	33.4	137.7	25.1	39.9
	1998	54.7	25.1	33.3	5.6
July	1997	31.2	39.1	15.3	29.9
	1998	75.0	77.1	141.6	36.3
August	1997	40.0	29.8	76.4	31.1
	1998	19.2	25.8	77.5	57.1
September	1997	146.3	0.3	114.6	0.0
	1998	48.4	94.6	51.9	14.2
October	1997	90.7	2.5	14.8	17.7
	1998	0.0	3.7	17.1	0.0

Source: Manga Agricultural Research Station

Results

The effect of sowing date on the growth, yield and yield components of the sorghum cultivar 'Kapaala' was significant ($P < 0.05$). Sorghum plant population at 14 DAS was significantly ($P < 0.05$) influenced by sowing date. Early sowing dates recorded significantly ($P < 0.05$) higher plant population than late sowing ones (Table 3). Sowing sorghum from 25 to 29 May (1) recorded the highest sorghum population, while the lowest population was observed when sown from 20 to 24 June (5). Mean increase in sorghum population when sowed on 1 over 5 was 111 per cent. Sorghum population when sowed on 1 was significantly ($P < 0.05$) higher compared to sorghum sown from 22 to 26 June (3), 6 to 10 July (4), and 5. Sowing sorghum from 8 to 12 June (2) similarly recorded superior population compared to 4 and 5. Sorghum population at harvest followed a similar trend to that recorded at 14 DAS.

Sowing sorghum on 1 and 2 had significantly ($P < 0.05$) higher plants at harvest compared to their counterparts sowed on 3, 4 and 5 (Table 3). Sowing sorghum on 3 and 4 also recorded superior plant population at harvest compared to that sown on 5. Sowing 'Kapaala' on 1 recorded the

highest number of heads at harvest, while sowing 'Kapaala' on 5 recorded the least (Table 3). Mean increase in number of heads harvested when sorghum was sown on 1 over that sown on 5 was 349 per cent. Sowing sorghum on 1 produced significantly ($P < 0.05$) higher number of heads compared to that observed when sorghum was sown on 2, 3, 4 and 5. Sowing sorghum on 2 also had significantly ($P < 0.05$) higher number of heads at harvest compared to their counterparts sown on 3, 4 and 5.

Number of mouldy heads of sorghum was significantly higher for sorghum sowed on 1 compared to the other sowing dates (Table 3). Sowing on 2 also had significantly ($P < 0.05$) higher mouldy heads compared to 3, 4 and 5. Sorghum sown on 5 produced the least number of mouldy heads compared to the other sowing dates. Sowing sorghum on 1 produced 280 per cent more mouldy heads compared to that sowed on 5.

Plant height of sorghum decreased significantly ($P < 0.05$) with delay in sowing date (Table 5). Sowing 'Kapaala' on 1 produced the tallest plants while sowing sorghum on 5 produced the shortest plants. The tallest sorghum

TABLE 3

Plant Population 2 WAS and at Harvest, Number of Heads Harvested, and Number of Mouldy Heads of 'Kapaala' as Affected by Date of Sowing (1997-1998)

<i>Sowing date code</i>	<i>Germinated hills 5 days</i>	<i>Plant population at harvest</i>	<i>No. of heads harvested</i>	<i>No. of mouldy heads</i>
1	129a	191a	166a	19a
2	123a	162a	121b	14b
3	105bc	126b	65c	11c
4	84cd	110b	63c	9c
5	61d	74c	37c	5d
Mean	100	133	90	12
CV (%)	3.67	3.52	5.09	4.22

Means in a column followed by the same letter(s) are not significantly ($P<0.05$) different

TABLE 4

Effect of Sowing Date on Percentage Germination, 1000-seed Weight, and Seed Moisture Content of Sorghum cv. 'Kapaala' (1997-1998)

<i>Sowing date code</i>	<i>% germination</i>	<i>1000-seed weight (g)</i>	<i>Seed moisture content (%)</i>
1	166a	31.50a	12.26a
2	121b	29.66a	12.12a
3	65c	20.42b	12.26a
4	63c	17.01b	12.94a
5	37c	18.26b	12.40a
Mean	34	23.39	12.40
SE	15.66	3.30	0.63

Means in a column followed by the same letter(s) are not significantly ($P<0.05$) different

plants were about 71 per cent taller than their counterparts sown on 5. Sorghum sown on 1, 2 and 3 produced significantly ($P<0.05$) taller plants than sorghum sown on 4 and 5.

The effect of sowing date on number of days to maturity of 'Kapaala' was significant ($P<0.05$) (Table 5). 'Kapaala' sown on 5 matured significantly early compared to the other sowing

dates. 'Kapaala' sown on 1 was the latest to attain maturity. Days to maturity varied significantly ($P<0.05$) with all sowing dates of 'Kapaala', with lately sowed dates resulting in early maturity compared to their early-sown counterparts. The most lately sowed 'Kapaala' matured 25 days earlier compared to its earliest sown counterpart (Table 5).

Results indicated that the germination percentages of sorghum seeds harvested from early sowings (May 29 and June 12) were significantly higher. As sowing was delayed, seeds harvested progressively showed decreases in germination percentages (Table 4).

In this study, it was also observed that 1000-seed weight of harvested seeds of sorghum progressively and significantly decreased as sowing was delayed (Table 4). Seed moisture content did not change with different times of sowing.

Sowing date significantly ($P<0.05$) influenced the percent threshing of 'Kapaala', with early sowing dates recording significantly ($P<0.05$) higher percent threshing values compared to their late-sown counterparts (Table 5). The highest percent threshing was recorded for 'Kapaala' sown on 1, while the lowest was observed for 'Kapaala' planted on 5. Sowing 'Kapaala' on 1 and 2 recorded significantly ($P<0.05$) higher percent threshing values than the

TABLE 5

Plant Height and Percent Threshing of Sorghum cv. 'Kapaala' (1997-1998)

Sowing date code	Plant height (m)	Days to maturity	% threshing
1	1.81a	122a	70.62a
2	1.77a	108b	66.97b
3	1.66a	105c	52.10b
4	1.25b	103c	51.51bc
5	1.06b	97d	40.17c
Mean	1.51	107	56.27
CV (%)	2.54	0.08	3.30

Means in a column followed by the same letter(s) are not significantly ($P < 0.05$) different

other sowing dates. Sowing 'Kapaala' on 3 also had a significantly ($P < 0.05$) higher percent threshing than sowing on 5.

Sorghum grain yield per plant (g) decreased significantly ($P < 0.05$) with delay in sowing. The highest grain yield per plant was recorded when sorghum was planted on 1 and the lowest when planted on 5. Mean increase in grain yield per plant when sowed on 1 was 723 per cent higher compared to 5. Grain yield per plant determined for 1 and 2 was significantly ($P < 0.05$) higher compared to the other sowing dates (Table 6).

Sorghum grain yield per hectare was highest when sowed on 1 and least when sowed on 5. Mean increase in grain yield per hectare when sowed on 1 over 5 was 125 per cent (Table 6). Sowing on 1 and 2 had significantly ($P < 0.05$) higher yields compared to the other sowing dates.

Straw yield per plant (g) and per hectare decreased significantly ($P < 0.05$) with delay in sowing (Table 6). The highest straw yield per plant and per hectare were

recorded for 1, and the lowest when sowed on 5. Straw yield per plant observed for sowing on 1 was superior to that for 4 and 5. Sowing 'Kapaala' on 1 produced significantly ($P < 0.05$) higher straw yields than when sown on 2, 4, and 5; and sowing on 3 also recorded superior straw yield per hectare over 5.

Discussion

Time of planting of improved, short-season cultivars is always important. It is assumed that the season for improved cultivars can

be tailored to most assured rainfall periods and avoid moisture stress. Though some cultivars have shown this flexibility for time of planting, the yield losses observed in delayed plantings are significant (IER, 1990).

Yield and yield components of 'Kapaala' significantly ($P < 0.05$) differed with sowing dates. Stand count at 14 DAS and at harvest decreased significantly ($P < 0.05$) with delay in sowing date. This might be attributed to less favourable weather during the growth and development of the lately sown sorghum.

TABLE 6

Grain and Straw Yields of Sorghum cv. 'Kapaala' as Affected by Sowing Date at the Manga Agricultural Research Station (1997-1998)

Sowing date code	Grain yield plant ⁻¹ (g)	Grain yield (kg ha ⁻¹)	Straw yield plant ⁻¹ (g)	Straw yield (t ha ⁻¹)
1	25.75a	1580a	174a	11.2a
2	23.65a	1288a	148ab	8.1b
3	8.70b	343b	147ab	5.6c
4	5.05b	118b	109bc	4.1cd
5	3.13b	117b	91c	2.3d
Mean	13.26	689	134	6.3
CV (%)	7.39	7.27	4.79	5.39

Means in a column followed by the same letter(s) are not significantly ($P < 0.05$) different

Number of mouldy sorghum heads decreased significantly ($P < 0.05$) with delay in sowing date. The early sowing dates produced grain during the peak of the rains; and because 'Kapaala' has compact heads, it created a favourable micro-climate for grain moulds to develop. Hence, the significant number of mouldy heads. The many sorghum heads without grain might be attributed to high incidence of insect pests and diseases observed with late sowings. Similar results have been observed by Bohringer (1986) who reported that early-sowed sorghum crops were heavily attacked by grain moulds and ergot (*Claviceps sorghi*) in a study to evaluate sowing dates for sorghum. In a study to determine the influence of planting date on abundance of panicle-infesting insects associated with sorghum, Acher *et al.* (1990) reported that sorghum planted during the first half of May matured early enough to avoid panicle-inhabiting insects.

Early-sown sorghum produced significantly ($P < 0.05$) taller plants than the lately sown counterparts. This might be attributed to more favourable weather during the growth and development of the early crops. Similarly, Narwal *et al.* (1996) reported that delay in sowing time decreased plant height of sorghum.

The effect of sowing date on sorghum germination was significant. A similar observation was reported in maize sowed in the Guinea savanna zone where seeds harvested from early sowings (late May to mid June) showed higher germination percentages. However, seeds harvested from the subsequent sowing dates (late June, mid July and late July) progressively showed decreases in germination percentages as a result of increasing levels of infection by *Fusarium moniliforme* (Assiedu *et al.*, 1989).

The decrease in 1000-seed weight may possibly be due to moisture stress, which may have occurred during the grain-filling period of the lately sown sorghum. The decrease in 1000-seed weight indicated that nutrient and dry matter accumulation in the seed was low, which could visibly be seen by the shrivelled seeds. Such

poorly formed seeds were low in germination and could be susceptible to field and storage diseases and pests as well as to environmental stresses at sowing. Seed moisture content did not change with different times of sowing. This implies that differences in seed weight were purely due to differences in dry matter accumulation.

Late sowing dates recorded significantly ($P < 0.05$) lower percent threshing compared to the early sown counterparts. This might probably be attributed to the many chuffy heads recorded for late sowing dates compared to the early-sown counterparts. Most late-sown sorghum matured in late October when the rains had ceased, thereby resulting in poor grain filling. Also, a high incidence of head bug infestation was observed on lately sown sorghum, thereby resulting in the significantly many chuffy heads recorded for the lately sown sorghum.

That lately sown 'Kapaala' resulted in early maturity might possibly be attributed to unfavourable weather associated with delayed sowing dates. 'Kapaala' sown later than June experienced inadequate rainfall because its amount and distribution were less and variable compared to sorghum sowed on 1 and 2. In months with drought such as in October, the lately sown sorghum matured earlier because of hastening in photosynthate partitioning to grain. In both years, 88 to 98 per cent of rainfall was recorded from May to September. The lately sown 'Kapaala' was stunted in growth owing to moisture stress, thereby resulting in early maturity.

The early-sown 'Kapaala' from 1 to 2 received enough rainfall in both years (1997/1998) as reflected in their vigorous and luxuriant growth, resulting in delayed maturity. Several workers have reported similar observations (Kasei & Afuakwa, 1991; Narwal *et al.*, 1996).

Thousand-grain weight (g) decreased significantly ($P < 0.05$) with delayed sowing. This might be attributed to the stunted growth associated with late planting dates as reflected in the shorter plants observed in later-sowed

sorghum. This was due to the growth and development of lately sowed sorghum coinciding with less favourable weather. The number of rainy days and total rainfall decreased with delayed sowing dates, thereby resulting in poor flowering and grain filling.

The decrease in straw yields with delayed sowing might probably be attributed to the poor stand establishment at 14 DAS and at harvest associated with lately sown sorghum. Alternatively, significantly higher chuffy heads were associated with late planting, thereby resulting in fewer grains per hectare. Adesuyun (1977) reported that grain yields could be reduced to as high as 78 per cent. He concluded that the magnitude of shoot fly (*Atherigona soccata*) attack becomes more severe if sowing is delayed. Rao, Paul & Subba-Rao (1979) reported that when four sorghum varieties were sown on four dates between early October and early November, the incidence of *A. soccata* and *Achilo* was lowest for the earliest sowing.

Sorghum grain yields and yield components for the five sowing dates indicated that the first two sowing dates 1 and 2 (end of May to mid June) significantly out-yielded the last three sowing dates. The early sowing dates yielded 634 per cent higher grain over the delayed sowing dates. Similar results were reported by Patel & Patel (1989) in a study to evaluate the effect of varieties and sowing time on yield and yield attributes of summer sorghum. The superior performance of the early sowing dates might be attributed to more favourable conditions that prevailed during the growth and development of the early crops. The later sowings suffered from reduced rainfall during critical stages of crop growth such as at flowering and at grain filling, which occurred in October, thereby resulting in lower grain yields.

The results of this study corroborate with those of Obeng-Antwi, Sallah & Frimpong-Manso (2002) who concluded that maize sowed from mid May to mid June at Manga yielded more grain

than later plantings, regardless of the maturity group of the variety. The results also confirm the estimates of Kasei & Afuakwa (1991). It can, therefore, be concluded that the optimal time of sowing 'Kapaala' in northern Ghana is from the 3rd week of May to the end of June.

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