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PLANTING DATE EFFECT ON GROWTH CHARACTERS AND YIELD OF SORGHUM UNDER A DRY FARMING-SYSTEM IN AN ARABIAN GULF ENVIRONMENT

By

A.M.A. ISMAIL* and A.H. ALI**
*Department of Bot.. Fac. of Science,University of Qatar, P.O. Box 2713, Doha, Qatar;
**Crop Science Section, Ministry of Agriculture, Doha, Qatar

تأثير موعد الزراعة على نمو وإنتاجية الذرة الرفيعة المنزرعة تحت نظام جاف في بيئة الخليج العربي

أحمد محمد علي إسماعيل و أحمد حسن علي

تصعب زراعة المحاصيل بصفة عامة في ظل الظروف المناخية السائدة في دولة قطر . وقد أجريت هذه الدراسة لتحديد أنسب المواعيد لزراعة الذرة الرفيعة في نظام زراعي جاف بدولة قطر . استخدمت المياه الجوفية في ري ثلاثة أصناف هي «شحانية - ١» ، سنسيتيك ٦٥٠٥» ، و«أبو سبعين» ، وقد زرعت هذه الأصناف في المواعيد ١ ، ١٥ سبتمبر، ١، ١٥ أكتوبر .

أظهرت النتائج أن تغير موعد الزراعة لم يكن له تأثير معنوي على الزمن اللازم للأزهار أو الزمن اللازم لوصول النباتات للنضج الفسيولوجي ، إلا أن هذا التغير في موعد الزراعة كان له أثر معنوي على طول النبات ، وزن الحبوب ، محصول الحبوب ، حيث أدى التبكير في الزراعة إلى إطالة الفترة الزمنية التي قضتها النباتات في استطالة الساق مما أدى إلى زيادة في وزن الرؤوس . هذا وقد أدى التأخر في الزراعة إلى تعرض لدرجات حرارة منخفضة أثناء الأزهار ودرجات حرارة مرتفعة أثناء امتلاء الحبوب مما أدى إلى انخفاض وزن الحبوب ، وانخفاض المحصول .

مكنت النتائج من إصدار توصيات تتضمن اعتبار الأول من سبتمبر أنسب المواعيد لزراعة أصناف الذرة الرفيعة المختبرة في دولة قطر ، وكذلك إمكان التأخر في الزراعة حتى الخامس عشر من شهر سبتمبر لكل الأصناف ، بينما تفوق الصنف «شحانية -١» في إنتاج الحبوب في جميع مواعيد الزراعة .

Key Words: Dry farming system, Growth characters, Planting date, Sorghum, Yield

ABSTRACT

Irrigated crop production in Qatar is a risky enterprise due to extreme weather conditions. Temperature is sufficiently warm to allow planting of grain sorghum [*Sorghum bicolor* (L.) Moench] from Aug through to Oct. Crops so planted early face the risk of very high temperatures and storms blowing during establishment whereas those planted late face the risk of very low temperatures and overcast during blooming and high temperatures during grain - fill. Consequently farmers have only the opportunity to plant sorghum over a limited and short 3-month potential planting period. The present investigation was carried out during the 1984/85 and 1985/86 growing seasons under irrigation from ground water to determine the optimum planting date for maximizing sorghum production under Qatari conditions. The experiments were conducted at the Field Crops' Experimental Station, Rodat Harma, 25.0°N, Qatar.

*Corresponding author

Three sorghum varieties: Sahania I, Sencetic 6505 and Abu Sabeen were planted in four dates, 1 Sep, 15 Sep, 1 Oct and 15 Oct on an alloctonus colluvial soil (calcareous sandy clay loam). The experiments were set up in a split plot design with four replications. Results revealed that planting dates had no significant effects on either number of days to half-blooming or number of days to physiological maturity, but planting dates had significant effects on plant height, head weight and final grain yield. Significant variety-by-planting date existed for plant height, head weight, and final grain yield.

By planting early the length of the stem elongation period was extended with proportionate increase in head weight. The milder temperatures during blooming and the warmer temperatures during grain - fill of the late planted crops contributed to the reduction in head weight and thereafter final grain yield.

The first of Sep was the best planting date for the three varieties. Expanding planting to 15 Sep could be possible, while planting after this period would result in yield reduction. Variety Sahania I was superior to the other two varieties in grain yield in both growing seasons.

Key Words: Dry farming system, Growth characters, Planting date, Sorghum, Yield.

INTRODUCTION

Following wheat (*Triticum aestivum L.*), rice (*Oryza sativa L.*) and maize (*Zea mays L.*) sorghum [*Sorghum bicolor (*L.) Moench] is the fourth most widely cultivated cereal grain crop in the world [1]. It is grown in many countries (different continents) e.g. India, Pakistan, China, Saudi Arabia, Nigeria, Sudan, Egypt, USA, Mexico and Argentina. It was reported that sorghum is grown in areas of relatively low rainfall and high temperatures and on soils which are deficient in several essential mineral nutrients, [2, 3] ."The ability of sorghum to produce good yields under conditions of low soil - moisture and high temperatures, that are unsuitable for any other grain - crop makes it the "camel" of the plant world"[4].

Until recently, little was known of the potential grain yield of sorghum in the dry regions of the Arabian Gulf. The peninsula of Qatar lies between 50° 45' and 51° 40' E longitude and 24° 46' and 26° 10' N latitude. Qatar lies within the vast desert belt extending from North Africa to Central Asia. This desert environment of Qatar is characterized by a long hot period (Apr - Nov) and by intervals of low and scanty precipitation during the remainder of the year (Dec - Mar). Sorghum is one of the crops which had been introduced recently to Qatar because it is among the plants that are most economical in their use of water [4]. Hoffman [5] reported that sorghum has the ability to minimize tissue water loss, and therefore it is a drought - tolerant species. In Qatar cereals like wheat, barley and maize are grown during the winter season (Nov - Mar) under irrigated cropping systems. However, sorghum is an important crop for forage as well as for grain production. This versatile and widely adapted crop is well suited as the sole crop that can be cultivated in Qatar following irrigation from groundwater by the end of the summer season and - beginning of the autumn season (Sep - Nov).

Among the factors that can be controlled by the producer, planting date is probably the most important, as the time of planting and the intensity of the growth cycle depend on the region and its climate (the historical climatic data and the uncertain future weather).

The objectives of this study were to measure yield and its components of three sorghum varieties planted fortnightly over a range of 45d, and to determine the optimum planting date for maximizing sorghum production under dry-land cropping system of Qatar.

MATERIALS AND METHODS

Research to compare responses of three grain sorghum varieties to date of planting was conducted at the Field Crops' Experimental Station, Rodat Harma State of Qatar during the two successive sorghum cropping seasons of 1984/85 and 1985/86. Three sorghum long varieties: Sahania I, Sencetic 6505 and Abu Sabeen were planted in four dates, 1 Sep, 15 Sep, 1 Oct and 15 Oct.

The soil type at the experimental site is called "Rodat Soil" of colluvial deposits which are accumulated by run - off carrying weathering products from surface rocks of neighbouring products i.e. alloctonus type of soil. These soils are described as calcaerous sandy clay loam ($CaCO_3$ = 34 - 60%, EC = 0.77 - 6.99 dS/m, organic matter = 0.78%, pH = 7.0 - 8.4; cations are: Ca, Mg, Na, K; anions are: sulphate, chloride and bicarbonate).

The experiment was designed in both seasons in randomized complete block design with a split - plot arrangement with four replicates. Planting dates were assigned to main plots and the varieties to the subplots.

The crop was full irrigated and nineteen postplanting irrigations were applied each season as shown in Table I. Irrigation water was pumped from wells. Distribution and conveyance of water to the field is by earth channel and plot irrigation is surface irrigated by basin. The amounts of water which were applied at each irrigation were not fixed values but depended on the soil temperature, air temperature and the rate of evapotranspiration. No water was given after the crop has reached the dough stage.

Table 1
Sowing dates, final harvest dates and the number of irrigations applied for each crop during 1984/85 and 1985/86 growing seasons.

Sowing date	Harvest date	Number and Scheduling of irrigations during the crop life	
		Month	Number
1 Sep		Sep	8
		Oct	6
		Nov	3
	22 Jan	Dec	2
15 Sep		Sept - Oct	8
		Oct - Nov	6
		Nov - Dec	3
	6 Feb	Dec - Jan	2
1 Oct		Oct	8
		Nov	6
		Dec	3
	7 Mar	Jan	2
15 Oct		Oct - Nov	8
		Nov - Dec	6
		Dec - Jan	3
	6 Apr	Jan - Feb	2

The seeds were drilled by hand at a rate of 30 kg on 6 rows. The row was 5 m long, the inter-row spacing was 60 cm and the intra-row spacing was 20 cm between plants. The area of each subplot was $18m^2$, and of plot $54m^2$ and the whole replicate area was $216m^2$. Thinning was carried out 21 days following emergence and only leaving two seedlings per hill. Phosphorus fertilizer (16%) was applied at a rate of 60 kg ha^{-1} after the seedling's stage. Nitrogen fertilizer was applied at a rate of 150 kg ha^{-1} in the form of urea (46% N) splitted two times during the growing season, three weeks after planting and before blooming. Hand hoeing to control the emerging weeds was used in both seasons. All data were taken from a $12m^2$ section of the four middle rows (5 m X 2.4 m).

Data recorded for each plot included date to half blooming, plant height, date to physiological maturity, head weight and grain yield. Blooming date was recorded by counting number of days from planting to the date on which about 50% of the heads in the subplot were completely out of their flag leaf sheaths. Plant height (average of ten plants) was measured as the distance from the ground to the average panicle tip. Physiological maturity date was determined when 50% of the heads in the subplot had seed at black layer half-way down the panicle. The average of ten heads from a subplot was recorded as the head weight. Grain yield was based on the weight of the threshed sample from the harvested section of the plot ($12m^2$) and converted to ton ha^{-1} at 13% moisture.

Data were analysed by analysis of variance for each growing season [6] and the season effect was considered random. Means were separated for significant main effects and interactions using the LSD test at the 5% probability level.

RESULTS AND DISCUSSION

Weather Conditions

Mean daily air temperature from 1 Aug to 30 Apr was 25.7°C in 1984/85. Typically mean maximum - minimum temperatures start to decline steadily from Aug and reach their lowest values in Feb, then they start to rise slowly from Mar. to Jun. The highest temperatures are reached during Jun. - Aug. In contrast to similarity patterns between 1984/85 and 1985/86 growing seasons for temperature ranges, precipitation patterns, albeit very scanty and meagre, differed markedly between the two seasons indicating that the main feature of the experimental site is its total aridity. Therefore no crops would be grown except under irrigated field conditions from ground water.

Because the two seasons (1984/85 and 1985/86) were similar climatically no significant year effect was detected.

The meteorological data recorded for seasons 1984/85 and 1985/86 are shown in Table 2. The mean relative humidity, which is considered as high ranged from 61.2 to 95.4% in 1984/85 and 1985/86 growing seasons respectively.

Table 2
Mean temperatures, relative humidity and rainfall during the two growing seasons.

Month	Temperature			Relative humidity			Rainfall
	Maximum	Minimum	Mean	Maximum	Minimum	Mean	
		__ °C __			__ % __		__ mm __
			1984/1985				
August 84	41.0	27.0	34.0	97.0	16.1	56.5	00.00
September	41.0	24.9	33.0	97.3	16.7	57.0	00.00
October	35.3	20.7	28.0	92.8	19.1	56.0	00.00
November	30.7	17.6	24.2	94.7	22.4	58.6	00.00
December	23.3	13.5	18.4	93.6	42.3	68.0	08.00
January 85	24.7	11.9	18.3	86.0	32.7	59.4	00.00
February	23.7	11.7	17.7	95.6	25.4	60.5	00.08
March	29.7	18.7	24.2	81.4	24.5	53.0	00.00
April	34.4	20.9	27.7	77.1	22.9	50.0	00.00
Mean	31.8	19.3	25.7	84.1	24.1	54.1	00.90
			1985/1986				
August 85	43.7	27.8	35.8	99.1	20.3	59.7	00.00
September	41.3	24.7	33.0	99.3	8.2	53.8	00.00
October	37.3	21.4	29.4	98.9	41.1	56.5	00.00
November	29.3	17.0	23.2	99.3	28.9	64.1	00.00
December	21.5	11.5	16.5	98.9	45.3	72.1	34.50
January 86	22.0	10.2	16.1	99.3	31.8	65.6	04.00
February	25.8	11.5	18.7	99.3	13.5	65.4	00.00
March	28.2	16.0	22.2	91.1	32.7	61.9	00.00
April	32.4	22.7	27.6	91.1	33.0	62.0	0.00
Mean	30.7	18.8	24.8	93.8	29.6	61.7	4.27

Photoperiod near the experimental location (25.0°N) was calculated using standard meteorological data and ranged from >10.2 to 13.8 h (Fig. 1).

Effect of Planting Date

Planting date has a significant effect ($P<0.01$) on plant height, head weight and grain yield in both growing seasons (Table 3). No significant differences ($P>0.05$) in days to half blooming nor number of days to physiological maturity were observed among all treatments in both seasons (Table 3).

As planting was delayed from 1 Sep to 15 Oct, plant height, head weight and grain yield continually declined ($P<0.01$) with a reduction in (a) plant height by 36 and 100 cm (b) head weight by 35 g, and (c) grain yield by 5.9 and 4.6 ton ha^{-1} in 1984/85 and 1985/86 growing seasons respectively.

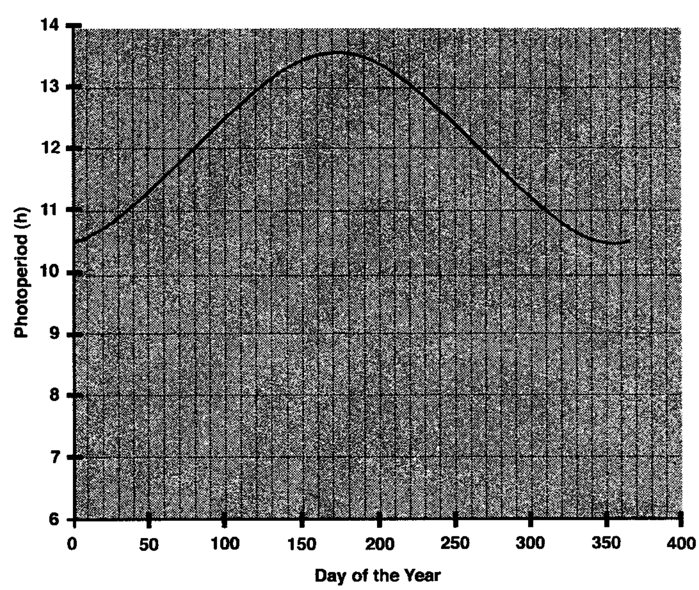

Fig. 1. Photoperiod at Doha, Qatar (25.0° N)

Table 3
The effect of planting date on flowering, plant height, physiological maturity, head weight and grain yield

Date of Planting	1984 / 1985					1985 / 1986				
	Half blooming	Plant height	Physiological maturity	Head weight	Grain yield	Half blooming	Plant height	Physiological maturity	Head weight	Grain yield
	days	cm	days	g	Ton per ha	days	cm	days	g	Ton per ha
1 sep	57	178	125	51	7.2	62	190	126	42	6.5
15 Sep	60	157	129	47	6.7	70	150	127	33	4.9
1 Oct	63	129	142	13	1.8	72	118	142	18	1.9
15 Oct	77	142	159	16	1.3	88	90	153	7	1.9
Significance	NS	**	NS	**	**	NS	**	NS	**	**
LSD (0.05)	-	9	-	2	0.4	-	12	-	4	0.6

** Significant at 0.01 probability level
NS = Not significant

During both growing seasons the first two growth stages of sorghum occurred in contrasting environments. For example, planting to blooming stage (vegetative growth) occurred in warm temperatures prevailing between Sep - Nov and blooming to physiological maturity (grain-filling stage) occurred in cool temperatures prevailing between Dec - Jan (Table 2) for the two early plantings. Conversely, planting to blooming stage occurred in cool temperatures between Dec - Jan and blooming to physiological maturity occurred during Mar - Apr when temperatures began to rise for the two late plantings. These results are consistent with those of [7] for sorghum production in a subtropical environment. Similarly, as planting date was delayed to 1 Oct and 15 Oct the grain yield was drastically reduced. For example, the percentage reductions in grain yield as the plantings were delayed were 7.0, 75.0 and 82% in season 1984/85; and 25.0, 70.0 and 71.0 in season 1985/86 for the planting dates 15 Sep, 1 Oct and 15 Oct respectively compared to the earliest planting or check planting (1 Sep).

Many environmental factors can affect yield through their effects on yield components i.e. temperature and photoperiod. Sorghum is a short day plant (flowers in the beginning of the winter season as the days shorten). The photoperiod stimulus is perceived by the leaves and a signal transmitted to the apex [8]. Although daylength changes are necessarily involved with changes either in radiant intensity or in total daily light, yet Fig. 1 illustrates that photoperiod *Per se* was not a growth limiting factor in this study but temperature may be the factor responsible for the observed variations and reductions in yield components and thereby grain yield. [9] indicated that optimum temperatures for sorghum vegetative growth are 27 - 30°C. Low temperature prevailing during the vegetative growth period of the two late planted crops might have affected the height of the plants shortening compared to the early planted plants.

Since the grain-filling period affects both seed number and seed size [10], it appears that the two late planted crops experienced rather warm temperatures in Feb - Apr thereafter affecting the grain filling process. This result is consistent with [11] finding that high temperature during the last part of panicle development reduced yield by causing floret abortion. These results with sorghum agree with [12] who indicated that photoperiod and temperature are independent environmental variables and only interacting in special circumstances. The results of this study suggest that the best planting date averaged over the two seasons for grain yield was 1 Sep - 15 Sep as the two late plantings gave the lowest yields.

Effect of Varieties

Varieties significantly influenced plant height, head weight and grain yield in both growing seasons. Varieties had no significant effect on either number of days to half blooming or days to physiological maturity (Table 4) in both growings seasons.

Table 4
The effect of varieties on yield and yield components of sorghum

Variety	1984 / 1985					1985 / 1986				
	Half blooming	Plant height	Physiological maturity	Head weight	Grain yield	Half blooming	Plant height	Physiological maturity	Head weight	Grain yield
	days	cm	days	g	Ton per ha	days	cm	days	g	Ton per ha
Sahania	69	134	143	35	4.5	78	126	144	30	5.2
Sencetic 6505	69	153	145	33	4.3	72	141	142	25	3.0
Abu Sabeen	55	169	129	29	4.1	69	145	126	20	3.1
Significance	NS	**	NS	**	NS	NS	**	NS	**	**
LSD (0.05)	-	8	-	2	-	-	9	-	4	0.6

** Significant at 0.01 probability level
NS = Not significant

Significant differences were detected among varieties in both seasons with respect to head weight, with Sahania I producing the highest head weight and Abu Sabeen the lowest one. The data indicated that Sahania I was superior to Sencetic 6505 and Abu Sabeen varieties in season 1985/1986. Therefore the observed relative differences between varieties are likely to be maintained irrespective of planting date.

Effect of Interaction Between Planting Date and Variety

Days to half blooming generally increased with later plantings (Table 5). The effect was most evident at the late Oct planting date. In 1984/85 growing season Abu Sabeen bloomed at an average of 66 d compared to 79 and 86 d for Sahania I and Sencetic 6505 respectively. A similar trend for Abu Sabeen was also detected in 1985/86 growing season. In neither growing season in which this trait was measured did a variety-by-planting date interaction occur.

Table 5
Head weight (g) as affected by varieties and planting date

Season	**1984/1985**			**1985/1986**		
Variety	Sahania I	Sencetic 6505	Abu Sabeen	Sahania I	Sencetic 6505	Abu Sabeen
Planting date						
1 Sep	56	55	43	49	41	34
15 Sep	50	60	30	44	30	26
1 Oct	16	3	21	20	20	15
15 Oct	17	12	20	8	8	5

LSD (0.05) = 5g 8g

Plant height was greatly reduced by late planting (Table 6). A variety-by-planting date interaction for plant height was evident in both growing seasons. It is interesting to note that the high yielding variety (Table 6) Sahania I was slightly shorter than the other two varities in both growing seasons.

In 1984/85 and 1985/86 growing seasons the number of days to physiological maturity increased with later plantings (Table 3). Generally the highest yielding variety (Sahania I) and the higher yielding one (Sencetic 6505) had more days to reach to physiological maturity in both growing seasons. A variety-by-planting date interaction did not occur in either season in which number of days to physiological maturity were counted.

A significant variety-by-planting date interaction in grain yield occurred in both growing seasons (Table 7). The yield performance of the three varieties was similar across dates of planting e.g. the three varieties produced higher yields in the early two planting dates than the late two ones. Variety difference in grain yield was greatest in 1 Sep planting date. The variety-by-date interaction shows that varieties were not all adapted to late planting.

Table 6
Plant height (cm) as affected by varieties and planting date

Season	**1984/1985**			**1985/1986**		
Variety	Sahania I	Sencetic 6505	Abu Sabeen	Sahania I	Sencetic 6505	Abu Sabeen
Planting date						
1 Sep	158	182	195	168	193	208
15 Sep	133	162	177	133	155	162
1 Oct	118	130	140	115	127	115
15 Oct	125	137	163	88	88	95

LSD (0.05) = 15 cm 18 cm

Table 7
Grain yield (Ton) as affected by varieties and planting date.

Season	**1984/1985**			**1985/1986**		
Variety	Sahania I	Sencetic 6505	Abu Sabeen	Sahania I	Sencetic 6505	Abu Sabeen
Planting date						
1 Sep	7.9	7.7	6.1	9.1	4.7	5.8
15 Sep	7.1	8.5	4.6	7.2	3.7	3.8
1 Oct	2.2	0.4	2.6	2.7	1.3	1.6
15 Oct	0.7	0.4	2.9	2.0	2.3	1.3

LSD (0.05) = 0.8 Ton ha^{-1} 1.1 Ton ha^{-1}
NS = not significant

These results are expected because varieties did not reach blooming synchronously as the time intervals between treatments and half blooming were much smaller than time intervals between planting dates. It is logical to state that differences between the entire duration of growth for sorghum varieties planted at different dates manifest themselves during the early stages of crop development. Plant height is very sensitive to temperature [12, 13, 14] yet crop height in the earliest planting was 25-30 cm taller than in the next planting; the additional height achieved in the earliest planting suggest that temperature was not a significant factor up to blooming. Early planted sorghum varieties have a substantially longer vegetative period in both growing seasons. This results in more leaves forming on the main stem which in turn results in more internodes and greater height.

From the evidence presented it is argued that the principal reasons that greater yields were not obtained in the late plantings were (a) mild temperatures prevailing during Dec - Jan which led to poor vegetative growth; Clarkson *et al.* [15] stated that for cereals the total demand for nutrients may be reduced at low temperatures thereafter growth is slowed down; and (b) there might have been a greater competition for phototoassimilates between the growing head and the elongating stem. It is suggested that a way of overcoming this competition is to genetically lengthen the stems of sorghum varieties that would be grown under irrigation in arid regions.

CONCLUSIONS

Planting early under relatively longer day length when growing plants at warmer temperatures significantly increased grain yield. A period of low temperature extending from Dec to Feb apparently decreased the growth of plants planted on Oct and a period of high temperature from Feb to Apr drastically affected the grain filling period for the same two late plantings.

Among the traits investigated in this study, plant height, head weight and grain yield were the most affected by planting dates, while the days to half blooming and number of days to physiological maturity were less affected. However, the three varieties responded similarly with respect to the planting date and temperature under which they were grown. Further studies on the interaction between varieties and planting dates for these traits would be of great use for sorghum breeders in arid regions.

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