Effect of sowing date on growth, development and yield of gero millet

P. N. EGHAREVBA, S. M. ABED and A. A. OKOLO
Institute for Agricultural Research
Ahmadu Bello University
Zaria.

Abstract

The objective of this study was to determine the most appropriate time for sowing millet *(Pennisetum typhoides)* in Samaru. Ex-Bornu millet, an improved local variety, was used and was sown at the currently recommended spacing of 0.28 x 0.75m. Sowing was spread over fourteen weeks (April to July) at biweekly intervals.

Seedling emergence and germination were dependent on the amount of moisture available. There was a curvilinear relationship between time of sowing and 50% heading, indicating a delay in heading when sowing is done too early or too late. Except for the first two sowings, time to 50% heading was positively correlated with accumulated heat units ($r = 0.81^{**}$; $r2 = 66\%$).

Inflection point on the quadratic curve, which was the best fit for grain yield on planting date, corresponded to the May 24th sowings. Every fortnight delay in sowing after this date resulted in a yield reduction of 294 kg ha−1. Grain yield was positively correlated with established number of plants per unit land area ($r = 0.92^{**}$; $r^2 = 85\%$).

Millet should be sown after the first 5 – 8 rains of the season.

Introduction

Millet *(Pennisetum typhoides S.* and H), in spite of its importance as the basic daily diet of many people in Africa and India, continues to receive very low attention in terms of research. While considerable work has been done on the influence of sowing date on the growth, maturity and yield of maize *(Zea mays* L.) (Zuber, 1966; Bunting, 1968; Genter and Jones, 1970) and of sorghum *Sorghum bicolor L.)* (Stickler and Pauli, 1966; Kassam and Andrews, 1975; Millington *et al.*, 1977), very little information is available on the effect of sowing date on the performance of millet. This has led to the habit of many farmers sowing with the first rain of the season. This first rain of the year does not follow any set pattern, it could fall as early as February or as late as May. Thus, this chance sowing with the first rain succeeds in only about 8% of the time (Egharevba 1979).Farmers usually give two reasons for sowing with the first rain. Firstly, they claim that the millet sown gives greater yield and has fewer pest problems. Secondly, the millet matures early enough to provide a source of food when other crops like maize and sorghum are still growing. These not withstanding, chance sowing with the first rain will only continue to give an overall low yield of millet. Only experimentally determined time of

sowing can give an increase in yield. This paper reports the effects of sowing date on growth, development and yield of Gero millet.

Materials And Methods

The experiment was conducted during the wet seasons of 1976 to 1978 in Samaru (11° 11'N, 7°; 38'E), Nigeria. Ex-Bornu millet, an improved local variety, was used in the trials which were laid out as randomized complete block designs with four replicates. The currently recommended spacing of 0.28 x 0.75m (equivalent to 50,000 plants per hectare) was used. Each plot consisted of 8 rows spaced at 0.75m apart and each row was 6m long for a total plot size of $_{36}$ m^2. The four inner rows were harvested for total yield determination.

Soils of the experimental area have been previously described by Jones (1973) Fertilizer (N and P_2O_5 equivalent to 75 and 30 kg ha^{-1} respectively) was applied at planting.

Seven sowing dates, designated d1–d7 (Table 1), were used. Sowing started each year on 12th April, and continued at 2-week intervals for a total of 7 plantings. At each planting, seeds were oversown but thinned to one plant per stand two weeks later. Weeds were controlled by hoeing while plants were sprayed periodically with carbaryl[1] at the rate of 1.12 kg ai/ha to control pests.

Observations and measurements made included: percent emergence, number of plants established, time to 50% heading and plant height. Accumulated heat unit was calculated according to the formula:–

$$\frac{(\text{Minimum temp} + \text{Maximum temp})}{2} - \text{base temperature}$$ (Arnold, 1960). Base temperature for millet was taken as 10oC (Kumar, personal Communication).

Results and Discussion

Emergence

Time to emergence, percent emergence and rainfall data are shown in Table 1. Time to emergence ranged from 5 to 13 days and was significantly longer in those sowing dates in which rainfall was below 50mm. Sowing dates with few rain days delayed emergence.

Percent emergence was significantly ($P < .05$) lower for the first two sowing dates in both 1976 and 1978. The first two sowings were not done in 1977 because of lack of rainfall, but percent emergence in d_3 and d_4 were significantly ($P < .05$) lower than others that year.

The delay in emergence of seedlings at the earlier sowing dates (d_1 and d_2) had to do with inadequate supply of moisture. Water is essential for

1 *Formulated as Vetox 85 (Shell Chemical Co.)*

TABLE 1. THE EFFECT OF SOWING DATE OF MILLET ON TIME TO EMERGENCE, % GERMINATION AND PLANT ESTABLISHMENT

Sowing Date	1976					1977				
	Days to Emerg.	Percent Emerg.	Pl. Estab. /m^2	Total Rainfall (mm)	No. of Rain days	Days to Emerg.	Percent Emerg.	Plt. Estab. /m^2	Total Rainfall (mm)	No. of Rain days
12 Apr. (d_1)	10	64	9	26.4	2	-	-	-	-	-
26 Apr. (d_2)	8	68	13	41.0	3	-	-	-	-	-
10 May (d_3)	6	89	20	100.1	6	13	41	11	26.3	3
24 May (d_4)	5	93	22	169.8	9	11	58	13	31.2	4
7 June (d_5)	5	90	15	220.4	5	6	84	19	132.3	6
21 June (d_6)	6	92	8	359.4	7	7	90	12	165.7	7
5 July (d_7)	6	90	4	502.6	6	5	89	6	182.3	6
Mean	6.6	83.7	13	202.8	5.4	8.2	72.6	12.2	107.6	5.2
S E	0.55**	3.59**	1.4**	-	-	.65**	2.89**	1.17ns	-	-
LSD (.05)	2.0	11.0	5.0	-	-	2.0	10.0	-	-	-

*** Significant at .01*

** Significant at .05*

ns Not significant at 0.5

TABLE 1.....Contd.

Sowing Date	1978					Sowing Date	The three years (1976, 77 & 78) Combined				
	Days to Emerg.	Percent Emerg.	Plt. Estab. per m^2	Total Rain-fall (mm)	No. of rain days		Days to Emerg.	Percent Emerg.	Pl. Estab. per m^2	Total Rain-fall (mm)	No. of Rain days
12 Apr.(d_1)	9	68	10	26.9	3	12 Apr.(D_1+)	9.5	66	9.5	26.6	2.5
26 Apr.(d_2)	8	72	13	48.7	2	26 Apr.(d_2+)	8.0	70	13.0	44.8	2.5
10 May (d_3)	5	89	19	107.6	5	10 May (d_3)	8.0	73	16.7	78.0	4.7
24 May (d_4)	5	92	22	172.5	6	24 May (d_4)	7.2	81	19.0	124.5	6.3
7 June(d_5)	6	90	16	298.6	8	7 June(d_5)	5.7	88	16.7	217.2	6.3
21 June(d_6)	5	92	10	392.6	4	21 June(d_6)	5.7	91	10.0	305.9	6.0
5 July(d_7)	6	92	5	450.3	4	5 July(d_7)	5.8	90	5.0	378.4	5.9
Mean	6.3	85.0	13.6	213.9	4.6	G. Mean	6.9	81.3	13.0	181.8	4.9
S. E.	.48**	2.91**	1.18**	-	-	S.E (n=9)	0.32**	1.85**	0.75**	-	-
L.S.D.(.05)	2.0	9.0	4.0	-	-	S E(n=6)	0.39	2.26	0.91	-	-

** Significant at .01*

ns Not significant at .05

+ d_1 and d_2 are based on 6 observations

d_3 to d_7 are based on 9 observations.

germination and if adequate moisture is not available, germination may either be delayed or fail to occur. This is substantiated by the findings of Zuber (1968) for maize and Evans and Stickler (1961) for sorghum, that partial wetting of seeds delayed germination and that the resultant seedlings were weak, giving poor stands. Similar poor stand establishment was observed for d_1 and d_2 (Table 1) in this study; and was also evident in the later sowings (d_6 and d_7), despite the fact that there were no significant differences in percent emergence from d3 to d7. Thus, there is a need to distinguish between seedling emergence and stand establishment. While seedling emergence is the appearance above ground of germinated seeds, stand establishment is the ability of the emerged seedling to develop and produce harvestable head. The lower stand establishment for the late sowings could be explained partly by progressive reduction in accumulated heat unit and reduction in available nutrient as a result of leaching.

Developmental phases

Number of days from sowing to heading, plant height and accumulated heat unit associated with the 14 week spread in dates of sowing are shown in Table 2. In 1976, heading occurred 58 days after planting in the first sowing while it occurred after 62 days in the 7th. The earliest time to heading was 53 days while the latest was 62, giving a total spread of 9 days. Similar spread for 1977 and 1978 were 6 and 9 days respectively, giving a mean spread of 8 days for the three years.

Plant height ranged from 162 cm in 1977 to 243 cm in 1976 for a mean of 209 cm and an average of 12% coefficient of variation over the three years. Accumulated heat units decreased with planting date indicating a general decrease in temperatures as the growing season progressed. There was a decrease of 48% in heat units between the first and the last sowing date in 1976. Corresponding decreases for 1977 and 1978 were 37 and 46% respectively. The overall decrease in heat units between the first and last plantings during the three years was 43%.

Days to 50% heading demonstrated a quadratic relationship with sowing date (Fig. 1). This indicates that date of heading is delayed by either planting too early or too late. Point of inflection in Fig. 1 is d4 (24 May). The regression line from first sowing date (10 April) to the point of inflection shows a negative linear function with correlation coefficient, $r = -0.91^{**}$ ($r2 = 83\%$) and a regression equation, $Y_i = 60.12 - 1.85X_i$ (Fig. 2). This means that there was a delay of 1.85 days in time of heading for each fortnight of sowing earlier than 24 May. Similarly, the regression line from point of inflection to the last sowing date (5 July) shows a positive linear function with a correlation coefficient, $r = 0.93^{**}$ ($r2 = 84\%$) and a regression equation, $Yi = 41.37 + 2.77X_i$. This again indicates that for each fortnight delay in sowing after 24 May there is a delay of 2.77 days in time to heading. This supports the findings of Bonaparte and Brawn (1976) for maize and Kassam and Andrews (1975) for sorghum that delay in sowing after establishment of rains leads to a delay in heading date.

TABLE 2. THE EFFECT OF SOWING DATE AND ACCUMULATED HEAT UNIT ON TIME TO 50% HEADING AND PLANT HEIGHT IN MILLET

Sowing Date	1976			1977		
	Days to 50% heading	Pl. ht. (cm)	Accum. ht. unit	Days to 50% heading	Pl. ht. (cm)	Accum. ht. unit
April 12th (d_1)	58	202	1524	-	-	-
April 26th (d_2)	57	215	1392	-	-	-
May 10th (d_3)	53	222	1158	56	194	1552
May 10th (d_4)	53	243	1040	54	218	1319
June 7th (d_5)	55	238	978	53	229	1150
June 21st (d_6)	59	196	892	57	183	1080
July 5th (d_7)	62	176	788	59	162	984
Mean	56.7	213.1	1110	55.8	197.2	1217.0
S.E.	1.65*	7.99	73.58**	1.62^{ns}	11.77^{ns}	69.59*
L.S.D.(0.5)	5.0	25	227	-		277

** Significant at .01
* Significant at .05
ns not Significant at .05

TABLE 2 (Contd.

Sowing Date	1978			Sowing Datee	The three years (1976, 77 and 78) Combined		
	Days to 50% heading	Pl. ht. (cm)	Accum. heat unit		Days to 50% heading	Pl. ht. (cm)	Accum. heat unit
12 Apr.(d_1)	59	208	1508	12 Apr.(d_1+)	58.5	205	1516
26 Apr.(d_2)	58	218	1400	26 Apr.(d_2+)	57.5	216	1396
10 May (d_3)	54	225	1242	10 May (d_3)	54.4	214	1317
24 May (d_4)	53	242	1166	24 May (d_4)	53.3	324	1175
7 June(d_5)	53	237	1156	7 June(d_5)	53.7	235	1095
21 June(d_6)	59	200	962	21 June(d_6)	58.3	193	798
55July(d_7)	62	167	842	5 July(d_7)	61.0	168	871
Mean	56.8	213.8	1182.3	G. Mean	56.6	209.2	1164.9
S. E.	0.94**	10.49**	54.16**	S.E.(n=9)	0.82**	5.77**	38.04**
L.S.D. (.05)	3.0	33	167	S.E.(n=6)	1.00	7.06	46.59

** Significant at .01

* Significant at .05

ns Not Significant at .05

+ d_1 and d_2 are based on 6 obervations

d_3 to d_7 are based on 9 observations

TABLE 3. CORRELATION COEFFICIENT, r MATRIX OF SOWING DATE (d_3 - d_7) AND DIFFERENT TRAITS IN MILLET

	Grain Yield	Establish-ment	50%. Heading	Plant Height	[illegible]	Days to Emergence	Percent Emer-gence	Total Rainfall	[illegible]	[illegible]
[illegible]	-.[illegible]**									
50% Headin.	-.[illegible]**	-.[illegible]***								
Pl. height	-.[illegible]**	-.[illegible]**	-.[illegible]**							
1000 GWT	.[illegible]**	.[illegible]***	-.[illegible]$^{n.s.}$	.[illegible]**						
Days to [illegible]	-.[illegible]$^{n.s.}$	-.[illegible]$^{n.s.}$	-.[illegible]$^{n.s.}$	-.12$^{n.s.}$	-.[illegible]$^{n.s.}$					
Germination	.[illegible]$^{n.s.}$	.[illegible]$^{n.s.}$	.[illegible]$^{n.s.}$	.0[illegible]$^{n.s.}$	.[illegible]$^{n.s.}$	-.[illegible]**				
Rainfall	-.[illegible]$^{n.s.}$	.[illegible]**	.[illegible]**	-.42$^{n.s.}$	.[illegible]$^{n.s.}$	-.[illegible]*	.[illegible]*			
Rainy Days	.[illegible]*	.[illegible]$^{n.s.}$	-.28$^{n.s.}$	.3[illegible]$^{n.s.}$	.[illegible]$^{n.s.}$	-.[illegible]*	.[illegible]*	.11$^{n.s.}$		
Heat Unit	.[illegible]$^{n.s.}$	.47*	-.65**	.[illegible]$^{n.s.}$	-.[illegible]$^{n.s.}$	.[illegible]**	-.[illegible]**	-.[illegible]**	-.[illegible]$^{n.s.}$	
Sowing Date	-.[illegible]**	-.77**	.91**	-.69**	-.[illegible]$^{n.s.}$	-.[illegible]$^{n.s.}$	.44*	.[illegible]**	.[illegible]$^{n.s.}$	-.[illegible]**

** *Significant at .01*

* *Significant at .05*

ns *Not significant at .05.*

TABLE 4. THE EFFECT OF SOWING DATE ON GRAIN YIELD AND 1000 KERNEL WEIGHT OF MILLET

Sowing Date	1976		1977		1978		All three Years Combined 1976, 77 & 78		
	Grain Yield kg/ha.	1000 K. wt. (grams)	Grain Yield kg/ha	100 K. wt. (grams)	Grain Yield kg/ha	100 K. wt. (grams)	Sowing Date	Grain Yield kg/ha	100 K. wt. (grams)
12 Apr. d_1	550	10.6	-	-	523	10.0	12 Apr. (d_1*)	[illegible]	10.[illegible]
26 Apr. d_2	850	10.2	-	-	749	10.2	26 Apr. (d_2*)	[illegible]	10.[illegible]
10 May d_3	1320	10.4	52[illegible]	9.8	1320	10.2	10 May (d_3)	1055	10.1
24 May d_4	1480	10.7	84[illegible]	10.2	1440	10.3	24 May (d_4)	1[illegible]	10.[illegible]
7 June d_5	1[illegible]	10.8	1[illegible]	10.4	1[illegible]	10.[illegible]	7 June (d_5)	[illegible]	10.[illegible]
21 June d_6	7[illegible]	10.4	[illegible]	10.1	[illegible]	10.1	21 June (d_6)	[illegible]	10.[illegible]
5 July d_7	4[illegible]	10.[illegible]	6[illegible]	9.9	[illegible]	10.1	5 July (d_7)	[illegible]	10.1
Mean	1[illegible]	10.[illegible]	[illegible]	10.0	[illegible]	10.[illegible]	Mean	[illegible]	10.[illegible]
S. E.	±1.[illegible]**	0.[illegible]	[illegible]**	0.[illegible]	[illegible]**	0.[illegible]	S. E.(n=9)	[illegible]**	0.[illegible]
L.S.D. (.05)	[illegible]	-	[illegible]	-	[illegible]	-	S.E.(n=6)	[illegible]	0.[illegible]

** Significant at .01

* d_1 and d_2 are based on 6 observations
d_3 to d_7 are based on 9 observations.

TABLE 5. CORRELATION COEFFICIENT, r MATRIX OF SOWING DATE ($d_1 - d_7$) AND DIFFERENT TRAITS IN MILLET

	Grain Yield	Establish-ment	50% Heading	Plant Height	1000 K Weight	Days to Emergence	Percent Emergence	Total Rainfall	No. of Rain days	Accum. ht. unit
Establishment	.92**									
50% Heading	-.82**	-.92**								
Pl. Height	.84**	.88**	-.84**							
1000 KWT	.60**	.52**	-.57*	.59**						
Days to emerg.	-.48*	-.24 n.s		-12 n.s	-.34 n.s					
% Germination	.44*	.16 n.s	.01 n.s	.05 n.s	.33 n.s	-.97**				
T-Rainfall	-.10 n.s	-.41*	.48	-.37 n.s	.02 n.s.	-57**	.67**			
No. Rainy days	.53**	.36 n.s.	-.37 n.s	.21 n.s	.23 n.s	-.64**	.69**	.41*		
Heat Unit	-.09 n.s	.21 n.s	-.28 n.s	.28 n.s	.16 n.s	.76**	-.83**	-.88**	-.62**	
Sowing Date	-.10 n.s	-.35 n.s	.31 n.s	-.46*	.02 n.s	-.55**	.62**	.82**	.55**	-.90**

** *Significant at .01*

* *Significant at .05*

ns *Not significant at .05*

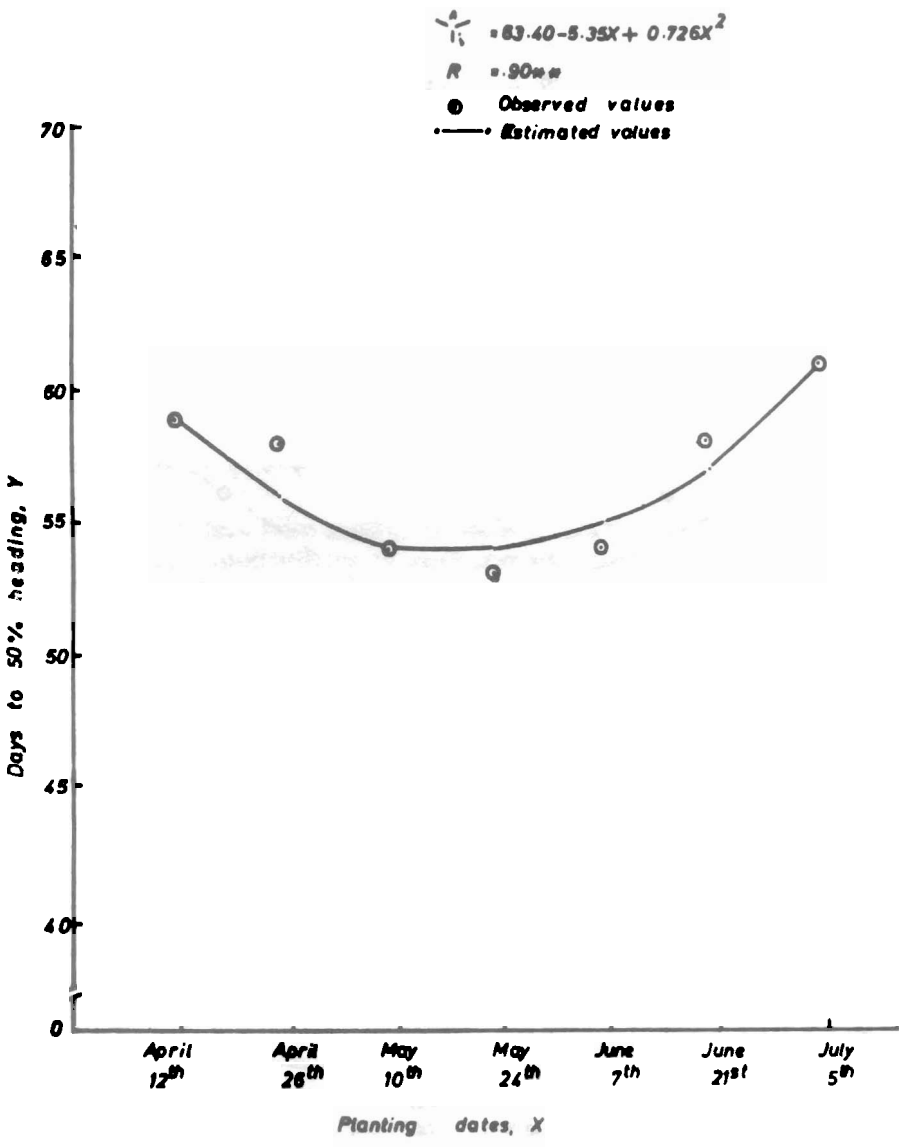

Fig. 1: The quadratic effect of sowing date on time to 50% heading in millet

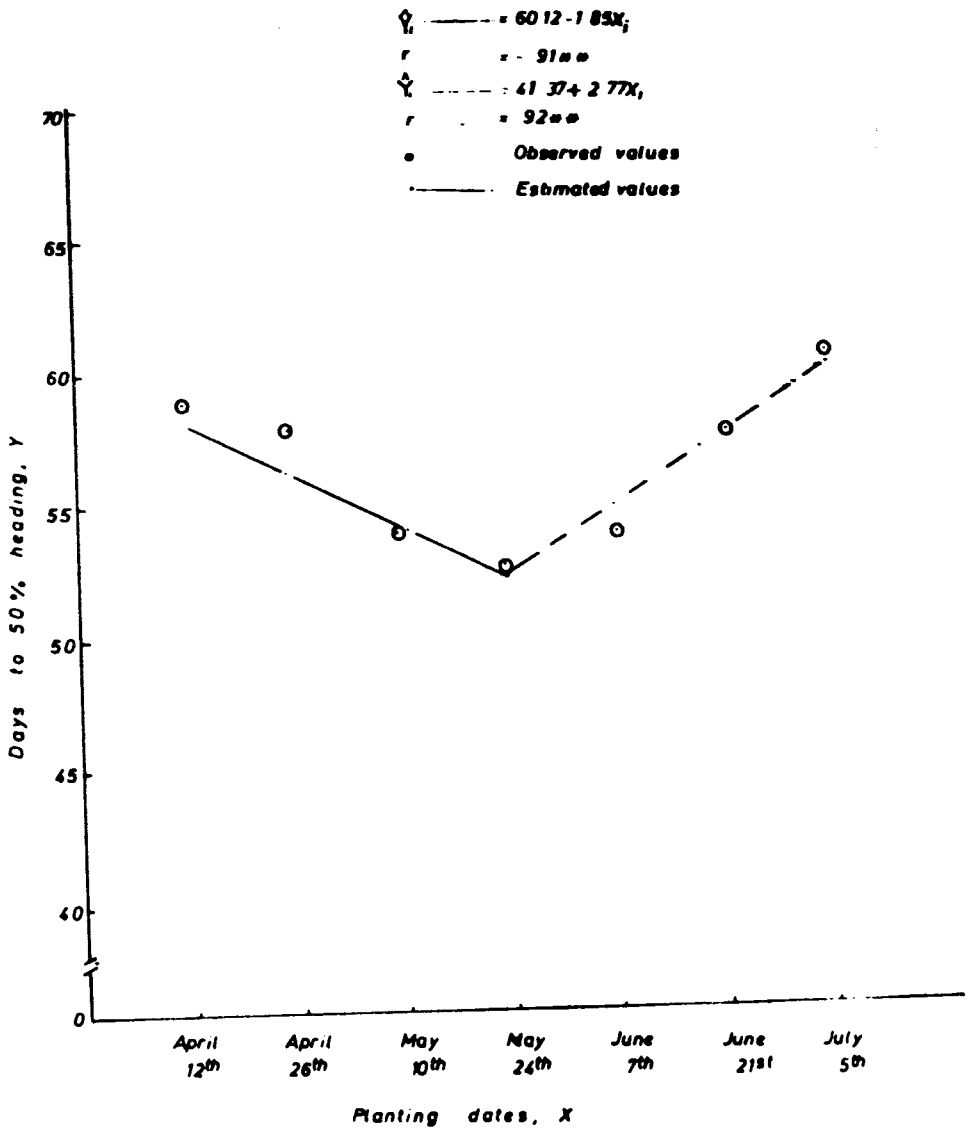

Fig. 2 : The linear effects of sowing date on time to 50% heading in millet

These studies however did not consider the effect of sowing too early.

The delay in heading date due to either sowing too early or too late can be explained partly by drought effect and partly by the decrease in accumulated heat units over the season. Millet, even though drought tolerant, requires certain critical minimum amount of moisture for optimum development. From the rainfall data (Table 1), it would seem that minimum rainfall requirement was not met at the April sowing dates and this could have slowed down the developmental processes. With the exclusion of the two April sowing dates, there was a highly significant negative correlation ($r = -0.65$; $r^2 = 42\%$) between total heat units accumulated and time to heading (Table 3). Heading time increased as heat unit decreased.

Grain Yield

The grain–yield data are shown in Table 4. The lower yield recorded in 1977 is evident from Fig. 3 and this certainly had to do with the rainfall pattern Rainfall was lower and did not become constant until about the first week in June (Table 1). Consequently, peak production was recorded for the sowing made in the first week of June (d5). Subsequent sowings led to a significant reduction in yield.

In 1976 and 1978, best yields were obtained from sowings made in May which coincided with the time when rainfall was regarded as being constant. This is so because while there was a total of 5 rain days up till 26 April of each year for a total of less than 50 mm, there were 15 (total of 128.8 mm) and 11 (total of 122.8 mm) rain days, respectively between 26 April and 24 May in 1976 and 1978. Averaged over the three years, sowings made on 24 May gave the highest yield.

Sowings made before and long after the rains were steady resulted in significant reduction in yield (Table 4). Grain yield, averaged across years, demonstrated a significant quadratic relationship with time of sowing (Fig. 4). This means that grain yield increased with each successive extension in date of sowing, got to a peak (inflection point on Fig. 4) and then declined. The first half of the curve is characterized by a positive linear function with a correlation coefficient, $r = 72$ ($r2 = 52\%$) and a regression equation, $Yi = 316.0 + 269.5\ Xi$ ($P < .05$); indicating that yield increased by 269.5 kg ha-1 for each fortnight delay in planting. On the contrary, the second half of the curve is characterized by a negative linear function with a regression equation, $Y1 = 2568.9 - 294\ Xi$ ($P < .01$) and a correlation coefficient, $r = -0.86$ ($r2 = 74\%$). Therefore, each fortnight delay in date of sowing after the rain became constant reduced grain yield by 294 kg ha-1.

Reduction in yield associated with delayed sowing could be explained partly by the fact that some of the late sown crops did not produce flowers while others that flowered, did not set seeds. The flowering period came at the peak of the rain which might have washed off some of the pollen, thus preventing maximum seed development. This is supported by Balsasubramanian (1959) who noted that heavy rainfall does interfere with

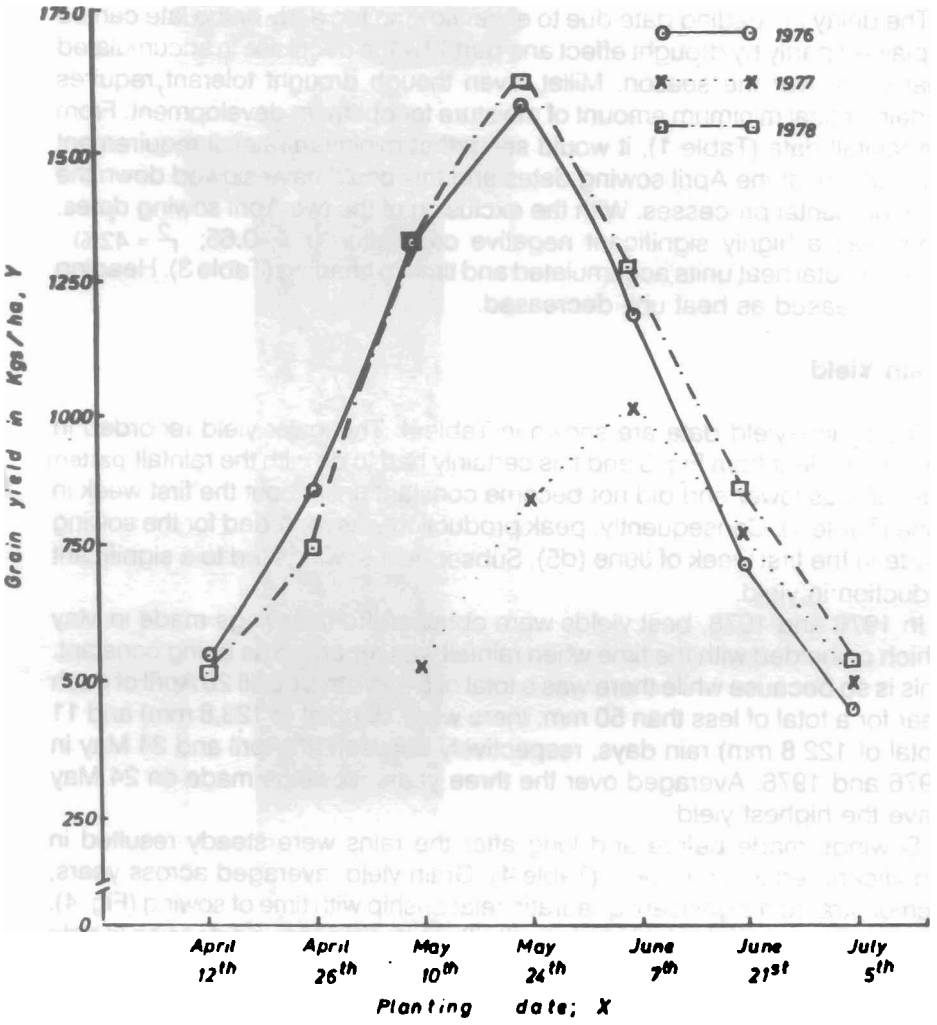

Fig 3 : The effect of sowing date on grain yields of millet for 1976 to 1978

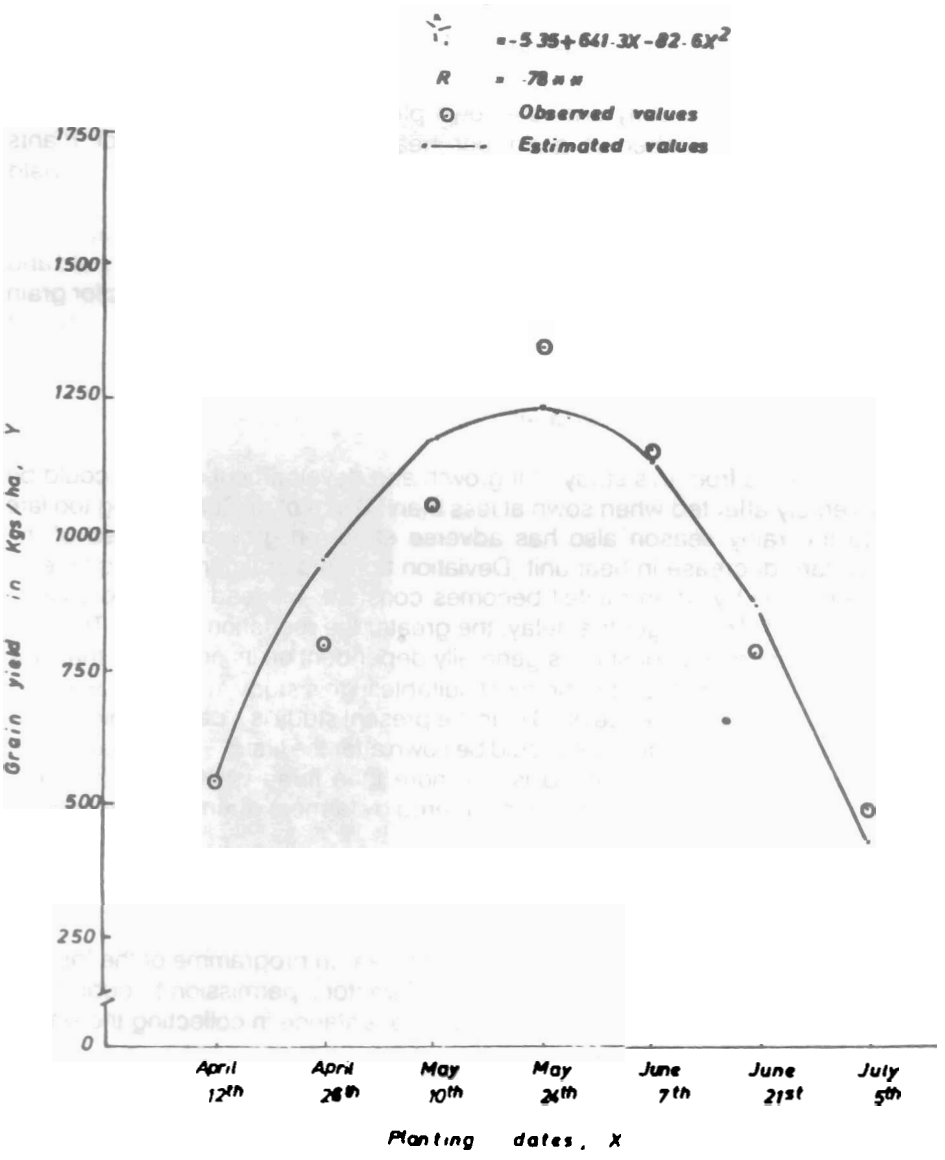

Fig 4 The quadratic effect of sowing date on grain yield of millet

seed setting. The early and late sown plants were characterized by small heads, fewer number of grain per head and fewer number of plants established (Table 1). The implication of plant establishment in yield reduction is obvious when it is considered that there is positive correlation between total yield and number of plants established (Table 5). It could also be inferred that since there was a positive correlation between grain yield and time to 50% heading, delayed heading reduced the number of days for grain filling. Grain yield in millet has been found to be related to duration and rate of filling (Egbarevba, 1979b).

Conclusion and Recommendation

It appears from this study that growth and development of millet could be adversely affected when sown at less than 50 mm of rainfall. Sowing too late into the rainy season also has adverse effect on growth because of the resultant decrease in heat unit. Deviation from the optimum sowing time as determined by when rainfall becomes constant, will lead to a decrease in grain yield. The longer the delay, the greater the reduction in yield. The time the rain becomes constant is generally dependent on its onset and thus, the May sowing date found to be most suitable in this study, may not always be the ideal. The experience of 1977 in the present study is a case in point. A rule of thumb, then, is that millet should be sown after the first 5 – 8 rain days of the season provided the spread is not more than three weeks. This will help eliminate some of the failures encountered by farmers when they sow with the first rain.

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