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EFFECT OF SOWING DATE AND NPK FERTILIZER RATE ON YIELD AND YIELD COMPONENTS OF QUALITY PROTEIN MAIZE (*Zea mays L.*)

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ABSTRACT

Two field trials were conducted in 1998 and 1999 wet seasons to determine the effect of three dates of planting (10,20 and 30 June) and four NPK levels (0:0:0, 120:18:33, 150:26:50 and 180:35:66 kg NPK/ha) on the yield and yield components (number of grains/cob, 100-grain weight, cob weight/plant, cob weight/ha, grain weight/plant and grain weight/ha) of quality protein maize. Yield and yield components data were computed from the net plots. Sowing on 30th June produced significantly lower number of grain/cob; cob yield/plant; cob yield/ha; 100-grain weight; grain yield/plant and grain yield/ha than the earlier sowing dates. There was no significant difference in yield and yield parameters between 10th and 20th June sowing dates. The application of 150:26:50 kg NPK/ha gave significantly higher number of grains/cob in both years, 100-grain weight in 1998 and grain yield/ha in 1999. However, cob weight/plant; cob yield/ha and grain weight/plant in 150:26:50 kg NPK/ha were significantly higher than the other rates except 180:35:66 in both years. Early sowing (June 10) and 150:26:50 kg NPK/ha were the best sowing date and fertilizer rate for growth and yield of Quality Protein Maize (QPM) variety GH110 - 5 in Northern Guinea Savanna ecological zone of Nigeria.

Keywords: maize, sowing, date, yield, rate, fertilizer.

INTRODUCTION

Maize ranks second to wheat in the world cereal production. Maize is the most important cereal crop in the sub-Sahara Africa and, with rice and wheat, one of the three most important cereal crops in the world. Maize is high yielding, easy to process, readily digested, and costs less than other cereals. It is also a versatile crop, allowing it to grow across a range of agro-ecological zones. Maize as a typical cereal responds favorably to fertilizer application, especially in the savanna, where the soils are generally low in fertility. Maize has a strong exhausting effect on the soil and it is generally observed that maize fails to produce good grain yield in plots without fertilizer application (Kumar, 1993). In most experiments, maize response to N is very significant. Under continuous cropping, fertilizer N is the most important nutrient for maize production. Savanna soils are also deficient in native P (Bache and Rogers, 1970). It is one of the important cereal crops grown in Nigeria, stretching from the coast to the savanna. The production of maize in the Nigerian savanna has since been transformed from that of a minor crop status to a major commercial grain crop competing with sorghum and millet crops in the grain economy of the nation (Elemo, 1993).

Quality Protein Maize in comparison with conventional maize has higher quality because it contains double the amount of lysine and arginine, higher level of tryptophan and cystein and no change in other amino acids except lower level of leucine. As a result, the QPM's amino acid profile gives a good balance of total essential amino acids and has an amino acid score adjusted for digestibility of 67% compared to 28.5, 31.0 and 33.0% values found for pioneer, dent and flint maize, respectively (Zarkadas *et. al.*, 1995). Hassan (1999) using different varieties of QPM (GH110 – 28 and Obatampa) reported an increase in grain yield with increase in fertilizer up to 120:26:50 kg NPK/ha. Quality protein maize being new maize recently introduced into the country needs to be verified for its growth, development and yield before dissemination to farmers. Fertilizer rate and date of sowing are the most important factors influencing crop growth, development and yield of maize. It was for this reason that sowing date and fertilizer rates were studied, in order to determine the best date of sowing and fertilizer rate for the production of QPM in northern Guinea savanna ecological zone.

MATERIALS AND METHODS

Field experiments were conducted during 1998 and 1999 rainy seasons at the Institute for Agricultural Research (I.A.R) Farm, Samaru, Zaria (11^0 $11^/$ N; 07^0 $38^/$ E, 686 meters above sea level) to assess the response of Quality Protein Maize (QPM) to sowing date and fertilizer (NPK) levels. The soils of the experimental sites were loam in both years (Table-1). Meteorological data for the years of the study are presented in Appendices I and II, respectively.

The treatments were three sowing dates (June 10, 20, and 30), and four NPK fertilizer levels (0:0:0, 120:18:33, 150:26:50, and 180:35:66 kg NPK/ha). A QPM hybrid (variety GH 110-5) was used as the test crop. The trials were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The experimental site was ploughed, harrowed and ridged 75cm apart. Seeds were sown by hand at one (1) seed per hole to give plant population of 53,200 plants per hectare. Compound fertilizer NPK 15:15:15 and urea (46% N) were applied at three and six weeks after sowing, respectively by placing in a hole and covered with soil to minimize lost and allow efficient use by the plants. Weeds were manually controlled by hoe weeding at 3 weeks after sowing and the ridges were then remoulded at 6 weeks after sowing.

Table-1. Physico-chemical properties of the soil of the experimental sites during 1998 and 1999 wet seasons at Samaru

Soil characteristics	Soil depth 0-15 1998	0-15 1999	15-30 1998	15-30 1999
Physical Characteristics g/kg				
Clay	12	14	14	20
Silt	48	40	44	38
Sand	40	46	42	42
Textural class	Loam	Loam	Loam	Loam
Chemical Characteristics				
pH 1:2.5 in H_20	5.70	5.50	5.00	5.20
pH 1:2.5 in 0.01 $CaCl_2$	5.20	5.20	4.80	4.60
Organic Carbon g/kg	0.43	0.50	0.33	0.35
Total nitrogen	0.09	0.09	0.07	0.08
Available Phosphorus	6.27	5.38	3.58	3.58
Exchangeable Bases (Cmol/kg)				
Ca	1.00	0.60	1.00	0.60
Mg	0.33	0.33	0.27	0.38
K	0.23	0.44	0.51	0.34
Na	1.06	1.14	1.00	1.06
H + Al	0.10	0.10	0.20	0.10
CEC	5.70	4.60	5.80	5.30

During the two wet seasons (1998 and 1999) no serious diseases were observed. However, a mild stem borer infestation occurred and a broad-spectrum insecticide (Cypermethrin and Dimethote) was used in controlling the pest at the rate of 0.75 kg ai /ha by spraying using knapsack sprayer.

Yield parameters (number of grains /cob, 100 grain weight, cob weight/plant, cob weight/ha, grain yield/plant and grain yield/ha) were measured from the net plot. Numbers of grains per cob were counted. This was done for five cobs in each plot and later averages were worked out and recorded. 100 grains were counted from each plot and weighed to get 100-grain weight. Five plants per plot were randomly selected and their cobs were harvested and weighed, the value for each plot was then divided by the number of plants (5) to get cob weight per plant. Cobs produced per plot were weighed and the value was then extrapolated to cob yield per hectare. Cobs harvested from the five randomly selected plants used for measuring cob weight per plant were threshed and the grains weighed, the value of the grain yield was then divided by the number of plants (5) to give grain yield per plant. Grain yield per plot was weighed and the value was then extrapolated to per hectare basis.

The data collected from the field were subjected to statistical analysis of variance and treatments means were compared using Duncan Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS

Table-2 shows the effect of sowing date and fertilizer (NPK) rate on number of grains per cob of quality protein maize. Crops sown on the 10^{th} and 20^{th} June were statistically similar in 1998, though significantly higher crops. In 1999, 10^{th} June sown plants produced a significantly higher number of grains per cob than the other two sowing dates; which were statistically at par. Increase in fertilizer rate from 0:0:0 to 150:26:50 kg NPK/ha significantly increased the parameter, while further increase to 180:35:66 kg NPK/ha significantly reduced it in both years.

Effect of sowing date and fertilizer rate on 100-grain weight (g) is presented in Table-2. 10^{th} June sown maize produced significantly higher 100 – grain weight in 1999 than the other sowing dates, which were statistically similar. Increasing fertilizer rate from 0:0:0 to 150:26:50 kg NPK/ha significantly increased 100 – grain weight in both years. Further increase in the rate to 180:35:66 kg NPK/ha significantly reduced the parameter only in 1998.
Effect of sowing date and fertilizer rate on cob weight per plant (g) of quality protein maize in 1998, 1999 are shown in Table-2. In 1998, sowing on 10^{th} and 20^{th} June produced statistically similar cob weights per plant, but were significantly higher than crop sown on 30^{th} June. In 1999, cob weight produced by QPM sown on the 10^{th} June was higher than those sown on the other two dates, which were statistically at par. Increasing fertilizer rate from 0:0:0 to 150:26:50 kg NPK/ha significantly increased cob weight per plant in both years. Further increase in the fertilizer

rate to 180:35:66 kg NPK/ha however, did not result in any increase in cob weight/plant.

Table-2. Effect of sowing date and fertilizer rate on number of grains per cob, 100-grain weight (g), cob weight per plant (g) cob weight (t/ha), grain yield/plant (g) and grain yield (t/ha) of Quality Protein Maize at Samaru in 1998 and 1999 wet seasons.

Treatment	Number of grains/cob		100-grain weight (g)		Cob weight/plant (g)		Cob weight (t/ha)		Grain yield/plant (g)		Grain Yield (t/ha)	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Sowing date												
10th June	451.67a	477.25a	18.18	23.93a	98.33a	119.44a	5.54a	6.44a	77.51a	100.72a	4.04a	5.35a
20th June	488.17a	415.83b	16.71	21.20b	93.47a	104.55b	5.21a	5.58b	77.50a	81.09b	4.03a	4.13b
30th June	354.58b	435.67b	16.51	21.04b	75.06b	102.75b	3.91b	5.26b	54.73b	78.81b	3.06b	4.26b
S.E. ±	18.572	12.220	0.773	0.469	5.732	3.577	0.309	0.190	5.254	2.856	0.257	0.180
Fertilizer rate kg NPK/ha												
0:0:0	194.78c	272.89c	11.44c	16.93c	57.04c	49.58c	2.43c	3.07c	25.96c	34.26c	1.28c	1.87d
120:18:33	452.44b	459.78b	16.40b	22.06b	14.07b	99.07b	4.46b	5.99b	62.27b	96.00b	3.31b	4.8 0c
150:26:50	576.56a	546.00a	21.72a	25.33a	134.76a	126.74a	6.74a	7.30a	101.22a	111.97a	5.24a	6.18a
180:35:66	502.11b	493.00b	18.96b	23.90a	29.59a	120.35a	5.91a	6.68a	90.21a	105.27ab	5.00a	5.47b
S.E. ±	21.446	14.110	0.892	0.542	4.131	5.517	0.357	0.219	6.067	3.298	0.297	0.208
Interaction												
D x F	NS	NS	NS	NS	NS	**	NS	*	NS	**	*	**

Means followed by the same letter(s) within a treatment group are not significantly different at 5 percent level of significance using DMRT

NS = Not significant.
* = Significant at p = 0.05
** = Significant at p = 0.01

Interaction between sowing date and fertilizer rates on cob weight per plant was significant only in 1999 (Table-3). When the same sowing date was examined at different fertilizer rates, sowing on 10th and 30th June revealed that increase in fertilizer rate from 0:0:0 to 120:18:33 kg NPK/ha significantly increased cob weight however, further increase to 180:35:66 kg NPK/ha had no significant effect on cob weight/plant. The crop sown on both 20th June showed that fertilizer application resulted in heavier cobs/plant than the control. When the different sowing dates were examined at the same fertilizer rate, the analysis revealed that there was no significant different between cob weight per plant produced at all the sowing dates at 0:0:0 and 150:26:50, while at 120:18:33 kg NPK/ha, sowing on 10th produced significantly higher cob weight per plant than 20th and 30th June which were statistically at par. However, at 180:35:66 kg NPK/ha sowing on 30th June produced significantly lower cob weight per plant than 20th June, but statistically similar with those sown on 10th June.

The influence of sowing dates and fertilizer rates on cob yield per hectare (t/ha) of quality protein maize is shown in Table-2. In 1998, cob yield per hectare produced by crops sown on 10th and 20th June were statistically similar but higher than those sown on 30th June. In 1999, 10th June sown crops produced higher cob yield per hectare than the other sowing dates, which were statistically similar. Increase in fertilizer rate from 0 to 150:26:50 kg NPK/ha significantly increased cob yield per hectare in both years. Further increases to 180:35:66 kg NPK/ha have no effect on cob yield per hectare in 1998 and 1999.

A significant interaction between fertilizer rate and sowing date on cob yield per hectare was observed in 1999 wet season (Table-3). When the same sowing date was observed at different fertilizer levels, increase in fertilizer levels from 0:0:0 to 150:26:50 significantly increase cob yield per hectare when crops were sown on 10th June. Further increase to 180:35:66 kg NPK/ha significantly reduced it. When crops were sown on 20th June, increase in fertilizer level from 0:0:0 to 120:18:33 kg NPK/ha significantly increased the cob yield/ha. However, further increase in fertilizer levels either from 120:18:33 to 150:26:50 or 150:26:50 to 180:35:66 kg NPK/ha have no effect on cob yield per hectare. When the crops were sown on 30th June, increase in fertilizer levels from 0:0:0 to 150:26:50 kg NPK/ha significantly increase cob yield per hectare, but further increase in fertilizer levels from 150:26:50 to 180:35:66 kg NPK/ha did not significantly affect the parameter.

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Table-3. Interaction of sowing date and fertilizer rate on cob weight per plant (g), cob weight/ha (t/ha) and grain yield/plant (g) of quality protein maize at Samaru all in 1999 wet seasons.

Treatment	Sowing date (June)		
	10	20	30
Fertilizer rate	**Cob weight per plant** (g)		
0:0:0	48.89i	60.00i	62.22i
120:18:33	131.11bcd	102.21fgh	108.88e-h
150:26:50	162.22a	118.22b-f	124.45b-e
180:35:6 6	135.56bc	137.78b	115.44c-g
S.E.±		7.155	
	Cob weight per hectare (t/ha)		
0:0:0	2.80i	3.37i	3.03i
120:18:33	7.00bc	5.47fgh	5.50fgh
150:26:50	8.70a	6.53b-f	6.67b-e
180:35:66	7.27b	6.93bcd	5.83efg
S.E.±		0.380	
	Grain yield per plant (g)		
0:0:0	27.36i	35.78i	39.65i
120:18:33	120.97ab	80.52gh	86.52e-h
150:26:50	137.14a	96.80def	101.98cde
180:35:66	117.42bc	111.27bcd	87.11efg
S.E.±		5.713	

Means followed by the same letter(s) within a treatment group are not statistically different at 0.05 level of probability using DMRT.

When various dates of sowing were examined at the same fertilizer level, planting on all the sowing dates did not affect cob yield per hectare at 0:0:0 kg NPK/ha fertilizer level. At 120:18:33 and 150:26:50 kg NPK/ha levels, sowing on 10th June significantly produced higher cob yield per hectare than 20th and 30th June sowings, which were statistically similar. However at 180:35:66 kg NPK/ha level, sowing on 30th June produced significantly lower cob yield per hectare than 10th and 20th June sowings which were statistically at par.

Response of grain yield/plant to sowing date and fertilizer rate is presented in Table-2. In 1998, crops sown on 10th June produced similar grain yield per plant with those sown on 20th June, but were significantly higher than the yield/plant produced by the crop sown on 30th June. In 1999 the difference between the grain yield/plant of the crop sown on 20th and 30th June was not significant however; they were significantly lower than the grain yield/plant recorded when the crop was sown on 10th June. Increasing fertilizer rates from 0:0:0 to 150:26:50 kg NPK/ha significantly increased grain yield per plant. A further increase in the rate to 180:35:66 kg NPK/ha did not have any significant effect on yield/plant.

There was a highly significant interaction between sowing date and fertilizer rate on grain yield per plant in 1999 wet season (Table-3). When the same sowing date was examined at different fertilizer rate, it reveals that for crop sown on 10th June, increase in fertilizer rate from 0:0:0 to 150:26:50 kg NPK/ha increased grain yield/plant. A further increase in fertilizer to 180:35:66 kg NPK/ha caused a significant reduction in grain yield/plant. Crop sown on 20th June exhibited a significant increase in grain yield per plant with increase in fertilizer rate. However, for the late sown crop of 30th June, fertilizer application caused a significant increase in grain yield/plant over the control.

Varying sowing date at 0:0:0 kg NPK/ha fertilizer rate did not affect grain yield per plant significantly but at 120:18:33 and 150:26:50 kg NPK/ha fertilizer rates, sowing on 10th June gave statistically higher grain yield per plant than both 20th and 30th June sown crop which were statistically similar. However, at 180:35:66 kg NPK/ha fertilizer rate, sowing on 30th June significantly produced lower grain yield per plant than the two earlier sowings, which were statistically at par.

Table-2, shows the effect of sowing date and fertilizer rate on grain yield per hectare (t/ha) of quality protein maize. In 1999 early sown plant produced significantly higher grain yield per hectare than the other sowing dates, which were statistically at par. However, in 1998, delay in sowing from 10th to 20th June had no significant effect on grain yield per hectare, though further delay up to 30th June resulted in a significant grain yield reduction. Increasing fertilizer rate from 0:0:0 to 150:26:50 kg NPK/ha significantly increased grain yield per hectare in both years, while further increase up to 180: 35:66 kg NPK/ha did not affect the grain yield in 1998, but significantly reduced grain yield per hectare in 1999.

The results revealed a significant interaction between sowing date and fertilizer rates on grain yield per hectare in 1998, 1999 wet-seasons is (Table-4). In 1998, when sowing dates were kept constant and fertilizer rates varied, it was observed that grain yield increased significantly from the control to 150:26:50 kg NPK/ha at 10th and 20th June sowing; further increase to 180:35:66 kg NPK/ha was not significant with 10th June sowing. At 30th

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June sowing however, fertilizer rates 0:0:0 and 120:18:33 kg NPK/ha produced statistically similar grain yield/ha, while further increase up to 180:35:66 kg NPK/ha produced significantly higher grain yield/ha. Keeping fertilizer rates constant while varying sowing dates, at 0:0:0 and 180:35:66 kg NPK/ha delay in sowing did not significantly affected grain yield/ha. However, at 120:18:33 and 150:26:50 kg NPK/ha delayed sowing from 10th to 20th June did not affect grain yield/ha, but further delay to 30th June significantly decreased grain yield/ha. Highest grain yield (6.3t/ha) was produced by the combined effect of 20th June sowing and 150:26:50 kg NPK/ha fertilizer rate, while the lowest yields were produced by 30th June sowing without additional fertilizer application.

A highly significant interaction was also observed between fertilizer rate and sowing date on grain yield per hectare in 1999 wet-season (Table-4). When sowing dates were kept constant and varied fertilizer rates, at 10th June sowing increase in fertilizer up to 150:26:50 kg NPK/ha significantly increased grain yield/ha, beyond which there was a significant yield reduction. Similar trend was recorded on 20th June sown crops, though further increase from 150:26:50 to 180:35:66 kg NPK/ha resulted in statistically similar yield. However, at 30th June sowing increase in fertilizer from 0:0:0 to 120:18:33 kg NPK/ha significantly increased grain yield/ha, while further increase up to 180:35:66 kg NPK/ha did not significantly affect grain yield/ha. When sowing dates were varied at constant fertilizer rate, at 0:0:0 delayed sowing did not significantly affect grain yield/ha, while at 120:18:33 kg NPK/ha delayed sowing from 10th to 20th June significantly decreased grain yield/ha, further delay to 30th June significantly increased grain yield/ha. However, at 150:26:50 kg NPK/ha delay in sowing date from 10th to 20th June significantly reduced grain yield, though further delay to 30th June did not significantly affect grain yield/ha. At 180:35:66 kg NPK/ha, sowing on 10th June produced higher grain yield/ha but only significant from sowing on 30th June. 10th June sowing and fertilizer rate of 150:26:50 kg NPK/ha produced highest grain yield (7.6t/ha) and the lowest yield (1.5t/ha) was produced by the interaction of 10th June sowing and 0:0:0 fertilizer rate.

Table-4. Interaction of sowing date and fertilizer rate on grain yield (t/ha) of quality protein maize at Samaru during 1998, 1999 wet seasons.

Treatment	Sowing date (June)		
	10	**20**	**30**
Fertilizer rate		**1998**	
0:0:0	1.47h	1.73h	0.63h
120:18:33	4.27c-f	3.67d-g	2.00h
150:26:50	5.57abc	6.30a	3.87d-g
180:35:66	4.87a-d	4.40b-e	5.73ab
S.E. ±		0.514	
		1999	
0:0:0	1.53h	1.90h	2.17h
120:18:33	6.10bc	3.53g	4.77de
150:26:50	7.60a	5.60bcd	4.63def
180:35:66	6.17b	5.47b-e	5.47b-e
S.E. ±		0.360	

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of significance using DMRT.

DISCUSSIONS

Higher growth and yield parameters particularly cob weight/plant (g), cob yield/ha, grain yield/plant (g), grain yield/ha and 100-grain weight (g) were observed during 1999 compared to 1998 wet season. These observations could be attributed to the favourable agro-climatic conditions particularly temperature, solar radiation and relative humidity which coincide with even rainfall distribution in1999. The lower growth and yield parameters recorded in 1998 could be attributed to the uneven rainfall distribution, which causes water logging that affects soil aeration, fertilizer use efficiency and plant metabolism, especially photosynthesis, assimilate formation and translocation, cell division and elongation etc. thus inducing stunted growth and development.

Higher yield and yield parameters particularly number of grains/cob, cob weight/plant, cob yield/ha, grain yield/plant, grain yield/ha and 100-grain weight were observed with early sown crop than the late sown in both years of the study. This might be due to the longer time available for the early sown crop to utilize available growth resources (light, nutrients, moisture etc) to produce

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and partition more assimilates to the various sinks for better vegetative growth, leading to the production of higher yield and yield components than the late sown crops in both years. This observation conforms to that of Moentono (1989) and Mendhe (1992), who reported that grain production/plant, 100-grain weight and grain yield increased with early sowing.

It was also observed that increase in fertilizer rate increased number of grains/cob, cob weight/plant, cob yield/ha, grain weight/plant, grain yield/ha and 100-grain weight. This may probably be attributed to NPK being part of the essential nutrients required for the promotion of the meristematic and physiological activities such as plant leaf spread, root development, plant DM production etc leading to an efficient absorption and translocation of water and nutrients, interception of solar radiation and assimilation of carbon dioxide. These activities promote higher photosynthetic activities leading to the production of enough assimilate for subsequent translocation to various sinks and hence the production of higher yield and yield components of maize. This is in conformity with the findings of Adediran and Banjoko (1995) and Anononymous (1997) who observed that the crucial yield and yield components such as 1000-grain weight, ears/plant, was produced with increase in fertilizer.

SUMMARY AND CONCLUSIONS

Field experiments were conducted during 1998 and 1999 wet seasons at the Institute for Agricultural Research Farm Samaru in the northern Guinea Savanna of Nigeria (11^{O} $11^{/}$N, 07^{O} $38^{/}$E), to determine the effect of sowing date and fertilizer rate on QPM variety GH 110-5.

The influence of sowing date on the test crop revealed that plants sown on 10^{th} June produced higher yield and yield components than those sown on the 20^{th} and 30^{th} June.

Fertilizer rate of 150:26:50 kg NPK/ha significantly produced higher yield and yield components particularly cob yield/ha, kernel weight/plant, 100-grain weight and grain yield/ha than the other fertilizer rates. In conclusion, the study revealed that plants sown early (10^{th} June) and given 150:26:50 kg NPK/ha gave the highest grain yield of 6.6t/ha. It is therefore advisable to be adopted by farmers producing quality protein maize in Northern Guinea Savanna ecological zone.

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Appendix-I. Samaru meteorological variables at ten day interval during the period of experiment in 1998.

Month	Days	Rainfall (mm)	Temperature (^{0}C) Max.	Min.	Relative Humidity (%) 10:00am	4:00pm	Sunshine Hrs.
June	0 – 10	50.4	32.3	18.9	83.7	70.1	7.00
	11 – 20	65.8	31.6	20.6	82.4	60.4	7.50
	21 – 30	13.4	33.0	20.7	81.2	64.3	6.90
July	0 – 10	42.8	30.7	19.7	83.7	66.0	5.80
	11 – 20	128.0	30.6	21.4	83.2	72.7	3.50
	21 – 30	25.6	31.1	23.0	85.9	80.5	4.92
August	0 – 10	136.6	31.5	22.7	87.7	83.9	4.92
	11 – 20	112.5	31.3	22.6	86.9	80.4	2.90
	21 – 30	224.5	31.1	22.3	88.3	81.2	4.60
September	0 – 10	79.8	30.3	22.8	87.4	75.0	5.05
	11 – 20	98.2	31.1	22.1	86.4	73.2	5.04
	21 – 30	43.0	30.5	22.5	84.5	70.8	6.50
October	0 – 10	27.0	30.8	21.8	83.0	72.2	5.84
	11 – 20	14.6	30.7	22.5	83.0	71.3	6.00
	21 – 30	4.0	33.0	22.6	71.7	49.4	4.00

Source: Meteorological unit, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria, Nigeria.

Appendix-II. Samaru meteorological variables at 10 days intervals during the period of the experiment in 1999.

Month	Days	Rainfall (mm)	Temperature (^{0}C) Max.	Min.	Relative Humidity (%) 10:00am	4:00pm	Sunshine Hrs.
June	0 – 10	74.2	33.6	25.0	74.0	52.6	6.12
	11 – 20	80.1	32.4	23.1	80.5	59.5	7.38
	21 – 30	84.0	30.4	21.5	80.6	66.6	6.53
July	0 – 10	100.1	30.1	22.1	84.4	64.4	6.09
	11 – 20	108.4	29.9	22.4	88.6	73.6	4.72
	21 – 30	77.0	29.5	22.4	80.1	78.5	3.25
Aigust	0 – 10	34.4	27.2	22.7	88.7	80.7	3.68
	11 – 20	69.8	28.9	20.5	89.4	74.5	4.84
	21 – 30	50.6	29.3	21.6	89.1	76.5	5.57
September	0 – 10	96.0	29.8	22.0	88.3	77.6	5.05
	11 – 20	10.9	30.2	22.1	83.8	71.9	7.51
	21 – 30	97.3	29.7	21.4	86.3	78.8	4.98
October	0 – 10	25.9	31.2	21.3	84.5	72.8	7.54
	11 – 20	4.5	31.4	20.3	73.3	55.2	5.43
	21 – 30	0.0	33.0	18.7	69.1	42.4	8.93

Source: Meteorological unit, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria, Nigeria.