

Yield of Wheat (*Triticum aestivum* L.) as Influenced by Planting Date and Planting Methods in the Sudan Savanna Ecological Zone of Nigeria

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ABSTRACT

Wheat is a temperate crop requiring low temperatures for growth and yield. Production of wheat in the Sudan savanna agro-ecological zone of Nigeria is restricted to periods of low temperatures that prevailed from early November to late February. Based on the above, field experiments were conducted in two locations at the University Teaching and Research Farm during 2016/2017 dry season to determine the most appropriate planting date and planting method in the study area. The two locations were: Fadama Teaching and Research farm at Jega (Lat. 12°12.99' N; long. 4° 21.90'; 197m above sea level) and the University orchard at Aliero (lat. 12°18.64'N; long. 4°29.85'; 262 above sea level). Both Jega and Aliero are located within Sudan Savanna ecological zone of Nigeria. Treatments consisted of factorial combinations of four Planting dates (1st November, 15th November 1st December and 15th December 2016) and three Planting Methods (Drilling, Dibbling and Broadcasting). The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Results revealed that grain number per spike; grain weight per spike, 1000-grain weight, straw yield, and grain yield were higher when planted in 15th November and 1st December. On the other hand, drilling and dibbling methods resulted in a higher stand count, plant height, leave number, leaf area index, days to 50% heading, grain number per spike, grain weight per spike, 1000-grain weight straw and grain yields than broadcasting method. Based on the results of this study, it could be concluded that planting of wheat from 15th November to 1st December coupled with either dibbling or drilling methods of planting gives the best wheat yield in the study area.

Key-words: Ecological Zone, Planting Date, Planting Methods, Savanna, *Triticum aestivum*

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to the tribe Tritaceae, which is one of the largest and most important family of Poaceae [1]. Wheat is the most widely cultivated cereal in the world [2]. It is essentially a temperate crop whose production is mainly in Europe, America, Asia, and northern and southern Africa [3]. The cultivation of the crop date back to sixteenth century and is successfully cultivated under irrigation in small quantity in the west and central Africa on high altitude [4].

Wheat production stands at about 740 million tonnes grown on 240 million hectares [5]. Global average yield is around 2.7 t·ha⁻¹ with high variability among countries and regions. The highest average yields were obtained in Western Europe, with more than 8 t·ha⁻¹ in contrast to less than 1 t·ha⁻¹ in countries in Central/West Asia and North Africa [6]. Nigerian production currently stands at 100,000 tonnes from 95,000 hectares with an average yield of 1.05 t·ha⁻¹ [7]; this is far below that of Germany (7.9 tons·ha⁻¹), France (6.6 tons·ha⁻¹) and Egypt (6.4 tons·ha⁻¹). Kebbi State wheat production was about 2.5t ha⁻¹ from 10,000 ha [8]. The principal parts of wheat flour are gluten and starch. Wheat starch constitutes most of the carbohydrate fractions; and is second to only gluten in economic value. Various dishes have evolved over time like bread, biscuits, semolina and spaghetti [3]. Wheat production remained at a very low level in Nigeria in spite of the ever-rising demand for the crop. This low

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production level has put the cost of its importation to be high [to the tune N635 billion] annually ^[9]. As such, Federal and State governments put effort to boost wheat production in Nigeria. The constraints to the cultivation of wheat in most growing areas in Nigeria include unfavourable climate, poor agronomic practices and preference for cultivation of vegetables. While the high-altitude regions of Jos, Mambila and Biu plateaus experience relatively low temperatures and are conducive for wheat production in both rainy and dry seasons; the period of harmattan (a hot, dry and dusty wind blowing over West Africa between the end of November and middle of March) in the lowland areas of the Sudan and Sahel Savannas provides low temperatures that support wheat production, provided irrigation facilities are available ^[10]. In these regions, wheat production can be possible during harmattan periods when temperatures are relatively low. Considering the short period of the cold season and the requirements of wheat for lower temperatures, it is pertinent to relate the planting date to coincide with the period of relatively low temperatures, as high temperatures inhibit growth and yield ^[11]. Late planting delays maturity compared to early planting, it shortens the grain-filling period and often result in the plant being subjected to moisture and heat stress. Planting wheat too early can expose wheat to pest and disease problem. Planting method for wheat varies according to locality and purpose of production. Wheat can be sown by dibbling, drilling or broad casting. Broadcasting requires more seed and where adequate moisture is not present in the soil it results to uneven germination. Less seed is required in drilling than broadcasting but requires skill and expertise; while dibbling requires more labor, hence increase the cost of cultivation. For effective extension package on wheat production in Sudano-Sahelian region like Kebbi State, a scientific knowledge on the most appropriate planting dates and planting methods for wheat is necessary. The objectives of the study are to determine the effect of planting date and planting methods on the productivity of wheat in the study area.

MATERIALS AND METHODS

The trials were conducted at the University Teaching and Research Farm during 2016/2017 dry season. The two locations are Fadama Teaching and Research farm at Jega (lat. 12°12.99' N; long. 4° 21.90'; 197 m above sea

level) and the University orchard at Aliero (lat. 12°18.64'N; long. 4°29.85'; 262 above sea level). Both Jega and Aliero are located in Sudan Savanna ecological zone of Nigeria. The areas have a long dry season that is characterized by cool dry air (harmattan) that prevails from November to February; and hot dry air extending from March to May. The locations are mainly used for cultivation of vegetable and cereal crops. Prior to sowing, soil samples were collected from nine randomly selected points within the experimental site at depth of 0-30 cm using soil auger. The samples were bulked to form a composite sample and sub-samples about 200g were collected using coning and quartering method. The samples were air dried, grounded, sieved and analyzed for physical and chemical properties. Treatments consisted of factorial combinations of four Planting dates (1st November, 15th November 1st December and 15th December 2016) and three Planting Methods (Drilling, Dibbling, and Broadcasting). The experiments were laid out in an RCBD with three replications. The variety used was Gan-Atilla.

The two sites were ploughed and harrowed to a good tilt. The lands were leveled to a field slope of 0.25–0.30% to drain at the tail of the field to ensure free water movement. The land was prepared into basins of 4x3 m (12 m²). Space measuring 1 m was left between blocks and 0.5 m between plots and the net plot area was 4m². Prior to sowing, the seeds were treated with Apron star 42 WS (20% w/w thiamethoxam, 20% w/w metalaxyl-M and 2% w/w difenoconazole) at the rate of 10g per 4.0 kg of seed, in order to protect the seeds from soil borne diseases and pests. Sowing was done as per treatment at seed rate of 140 kg ha⁻¹. Broadcasting: Seeds were broadcast by hand all over the plot followed by raking to ensure uniformity in seed distribution and contact with soil. Drilling: Seeds were drilled at a depth of 2–3 cm in rows spaced 20 cm apart. Dibbling: Seeds were dibbled at a spacing of 20x20 cm.

Water channels were constructed for an effective supply of water for each plot during irrigation. The water was applied to the field at 3 days interval. NPK mineral fertilizer was applied at a rate of 120 kg N ha⁻¹, 60 kg P₂O₅ ha⁻¹ and 60 kg K₂O ha⁻¹. Half nitrogen and full dose of potassium and phosphorus were worked into the soil during seed bed preparation using NPK 15:15:15, while the second dose of 60 kg N ha⁻¹ was applied prior to tillering using urea (46% N) as source of nitrogen. Weeds

were controlled manually using hand hoe at 3 and 6 WAS to ensure weed-free plots. No disease outbreak and insect infestation were recorded. Rodents were controlled using baits and traps. Harvesting was done manually from the net plot area (4 m²) at physiological maturity using a sickle when 50% of peduncles had turned brown. The plants were cut down at the ground level and sun dried. The spikes were threshed carefully using pestle and mortar to separate the grains from chaff. Data were collected on the following yield parameters. Tiller count, spike length, grain per spike, 1000-grain weight and Grain yield.

Statistical Analysis- The data collected were subjected to analysis of variance procedure and the difference among the treatment means was compared using Duncan's Multiple Range Test (DMRT) as described by Duncan^[12].

RESULTS

Soil Physical and Chemical Properties of Experimental Site

Physical and chemical properties of soils of study locations prior to the experiments are presented in Table

1. The result indicated that particle size distribution at the two locations was dominated by sand, with values of 84% and 72% for Aliero and Jega, respectively. For silt particles, it was 10 and 15.7%, respectively. Least particle size distribution was observed with clay having recorded 6.0% for Aliero and 11.5% for Jega. The soils of the two locations were found to be sandy loam. This suggests that the soil in both locations has high macro porosity and low ability to retain water. Soil pH at Aliero (7.46) and Jega (6.25) indicated that the soils of Aliero were slightly alkaline while that of Jega was slightly acidic. Organic carbon; total N, available P and Ca were observed to be low in both locations. Exchangeable Mg was moderate, while exchangeable K and Na were higher in both Aliero and Jega locations. Records of temperature were taken (November 2016 to March 2017) from the meteorological unit of Kebbi State University of Science and Technology Aliero, Nigeria. Minimum and maximum temperature ranges were 18–29°C and 30–42°C, respectively shown in Table 1.

Table 1: Physical and chemical properties of soil of the experimental sites at Aliero and Jega during 2016/2017 dry season

Properties	Aliero	Jega
	0–30 cm depth	
Particles size Analysis		
Sand (%)	84.00	72.50
Silt (%)	10.00	15.70
Clay (%)	6.00	11.80
pH (1:2:5)	7.46	6.25
Organic carbon (%)	0.16	0.28
Total Nitrogen	0.03	0.04
Available Phosphorus (Mg kg⁻¹)	0.08	0.34
Exchangeable bases (Cmol kg⁻¹)		
Ca	0.35	0.65
Mg	0.45	0.40
K	0.97	1.18
Na	0.45	0.52
Cation exchange capacity (mol kg⁻¹)	2.20	2.75

Table 2: Air temperature of the study area from November 2016 to March 2017

Planting dates	Temperature °C (Max)	Temperature °C (Min)	Temperature °C (Mean)
Nov 1–14	36.31	20.21	28.28
Nov 15–30	37.78	20.03	28.91
Dec 01–15	36.07	19.87	27.94
Dec 16–31	33.01	18.09	25.55
Jan 01–15	31.42	16.69	24.04
Jan 16–31	34.87	17.97	26.42
Feb 01–14	34.25	20.04	27.36
Feb 15–28	34.84	19.61	27.23
Mar 01–15	39.05	21.66	30.36
Mar 16–31	40.94	23.67	32.28

Source- KSUSTA Meteorological station

Tillers per Plant- Effect of planting date and planting method on number of tillers per plant for Aliero and Jega locations as well as the mean of the two locations are presented in Table 3. Planting date and planting method

had no significant effect on number of tillers per plant in both locations and combined mean. Similarly, there was no significant interaction between planting date and planting methods.

Table 3: Effect of planting date and planting method on tiller count at 5WAS in Aliero, Jega and Mean

Treatment	Tiller count 5 WAS		
	Aliero	Jega	Mean
Panting Date			
1 st November	5.45	5.68	5.57
15 th November	5.40	5.27	5.39
1 st December	5.07	5.53	5.30
15 th December	5.08	5.09	5.08
SE±	0.31	0.31	0.31
Planting methods			
Dibbling	5.39	5.71	5.55
Drilling	5.79	5.59	5.64
Broadcasting	5.58	5.30	5.44
SE±	0.26	0.27	0.26
Interaction			
PD x SM	NS	NS	NS

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

NS = not significant at 5%. WAP= Week after planting

Spike length- The result on the effect of planting date and planting methods on spike length is presented in Table 4. Planting date and planting method had no significant effect on spike length in Aliero, Jega and the

combined mean. There was also no significant interaction of planting date and planting method in both locations and the combined.

Table 4: Effect of planting date and planting method on spike length (cm) in Aliero, Jega and Mean

Treatment	Spike length (cm)		
	Aliero	Jega	Mean
Panting Date			
1 st November	6.77	8.36	7.57
15 th November	7.00	8.11	7.55
1 st December	7.00	8.03	7.51
15 th December	7.22	8.51	7.86
SE±	0.31	0.32	0.31
Planting methods			
Dibbling	8.33	8.25	8.29
Drilling	7.29	8.25	7.77
Broadcasting	7.12	8.24	7.68
SE±	0.30	0.32	0.31
Interaction			
PD x SM	NS	NS	NS

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

NS = not significant at 5%, WAP= Week after plantings

Grains per spike- Planting date had a significant effect on the number of grains per spike in Aliero, Jega and mean of the two locations as presented in Table 5. The result showed that delay in planting on from 1st November to 15th November gave more grains per spike than planting earlier. Further delay in planting up to 15th December did not give any significant increase in grains per spike.

Planting method had a significant influence on grains per spike in both locations and the combined mean. Dibbling and drilling methods resulted in more grains per spike than broadcasting method. There was no significant interaction of planting dates and planting methods in Aliero, Jega and the combined locations.

Table 5: Effect of planting date and planting method on number of grains per spike in Aliero, Jega and Mean

Treatment	Grains per spike		
	Aliero	Jega	Mean
Panting Date			
1 st November	23.62b	26.11b	24.56b
15 th November	37.88a	39.22a	38.05a
1 st December	38.66a	39.44a	36.55a
15 th December	37.00a	37.88a	37.44a
SE±	3.950	2.780	2.440
Planting methods			
Dibbling	38.41a	37.25a	37.83a
Drilling	36.75a	36.08a	36.41a
Broadcasting	24.71b	23.67b	24.16b
SE±	3.420	2.410	2.120
Interaction			
PD x SM	NS	NS	NS

Means followed by the same letter (s) within a column in each treatment are not significantly different at 5% using DMRT

NS = Not significant at 5%, WAP = Week after planting

1000-grain weight (g)- Result on the effect of planting date and planting method on 1000-grain weight for Aliero, Jega and mean of the combined locations are presented in Table 6. Planting date had a significant effect on 1000-grain weight. Planting on 15th November and 1st December recorded heavier grains than the other planting dates. On the other hand, 1000-grain weight

was significantly influenced by planting method in both locations and combined mean. Heavier grains were recorded by dibbling and drilling methods than broadcasting method. There was no significant interaction of planting date and planting method in Aliero, Jega and mean of the combined locations.

Table 6: Effect of planting date and planting method on 1000-grain weight (g) in Aliero, Jega and Mean

Treatment	1000-grain weight (g)		
	Aliero	Jega	Mean
Panting Date			
1 st November	19.66b	20.88b	20.27b
15 th November	25.44a	28.22a	26.83a
1 st December	26.33a	26.77a	26.55a
15 th December	19.33b	20.44b	19.88b
SE±	1.28	1.24	1.37
Planting methods			
Dibbling	23.25a	27.75a	25.50a
Drilling	23.25a	27.66a	25.45a
Broadcasting	16.25b	17.83b	17.04b
SE±	1.11	1.08	1.83
Interaction			
PD x SM	NS	NS	NS

Means followed by the same letter (s) within a column in each treatment are not significantly different at 5% using DMRT
NS = not significant at 5%, WAP= Week planting

Grain yield (t ha⁻¹)- Yield of wheat as influenced by planting date and planting method for Aliero, Jega the mean of the two locations is presented in Table 7. In Aliero, planting on 15th November and 1st December resulted in the higher yield than 1st November and 15th December planting. In Jega, 15th November and 1st December planting gave the higher yield than 1st November, which in turn was higher than 15th December planting. In the combined mean, planting from 1st November up to 1st December gave similar yield, which was significantly higher than on 15th December. On the other hand, planting method had a significant effect on yield in both locations and the combined mean where dibbling and drilling methods resulted to higher yield than broadcasting. There was significant interaction of planting date and planting method on yield in Aliero, Jega and mean of the combined locations. In Aliero

location, yield was higher when planting was done on 1st December with dibbling method. The lowest yield was recorded when planting was done on 15th December with broadcasting method. At Jega, location, higher yield was obtained when planting was done on 15th November with dibbling method which was statistically the same with 1st December with dibbling and drilling methods. The lowest yield was recorded when planting was done on 1st November with broadcasting method. In the mean of combine locations, planting on 15th November and 1st December with dibbling method gave higher yield than other planting dates and planting methods. The lowest yield was recorded when planting was done on 15th December with broadcasting methods.

Table 7: Effect of planting date and planting method on yield in Aliero, Jega and Mean

Treatment	Yield (t ha ⁻¹)		
	Aliero	Jega	Combined
Planting Date			
1 st November	4.55b	4.54b	4.54a
15 th November	5.93a	5.88a	5.91a
1 st December	6.58a	6.66a	6.58a
15 th December	4.04b	3.84c	3.94b
SE±	0.352	0.391	0.374
Planting methods			
Dibbling	5.41a	6.08a	5.75a
Drilling	4.81a	5.41a	5.11a
Broadcasting	3.08b	3.23b	3.15b
SE±	0.311	0.314	0.307
Interaction			
PD x SM	**	**	**

Means followed by the same letter (s) within a column in each treatment are not significantly different at 5% using DMRT

NS = not significant at 5%, WAP= Week after planting

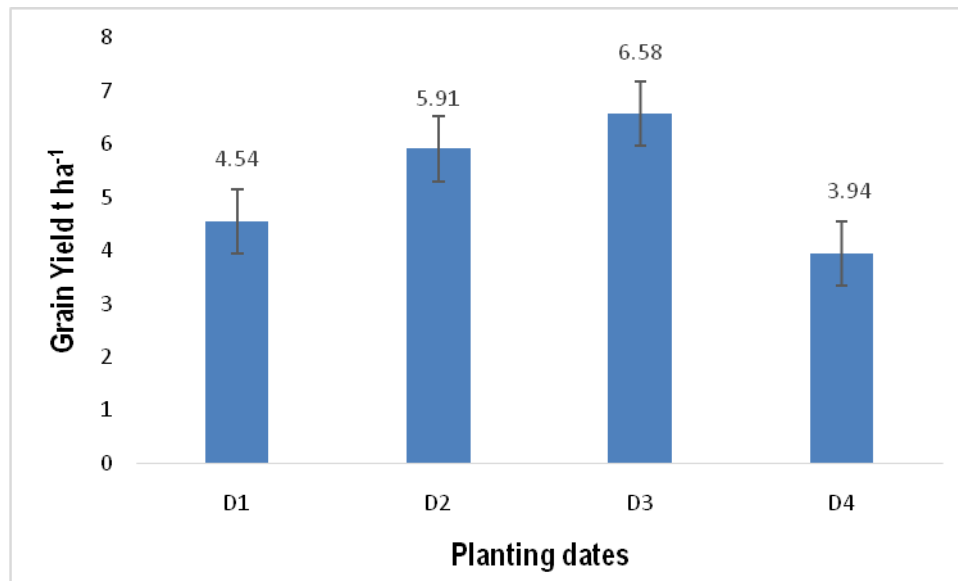


Fig. 1: Mean wheat yield at different planting dates

Table 8: Planting date x sowing method interaction on yield (t ha⁻¹) at Aliero

Sowing methods	Planting dates			
	1 st November	15 th November	1 st December	15 th December
Dibbling	4.66b	5.00b	6.66a	5.33b
Drilling	4.00c	4.00c	4.33b	4.00c
Broadcasting	4.66b	5.33b	5.33b	2.00d
SE±	0.660			

Means followed by the same letter (s) are not significantly different using DMRT at 5%

Table 9: Planting date x sowing method interaction on yield (t ha⁻¹) at Jega

Sowing methods	Planting dates			
	1 st November	15 th November	1 st December	15 th December
Dibbling	5.00b	6.00a	6.66a	4.33b
Drilling	5.00b	5.00b	6.00a	4.33b
Broadcasting	3.33c	4.33b	5.00b	5.00b
SE±	0.705			

Means followed by the same letter (s) are not significantly different using DMRT at 5%

Table 10: Planting date x sowing method interaction on yield (t ha⁻¹) at combine mean

Sowing methods	Planting dates			
	1 st November	15 th November	1 st December	15 th December
Dibbling	4.83b	6.66a	6.66a	4.83b
Drilling	4.50b	5.00b	5.33b	4.16c
Broadcasting	4.00c	5.16b	5.33b	3.66
SE±	0.703			

Means followed by the same letter (s) are not significantly different using DMRT at 5%

DISCUSSION

Higher yield and yield components particularly grain yield, grain number per spike, and 1000-grain weight were positively influenced by 15th November and 1st December planting dates. These positive responses could be linked to lower temperatures that prevailed during critical phenological stages of wheat like flowering (6–8 weeks after planting) for determining wheat yield. The crop planted on the 15th November and 1st December was 6 and 8 weeks old, respectively. This coincided with the coolest periods of the season that is 15th–31st January (Fig. 1). These low temperatures might have led to higher production and partitioning of assimilates to the various grains, leading to higher yield and yield components. Grain number per spike was significantly influenced by 15th November, 1st and 15th December planting date. Hanson ^[13] as well as Ahmad ^[14] reported significant variation in the number of grains per spike with respect to planting dates. Result indicated a yield reduction of 40 to 45%, when planting was delayed up to 15th December. A similar result was reported by Sokoto and Singh ^[11]. The non-significant response of some growth and yield characters particularly tiller count and spike length, be attributed to the genetic makeup of the crop variety Atilla.

Higher yield and yield components grain yield, grain number per spike and 1000-grain weight were positively influenced with dibbling and drilling methods. This could be attributed to efficient aeration, water utilization, utilization of applied fertilizer and light interception which collectively enhanced effective photosynthesis and consequent translocation of this photosynthate, hence the higher yield. Vijyakumar *et al.* ^[15]; Roy *et al.* ^[16] reported higher wheat yield with dibbling and drilling method which they linked to efficient uptake of growth nutrients. The non-significant response of some yield characters particularly tiller count and spike length could be due to the genetic makeup of the crop Atilla. Abbas *et al.* ^[17] reported non-significant response of planting method to tiller count. Sikander *et al.* ^[18] further stated that wheat grain yield was significantly higher in dibbling and drilling methods in comparison with broadcasting method.

It was also observed that there was the significant interaction of planting dates and planting methods with respect to grain yield. This could be due to the effect of low temperature that prevailed during 15th January couple with efficient aeration and light interception provided by dibbling and drilling methods, which had direct bearing on metabolic processes that influence the

translocation of dry matter and also shown the importance of environmental factors as the universal media through which temperature, day length and moisture are made adequate for plant growth and development. Planting earlier or delay in planting than 15th November or 1st December with broadcasting method might lead to unfavorable environments for grain yield as a result of high temperature and high competition among plants for space, which affected the biological processes that might likely limit crop performance by Reddy and Reddi ^[19]; Singh ^[20].

CONCLUSIONS

Based on the results of this study, it could be concluded that planting of wheat from 15th November to 1st December coupled with either dibbling or drilling methods of planting has given the best wheat yield in the study area.

Additional research with a different seed rate should be carrying out to determine the optimum seed rate for wheat production in the study area.

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CONTRIBUTION OF AUTHORS

All authors are equally contributed in this article.

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