ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 6 No. 4 December 2020*

Yield and Brix of Watermelon as Affected by Time of Planting and Variety at Bunkure, Sudan Savanna Ecological Zone of Nigeria

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Abstract

The objective of this study is to find out the watermelon variety that will give the best yield and brix (flavor) when grown under a suitable date or time of planting. Consequent upon this, two field experiments were conducted in 2015and 2016 at Bunkure in the Sudan savanna ecological zone of Nigeria to evaluate the yield and brix or taste of watermelon fruits in response to time of planting and variety. Six times of plantings: Early rainy season, mid rainy season, late rainy season, early dry season, mid dry season and late dry season) and five watermelon varieties – Crimson sweet, Sugar baby, Congo, Grey bell and a local land race variety (a local variety) were laid out in a split plot experimental design with three replications. The times of plantings were the main plots while the varieties were the sub plots. The results of the experiment (which was repeated) indicated that, the planting done during the mid dry season had the highest yield net yield 33.4 and25.7 Tons/ha in 2015 and 2016 respectively and fruit brix was 9.5 and 18.% in the same period) compared with other times of planting. Amongst the varieties, Grey bell had the highest yield net yield of 30.3 and 24.3Tons/ha in 2015 and 2016 and fruit brix of 8.7% and 17% in the same period respectively, followed by Crimson sweet with 30 and 22.2 tons/Ha in 2015 and 2016, brix of 7.9% and 16,6% in the same period, while the land race variety had the lowest values 26.9 and 21.2 tons/Ha and brix of 7.0% and 16.5% in the same period. Similarly, the combined analysis conducted also indicated that the mid dry season planting had higher net yield of 29.3 tons/Ha and fruit brix or flavor (13.3%) compared to other times of planting while amongst the varieties although there was no significant difference at P≤ 0.05. With regards to the net yield, Grey bell had the highest flavor or brix of 12.9% compared to other varieties. It was thus concluded that while the Sudan savanna mid dry season is best suitable for watermelon cultivation especially Grey bell which had superior flavor (brix) compared to other watermelon varieties tested.

Keywords: Watermelon varieties, Time of planting, land race, fruit yield and brix**,** Sudan savannah

Introduction

In Nigeria, commercial production of watermelon is both during the rainy and dry seasons. Seasonally damp or flooded "fadama" and river valleys of the Sudan and Sahel savannah

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are used in dry season (Anikwe *et al*., 2015). Although there are no official production data for the country, the states of Borno, Yobe, Bauchi, Kano, Gombe, Jigawa and Kaduna are the leading areas of watermelon production in Nigeria (Majia, 1999).
The growth, yield and fruit quality (taste) of watermelon depends on adequate climatic factors such as precipitation, relative humidity, solar radiation, evaporation which occur in sequential or different stages (Aguyoh *et. al*., 2010) These stages include the plants emergence stage, vegetative stage, flowering stage, fruit formation stage and its ripening stage (Ajisefinnani, 2004).

At each of watermelon growth stages, it is observed to increase in height and the leaves are also seen to be larger as they increase in area while the roots go deeper into the soil to absorb nourishment and water for growth and support (Schippers, 2000). Ban *et. al*. (2006) and Enujeke (2013) attributed the differences between the growth, yield and quality characters of crop varieties to photosynthetic activities of leaves, differences in distribution of leaf surface and crop canopy, leaf arrangement, differences in chlorophyll content and activity of photosynthetic enzymes. The differences in growth, yield and their components among watermelon cultivars were influenced by the variations in the seasonal conditions, their genetic structure and potentiality of the crop plants to transport synthesized materials within them (Sabo *et al*., 2013). Temperature is a major determinant of the rate of plant development and, under climate change; warmer temperatures that shorten development stages of determinate crops will most probably reduce the yield of a given variety. High temperature stress for instance, has a wide range of effects on plants in terms of physiology, biochemistry and gene regulation pathways (IITA, 2013).Muhammad *et al.* (2013) further examined the correlation between temperatures and watermelon fruits during the latter half of the fruit developmental period and sugar accumulation. Varietal differences determine the growth and yield of crops (Wehner *et al*., 2001). The growth characters of watermelon such as plant height, vine length, leaf area, number of leaves or branches, and fruit production were influenced by genetic factors of the different varieties (Goreta *et al*., 2005). Wehner and Guner (2004) attributed differences between the growth characters of crop genotypes to photosynthetic activity of leaves i.e. internal factors and/or to the differences in high distribution on leaf surface of the crop canopy, leaf arrangement, differences in chlorophyll content, activity of photosynthetic enzymes and differences in stomatal conductance values. Therefore, this study aimed at relating the yield and brix (flavor) of five watermelon varieties to the effects of times of planting and varietal differences and determine watermelon variety with highest yield and brix (flavor) in the Sudan savanna ecological zone.

Materials and Method

Experimental Site

The experiment was carried out by sowing the watermelon varieties in six planting times (dates) between 2015 and 2016 at Bunkure LGA in Kano state in the Sudan savanna ecological zone of Nigeria $11^{o}40^{1}$N and $008^{o}30^{I}$ E and 884m above sea level. The area has an annual rainfall of 1000 – 1500mm. The rainy season starts from May and ends in October and the dry season is between November and April. The soil's textural class is sandy loam.

Selection and Determination of Treatments

Four watermelon varieties (Crimson sweet – V6390-w, Sugar baby - LN 3163, Congo - W-507 and Grey bell – LN3154) and an unimproved variety were selected, combined and grown within six sowing or planting times/dates which started from June, 2015 and ended in April, 2016 as follows: 15thJune, 2015 (Early rainy season), 15thAugust, 2015 (Mid rainy season),

15thOctober, 2015 (Late rainy season); 15thDecember, 2015 (Early dry season); 15thFebruary, 2016(Mid dry season) and 15th April, 2016 (Late dry season). Four of the selected watermelon varieties were improved and sourced (bought) from the Kano state Horticultural Institute (about 500g/variety) while the unimproved variety (about 1kg) was collected free of charge from the local watermelon farmers in the study area.

Experimental Design, Plots Layout and Allocation of Treatments

A split plot design was used for the experiment with the time of planting as the main factor (factor A) with six treatments (Early rainy season, mid rainy season, late rainy season, early dry season, mid dry season and late dry season) assigned randomly to the main plots. The second factor (factor B) was the watermelon variety consisting of five treatments (Crimson sweet, Sugar baby, Congo, Grey bell and the unimproved variety) which were also randomly assigned (planted) in the subplots.

The site, about 1.5ha was divided into six equal large blocks of 2500m^2. Each block was further subdivided into 15 subplots of 10x 5m each. A 1m walkway was constructed between the subplots to facilitate easy movements for operations. The 15 subplots were assigned randomly to the five watermelon varieties (Crimson sweet, Sugar baby, Congo, Grey bell and the unimproved variety) which were also replicated three times (3x). There were 15 subplots constructed for each time of planting, thus amounting to 90 subplots for the plantings altogether.

Weather Record

The weather record obtained from the meteorological unit of the IITA Kano office covering the study area indicated that, the early dry season plantings (June- December, 2015) total rainfall of 122.1mm, 201.1mm and 50.1mm was received (June to October); minimum and maximum temperatures of 23.1^{o}c and 33.9^{o}c; 27.3^{o}C and 34.5^{o}C and 22.6^{o}Cand 36.1^{o}C and higher total sunlight or radiant energy of 59.4; 59.5 and 59.7 MJ/m^2/day were received, respectively. In 2016 (January to April), minimum and maximum temperatures were 23.5^{o}C and 35.9^{o}C; 27.9^{o}C and 35.5^{o}C and 22.5^{o}C and 36.5^{o}C and higher total sunlight or radiant energy of 59.7; 59.7 and 59.7 MJ/m^2/day was received, respectively (IITA, 2013)

Yield and Yield components

Number of watermelon flowers (male and female) formed at 75% flowering was determined by counting the number of the flowers (male and female) on each of the five randomly sampled plant in each plot at two weeks intervals from 8 weeks after sowing (WAS). The total numbers of flowers (male and female) was determined and mean values recorded. The yield of watermelon fruits picked was obtained from the net plot which was 4 x 3m or 12m^2 in each plot. After each harvest (3 pickings), fruits harvested were weighed and converted to yield per hectare. Grading of fruits which separates the watermelon fruits into large (7Kg and above), medium (4 - 6Kg) and small fruits (1 – 3Kg) from each plot was carried out in the field after weighing using the 'Jenway Top Loading balance' scale and means from each plot was recorded as proposed by Robbinson (1997)

Brix (flavor)

Brix (flavor or taste) from fruit flesh was measured by a manual digital refractometer (Hannah HI96801) (Arslan, 2010)

Data Collection and Analysis

Data for all measurements were subjected to analyses of variance and the differences between the means were compared by LSD test ($p<0.05$) using Genstat 17th Edition, 2007 according to Obi (2000).

Results

Effect of time of planting and Variety on the Yield Components of Watermelon

The combined analysis of the data obtained on the number of watermelon flowers between 2015 and 2016 shown in table 1.0 indicated that the although the number of male flowers produced across the times of planting were not significantly different, the mid dry season planting hat the highest number of male flowers (52.5), followed by mid rainy, and late dry season plantings 51.9 and 51.8 respectively while early dry season 46.4 had the lowest number of male flowers. The mid dry season also had the highest number of female flowers 8.4/stand while early rainy season had the lowest number of female flowers 4.6/stand. Amongst the varieties, Grey bell had higher number of female flowers 7.8 compared to the rest of the varieties which were similar. Table 2.0 also presented the analysis of the data obtained between 2015 and 2016 on the yield of watermelon. The combined analysis indicated that, the mid dry season and mid rainy season had the highest yield of 29.3 and 28.0 tons/Ha respectively while late dry season had the lowest yield of 19.3. Amongst the varieties, Grey bell had the highest yield 27.3 tons/Ha while Crimson sweet had the lowest yield 26.1. Table 3.0 showed the analysis of data on fruit sizes between 2015 and 2016. According to the combined analysis, there was no significant difference between the times of planting on the yield (tons/Ha) of Large and medium fruits produced but, mid rainy season and early dry season produced the highest yield of small fruits (13.2 and 14.4 tons/Ha respectively) while mid dry season had the lowest yield of small fruits 8.2tons/Ha.

Effect of Time of planting and Variety on the brix (flavor or taste) of watermelon fruits

The combined data on fruit brix or flavor (taste) of watermelon obtained between 2015 and 2016 was analysed and it showed that the mid dry season watermelon had the highest fruit taste (brix) of 13.3% while the mid rainy season watermelon produced fruits with the lowest taste 11.0%. Amongst the varieties, Grey bell had the highest taste or flavor of 12.9% while the land race (local variety) had the lowest taste or brix of 11.5%

Discussion

Weather Data for Bunkure between 2015 and 2016.

The summary of the weather data recorded in 2015 and 2016 indicated that June to October period had an average rainfall of 124.4mm; minimum and maximum temperatures of 28.1^{o}C and 31.1^{o}C and higher total sunlight or radiant energy of 59.5 MJ/m^2/day were received, respectively while in 2016 (January to April), minimum and maximum temperatures 29.1^{o}C and 22.5^{o}C and 32.2^{o}C and higher total sunlight or radiant energy of 59.7 MJ/m^2/day was received, respectively. As a vegetable the watermelon requires moderate rainfall, moderate to high temperatures and ample sunshine which translates in high growth, yield and better fruit quality. Although conditions throughout the selected planting periods favor watermelon cultivation, variability in the frequency, intensity and distribution of the conditions greatly affect their growth rates and thus yield and fruits quality as opined by Muhammad *et. al*. (2013).

Number of watermelon flowers

From the combined data analysis in table 1.0, the times of planting recorded no significant differences on the number of male flowers but there was significant difference in the number of flowers where the mid dry season recorded the highest number of female flowers followed by mid rainy, early dry and late dry season plantings while early rainy season recorded the lowest number of female flowers. Amongst the varieties, Grey bell recorded the highest number of male and female flowers compared to other varieties. Flower sets and drops are usually influenced by factors such as, sunshine, wind speed, Relative humidity and temperature. The conditions of the mid dry season (February) and differences in the genetic composition of the varieties might also have been optimum and thus responsible for the high number of flowers recorded as reported by Ajisefinanni (2004).

Yield (tons/ha) and Flavor (brix) of watermelon fruits

The combined data analysis in Table 2.0 shows the effect of time of planting and variety on the yield and flavor (brix) of watermelon. The mid dry season and mid rainy season had the highest net yield (kg/Ha) followed by late rainy season planting while the late dry season planting recorded the lowest net yield. Amongst the varieties, no significant difference in the yield was recorded. For the fruit brix (flavor), the mid dry season recorded the highest flavor (brix) followed by the late rainy and late dry season plantings while the mid rainy season recorded the lowest brix. Amongst the varieties, Grey bell recorded the higher brix followed by Crimson sweet, Sugar baby and Congo while the local land race recorded the lowest fruit flavor (brix).The high yield obtained during mid rainy and mid dry plantings was probably because of high growths and flowers settings in the plants as a result of available soil moisture content, ambient temperature, relative humidity and in addition to the compatibility of the genetic compositions of the varieties with the conditions prevalent in the times of planting as concurred by Goreta *et. al.* (2005).

Watermelon Fruit Sizes

The combined analysis in table 3.0 shows no significant differences between the times of planting and varieties with regards to the large (7kg and above) and medium sized (4-6kg) fruits harvested. However, the mid rainy season and early dry season plantings recorded highest number of small fruits followed by the early rainy season while the mid dry season planting recorded the lowest number of small fruits. Amongst the varieties, no significant difference was observed. Like flowers, fruit sets and sizes are also influenced by factors such as moisture, sunshine temperature genetic compositions which if optimally available and compatible photosynthetic activities will increase resulting into larger fruits as supported by Enujeke (2013).

Table 1.0: Effect of time of planting and variety on the Number of Watermelon Flowers at 50% flowering

Values within columns followed by the same letter are not significantly different at P≤ 0.05 According to LSD.
KEY: TP = Time of planting, VAR = Variety, LSD = Least significant Difference, Flw = Flower

Mean Number of Watermelon Flowers at 50% Flowering at Bunkure between 2015 and 2016						
Treatment	2015		2016		Combined	
Time of planting	Male flw	Female flw	Male flw	Female flw	Male flw	Female flw
Earlyrainy season	41.3	4.7^{d}	52.4^{ab}	4.5^{e}	46.9	4.6^{c}
Mid rainy season	50.2	7.7^{b}	52.5^{ab}	7.8^{b}	51.9	6.6^{b}
Late rainy season	50.7	6.0^{c}	50.4^{bc}	7.3^{bc}	51.1	6.6^{b}
Early dry season	48.6	5.7^{c}	44.2^{c}	6.8^{c}	46.4	6.3^{b}
Mid dry season	52.5	8.8^{a}	58.7^{a}	8.5^{a}	52.5	8.4^{a}
Late dry season	44.9	7.8^{b}	52.2^{ab}	5.6^{d}	51.8	6.7^{b}
LSD (P≤ 0.05)	11.9	0.8	7.3	0.6	6.59	0.51
Variety						
Crimson sweet	49.1	6.7^{bc}	49.3^{bc}	6.8^{b}	49.2^{b}	6.7^{b}
Sugar baby	46.8	7.0^{b}	52.4^{b}	6.4^{bc}	49.6^{b}	6.7^{b}
Grey bell	60.3	8.0^{a}	61.3^{a}	7.7^{a}	60.8^{a}	7.8^{a}
Congo	44.8	6.2^{c}	47.0^{bc}	6.4^{c}	45.9^{b}	6.3^{bc}
Land race	49.1	6.5^{bc}	45.4^{c}	5.9^{c}	47.2^{b}	6.5^{b}
LSD (P≤ 0.05)	10.8	0.8	6.7	0.5	6.02	0.5

Table 2.0: Effect of time of planting and variety on the Yield (tons/ha) and Brix (Flavor) of watermelon fruits

Values within columns followed by the same letter are not significantly different at P≤ 0.05 According to LSD.

Mean watermelon yield (tons/Ha) and Brix (flavor) at Bunkure between 2015 and 2016						
Treatment	2015		2016		Combined	
Time of planting	Yield	Brix	Yield	Brix	Yield	Brix
Earlyrainy season	25.6^{bc}	7.4^{cd}	18.2^{c}	14.9^{d}	20.0^{c}	11.5^{d}
Mid rainy season	30.8^{ab}	7.1^{d}	20.3^{b}	15.5^{c}	28.0^{a}	11.0^{e}
Late rainy season	24.9^{d}	8.0^{b}	19.9^{b}	16.9^{b}	25.2^{b}	12.7^{b}
Early dry season	27.6^{abc}	7.8^{bc}	20.1^{b}	17.1^{b}	20.3^{c}	12.3^{c}
Mid dry season	33.4^{a}	9.5^{a}	25.7^{a}	18.1^{a}	29.3^{a}	13.3^{a}
Late dry season	24.4^{c}	7.6^{bc}	20.7^{b}	17.4^{b}	19.3^{d}	12.8^{b}
LSD (P≤ 0.05)	6.1	0.4	4.8	0.6	3.9	0.4
Variety						
Crimson sweet	30.0	7.9^{b}	22.2	16.6	26.1	12.2^{b}
Sugar baby	28.8	7.7^{b}	21.6	16.5	25.2	12.1^{b}
Grey bell	30.3	8.7^{a}	24.3	17.0	27.3	12.9^{a}
Congo	28.7	7.6^{b}	18.9	16.5	22.9	12.1^{b}
Land race	26.9	7.0^{c}	21.2	16.5	22.9	11.5^{c}
LSD (P≤ 0.05)	5.6	0.4	4.4	0.6	3.6	0.3

KEY: TP = Time of planting, VAR = Variety, LSD = Least significant Difference, Flw = Flower

Table 3.0: Effect of time of planting and variety on the Size of watermelon fruits

Mean Watermelon Fruit sizes at Bunkure between 2015 and 2016									
Treatment	2015			2016			Combined		
Time of planting	LGF	MDF	SMF	LGF	MDF	SMF	LGF	MDF	SMF
Early rainy season	6.5	10.9[a]	13.6[abc]	4.1	6.9	7.2[c]	5.6	7.4	11.4[b]
Mid rainy season	7.2	8.4 [b]	14.1[b]	5.8	7.3	10.3[ab]	5.5	8.2	13.2[a]
Late rainy season	6.1	8.4 [b]	18.4 [a]	5.1	6.4	5.2 [c]	5.6	7.8	10.7[bc]
Early dry season	6.3	10.5[ab]	9.6[c]	6.0	7.2	12.4 [a]	6.0	8.8	14.4[a]
Mid dry season	7.4	11.0 [a]	11.2[c]	5.5	7.9	11.7 [a]	6.2	9.3	8.2[c]
Late dry season	5.2	8.5 [b]	12.5[b]	5.0	7.7	8.0[bc]	6.1	8.9	10.3[bc]
LSD (P≤ 0.05)	1.76	2.31	4.03	1.43	1.74	2.86	1.12	1.43	2.50
Variety									
Crimson sweet	6.6	9.2	13.9	5.2	7.8	9.2	6.0	8.5	11.6
Sugar baby	6.0	9.3	12.9	5.9	7.5	8.2	6.2	8.4	10.6
Grey bell	6.8	10.0	13.7	6.1	7.4	10.8	6.3	8.7	12.3
Congo	6.6	9.7	11.0	4.2	6.7	7.9	5.1	8.2	9.5
Land race	6.1	9.8	12.8	4.8	6.8	9.6	5.4	8.3	11.2
LSD (P≤ 0.05)	1.61	2.11	3.68	1.30	1.59	2.61	1.03	1.31	2.28

Values within columns followed by the same letter are not significantly different at P≤ 0.05 According to LSD. KEY: TP = Time of planting, VAR = Variety, LSD = Least significant Difference, LGF = Large Fruit, MDF – Medium Fruit, SMF – Small

Conclusion

The analysis conducted showed that, mid dry season provides the best growing conditions for most watermelon varieties where higher yield and greater taste (flavor) could be obtained compared to other times of planting tested. Also amongst the varieties Grey bell had the highest net yield and flavor (brix) followed by Crimson sweet, Sugar baby and Congo while the unimproved variety (land race) had the lowest values. The watermelon farmers especially those in the Sudan Savanna of Nigeria should be conscious of the many varieties of watermelon in cultivation and to be selective of a variety that will adequately adapt to the natural growing conditions (mid dry season) in their ecological zone with view to cultivating a variety that can out compete other varieties grown elsewhere in terms of yield and taste (flavor or brix) and inevitably higher profits.

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