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Adaptability study of banana (*Musa paradisiacal var. sapiertum*) varieties at Jinka, southern Ethiopia

Tekle Yoseph[1, *], Wondewosen Shiferaw[1], Zemach Sorsa[2], Tibebu Simon[2], Abraham Shumbullo[2], Woineshet Solomon[3]

[1]Southern Agricultural Research Institute, Jinka Agricultural Research Center, Department of Crop Science Research Process, Jinka, Ethiopia
[2]Department of Plant Sciences and Horticulture, Wolaita Sodo University, Wolaita Sodo, Ethiopia
[3]Southern Agricultural Research Institute, Hawassa Agricultural Research Center, Department of Crop Science Research Process, Hawassa, Ethiopia

Email address:
tganta@yahoo.com (T. Yoseph)

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Abstract: A field experiment involving eleven improved banana (Musa paradisiacal var. sapiertum) varieties and one local check was carried out at Jinka Agricultural Research Center during the 2006 to 2009 cropping seasons under rain fed conditions to identify the best performing variety to the target areas of South Omo Zone. The banana varieties included in the field experiment were eleven improved (Kampala, Pisang, Lacatan, Poyo, Dwarf Cavendish, Giant Cavendish, Butuzua, Grand Naine, Robusta, Williams-1, Williams-2) and a local check. The experimental design was a randomized complete block design (RCBD) with three replications. Phenological and growth parameters, bunch yield and yield components were studied. The result showed that days to flowering were significantly affected by variety while days to maturity were not significantly influenced by variety. Psedostem height was significantly affected by variety; whereas, variety had brought no significant effect on psedostem circumference. All the yield and yield components studied were significantly affected by variety except finger diameter. Bunch yield advantages of 59.11%, 55.87% and 47.55%, were obtained from the improved banana varieties Dwarf Cavandish, Giant Cavandish and Poyo, respectively over the local check. The highest bunch yields of (45.333 t ha^{-1}) and (42.000 t ha^{-1}) were recorded for the varieties Dwarf Cavendish and Giant Cavendish, respectively. Therefore, it can be concluded that use of the improved banana varieties such as Dwarf Cavendish or Giant Cavendish is advisable and could be appropriate for banana production in the test area even though further testing is required to put the recommendation on a strong basis.

Keywords: Banana Variety, Bunch Yield, Growth Parameters, Phenological Parameters, Yield Components

1. Introduction

Banana (*Musa paradisiacal var. sapiertum*) is one of the most important tropical fruits and evolved in the humid tropical regions of South East Asia with India as one of its centers of origin. Banana represents the world's second largest fruit crop with an annual production of 129,906,098 metric tons [1]. It ranks as the fourth most important global food commodity after rice, wheat and maize in terms of gross value of production [2]. About 70 million people are estimated to depend on banana fruit for a large proportion of their daily carbohydrate intake [3]. Banana is the major staple food in developing countries. The fact that it produces fruit throughout the year adds to its importance as a food security crop in Africa. It is a primary food and cash crop for over 30 million people in East Africa. Banana is now a major food crop in Africa estimated to meet more than a quarter of the food energy requirements in the continent [4]. It is a staple food and good source of income for a number of African countries especially East and Central Africa [5]. Banana is a source of potassium, magnesium, copper, manganese and vitamin C, but is low in iron and vitamin A [6].

Uganda is Africa's largest producer while Rwanda and Burundi are the second and third largest producers in East Africa, respectively [7]. Banana has been cultivated for several years in Ethiopia as a garden plant. In Ethiopia, the

major banana producing regions are Southern, Oromia and Amhara regions [8]. During the 2010/2011 production season about 31, 885.86 hectares of land has been covered with banana and the estimated annual production was about 270571.516 tones [9]. The actual yields are less than 40 t ha^{-1} $year^{-1}$[10]; whereas, the potential yield of banana is greater than 70 t ha^{-1} $year^{-1}$ [11]. The poor productivity of banana has been attributed to a number of biophysical factors [12].

Banana is the most important crop in Ethiopia, but over the years a number of problems tend to faced against the production of this crop in the country. Out of these, lack of improved varieties is the critical problem to banana. It is the most important cash crop in some parts of Southern Ethiopia, especially Gamo Gofa Zone. But, banana production is also familiar in South Omo Zone of Southern Ethiopia. Though, the crop is important in the target area, a number of factors constrained productivity of the crop in the target areas. This is associated with the lack of improved varieties has been appreciated as one of the primary sources of lower banana production in the target areas. There had no trend of using improved of banana varieties in the existing production system, so that it was the number one problem in the study areas. Hence; there is need to introduce improved banana varieties to the target area is crucial for banana production and productivity. Therefore, this study is aimed at and initiated with the objective of selecting the best performing banana varieties to the target area.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at research farm of Jinka Agricultural Research Center located 729 kms South West of the capital Addis Ababa at E 36^0 33' 02.7" Longitude and N 05^0 46' 52.0" Latitude and at an altitude of 1383 meters above sea level. The long term weather data for the center revealed that the maximum and minimum monthly average temperature of the center is 27.55^0C and 16.55^0C, respectively; whereas, the maximum and minimum monthly average temperature of the growing periods was 27.576^0C and 16.622^0C, respectively. The long term rainfall data for the area showed that the mean annual rainfall of the area is 1274.67 mm; while the mean monthly rainfall of the area for the growing seasons was 121.7188 mm. Rainfall pattern of the area over the years have been bi-modal with peaks around September and October and spans from February to November. The experiment was conducted during the 2006 to 2009 cropping seasons under rain fed conditions.

Table 1. *The Weather Data for Jinka, During the Years 2006 to 2009.*

Month	MaximumTemp. (°c)	Minimum Temp. (°c)	Rainfall (mm)
January	31.22	15.71	56.65
February	30.71	17.22	67.05
March	28.35	17.25	115.28
April	26.51	17.23	190.98
May	26.43	17.61	150.85
June	26.66	16.66	172.70
July	26.23	16.55	59.00
August	25.92	16.76	105.23
September	27.18	17.38	130.35
October	26.66	17.24	188.73
November	25.71	16.17	128.63
December	25.32	16.09	95.20

2.2. Treatments and Experimental Design

The experiment was executed by using eleven improved banana varieties and one local check. The field experiment was laid out in a randomized complete block design (RCBD) with three replications. Four banana plants were used in a single plot basis by using square planting method to make a unit plot area in spacing of 2.5 m between rows and 2.5 m between plants within a row making a gross plot area of 25 m^2.

2.3. Data Collection

2.3.1. Phenological Parameters and Growth Parameters

Phenological parameters such as days to flowering and days to maturity were recorded. Days to flowering was recorded by counting the number of days after establishment when 50% of the plants per plot had the first open flower. Days to maturity were recorded when 90% of flowers per plot was matured. At mid flowering stages crop growth parameters such as psedostem height and Psedostem Circumference were measured.

2.3.2. Bunch Yield and Yield Components

The matured bunch was harvested for determination of bunch yield. Number of hands per bunch, number of fingers per hand, bunch weight, finger weight per hand and finger diameter was measured. All the phenological, growth, yield and yield components were recorded at every harvest of the growing period. All the data recorded throughout the growing periods were averaged over every harvest in the growing seasons for data analysis and computation. The weight of a bunch is determined by the total number of hands per bunch and fingers produced per hand, therefore, the weight of bunch is a function of the total number of hands and fingers obtained from the entire bunch.

2.4. Statistical Analysis

Analysis of variance was performed using the GLM procedure of SAS Statistical Software Version 9.1 [13]. Effects were considered significant in all statistical calculations if the P-values were $\leq$ 0.05. Means were separated using Fisher's Least Significant Difference (LSD) test.

3. Results and Discussion

The analysis of variance results for mean squares revealed that days to flowering and days to maturity were significantly (P< 0.01) influenced by varieties (Table 2). The analysis of variance result for mean squares also depicted that psedostem height was significantly (P< 0.001) affected by varieties while; psedostem circumference was not significantly affected by varieties (Table 2).

Table 2. *Mean Square Values for Crop Phenology and Growth Parameters of Banana at Jinka, in 2006 to 2009.*

Source	DF	Days to Flowering	Days to Maturity	Psedostem Height (m)	Psedostem Circumference (cm)
Replication (R)	2	420.1512ns	2975.076ns	0.3673ns	. 1.98ns
Variety (VAR.)	11	2141.315**	15461.48**	1.0103***	5.98ns
Error	22	548.15767	4303.0304	0.1537	9.62

*, ** and *** indicate significance at P< 0.05, P< 0.01 and P< 0.001, respectively and 'ns' indicate non significant

Table 3. *Crop Phenology and Growth Parameters of Banana as Affected By Variety at Jinka, in 2006 to 2009.*

Treatments	Days toFlowering	Days to Maturity	Psedostem Height (m)	Psedostem Circumference (cm)
Variety(Var.) Kampala	221.06ab	451.25bc	1.9533bc	44.00bcd
Pisang	202.22ab	380.19bcd	1.3233cde	40.333cd
Lacatan	212.86ab	451.48bc	1.9567bc	41.667cd
Poyo	187.89b	353.56cd	2.1433b	45.000bc
Dwarf Cavendish	227.97ab	311.67d	1.0333e	44.000bcd
Giant Cavendish	234.84a	483.00ab	1.9000bcd	50.667a
Butuzua	187.96b	399.67bcd	1.8000bcd	41.333cd
Grand Nain	206.89ab	415.93bcd	1.6567bcde	49.667ab
Robusta	225.37ab	357.04bcd	1.6933bcde	37.000d
Williams-1	212.96ab	419.78bcd	1.1833de	40.667cd
Williams-2	134.63c	363.81bcd	1.1933de	41.667cd
Local Check	214.81ab	580.93a	3.2000a	37.667cd
LSD 0.05	39.645	111.08	0.66	4.46
CV (%)	11.37	15.84	22.36	6.15

Note: Means with the same letters within the columns are not significantly different at P < 0.05.

The result of analysis of variance for mean squares depicted that bunch weight was significantly (P< 0.001) affected by varieties, finger weight was significantly affected (P< 0.01) by varieties (Table 4). This finding has confirmed the previous report [14]. According to the result of analysis of variance for mean squares; number of hands per bunch was significantly (P< 0.05) affected by varieties, number of fingers per hand was significantly (P< 0.001) influenced by varieties whereas; varieties had not brought a significant effect on finger diameter (Table 4). The maximum number of hands per bunch of (7.3333) was recorded for the improved banana variety Pisang and the minimum number of hands per bunch of (4.3333) was recorded for the local check (Table 5). The maximum number of fingers per hand of (80.000), (79.000) and (77.333) were recorded for the improved banana varieties Dwarf Cavendish, Giant Cavendish and Poyo, respectively and the minimum number of fingers per hand of (27.000) was noted for the local check (Table 5). The highest finger weights of (10.000 kg hand^{-1}), (9.667 kg hand^{-1}) and (9.000 kg hand^{-1}) were noted from the improved banana varieties Dwarf Cavendish, Robusta and Giant Cavendish, respectively and the least finger weight of (3.167 kg hand^{-1}) was recorded from the local check (Table 5). The maximum bunch yields of (45.333 t ha^{-1}), (42.000 t ha^{-1}) and (35.333 t ha^{-1}) were recorded from the improved banana varieties Dwarf Cavendish, Giant Cavendish and Poyo, respectively and the minimum bunch yield of (18.533 t ha^{-1}) was noted from the local check (Table 5). The bunch yield advantages of 59.11%, 55.87% and 47.55% were obtained from the improved banana varieties Dwarf Cavendish, Giant Cavendish and Poyo, respectively over the local check in this study. The bunch yield advantage obtained from the improved banana varieties is related with the increased number yield attributing parameters such as number of fingers per hand in improved banana varieties than the local check.

According to the above findings, the improved banana varieties had resulted in greater bunch yield than the local

check. This finding has confirmed the previous reports that indicate the potential of improved banana varieties over the local check [14, 15, and 16]. From the above findings it could be suggested that use of the improved banana varieties had brought a proportional yield increment than the local check.

Table 4. *Mean Square Values for Yield and Yield Components in Banana at Jinka, in 2006 to 2009.*

Source	DF	Bunch Yield (t ha^{-1})	Finger Weight (kg hand^{-1})	Number of Hands (bunch^{-1})	Number of Fingers (hand^{-1})	Finger Diameter (cm)
Replication (R)	2	29.204ns	3.0044^{ns}	3.527ns	271.194ns	0.3027^{ns}
Variety (Var.)	11	229.792***	13.109**	2.656*	647.868***	0.1563ns
Error a	22	33.907	3.387	1.1324	111.861	0.1008

*, ** and *** indicate significance at P< 0.05, P< 0.01 and P< 0.001, respectively and 'ns' indicate non significant

Table 5. *Yield and Yield Components of Banana as Affected By Variety at Jinka, in 2006 to 2009.*

Treatments	Bunch Yield (t ha^{-1})	Finger Weight (kg hand^{-1})	Number of Hands (bunch^{-1})	Number of Fingers (hand^{-1})	Finger Diameter (cm)
Variety (Var.)					
Kampala	24.000defg	3.667cd	5.3333abc	64.333ab	3.8067a
Pisang	34.000bcd	7.167ab	7.3333a	60.000b	3.0833a
Lacatan	33.333bcde	6.333bcd	6.6667ab	53.000b	3.0900a
Poyo	35.333abc	6.667abc	4.6667bc	77.333a	3.5067a
Dwarf Cavendish	45.333a	10.000a	6.6667ab	80.000a	3.4967a
Giant Cavendish	42.000ab	9.000ab	5.3333abc	79.000a	3.5467a
Butuzua	22.667efg	7.167ab	6.6667ab	46.000b	3.2700a
Grand Nain	33.333bcde	7.633ab	6.0000abc	58.667b	3.5700a
Robusta	30.667cdef	9.667ab	5.6667abc	49.667b	3.4267a
Williams-1	21.333fg	8.167ab	5.0000bc	45.333b	3.0967a
Williams-2	20.000fg	7.000abc	5.0000bc	49.000b	3.3100a
Local Check	18.533g	3.167d	4.3333c	27.000c	3.2133a
LSD 0.05	9.86	3.12	1.80	17.91	NS
CV%	19.38	25.79	18.60	18.90	9.42

Note: Means with the same letters within the columns are not significantly different at P <0.05.

The result of the Pearson correlation coefficient depicted that, among yield and yield components and some growth and phenological traits in this study, number of hands per bunch (r = 0.24807), finger weight (r = 0.23027), finger diameter(r= 0.09211), psedostem height (r = 0.16236), psedostem circumference (r = 0.30515), days to flowering (r=0.20209) and days to maturity (r = 0.18577) were positively correlated with bunch weight (Table 6). Bunch weight was also correlated significantly positively (r = 0.577***) with the number of fingers per hand (Table 6). This result is in agreement with the previous report [14]. The number of hands per bunch was negatively correlated with finger weight, finger diameter, psedostem height, psedostem circumference and days to maturity; whereas, it was associated positively with the number of fingers per hand and days to flowering (Table 6). The number of fingers per hand was positively correlated with psedostem height and days to flowering; while, it was correlated negatively with psedostem circumference and days to maturity (Table 6). The number of fingers per hand was positively (r = 0.29422) associated with finger weight (Table 6). On the other hand, the total number of fingers per hand was correlated negatively with fruit weight [14]. Finger weight was positively correlated with finger diameter, psedostem height, days to flowering and days to maturity but it was associated negatively with psedostem circumference (Table 6). Finger diameter was positively correlated with psedostem height, psedostem circumference, days to flowering and days to maturity (Table 6). Psedostem height was positively correlated with psedostem circumference but it was correlated negatively with days to flowering (Table 6). On the other hand, psedostem height was correlated significantly positively (r = 0.518**) with days to maturity (Table 6). Psedostem circumference was positively associated with days to flowering and days to maturity (Table 6). Days to flowering was positively correlated with days to maturity (Table 6). This result has confirmed the previous findings being reported [14].

It is observed from this result that the major variables contributing to the bunch yield were biologically related and the contributions of such correlated and related variables influence positively the performance of the other, hence, the variables that showed negative association will inhibited the performance of the other and this largely depends on their attributes to the performance of the particular traits measured. From this study, it was possible to observe that for example, the variable bunch weight was positively correlated with all the entire traits in this experiment. This study has confirmed that total number of hands per bunch, number of fingers per hand, finger weight and finger diameter are the major

contributing factors to bunch yield.

Table 6. *Pearson Correlation Coefficient for Nine Traits of the Improved Banana Varieties at Jinka, in 2006 to 2009.*

Traits	BWT	NHD	NFG	FWT	FDM	PSHT	PSCM	DTF	DTM
BWT	1	0.24807	0.577***	0.23027	0.09211	0.16236	0.30515	0.20209	0.18577
		0.1446	0.0002	0.1767	0.5931	0.3441	0.0703	0.2372	0.278
NHD		1	0.15969	-0.26726	-0.03607	-0.01087	-0.05164	0.12068	-0.1821
			0.3522	0.1151	0.8346	0.9498	0.7649	0.4832	0.2878
NFG			1	0.29422	0.25639	0.14796	-0.06632	0.02189	-0.10999
				0.0815	0.1312	0.3891	0.7007	0.8992	0.5231
FWT				1	0.008	0.07282	-0.22296	0.03026	0.20097
					0.9631	0.673	0.1912	0.8609	0.2399
FDM					1	0.12902	0.04579	0.05074	0.00836
						0.4533	0.7909	0.7688	0.9614
PSHT						1	-0.11816	0.02899	0.518**
							0.4925	0.8667	0.0012
PSCM							1	0.22928	0.00152
								0.1786	0.993
DTF								1	0.12739
									0.4591
DTM									1

DTF = days to flowering, DTM = days to maturity, PSCM = psedostem circumference, PSHT= psedostem height, FDM = finger diameter, FWT = finger weight, NFGS = number of fingers per hand, NHD = number of hands per bunch, BWT = bunch weight

4. Summary and Conclusion

Using improved varieties of banana could make an important contribution to increase agricultural production and productivity in areas like Jinka where there is low practice of using improved technologies such as improved crop varieties. To this end, use of improved banana technologies such as improved varieties could be one of the alternatives to improve productivity by small farmers. However, the use of improved banana varieties is not yet studied in the area. Thus, this research work is initiated to investigate the impact of including improved banana varieties on the existing production system is of paramount important.

Study on banana variety was conducted at Jinka under rain fed conditions in 2006 to 2009. The objective of the study was to determine the best performing banana varieties that will improve banana production and productivity in the target area. The experiment was carried out using the randomized complete block design (RCBD) with three replications at Jinka in 2006 to 2009. During the field implementation, eleven improved banana varieties and one local check were used. According to the results of analysis of variance, all the phenological and growth parameters were significantly affected by varieties except psedostem circumference. Days to flowering and days to maturity are also phenological determinants of yield including psedostem height at flowering which is almost the time for plant to use all the growth traits to produce their food especially during photosynthesis.

All the yield and yield components studied in this experiment such as bunch yield, number of hands per bunch, number of fingers per hand and finger weight were significantly affected by varieties; whereas, variety had not brought a significant effect on finger diameter. The highest bunch yields of (45.333 t ha^{-1}) and (42.000 t ha^{-1}) were recorded for the banana varieties Dwarf Cavendish and Giant Cavendish, respectively. Therefore, it can be concluded that use of the improved banana varieties such as Dwarf Cavendish or Giant Cavendish is advisable and could be appropriate for banana production in the test area even though further testing is required to put the recommendation on a strong basis.

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