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FIELD EVALUATION OF IRRADIATED WILLIAMS BANANA CULTIVAR UNDER THE ARID CONDITIONS OF THE SUDAN

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Abstract: The experiments were conducted to compare the agronomic performance of five irradiated clones (W-31, W-206, W-203, W-149 and W-193/3,) with standard Williams and Dwarf Cavendish cultivars under the arid conditions of the Sudan. The plants were planted at 2.5×2.5 m in a 10×10 m plots with four replications in a randomized complete block design. All suckers were removed at the early stages except two suckers left with the mother plant. Vegetative growth parameters and growth cycle duration were measured. The irradiated Williams clones and original Williams cultivars were significantly higher in pseudostem height, whereas Dwarf Cavendish was the shortest and clone W-193/3 was the highest. Similar results were obtained with Clone W-193/3, in pseudostem girth and number of intact functional leaves at shooting, irradiated banana clones showed vigorous growth than Williams and Dwarf Cavendish cultivar. Banana clone W-193/3 characterized vigor in growth and shorter crop cycle in the three crop cycles.
Keywords: banana, field evaluation, clone, irradiation.

Introduction

Bananas represent the world's second largest fruit crop with an annual production of 129,906,098 metric tons (FAOSTAT, 2010). They rank as the fourth most important global food commodity after rice, wheat and maize in terms of gross value of production (INIBAP, 1992).

The most important purpose of banana breeding is to develop genetically diverse cultivars for long term protection against epidemic diseases. Among the Cavendish groups there has been a trend towards selecting dwarf types designed for more yield due to less wind damage and shorter ratooning cycles. However, there were difficulties of improving banana through conventional methods, because of their triploidy nature, sterility and seedlessness. Alternative approaches such as induction of mutation were therefore have been pursued.

Mutation breeding enhances the possibility of altering genes by exposing plants parts containing shoot meristems to chemical or physical mutagens. The main advantage of mutation induction in vegetatively propagated crop is to gain one or more desirable characters which are not attainable by conventional method (Novak and Micke 1988).

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Banana export trade is largely based on farmer's selections of the somatic mutants of the 'Cavendish subgroup' which have a narrow genetic base (Ortiz and Vuylsteke, 1996). The natural rate of somatic mutation is very low with bananas propagated conventionally (Stover and Simmonds, 1987). A program was being conducted jointly by FAO and the International Atomic Energy Agency in Austria where an early- flowering mutant of AAA 'Grand Nain' was produced by irradiation (Novak *et al.,* 1990). Using the *in vitro* techniques, an early flowering mutant clone 'GN60Gy/A' was induced by gamma irradiation from the dessert banana cultivar 'Grand Nain'. An early flowering triploid mutant (Fatom-1) was also reported in Taiwan (Tan *et al.*, 1993).

Bananas have been introduced into Sudan in late 19th century (Bedri, 1994). The cultivar Dwarf Cavendish covers almost 95% of the cultivated area as it is adapted to different climatic conditions, however, it is prone to choke throat disease "the constriction of bunches emerging in winter" and not suitable for export (Samson, 1980). Hence, intense efforts have been exerted in evaluation of new banana cultivars and clones to select the most promising ones for propagation and distribution in order to gain a foothold in international banana markets.

Efforts to improve banana production in Sudan were started in 1994 by introducing new banana germplasm; that consisted of cvs Grand Nain, Williams Hybrid, GN60GY\A, HIA-1 and FHIA-3 (Mohmoud and Elkashif, 2003). Gamma irradiated clones of banana Williams cultivar were also introduced through the International Atomic Energy Agency (IAEA). Mutation-breeding project was established in the Gezira Research Station, ARC, Wad Medani, and then extended to Khartoum. It had been recommended that, research should be focused on the banana cultivar Williams and their mutants to find an alternative for Cavendish banana with a potentiality to produce more than Dwarf Cavendish in Sudan, because the cultivar Williams has proven its value to produce under warm, arid tropics (Swennen, 1996).

Therefore, to meet these requirements, it is imperative to improve banana productivity through intensive research work aiming to evaluate the irradiated clones of the banana cultivars Williams in comparison to Dwarf Cavendish and original Williams cultivars for their growth performance. The objective of this work was to evaluate vegetative growth behavior of irradiated Williams clones under field conditions of the Sudan.

Materials and Methods

Experiments were conducted at Shambat Agricultural Research Station field, ARC (15º 39′N; 32º 39′E). Tissue cultured plantlets of irradiated Williams clones were introduced as by ARC at Wad Medani, from Vienna, Austria. Preliminary evaluation trials based on total yield and the number of harvests was conducted for two years. The selected irradiated clones (W193/3, W149, W203-, W206, and W31) together with original Williams and Dwarf Cavendish cultivars were multiplied *in vitro*. Uniform tissue cultured plantlets were selected and planted at 2.5×2.5 m (between rows and plants) in 10×10 m plots. The experiments were set in a randomized complete block design with four replications and original Williams and Dwarf Cavendish cultivars were used as controls. Data collected were pseudostem height and diameter (girth), number of functional leaves, leaf length and width, days to shooting and days to harvesting. Pseudostem height was measured at a distance of 5 cm from the base to the point of junction of the upper two youngest leaves (the point where the bunch stalk (peduncle) comes out of the pseudostem before it bends to support the bunch) using a tape meter for the three cycles of growth. Pseudostem diameter (girth) was also measured at 5 cm above the level of soil surface, using tape meter. Number of leaves produced was counted and the last counted leaves were marked with a permanent label to facilitate counting. Leaf length and width of the fourth leaf below the inflorescence were measured at shooting time after cutting off the leaves, using a sharp knife. The length was measured from the lamina tip while the width was measured at the widest part of the leaf, using tape meter. Leaf area was calculated as the product of length and width times a factor (0.8) as described by Murry (1960). Contrast analysis was performed using Gen Stat for Windows 9th edition 2006. Mstatc computer program was used for analysis of data. Means separation was done according to Duncan's multiple range test, at 5% level.

Results and Discussion

The contrast analyses that conducted for three groups of banana plant materials i.e. Williams mutants (W-149, W-31, W-193/3, W-203, W-206), conventional Williams cultivar and Dwarf Cavendish cultivar showed significant differences between entries within groups for all evaluated traits (Tables 1 and 2). With respect to vegetative growth, the mutant groups were characterized by significantly taller and thicker stem, more functional leaves and shorter growth cycles compared to conventional Williams and Dwarf Cavendish cultivars (Table 1). Plant height, pseudostem girth and number of intact functional leaves were significantly high

in conventional Williams group compared to Dwarf Cavendish group. Similar results were reported by Irizarry *et al.* (1989). No bunch support was needed for mutant Williams plants which reduces the cost of production and wind damage. Israeli *et al.* (1991) observed height reduction in somaclonal variants from 250 to 290 cm.

Further test of vegetative growth for the five mutants of Williams cultivars indicated significant differences between Williams's clones, original Williams and Dwarf Cavendish cultivars in the plant crop, first ratoon and second ratoon. The results in Table 2 indicate that there were highly significant differences in pseudostem height of banana clones and cultivars over three successive crop cycles. Clone W-193/3 had significantly taller pseudostem compared to the other clones and cultivars. No significant differences were observed between clones W-149, W-31, W-203 and W-206 and their values surpassed that of original Williams and Dwarf Cavendish cultivar. Dwarf Cavendish had the shortest pseudostem compared with other clones and cultivars. The same trend was observed in the first and second ratoon. Similar results were obtained by Morton, (1987) and Sauco *et al.* (1998) who reported that there was a wide variation in pseudostem height between cultivars in the Cavendish subgroup, with Dwarf Cavendish being the shortest and Lactana being the longest. The same trend was observed in both first and second ratoon.

Pseudostem girth of all irradiated banana clones (W-149, W-31, W-203 and W-206 W-193/3) was comparable and significantly higher than that of original Williams and Dwarf Cavendish cultivar in the three successive crop cycles (Table2). These results were in agreement with that obtained by Ahmed (2003) who evaluated a number of introduced banana clones at different spacing. Pseudostem girth was significantly higher on clone W-193/3 than other clones and cultivars. The lowest value of pseudostem girth was obtained with Dwarf Cavendish compared to all clones and Williams cultivar.

The number of intact functional leaves were significant differently different in the experimented banana clones in the three successive cycles. The highest values were recorded in Williams clone W-193/3 followed by the rest of irradiated clones. All irradiated clones were comparable and had significantly higher number of intact functional leaves compared with Dwarf Cavendish and Williams control. Pseudostem girth and number of intact functional leaves maintained the same trend in the banana clones; both characters were significantly higher than that of local Dwarf Cavendish and original Williams cv., which is in agreement with Viswanath *et al*. (1997). Increased vigor of banana plant is generally expressed by large pseudostem circumferences (Daniells, 1988). These results might be

explained and supported by the fact that growth in circumference of the pseudostem is closely related to number of leaves, since the pseudostem consists of overlapping leaf sheaths as stated by Stover, (1979). The number of functional leaves on each mature banana plant remained approximately constant, ranging between 10 to 15 before flowering (Purseglove. 1972). Exceptions of 20-28 leaves were also observed Simmonds (1966).

The duration of planting to flowering and the period from flowering to harvest are considered as one of the most important phonological parameters. There were a highly significant differences between the five banana clones and cultivars in the number of days from planting to shooting and from shooting to harvesting of the plant crop, first ratoon and second ratoon (Table 3). Clone W-193/3 had significantly shorter time to flowering and to harvesting than other clones and cultivars over the three successive cycles. Dwarf Cavendish and original Williams cultivar, on the other hand, had significantly longer cycle than all clones, No differences were detected between clones (W-149, W-31, W-203, and W-206) with respect to the measured parameters. These results are consistent with reports of Mak *et al.* (1996) that irradiated clones of banana were earlier in flowering than the original parental one. The data were also in agreement of Robinson and Nel (1988) where in subtropical areas the duration from flowering to harvesting of Cavendish subgroup ranged between 110-240 days. However there were contradicting reports about the effect of genotype on plant crop cycle duration. Alvarez (1997), for instance, reported significant differences in vegetative cycle of tetraploid FHIA hybrids and triploid Grand Nain for several crop cycles. He reported that Grand Nain had shorter crop cycle duration than FHIA-02 and FHIA-18 and longer than FHIA-01 VI and SH-3436 somaclonal cultivars. Similarly, significant differences were also observed by Herrera and Manuel (2003) for flowering time between FHIA-20, FHIA-21 hybrids and Africa Dominico harton varieties, in which they found that FHIA-21 was the latest to flower. These contradicting results might be due to differences in the genomic groups. Sundararaju (1998) reported that banana fruit bunch matures over a period of 90 to 150 days after shooting depending upon cultivars and growing condition. Similarly, Stover and Simmonds (1987) reported that, in the tropics, bunch maturation time of AAA clones varies from about 80 days to 150 in the cool months.

Table 4 reveals a significant difference in leaf length and width of the mother plant, where the tested clones and cultivars. W193/3 banana clone was significantly superior in leaf length and width than all clones and cultivars. The leaves of Dwarf Cavendish cultivar were significantly shorter compared with other clones and original Williams cultivar. Clones W-

31, W-203, and W-206 and cloneW-149 were similar in leaf length and width, but had significantly longer leaves than original Williams. Significant differences were observed in leaf area. This might be related to the cultivar vigor (Skutch, 1930) or genetic characters as a result of irradiation (Karamura and Karamura, 1995). The latter noted that cultivar genome affected leaf morphology.

References

[1] Ahmed, A.D. (2003). *Evaluation of some introduced banana clones* (*Musa* AAA) *grown at two spacing*. MSc. Thesis, Faculty of Agricultural Sciences, University of Gezira. Wad Medani, Sudan.

[2] Alvarez, J.M. (1997). Introduction, evaluation, multiplication and dissemination of FHIA hybrids in Cuba .INFO*MUSA,* 6 (2):10 -14.

[3] Bedri, A.A. (1984) Horticulture production in the Sudan, past, present and future. *Acta Horticulturae*, 143:25-29.

[4] Daniells, J.W. (1988). Comparison of growth and yield of bananas derived from tissue culture and conventional planting material. *Banana Newsletter*, 11:2.

[5] FAOSTAT. (2010). Food and Agricultural Organisation of the United Nations.

[6] Herrera, J.W. and A.L. Manuel. (2003). Characterization of the growth and production of some hybrids and cultivars in Colombia. INFO*MUSA,* 12(2):22-24.

[7] Irizarry, I.I.; E. Rivera; I.B. De Caloni and R. Guadalupe. (1989) Performance of elite banana (Musa. AAA) cultivars in four locations of Puerto Rico. *Journal of Agriculture of the University of Puerto Rico*, 65: 395-400.

[8] INIBAP (1992) International network for the improvement of banana and plantain. Annual Report. 1992. Montpellier. France.

[9] Israeli Y.; O.Reuveni and E. Lahav (1991). Qualitative aspects of Somaclonal varitations in banana propagated by *in vitro* techniques. *Scientia Horticulturae*, 48: 71-88.

[10] Karamura, E.B. and D.A. Karamura (1995). *Banana morphology*-part II: the aerial shoot: In Bananas and Plantains. S.Gowen (ed.). Chapman and Hall Pp. 190-205.

[11] Mak, C., Y.W. Ho, Y.P. Tan and R. Ibrahim (1996). Novaria-a new banana mutant induced by gamma irradiation. In: Report of the first FAO/IAEA research co- ordination meeting on cellular biology and biotechnology mutation techniques for creation of new useful banana genotypes, 20-24 Nov.,1995,Vienna,Austria, IAEA 312. D2. R. C. 579.

[12] Mohmoud, H.I. and M.E. Elkashif (2003). Evaluation of plant crop of introduced banana clones and the effects of packaging on fruit quality. *Gezira Journal of Agricultural Science* 1 (1): 45-50.

[13] Morton, F.J. (1987). *Banana* In: *Fruits of warm Climates*. Morton (ed). Miami, Florida USA Pp. 29-46.

[14] Murry, D.B. (1960). The effect of deficiency of the major nutrients on growth and leaf analysis of banana. *Tropical Agriculture*, Trinidad 37(2): 97-106.

[15] Novak, F.J. and A. Micke, (1990). Mutation breeding and *in vitro* techniques for crop improvement in developing countries. In *gene manipulation for plant improvement in developing countries*. SABRAO Proc. pp: 63-86, Kuala Lumpur.

[16] Oritz, R. Vuylesteke, D. (1996). Recent advances in *Musa* genetics, breeding and biotechnology. *Plant breeding Abstract*, 66 (10): 1355-1363.

[17] Purseglove, J.W. (1972). *Tropical Crops, Monocotyledons*, Vol.2. Longmans, London pp. 343-384.

[18] Robinson J. and D.J. Nel. (1988). *Characteristics of new banana cultivars* Information Bulletin, Citrus and Sub-tropical Fruit Research Institute, South Africa 193: 7-8.

[19] Samson, J.A. (1980). *Banana and Plantains, Tropical Fruits*. Longmans, London, Pp. 119-161.

[20] Sauco, G.V., J.C. Cabera, P.M.H. Delgado and M.C.R. Pastor. (1998). Evaluation of medium-height Cavendish banana cultivars under the subtropical conditions of the Canary Island. International symposiumon Banana in the subtropics. *Acta Horticulturae*, 490: 490-506.

[21] Simmonds, N.W. (1966).*Vegetative morphology and Physiology*. In: *Banana*, Longman. Publishers, New York, USA. Pp. 308-312.

[22] Skutch, A.F. (1930). On the development and morphology of the leaf of the banana (*M. Sapientum* L.) *American Journal of Botany* ,17, 252-271.

[23] Stover, R.H. and N.W. Simmonds. (1987*) Banana*, 3rd edition Tropical Agriculture series. Longman, Essex, UK, Pp.468

[24] Sundararaju. P. (1998). *Status paper on banana in India*, In*: Banana and food security* C. Picq, E. Fouré and E.A. Frisson (eds.). International symposium, 10-14 November 1998, Douala, Cameroon Pp. 209-225.

[25] Swennen, R. (1996). Mutation breeding for banana improvement through irradiation in Sudan. Report of expert mission for the IAEA project SUD/5/23.IAEA-RU-6083, Vienna, Austria. Strategies. *ACIAR Proceedings* 21. ACIAR, Canberra.

[26] Tan, Y.P.; Y.W. Ho and C. Make. (1993) Fatom-I: an early flowering mutant derived from mutation induction of Grand Nain, a Cavendish banana. *Mutation Breeding Newsletter*, 40:5-6.

[27] Viswanath, P., A.N. Al-Bakty and S. K. Ndaaf (1997). Performance of banana (*Musa* spp.) cultivars in Sultanate of Oman. *INFOMUSA, 6*(2): 21-22.

Table 1. Contrast analysis of different banana groups for vegetative growth, cycle time, yield and yield components

Group	Plant height (cm)	Girth of plant (cm)	No.of functional leaves	No. of days	
				Planting to shooting	Shooting to harvesting
Mutant(M)	195.5	62.3	18.31	323.3	83.2
Williams(W)	188.6	54.6	15.83	348.8	101.8
Dwarf Cavendish(DC)	152.3	47.5	14.2	369	116.3
Mean	188.3	59.1	17.37	333.5	90.6
M vs. Williams	*	*	*	*	*
M. vs. D.C	**	**	**	**	**
W vs. D.C	*	*	ns	*	*
SE±	1.88	2.28	0.504	7.49	2.15
CV%	3.0	11.6	8.7	6.7	7.1

Table 2. Comparative morphology of irradiated Williams clones, original Williams and Dwarf Cavendish

Cultivars and clones	Plant height (cm)			Girth (cm)			No. of functional leaves		
	plant crop	first ratoon	second ratoon	plant crop	first ratoon	second ratoon	plant crop	first ratoon	second ratoon
Dwarf Cavendish	148.5 d	153.0d	156.0d	43.0d	43.2d	43.0d	12.8d	14.5d	15.3d
Williams	180.1 c	187.0c	188.0c	49.6c	50.1c	51.7c	14.3c	16.9c	16.3c
W -193/3	200.0 a	205.0a	206.0a	69.5 a	76.3a	76.0a	19.9a	20.6a	22.2a
W- 31	189.1 b	193.0b	195.0b	58.1b	59.1b	60.5b	17.3b	17.2b	18.0b
W- 203	191.7 b	194.0b	195.0b	57.5b	61.0b	60.9b	16.5b	18.0b	18.3b
W- 206/1	191.8 b	194.4b	194.0b	57.4b	59.0b	60.5b	16.3b	17.9b	18.2b
W-149	191.5b	196.0b	198.0b	55.0b	61.1b	61.0b	17.3b	18.3b	18.5b
Mean	185.9	188.85	190.286	55.7	60.4	61.214	16.34	16.9	18.1
S.E.	2.48	1.81	1.876	1.917	0.65	0.4665	1.81	0.2324	0.3276
CV %	2.3	1.67	10.55	5.97	10.47	1.32	0.1703	2.291	3.13

The same letters within columns indicates that no significant differences between treatments at 5% level according to Duncan's Multiple Range test.

Table 3. Comparative phenology of irradiated Williams clones, original Williams and Dwarf Cavendish cultivar

Banana clones	Days to shooting			Days to harvesting		
	Plant crop	1st ratoon	2nd ratoon	Plant crop	1st ratoon	2nd ratoon
Dwarf Cavendish	379.0a	368.0a	360.0a	120.0 a	117.0a	112.0a
Williams	350.0b	346.0b	350.0b	105.0b	102.0b	99.0b
W -193/3	277.1d	275.0d	270.7d	73.6d	71.0d	69.0d
W- 31	339.0c	333.0c	330.6c	89.6c	87.2c	86.3c
W- 203	338.0c	336.0c	328.3c	87.2c	86.0c	84.6c
W- 206/1	338.0c	335.0c	330.1c	88.0c	86.0c	85.1c
W-149	340.0c	338.0c	331.4c	86.0c	85.3c	83.0c
Mean	338.162	333.4	329.14	92.62	90.695	88.448
S.E.	2.903	1.305	0.9840	1.50	2.53	1.59
CV %	1.49	1.17	0.52	0.8002	4.83	3.11

The same letters within columns indicates that no significant differences between treatments at 5% level according to Duncan's Multiple Range test.

Table 4. Leaf dimensions of the banana cultivars and clones of cv. Williams, Data taken for mother plant crop

Banana clones	Leaf length (cm)	Leaf width (cm)	Leaf area m^2
Dwarf	147.3d	60.5d	0.71d
Williams	173.6c	70.0c	0.97c
W-193/3	212.2a	82.5a	1.40a
W-31	202.2b	75.3b	1.20b
W-203	205.3b	75.9b	1.20b
W-206/1	204.5b	73.9b	1.20b
W-149	201.0b	73.8b	1.20b
Mean	192.3	73.05	1.10
SE±	7.53	3.65	0.38
C.V%	7.78	10.34	4.3

The same letters within columns indicates that no significant differences between treatments at 5% level according to Duncan's Multiple Range test.