Effect of pre - and post-harvest treatments on yield and fruit quality of selected banana cultivars

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ABSTRACT

This study was conducted at the experimental farm of the National Institute for the Promotion of Horticultural Exports during 2005/06 to investigate the effect of different materials used for pre-harvest bagging of banana bunches on fruit quality and yield of selected cultivars. Bagging materials used were cotton cloth, jute and transparent polyethylene film. The cultivars were Grandnain (GN), William's Hybrid (WH) and the locally grown Dwarf Cavendish (DC). Treatments were arranged in a split-plot design with three replications. The cultivars were the main plots and the bagging materials were the sub-plots. Also, the effects of post-harvest packaging treatments on fruit quality were studied. Packaging treatments were cartons lined with polyethylene film, cartons without polyethylene and the unpackaged control. Jute and cotton cloth bagging materials significantly reduced the incidences of sunscald and physical injury in banana bunches as compared to polyethylene and the unbagged control. Also, the highest bunch and hand weights were obtained when cloth and jute materials were used as compared to the other treatments. The cloth bagging material resulted in the longest green life and the unbagged control resulted in the shortest. The cultivar WH resulted in the longest green life and the highest yield components, followed by GN and the lowest values were recorded for DC. In all cultivars, post-harvest packaging of banana fruit in cartons lined with polyethylene film resulted in the longest green life, the highest TSS content and the best taste, followed by those packed in cartons only and the worst results were obtained by the unbagged control. The cultivars WH and GN were superior in all fruit quality parameters as compared to the locally grown DC cultivar.

INTRODUCTION

Banana bagging is done to protect banana fruits from physical injury, sun-burn, leaf scratch, dust and insects during fruit development and growth. The most commonly used covers are those made from plastic materials of different thicknesses and colours (Trever, 2003). The covers are pulled over bunches immediately after fruit set and tied to the stalk, with the lower end left open (Sargent and Sidahmed, 1987).

Transparent polyethylene can be used only under high density planting systems when sunscald is not a problem; otherwise blue bags have been very effective in protecting bunches from sunscald (Choudhury *et al.*, 1997).

Bunch bagging has been reported to increase yield, fruit size and improve fruit quality. Bunches developed in bags were bigger, cleaner, attractive, and dark green in colour. Fruits of bagged bunches showed neither scratches nor blemishes, whereas those of unbagged bunches showed physical injury (Weerasinghe and Ruwanpathirana, 2002).

In Sudan, the major banana production areas are the Gash Delta in Kassala State, along the Blue Nile and in the River Nile State (Hamid, 1992). The locally grown banana cultivar is the Dwarf Cavendish which has small fingers and does not compete in international markets. Mahmoud and Elkashif (2003) and Elkashif *et al.* (2005) evaluated several clones which were introduced from Vienna and found that clones of Williams Hybrid and Grandnain were superior in yield and fruit quality than Dwarf Cavendish.

Although Sudan has a great potential to become one of the leading countries in banana production and export, yet there is a need to develop proper pre and post-harvest handling practices to improve the quality of Sudanese bananas so as to meet the requirements of international markets. Therefore, the objectives of this research are to (1) study the effect of banana bunch covering materials on the reduction of pre-harvest injures, yield and fruit quality of three banana cultivars and (2) find out the best post-harvest treatments for the longest green life and best fruit quality.

MATERIALS AND METHODS

This study was undertaken in the National Institute for the Promotion of Horticultural Exports (NIPHE) research farm at Hantoub area, along the eastern bank of the Blue Nile, lat. 19.5^0 N, long. 33.4^0 E during 2005/06. Experiments were carried out in an established banana plantation where all the cultural practices were carried out as recommended (Hamid, 1992). Three cultivars were used: Dwarf Cavendish (DC), Grandnain (GN) and Williams Hybrid (WH). Bunch bagging treatments used were: (1) cloth (Damouria), (2) jute, (3) polyethylene (transparent), and (4) uncovered (control). Bunch cover dimensions were 110 cm long and 85 cm in diameter. The bunches were covered after fruit set, the covers were tied to the top of the stalk and left till fruits reached the mature green stage.

Experiments were arranged in a split-plot design with three replications, with the banana cultivars as the main plots and bunch bagging materials as the sub plots. There were five bunches in each replication.

Banana bunches were harvested, weighed and total yield was determined. Then they were dehanded and the hands were weighed. The number of hands per bunch and number of fingers per hand were

determined. Physical injury and sunscald were rated according to 5 points scale for each. (1) no injury, (2) slight injury, (3) moderate injury, (4) high injury, and (5) severe injury.

Banana hands were washed with tap water to remove dust and latex, disinfected with sodium hypochlorite (125 ppm), and packed either in cartons lined with polyethylene film, cartons without polyethylene, or left unpacked on shelves (control).

Fruits from all treatments were stored at 14^0C and ambient relative humidity. The green-life, which was the number of days required to reach the first signs of ripening (slight yellow colour change), was determined. Then the fruits were treated with Ethrel in aqueous solution (2 ml/l) by dipping for 2 minutes, air dried and ripened at 20^0C and ambient relative humidity.

Colour changes were determined daily according to Chiquita Company colour chart scores: dark green (=1), light green (=2), pronounced yellow shading (50% green 50% yellow) (=3), predominantly yellow (=4), yellow with green tips (=5), full yellow (=6), and yellow with brown flecks (= 7).

Total soluble solids (TSS) were measured at the full yellow stage using a hand refractometer. Fruit taste was evaluated by a taste panel of five panelists according to a 5 points scale. Unacceptable (=1), slightly acceptable (= 2), acceptable (=3), good (=4), and excellent (=5).

Data were subjected to analysis of variance and means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Effect of cultivar and bagging material on sunscald and physical injury

The bunch bagging technique is used to protect banana from scratches resulting from the friction of banana leaves. It is also important to protect fruit from dust and insects, especially the banana fruit fly.

The main effects of banana cultivars and bagging material on sunscald and physical injury are shown in Table 1. Results show that DC had the highest scores of sunscald and physical injury as compared to the other two cultivars. Jute bagging material was significantly superior in both parameters tested followed by cloth and then polyethylene. However, the control recorded significantly the worst results. This was because cotton cloth and jute textile protected bunches from leaf abrasion and direct solar radiation and hence resulted in clean sound bunches free from any sorts of blemishes. On the other hand, bunches bagged in transparent polyethylene were exposed to direct sun light which caused sunscald. Unbagged bunches were subjected to physical injury caused by leaf movement and were also exposed to solar radiation which caused sunburn. These results agreed with the findings of Trever (2003) who reported that sun scorches were observed when transparent polyethylene was used as a bagging material for banana.

Table 1. Main effects of cultivars and bagging material on sunscald and physical injury of banana fruit.

Cultivar	Sunscald	Physical injury
DC	2.58 a	3.00 a
GN	2.33 b	2.75 b
WH	2.33 b	2.75 b
Sig.	*	*
Bagging materials		
Cloth	2.00 b	2.55 c
Jute	1.11 c	1.44 d
Polyethylene	2.11 b	3.22 b
Control	4.44 a	4.11 a
Sig.	***	***

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
* and ***Indicate significance at P< 5% and 0.1%, respectively.

Table 2 shows the interaction effects of cultivar and bagging material on sunscald and physical injury of banana fruit. In all cultivars, the jute bagging material gave the best results. Cloth and polyethylene materials were not significantly different in their effect on sunscald and physical injury. The untreated control gave the worst results.

Table 2. Interaction effects of cultivar and bagging materials on sunscald and physical injury of banana fruit.

Cultivar	Bagging material	Sunscald	Physical injury
	Cloth	2.00 b	2.66 bc
DC	Jute	1.00 c	1.00 d
	Polyethylene	2.00 b	3.00 b
	Control	4.33 a	4.33 a
	Cloth	2.00 b	2.30 c
GN	Jute	1.33 c	1.66 c
	Polyethylene	1.66 bc	3.00 b
	Control	4.33 a	4.00 a
	Cloth	2.33 b	2.66 bc
	Jute	1.00 c	1.66 c
WH	Polyethylene	2.33 b	3.66 ab
	Control	4.66 a	4.00 a
Sig. level		*	*

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
* Indicate significance at P< 5%.

Effect of cultivar and bagging material on yield components

The yield components of three banana cultivars are shown in Table 3. The cultivar WH resulted in the highest yield components followed by GN and the lowest scores were recorded for DC. Similar results were obtained by Mahmoud and Elkashif (2003).

Table 3 also shows the main effects of bagging material on yield components. The highest bunch and hand weights were obtained when cloth and jute materials were used as compared to polyethylene and the untreated control. However, jute material resulted in the highest number of fruits per hand. This was probably because bunch bagging increased relative humidity around the bunches and hence reduced the rate of transpiration, maintained fruit turgidity and increased growth rate which was culminated in higher yields as compared to un-bagged bunches. These results agree with those of Wearasinghe and Ruwanpathirana (2002) who reported that bunch covering, irrespective of the material, had produced bunches which were 32% heavier than uncovered ones.

Table 3. Main effects of cultivar and bagging material on yield components of the plant crop of banana.

Cultivar	Bunch wt. (kg)	No. of hands per bunch	No. of fingers per hand	Hand wt. (kg)
DC	13.79 c	8.41	12.75c	1.48 c
GN	14.07 b	8.66	13.25b	1.50 b
WH	15.99 a	8.58	14.33a	1.69 a
Sig. level	*	NS	*	*
Bagging material				
Cloth	15.41 a	8.55	13.22 b	1.61 a
Jute	15.77 a	8.88	14.22 a	1.65 a
Polyethylene	13.60 b	8.66	13.22 b	1.46 b
Control	13.70 b	8.11	13.11 b	1.50 b
Sig. level	*	NS	*	*

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

* and NS indicate significance at $P \leq$ 5% and not significant, respectively.

Table 4 shows the interaction effect of cultivar and bagging material on yield components. Results indicated that DC and GN recorded the highest yield components when covered by jute material. However, WH obtained the highest yield when covered by cloth. Polyethylene and control recorded the lowest values in all parameters tested. Jannoyer and Chillet (1998) evaluated different types of bagging materials and found that bunch bagging decreased exposure to radiation and hence sunscald and reduced in-bag temperature. They also found that the number of days from flowering to harvest were reduced, fruit growth was improved and yield was significantly increased in bagged bunches.

Table 4. Interaction effects of cultivars and bagging material on yield components of the plant crop of banana.

Cultivar	Bagging material	Bunch wt (kg)	No. of hands per bunch	No. of fingers per hand	Hand wt (kg)
DC	Cloth	13.56 c	8.33 bc	11.66 d	1.46 cd
	Jute	17.75 ab	10.00 a	14.66 a	1.65 b
	Polyethylene	12.73 c	8.33 bc	13.00 b	1.36 d
	Control	11.13d	7.00 c	11.66 d	1.43 cd
	Cloth	14.50 b	8.00 bc	13.00 b	1.66 b
	Jute	18.90 a	9.66 a	14.00 ab	1.73 ab
GN	Polyethylene	11.93 d	8.66 bc	13.66 d	1.40 cd
	Control	10.96 d	8.33 bc	12.33 c	1.20 e
	Cloth	19.00 a	9.00 ab	15.33 a	1.86 a
	Jute	15.30 b	9.00 ab	15.00 a	1.63 b
WH	Polyethylene	15.06 b	8.66 bc	14.33 a	1.53 c
	Control	14.60 b	7.66 c	12.66 c	1.73 ab
Sig. level		*	*	*	*

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

* Indicate significance at P< 5%.

Green life

Banana fruit green life is a very important characteristic in the evaluation of banana clones for export. Clones which have a long green life or ripen slowly would facilitate the distribution and marketing of fruits before post-harvest deterioration and losses occur.

The main effect of cultivar and bagging material on banana fruit green life was significant (Table 5). The longest green life was shown by WH and the shortest by GN and DC which were not significantly different. Elkashif *et al.,* (2005) evaluated introduced banana clones and found that WH had the longest green life and DC had the shortest. The main effect of bagging material on green life was significant (Table 5). The cloth bagging material had the longest green life and the unbagged control had the shortest. There were no significant differences between jute and polyethylene on green life. Similar results were reported by Chillet and Jannoyer (1996).

Table 5. Main effect cultivars and bagging material on green life of banana fruit.

Cultivar	Green life (days)
DC	8.44 b
GN	9.91 b
WH	14.66 a
Sig. level	*
Bagging material	
Cloth	13.48 a
Jute	11.07 b
Polyethylene	10.00 bc
Control	9.48 c
Sig. level	*

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.

* Indicate significance at P< 5%.

The interaction effects of cultivar and bagging material on banana fruit green life is highly significant (Table 6). In all tested cultivars, the cloth bagging material resulted in the longest green life. Jute material came second and there was no significant difference between polyethylene and the un-bagged control which recorded the shortest green life. This was probably because bunch bagging reduced water loss from fruits, maintained fruit firmness and hence resulted in a longer green life compared to un-bagged bunches. Regardless of bagging material, WH cultivar resulted in the longest green life and DC in the shortest.

The main effect of post-harvest packaging treatments on fruit green life was significant (Table 7). Banana fruits packaged in polyethylene film and placed in cartons had the longest green life as compared to the other treatments. These results are in agreement with those reported by Dadzie and Orchard (1997) and Mahmoud and Elkashif (2003).

Table 6. Interaction effect of cultivar and bagging material on green life of banana fruit.

Cultivar	Bagging material	Green life (days)
	Cloth	9.44 b
DC	Jute	9.11 b
	Polyethylene	9.11 b
	Control	7.11 c
	Cloth	11.92 a
GN	Jute	12.55 a
	Polyethylene	8.22 c
	Control	9.00 b
	Cloth	12.11 a
WH	Jute	11.55 b
	Polyethylene	9.62
	Control	8.51
Sig. level		**

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
**Indicate significance at P<1%.

Table 7. Main effect of packaging treatments on green life of banana fruit.

Packaging treatments	Green life (days)
Carton only	11.41 b
Carton + polyethylene	12.22 a
Control	9.38 c
Sig. level	*

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
* Indicate significance at P< 5%.

The interaction effect of cultivar and post-harvest packaging treatments on fruit green life is highly significant (Table 8). Fruits of the cultivar WH packaged in polyethylene film and placed in cartons had the longest green life and those of DC left unpackaged (control) had the shortest. In all cultivars, fruits wrapped in polyethylene and placed in cartons had the longest green life as compared to the other treatments. Fruits placed in cartons without polyethylene wrap had a longer green life than the control (no cartons). This was probably due to the beneficial in-package environment with high relative humidity and modified atmosphere which reduced water loss, prevented shriveling, delayed ripening and hence increased the green life of fruits.

Table 8. Interaction effect of cultivars and packaging treatments on green life of banana fruit.

Cultivar	Packaging	Green life
DC	Carton only	7.83 e
	Carton + polyethylene	10.58 cd
	Control	6.91 f
GN	Carton only	9.91 d
	Carton + polyethylene	11.75 c
	Control	8.08 d
WH	Carton only	14.33 b
	Carton + polyethylene	19.25 a
	Control	10.41 cd
Sig. level		**

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
** Indicate significance at P< 1%.

The main effect of cultivar on fruit quality is significant (Table 9). The cultivars GN and WH resulted in the highest values of the quality parameters tested as compared to the local DC cultivar. Elkashif *et al*, (2005) and Mahmoud and Elkashif (2003) compared the quality of introduced banana clones with the locally grown cultivar DC and found that WH and GN had superior quality attributes than those of DC.

Table 9. Main effect of cultivar on colour, TSS and taste of banana fruit.

Cultivar	Colour	TSS	Taste
DC	3.41 b	19.59 c	3.30 b
GN	4.69 a	21.10 a	4.45 a
WH	4.89 a	20.3 b	4.32 a
Packaging treatments			
Carton only	3.89 b	19.06 b	3.30 b
Carton + polyethylene	4.33 a	20.15 a	3.54 a
Control	3.71 b	18.58 c	3.09 c
Sig. level	*	***	***

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
*Indicate significance at P< 5%.

The main effect of post-harvest packaging treatments on fruit quality is highly significant (Table 9). Banana fruit packaged in polyethylene film and placed in cartons had the best quality attributes and the worst was recorded for the unpackaged control. These results are in agreement with those reported by Ibrahim *et al.* (1994).

The interaction effect of cultivar and post-harvest packaging treatments on fruit quality are significant (Table 10). In all cultivars, packaging banana fruit in cartons lined with polyethylene film resulted in the highest TSS and the best taste, followed by those packed in cartons only and the worst results were obtained by the unpackaged control. The cultivar WH recorded the highest values compared to the two cultivars. Kojima *et al.* (1994) and Choudhury *et al.* (1997) studied the effect of different packaging treatments on the biochemical composition of banana. They found that polyethylene packaging of banana fruit increased TSS and improved fruit quality.

Table 10. Interaction effects of cultivar and packaging treatments on TSS and taste of banana fruit.

Cultivar	Packaging treatments	TSS	Taste
	Carton only	19.02 ab	3.34 bc
DC	Carton + polyethylene	20.06 a	3.38 bc
	Control	18.48 b	3.19 bc
	Carton only	17.58 c	3.25 bc
GN	Carton + polyethylene	19.33b ab	3.68 a
	Control	17.26 c	2.99 c
	Carton only	19.77 ab	3.40 a
	Carton + polyethylene	20.17 a	3.48 a
WH	Control	18.69 b	3.07 bc
Sig. level		*	**

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

* and ** indicate significance at $P \leq$ 5% and 1%, respectively.

In conclusion, pre-harvest bagging of banana bunches using cotton cloth or jute material reduced physical injury and sunscald, increased yield, increased green life and improved fruit quality. Post-harvest packaging of banana fruit in cartons lined with polyethylene film increased green life and improved quality of fruits. The cultivars WH and GN were superior in all parameters tested than the locally grown DC cultivar.

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تأثير معاملات قبل وبعد الحصاد على الإنتاج وجودة الثمار لبعض أصناف الموز المنتخبة

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الخلاصة

أجريت هذه الدراسة بالمزرعة التجريبية للمعهد القومي لتنمية الصادرات البستانية في الموسم 06/2005 لدراسة تأثير مواد تغطية سبائط الموز قبل الحصاد على جودة الثمار والإنتاج لبعض الأصناف المنتخبة. مواد التغطية المستخدمة كانت قماش قطني (دمورية) وخيش وكيس نايلون شفاف. الأصناف كانت قران نين (GN)، وليامز هايبرد (WH) والكافندش القزم (DC). استخدم تصميم القطع المنشقة بثلاث مكررات. كانت الأصناف هي القطع الرئيسة ومواد التغطية القطع الثانوية. كذلك شملت الدراسة تأثير معاملات التغليف بعد الحصاد على جودة الثمار. معاملات التغليف كانت كراتين مبطنة بأكياس النايلون، كراتين بدون نايلون وأخرى بدون كراتين. مواد التغطية من الدمورية والخيش أعطت انخفاضاً معنوياً في لفحة الشمس والإصابة الفيزيائية لسبائط الموز مقارنة بكيس النايلون الشفاف والسبائط المكشوفة. كذلك أعطت مواد التغطية المذكورة أعلى معدل لوزن السبائط والكفوف بالمقارنة مع المعاملات الأخرى. أعطت الدمورية أطول فترة صلاحية للثمار كما أعطت السبائط المكشوفة أقل فترة. أعطى الصنف WH أطول فترة صلاحية للثمار وأعلى إنتاجية، يليه GN وأقل معدلات كانت للصنف DC. تغليف الثمار في الكراتين المبطنة بأكياس النايلون أعطي أطول صلاحية للثمار وأعلى معدل للمواد الصلبة الذائبة وأفضل مذاق تليه الثمار المغلفة بكراتين فقط وأقل المعدلات كانت للثمار غير المغلفة. الأصناف WH و GN أعطت أفضل خصائص الجودة للثمار بالمقارنة مع الصنف المحلي DC.