Evaluation of banana bunch protection materials for optimum fruit production on cultivars grown in Mozambique

Rodrick Kutinyu, Connie Fraiser, Wonder Ngezimana and Fhatuwani N. Mudau*

University of South Africa, Department of Agriculture and Animal Health,
Private Bag X6, Florida, 1710, South Africa
*Corresponding author E-mail: mudaufn@unisa.ac.za

Abstract

Mozambique has the potential to boost its banana exports. To fully realise this, agronomic practices in production should be fully developed to combat physiological disorders associated with banana within the region. Currently, lower temperatures are being experienced in some production sites, consequently affecting yield and quality. The objective of this study is to evaluate the use of bunch protection covers on Grand Nain and Williams banana cultivars. Treatments consisted of: white perforated polythene; white non- perforated polythene; blue perforated polythene; blue non-perforated polythene; green perforated polythene; green non-perforated polythene and cheese cloth bags. Bunches left un-bagged were used as a control. Bunch covers were applied after the bracts covering the hands have fallen off and when the fingers were curling upwards, and the floral remnants have hardened. Banana bunch covers significantly increased yields (ton/ha) in the cultivars with significant reduction of fruit defects. Inconsistent results were shown on use of bags of various designs, viz. colour and perforation; however the use of perforated bags is recommended to reduce high relative humidity inside the bags.

Keywords: Banana, bunch protection materials

INTRODUCTION

Banana production within Mozambique region shows potential for growth (Uazire et al., 2008). However, recent climatic data collected from weather stations showed a decrease in temperatures during the past 3 years with minimum winter temperatures dropping to 11.8 ℃. Temperatures below 12 to 13 ℃ can cause under peel discolouration (UPD) which indicates that the fruit was subjected to chilling temperatures during the development stages (Hailu et al., 2013; Robinson and Sauco, 2010). Fruit with severe under peel discolouration (UPD) will not ripen to a bright yellow colour and will therefore not be acceptable to export markets (Fonsah, 2003; Snowden, 2010).

The low temperature also retards growth, extending the period between flowering and the harvest of the fruit. For centuries, old banana leaves have been wrapped around maturing bunches in New Guinea (Heenan, 1973). It was later shown that banana bunches covered with hessian were protected against winter chilling which improved fruit quality (Turner, 1984). Considerable physical injury and damage to the fruit peels can also be caused by blowing of adjacent leaves and rubbing leaf petioles onto the developing bunch (Anon, 2003), ultimately causing cellular damage and subsequent fruit scarring (Muchui et al., 2010). Bunch covers have been shown to reduce this damage incurred during fruit growth (Weerasinghe and Ruwapathirana, 2002).

Banana fruit protection bags are used throughout the commercial banana growing areas of the world (Muchui et al., 2010). These bags are mainly used to improve fruit production and quality, especially fruit intended for the export markets. The bags are made in various colours, and designs, however with the ultimate aim of suitability for use in banana growing regions (Stover

and Simmonds, 1987; Galan et al., 1996; Jannoyer and Chillet, 1998; Muchui et al., 2010). Some of the quality parameters improved by use of covers include acceptable skin appearance and colour, increase in finger length and bunch weight as well as reduced fruit defects for example sunburn and fruit splitting (Anon., 2003; Jannoyer and Chillet, 1998; Johns, 1996; Muchui et al., 2010). The bagging technique has also been used on several fruits, to protect them from low temperatures (Amarante et al., 2002; Harhash and Al-Obeed, 2010; Mohamed and Al-Qurashi, 2012; Robinson, 1993) and has been shown to reduce winter stress under supra-optimal condition, which resulted in early fruit maturation (Muchui et al., 2010).

Currently, proper agronomic practices have not been developed to combat physiological disorders associated with banana production in Mozambique. There are inconsistent results reported with the different bags currently in use, especially during the cool winter months. The objective of this study is to evaluate bunch protection covers on Grand Nain and Williams banana cultivars with the aim of developing management practices suitable for banana production and achieve exportable fruit quality in Northern Mozambique.

MATERIALS AND METHODS

This trial was conducted in Namialo, Nampula, Mozambique; its geographical coordinates are 14.88˚ S., 40.04˚ E. Banana flowers of the same stage of development (when the hands had started to turn upwards) were marked and bunches were protected using the different fruit protection bags. The studies were carried out over two consecutive seasons i.e. 2012 and 2013. Average temperatures at the experimental site were 24.9 and 23.7 ˚C for 2012 and 2013 banana growing seasons respectively.

Treatments consisted of a control (no bag on bunches), white perforated polyethylene bag, white non-polyethylene bag, blue perforated polyethylene bag, blue non-perforated bag, green perforated bag, green polyethylene non-perforated bag and cheese cloth replicated 26 times arranged in a randomised complete block (RCBD). Bunch covers were applied after the bracts covering the hands had fallen when the fingers were curling upwards, and the floral remnants had hardened. Covers were slid up from the bottom of the stalk and secured to the bunch stalk above the first hand of the fruit. Covers were left on bunches until harvest (full three quarter maturity). Temperature loggers were placed in for all treatments up to day of harvesting (Tables 1 and 2). At harvest, data were recorded on several yield parameters including; weight of hands, box stem ratio (BST), yields (ton/ha) and marketability. Weight of hands was evaluated as; Gross hand weight: Total Fruit Weight- Stalk Weight = Gross hand weight (divisible by the number of hands per bunch). The box to stem ratio is a measure used for actual productivity on a daily basis with standard market box weight of 13.5 kilograms net fruit weight. Hence, the Box Stem Ratio becomes the marketable fruit weight (net fruit weight) divided by 13.5, where marketable fruit weight is the total fruit weight less of all defects.

Analyses of variance (ANOVA) were performed on recorded data using the GLM (General linear model) procedure of SAS version 8.0 (SAS Institute Inc., 1999). Any treatment means found to be significantly different were separated using Duncan Multiple range test (DMRT) at $p < 0.05$.

RESULTS

Results of the temperature loggers placed in all treatments for both seasons showed higher temperatures inside the bags than the outside air temperature in most of the treatments with the

exception of treatments with white, green, and blue perforated bags in some seasons. For treatments with Grand Nain cultivar, average temperatures inside the bags ranged from 26.9 ˚C to 29.6 ˚C in 2012 and 28.1 ˚C to 31 ˚C in 2013 (Table 1). Treatments with Williams banana cultivar had average temperatures inside the bags ranging from 25.7 ˚C to 29.6 ˚C in 2012 and 26.5 ˚C to 30.5 ˚C in 2013 (Table2).

During 2012 and 2013, bagging treatments did not considerably improve weight of hands, banana finger weight, total fruit weight, marketable weight, and percentage marketable fruit weight and box stem ratio (BSR) of Grand Nain (Tables 3 and 4). However, there was a reduction in fruit defects in all bagging treatments compared to control (no bags).

In Williams banana cultivar, bagging treatment tended to be inconsistent between the two seasons (Tables 5 and 6). During 2013 bagging treatments improved weight of hands, whereas no significant differences were observed on weight of hands during 2012 (Table 5). Bagging of banana bunches reduced defects in both seasons, though no substantial responses were shown in marketability percentage. In 2012/2013, marketable weight tended to be inconsistent with blue perforated polythene and green non- perforated significantly increasing marketable weight. However, no differences were observed during 2013. Both green and blue perforated bags improved box stem ratio. However, no differences were observed during 2013. Bagging treatments increased Williams' cultivar yields per hectare in both seasons (Tables 5 and 6).

DISCUSSIONS

Results from the trials indicate that yield and quality performance of covered banana bunches is dependent on a number of factors, including type of cover, season and cultivar. Bunch cover application resulted in increase in yield (ton/ha) even though inconsistent results were drawn from other parameters. These could be due to interaction between different light intensity and temperature. Such temperature fluctuations inside the bunch covers due to weather patterns and bunch cover designs were shown in banana production across regions (Cuneen and McEntye, 1988; Johns and Scott, 1989).

The average temperatures inside the bags in both banana cultivars were higher than the outside air temperature. The blue and green non-perforated bags resulted in the highest temperature increase than the other bag types. In studies done by Cuneen and McEntye (1988), no significant differences in yields per hectare and quality were found for the different coloured bags, although yields were highest for bunches inside the clear silver bags. In some instances in the tropics benefits are related more to blemish control and reduction of pest damage (Anon., 2003). In winter, even the use double bunch covers improved the yield of bananas (Johns, 1996). Use of bunch covers to control against chilling temperature, would also reduce incidences of under peel discolouration (Snowden, 2010).

Bunch covers can also increase the marketability of banana fruits through increase in size and quality. The use of different bunch cover combinations during summer in South Africa resulted in low proportion of clean fingers (9-12%) with however a relatively high relative humidity in polyethylene bags resulting in the highest percentages of soft rots (15%) and uneven

ripening (Robinson and Nel, 1982). Building up of high relative humidity inside the banana bags can however be reduced with use of perforated bags (Anon., 2003; Muchui et al., 2010), ultimately preventing multiplication of fungi. Sizes of the holes should also vary with climatic conditions within production areas. Besides effect of presence of holes on changes in humidity and temperature inside bunch covers, colour of the covers also plays a role in micro environment characteristics.

Muchui et al. (2010) reported that using perforated dull and shiny blue bunch covers resulted in higher quality and yields of bananas. Bunch appearance and size of hands were also affected by colour of the bunch covers and polyethylene density in banana produced in the Caribbean (Vargas et al., 2010). Crop duration, particularly days taken from flowering to physiological maturity and production per day can also be influenced by different bunch cover treatments (Vargas et al., 2010). The use of covers of various colours may also be depended on seasons (Stevenson, 1976). Bunch covers performed the same in summer but in winter the use of transparent material speeded up the filling and harvesting of banana bunches (Johns, 1996; Johns and Scott, 1989; Stevenson, 1976).

The use of various colours in different seasons, climate or regions has shown their different performance capabilities towards banana physiological growth. Photosynthetically Active Radiation (PAR) which is responsible for light intensity required in growth and development becomes filtered through various bunch cover colour designs. Transparent covers let in more light than blue or green covers. However, banana production regions mostly use blue covers as they let in heat without causing sun scald (Muchui et al., 2010), because it blocks UV

rays. Transparent covers can further be treated to block ultraviolet and infrared rays. These transparent bunch covers with specific UV and IR permeability properties were found to allow better light and temperature conditions for banana growth (Jannoyer and Chillet, 1998).

It is evident that bagging treatments significantly increased yields (ton/ha) of Grand Nain and Williams cultivars with significant reduction in fruit defects. Therefore, bagging treatments are recommended in marginal climatic condition of Namialo in Northern Mozambique. However, there is need to evaluate effects of various perforated bunch covers on yield and quality of banana and also the cost benefit analysis of use of covers.

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Table 1. Average temperature (^{o}C) in Grand Nain banana bunch covers for 2012 and 2013 season

	2012			2013		
	Min	**Max**	**Ave**	**Min**	**Max**	**Ave**
Control	13.4	44.7	27.5	13.1	45.1	27.9
Blue perforated	14.1	42.2	27.9	14.8	41.8	28.3
Green non-perforated	13.2	41.6	28.1	14.2	43.0	31.0
White non-perforated	15.1	41.6	27.8	15.8	42.6	29.5
Blue non-perforated	14.5	43.3	29.6	15.5	43.8	30.6
White perforated	13.9	42.5	28.8	14.0	40.5	29.3
Green perforated	14.4	38.0	26.9	15.2	41.3	28.1
Cheese cloth	15.6	44.4	28.5	15.0	43.8	29.1

Table 2. Average temperature (^{o}C) in Williams's banana bunch covers for 2012 and 2013 season

	2012			2013		
	Min	**Max**	**Ave**	**Min**	**Max**	**Ave**
Control	12.1	42.1	28.1	12.9	44.8	28.8
Blue perforated	13.1	41.4	27.7	13.6	41.0	29.2
Green non-perforated	13.0	43.3	28.2	14.4	42.6	30.1
White non-perforated	14.7	43.0	28.2	14.2	44.4	30.5
Blue non-perforated	13.8	40.8	28.6	14.5	43.9	28.1
White perforated	12.7	41.5	27.6	13.8	39.5	28.2
Green perforated	13.4	41.8	25.7	14.6	41.8	26.5
Cheese cloth	14.8	43.4	29.6	14.3	44.8	29.9

Table 3. Effects of bunch covers on yield performance of Grand Nain banana variety in 2012

Treatment Tree bags	Weight hands (kg)	Defects (kg)	Weight in Kilos (kg)	Total Fruit Weight (kg)	Marketable Weight (kg)	Marketabl Percentage (%)	Box stems ratio (BSR)	Yield (ton/ha)
Control	3.13 a	4.66 a	1.90 a	17.63 a	13.67 a	77.90 a	1.03 a	32.75 b
Green perforated	3.21 a	4.01 b	2.13 a	17.88 a	13.86 a	76.35 a	1.04 a	39.81 a
Green non perforated	2.86 a	3.13 b	1.88 a	17.33 a	14.01 a	81.54 a	1.05 a	39.25 a
White perforated	2.48 a	2.23 b	1.98 a	16.63 a	11.40 a	72.93 a	0.85 a	39.77 a
White non perforated	3.04 a	2.33 b	1.79 a	17.21 a	14.89 a	86.78 a	1.10 a	41.68 a
Blue perforated	2.88 a	3.61 b	1.90 a	16.71 a	13.10 a	77.28 a	0.96 a	36.68 a
Blue non perforated	3.18 a	3.96 b	1.81 a	16.36 a	11.70 a	69.79 a	0.86 a	38.29 a
Cheese Cloth	2.95 a	2.64 b	1.81 a	17.63 a	13.95 a	84.53 a	1.03 a	39.05 a

Means in a column followed by the same letter are not significantly different ($p>0.05$) using Duncan Multiple Range Test (DMRT)

Table 4. Effects of bunch covers on yield performance of Grand Nain banana variety in 2013

Treatment Tree bags	Weight hands (kg)	Defects (kg)	Weight in Kilos (kg)	Total Fruit Weight (kg)	Marketable Weight (kg	Marketable Percentage (%)	Box stems ratio (BSR)	Yield (ton/ha)
Control	2.95 a	13.88 a	1.65 a	15.94 a	9.43 a	59.98 a	0.68 a	26.40 b
Green perforated	3.33 a	5.03 b	1.70 a	17.70 a	12.66 a	70.76 a	0.95 a	35.50 a
Green non perforated	3.15 a	3.95 b	2.03 a	17.09 a	13.14 a	76.24 a	0.98 a	36.80 a
White perforated	2.95 a	5.13 b	1.85 a	15.68 a	10.54 a	64.51 a	0.78 a	29.51 a
White non perforated	2.81 a	4.22 b	1.84 a	16.94 a	12.71 a	75.40 a	0.96 a	35.61 a
Blue perforated	3.06 a	4.59 b	1.25 a	17.00 a	12.41 a	80.19 a	0.93 a	34.75 a
Blue non perforated	2.94 a	3.33 b	1.61 a	16.66 a	13.34 a	71.13 a	0.99 a	37.35 a
Cheese Cloth	3.12 a	4.09 b	1.51 a	15.74 a	11.65 a	71.45 a	0.86 a	32.63 a

Means in a column followed by the same letter are not significantly different ($p>0.05$) using Duncan Multiple Range Test (DMRT)

Table 5. Effects of bunch covers on yield performance of Williams's banana variety in 2012

Bagging treatment	Weight hands (kg)	Defects (kg)	Weight in Kilos (kg)	Total Fruit Weight (kg)	Marketable Weight (kg)	Marketable Percentage (%)	Box stems ratio (BSR)	Yield (ton/ha)
Control	3.09 a	3.48 b	1.75 b	16.37 a	12.05 b	73.93 a	0.89 b	31.02 b
Green perforated	3.09 a	4.32 a	1.90 a	16.47 a	12.99 b	79.30 a	0.97 b	36.37 a

Green non perforated	2.90 a	5.11 a	3.07 a	15.75 a	20.75 a	64.42 b	4.25 a	33.75 a
White perforated	3.07 a	3.72 a	2.40 a	17.13 a	13.41 b	79.88 a	1.00 b	37.55 a
White non perforated	3.01 a	3.60 a	2.00 a	17.33 a	13.74 b	79.44 a	1.02 b	38.46 a
Blue perforated	2.94 a	4.47 a	2.54 a	15.47 a	17.66 a	71.89 a	3.55 a	32.16 a
Blue non perforated	3.13 a	4.10 a	1.84 a	17.04 a	12.88 b	73.21 a	0.92 b	34.97 a
Cheese Cloth	3.12 a	3.35 b	1.96 a	17.34 a	13.98 b	80.85 a	1.03 b	39.14 a

Means in a column followed by the same letter are not significantly different (p>0.05) using Duncan Multiple Range Test (DMRT)

Table 6. Effects of bunch covers on yield performance of Williams's banana variety in 2013

Treatment Tree bags	Weight hands (kg)	Defects (kg)	Weight (kg)	Total Fruit Weight (kg)	Marketable Weight (kg)	Marketable Percentage (%)	Box stems ratio (BSR)	Yield (ton/ha)
Control	2.30 b	6.19 a	1.45 b	15.94 a	9.75 a	60.71 a	0.72 a	27.29 b
Green perforated	2.73 a	4.99 b	1.55 a	15.89 a	10.90 a	67.93 a	0.80 a	30.52 a
Green non perforated	3.02 a	5.03 b	1.47 a	15.77 a	10.75 a	67.23 a	0.79 a	30.07 a
White perforated	2.75 a	4.70 ab	1.62 a	16.20 a	11.50 a	70.28 a	0.85 a	32.18 a
White non perforated	2.79 a	6.46 a	1.53 a	16.24 a	9.78 a	59.19 a	0.72 a	32.19 a
Blue perforated	2.70 a	4.53 b	1.47 a	15.13 a	10.61 a	69.76 a	0.78 a	29.71 a
Blue non perforated	2.68 a	4.65 b	1.63 a	15.80 a	11.15 a	68.55 a	0.83 a	31.22 a
Cheese Cloth	2.81 a	4.42 b	1.71 a	15.51 a	11.09 a	70.68 a	0.82 a	31.06 a

Means in a column followed by the same letter are not significantly different (p>0.05) using Duncan Multiple Range Test (DMRT)