

DILLA UNIVERISTY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF HORTICULTURE

EFFECT OF PRE-HARVEST BUNCH COVERING MATERIALS ON YIELD AND QUALITY OF BANANA

M.SC. THESIS

BY

ABEJE ABREHA BARAKI

JUNE, 2019

DILLA, ETHIOPIA

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M.SC. THESIS SUBMITTED TO DEPARTMENT OF HORTICULTURE, COLLAGE OF AGRICULTURE & NATURAL RESOURCE, SCHOOL OF GRADUATE STUDIES, DILLA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN HORTICULTURE

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M.Sc. RESEARCH THSIS ADVISORS' APPROVAL FORMAT

This is to certify that the thesis entitled "Effect of Pre-Harvest Bunch Covering Materials on Yield and Quality Banana" submitted in partial fulfillment of the requirements for the degree of Masters' with specialization in Horticulture, the Graduate Program of the School of Dilla University, and has been carried out by Abeje Abreha Id No RPGHor-001/17 under our supervision. Therefore, we recommended that the student has fulfilled the requirements and hence here by can submit the thesis to the department.

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Name of major advisor Signature Date

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Name of co advisor Signature Date

DEDICATION

I dedicate this thesis manuscript to all my family members**,** for nursing me with affection and love and for their dedicated partnership in the success of my life.

STATEMENT OF AUTHOR

First, I declare that this thesis is a result of my genuine work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an advanced MSc degree at the Dilla University and is deposited at the University Library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author was born on November 1976 EC in Alaje, Southern zone of Tigray regional state. He attended and accomplished his elementary school, secondary school and his preparatory school in Wedishire elementary, Mekelle High school and AtseYohannees fourth comprehensive high school respectively in Mekelle town. He joined Mekelle University in 1997 and graduated with the degree of Bachelor of Science of Dry land crop and horticultural science (Agronomy stream) in 1999. After his graduation, he was employed as an expert of crop production in Gamo Gofa zone where he worked for nine years. In 2009, he joined the school of graduate studies of Dilla University to pursue a study leading to the Degree of Masters of Science in Horticulture.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
GoIMoA	Government of India Ministry of Agriculture
CFC	Common Fund for Commodities
CSA	Central Statistical Agency
CV	Coefficient of Variation
FAO	Food and Agricultural Organization of United Nations
FAOSTAT	Food and Agriculture Organization Statistical Database
FDRE-PCC	Federal Democratic Republic of Ethiopia, Population Census Commission
PAR	Photo synthetically Active Radiation
LSD	List Significant Difference
Qth^{-1}	Quintal per hectare
m.a.s.l	Meter above sea level
RCBD	Randomized Complete Block Design
RH	Relative humidity
SAS	Statistical Analysis Software
TSS	Total Soluble Solids
TTA	Total Titrable Acid

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Effect of Pre-Harvest Bunch Covering Materials on Yield and Quality Banana

ABSTRACT

Banana is becoming an important tropical fruit in Ethiopia, however, its production and quality is highly affected by pre and postharvest factors. The current research was conducted at Arba Minch area of Cnano Mile nursery and Training Center to evaluate the Effect of pre harvest bunch covering materials on yield and quality of banana. Four types of bunch cover bags (blue polyethylene, green polyethylene, white polyethylene and gunny bag) along with control (no cover) were tested on two banana cultivars (Grand Naine and Williams) in the already established orchard. ninety banana plants that have the same flowering stage were taken from both cultivar and the experiment was organized using ten treatments in three replication, in which one treatment accommodated 3 plants, using Randomized Complete Block Design (RCBD).The selected banana plant bunches were covered at the stage when fruits starting curled up and floral ruminant's start to drying in which the time 2-3 weeks after flowering (opening the first hand). At the time of physiological maturity bunches were harvested and randomly taken one bunch from each treatment and totally 30 bunches for data collection. Physically measurable data on fruit yield character and quality parameter as visual appearance was measured at the time of harvesting; while post harvest quality parameters were recorded after samples ripened. Significantly ($p < 0.05$) minimum days (108.2 days) were recorded in Williams cultivar compared to (114.2 days) in Grand Naine cultivar from flowering to physiological maturity. Covered bunches showed v5ery highly significant ($p < 0.001$) variation exhibiting minimum fruit bruises and existence of dirties in comparison to bunches without covers. The highest (160.75 g) fruit weight were recorded from blue polyethylene bag showing very highly significant ($p < 0.001$) difference (134.83g) from no covered bunches. Maximum fruit length (18.42 cm) from blue cover and minimum fruit length (15.58 cm) from bunches covered by gunny bag and control was recorded. The highest (11.5 cm) and the lowest (9.83 cm) fruit girth was recorded from bunches covered by blue and control, respectively. Similarly, highest (18.92 kg) and lowest (15.83 kg) bunch weight were observed in bunches covered by blue polyethylene bag and control, respectively. The productivity was ranged between 31.53 tone/ha and 26.67 ton/ha and 26.79 ton/ha, with highest value recorded from bunches covered by blue, and the lowest value observed from gunny bag and control in respective order. Highest (2.68) Pulp to peel ratio was recorded from blue covered fruits and the lowest (2.26) recorded from gunny bag covered fruits. Highest (22.33) and the lowest (18.5) TSS was recorded from blue and control respectively. Grand Naine cultivar recorded significantly ($p<0.05$) higher values in fruit weight (148.63 gm), fruit length (16.91cm), fruit girth (10.93 cm) , bunch weight (17.4 kg), productivity (29 tone/ha), and pulp to peel ratio (2.47) than Williams cultivar. Parameters such as days to physiological maturity, number of fruits per hand, hands per bunch, length of bunch and acid percentage didn't significantly ($p>0.05$)influenced. Yield parameters of fruit height, girth, weight, bunch weight, productivity and quality parameters of pulp to peel ratio and TSS were positively influenced bunch cover types. Among the cover types tested in this experiment the blue one was found to be the superior of others depending on all the influenced parameters.

Keywords: Bunch cover, banana quality, Banana yield, Grand Naine, Williams

1 INTRODUCTION

1.1 Back Ground of the Study

Banana is one of the major growing fruits in many developed and developing countries in the world. Banana and plantains (*Musa* species) are indigenous to Southeast Asia and the Pacific, in which banana refers fresh fruit types and while plantains refer to cooking types (Nayar, 2010). Banana is rich source of nutritional values such as carbohydrates, potassium, fiber, magnesium, as well as vitamin C, B6 and A (Dodo, 2014). The main production area lies between 30˚ North and South latitudes at about mean temperature of 27 °C optimal for growth and the minimal temperature for growth is about 16 °C with 100 mm of average monthly rainfall distribution.

Globally, banana is the fourth most important crop of the food market next to rice, wheat and maize in 2010, world commerce in banana was valued at US Dollar 8.05 billion and the total world production of banana was about 106,541,709.00 tons in 2013 (FAOSTAT, 2016). This makes banana to be the prime leading fruit crop in terms of volume and value in the world market. For many African, Asian and Latin American countries, banana is one of the most important crops for foreign exchange earnings (FAOSTAT, 2012). In 2014, total world export of bananas was reported to be about 11 billion dollars (Workman, 2015).

In Ethiopia, Especially in the south and southwestern parts, it has a great socioeconomic importance, contributing much to the overall well-being of rural communities including food security, income generation, and job opportunity creation (Woldu *et al*., 2015). Banana is mainly used as a source of income for subsistent farmers and also used for local consumption as a fresh fruit (EHSS, 2015). From107, 890.60 hectares of land cultivated for fruit crops, banana contributed about 58.59% followed by avocado (16.53%) in 2016/2017 (CSA, 2017). Gamo Zone of the SNNPR is the leading banana producer in Ethiopia (Alemu, 2017).The production of banana in this Zone contributes 70% of the total banana market supply of the country (CFC, 2004).

According to Livestock and Irrigation Value Chains for Ethiopia Smallholders (LIVES, 2014b) report, The Southern Nations, Nationalities, and Peoples (SNNP) regional state is the

main banana producing region in Ethiopia and the Arba Minch, Bench Maji, and Sidama areas are the major banana producing districts in the SNNPR state in Ethiopia, of which Arba Minch alone covers over 80% of the domestic market share in Ethiopia. According to LIVES (2014a) report, the banana yield per unit area of land declining in Arba Minch area; and fluctuation in productivity from improper agricultural activities (CSA, 2015; Gezimu and Rik, 2016; Mamuye, 2016).

The major commercial cultivars grown by small-scale growers across the study areas are Dwarf Cavendish, Giant Cavendish (Williams or Robusta), Grand Naine and Poyo which belongs to the monospecific triploid bananas (Cavendish sub group of AAA genome) cultivars (Woldu, 2015). Goncalves and Kernaghan (2014) and stated that the Cavendish sub group is the most important in the world market and encompasses the majority of exporting cultivars such as the Williams and Grand Naine and these are the bananas to be found in most supermarkets in European countries. Bakry *et al*. (2009) consistently reported that, the main banana cultivars for export markets known's Grand naine, Poyo and Williams.

Banana markets have high commercial significance and the demand for quality produce becomes increases from time to time (Lindsay *et al*., 2004). As Amarante *et al*. (2002) report showed that, improved quality includes appealing skin color, reduced sunburn, reduced fruit splitting and increased fruit grade (length, girth and weight) and bunch weight are few of them. To enhance the quantitative and qualitative aspects of banana fruit, there should be an effort to protect banana bunches, specifically for the dessert.

To improve the yield and quality of banana fruit, different protection bags with various colors, in the form of perforated and non-perforated type have been extensively used in both tropical and subtropical banana growing countries and then becomes mandatory to use covering materials as a minimal satandard (Amani and Avagyan, 2014; Muchui *et al*., 2010; Stover and Simmonds, 1987). Protection of young bunches of fruits with polyethylene bag covering is one of the measures use in the producers countries (Amani, 2007). Some of the quality and quantitative parameters that can be improved using protection bags are acceptable skin appearance and color increase in fruit length and bunch weight as well as reduced fruit defects for example sunburn and fruit splitting (Amarante *et al*., 2002).

Inside the covered bunches by polyethylene bags it creates confined microclimate as temperature and humidity and decreasing direct contact of radiation around the fruit surface and this could help in proper finger growth and development (Sarkar ., 2015; Pathak *et al*. 2017). This could be due to the green house effect inside the cover where in the filling rate becomes higher than the uncovered.

Physically bunches (especially for dessert banana) should be free from spots, bruises, harbor of spiders and insect webs and any attacks. To protect this problem and to maintain the physical quality, banana bunch protection sleeves are used throughout the commercial banana growing areas of the world. Using these bags have advantages on protecting physical appearance as caused by sunburn, dust, cold temperature, rain, quantitative increment in the production, expressed by bunch weight, fruit grades (length, width and girth) and internal post-harvest quality characters as sugars, total soluble solid (TSS), acid percentage and shelf life, etc (Muchui *et al*., 2010; Shwet *et al*., 2018). As Dadzie and Orchard (1997) stated that, assessment of bunch weight and fruit characteristics such as fruit weight, length, circumference and volume are important post-harvest selection criteria and assessment of the post-harvest quality attributes (such as peel and pulp colour, pulp firmness, total soluble solids, moisture and dry matter content).

Quality of bananas in terms of external appearance, internal quality and standard sizes are influenced by several factors such as favorable environmental condition and pre-harvest production practice like bunch covers application (Hewett, 2006). The internal quality attributes such as texture, sweetness, aroma, acidity, flavor and presumed nutritional values of the fruit are important in ensuring repeated purchasing by the consumers (Hewett, 2006; Shewfelt, 2009). Covered bunches of banana have better internal quality parameters like shelf life, TSS, total sugar and non-reducing sugar (Surajit, 2014). The above author stated a probability of this increment is due to the high temperature under covered which favored the conversion of starch in to sugars.

In Ethiopia there is a favorable agro ecological suitability for banana production such as temperature, rainfall, irrigation, soil type and market demand. But current productivity of this crop is far below the potential which can produce under good agricultural practices. As CSA (2016/17) report showed that from the total hectare of 63,212, the total production is

53,8,302.3 tones with average productivity of 8.5 tha^{-1}, which is less in 43% compared to the world average productivity of 19.74 tha^{-1} (FAO, 2014). In addition to this low productivity, there is low quality of the produce. External appearances are significantly influenced by pre-harvest production practices and post-harvest handling problems. Pottes *et al*. (2014) reported that the export amount from Africa is low despite the fact that nation is one of the world's producers of banana.

The physical appearance of the peel is especially important in the highly competitive export market with uniform colored and with blemish-free peels. Among the causes of low productivity and quality of the produce in Ethiopia, low plant management practices, lack of bunch cover technologies and unfavorable packaging and transporting technologies and blowing dust and debris which hits the delicate outer skin that cause cellular damage and subsequent fruit scarring are the major ones. In addition, the blowing of adjacent leaves and rubbing of leaf petioles onto the developing bunch can cause considerable physical injury and abrasion damage to the fruit peels. Pre-harvest insect feeding is also a main cause of peel damage to bananas (Shanmugasundaran and Manavalan, 2002). Direct sun creates sun burn on upper surface of the fruits which can't compete in the world market.

1.2 Statement of the Problem

Due to the above-mentioned quality problems; Ethiopia doesn't get the opportunity to penetrate the export market for banana. Therefore, the production of banana is limited only for local market. In the case of Arba Minch area attempts were started to export banana to Saudi Arabia in the year 2011, however, after few markets the export system was terminated immediately within that year due to the low price than the local market and due to the lack of the protecting bags of minimal requirement. This may happen because of the quality problem due to pre harvest and/or postharvest factors that might result to low grade banana. Because of bunches was without cover, the upper hands were sunscald and the lower hands were under weighted, in which the buyers sorted out. Therefore, it is vital to improve the pre-harvest and post-harvest handling mechanism to improve fruit yield in the case standard grade characteristics and maintain post-harvest quality aspects to change the current problem of banana industry in the study area. Not only for increasing yield and quality, using by itself the covered bunch is becoming mandatory for the global market. Thus, considering the above

problems the current study was conducted aimed to the following general and specific objectives.

1.3 Objectives

General Objective:

❖ The general objective of this study is to improve the quantity and quality of banana fruit production through identifying appropriate pre harvest bunch covering materials.

Specific objectives:

➢ To evaluate the effect of different pre harvest bunch cover materials on yield characteristics of Grand Naine and Williams cultivars of banana fruit

➢ To evaluate the effect of different pre harvest bunch cover materials on physical and chemical quality of Grand Naine and Williams cultivars of banana fruit

2 LITERATURE REVIEW

2.1 Banana Plant Botanical Description

2.1.1 Origin, distribution and cultivation

Banana and plantain are belongs to the *Musacea* family and to the genus *Musa*. A wide variety of historic references mentioned that the origin of bananas is South East Asia, in jungles of Malaysia, Indonesia and the Philippines where a number of varieties of wild bananas presently grow (Samson, 1980). According to Daniel *et al*. (2001) the dispersal of banana out of East Asia was as a result of human movement across the world. The main production centers of banana cover the humid tropics, subtropics and arid tropics of the wide range of areas from 175 ° E to 150 ° W longitude and from 30° N latitude and 23°S of the tropics with well distributed rainfall that exceed 2000 mm and warm temperature around 25-30°C (Nayar, 2010). According to Smale (2006) in East Africa bananas have evolved in to an important zone of secondary genetic diversity for the east African highland bananas (*Musa* AAA).

Genetically the *Musa* species are grouped according to chromosome number (ploidy) sets they contain and the relative proportion of *Musa acuminata* (A) and *Musa balbisiana* (B) in their genome. Most familiar, cultivated varieties or cultivars are triploid hybrids (AAA, AAB, and ABB), diploids (AA, AB, and BB) and tetraploids (AAAA, AABB, and ABBB). Fruits of *Musa* species are typically sterile or have extremely low fertility and they produce fruit pulp without pollination and fruit lacking seed (i.e. they are parthenocarpy); although sterility and parthenocarpy are important factors that contribute to the continued desirable characteristics of banana fruits it has impeded or hinders the progress in breeding programs (Nelson *et al*., 2006). At this time banana cultivation continues to be one of the principal agricultural activities for many countries of Latin America, Asia, Caribbean and Africa (FAO, 2012).

From the *Musa* AAA genome the Cavendish subgroup cultivars of Grand Naine and Williams are highly distributed and commercially cultivated and popular fruits. Grand Naine is a tall saturated plant and a heavy yielder with long cylindrical bunch. On an average it produces a bunch weighing 25 kg and may go up to 32-35 kg with 8-10 hands with 200-220 fruits/bunch.

The length of the fruit is 15-21 cm and girth is 12-13 cm and it has better tolerance to abiotic stresses (GoIMoA, 2015). The cultivar Williams is believed to have first appeared as a tall mutant in a dwarf Cavendish plantation in Australia in 1910 and it was introduced in Hawaii in 1953. Fruits are 15-20 cm long and slightly curved. It is highly susceptible to black leaf streak, it is resistance to fusarium wilt of race 1, but susceptible to race 4, have good tolerance to wind and cold and it is less sensitive to water stress than Grand Naine (Weber *et al*., 2017).

2.1.2 Nutritional and medicinal value of banana

Banana is a climacteric fruit made up of peel counting easily for 30% of the total fresh weight of the fruit, and edible pulp that has a high nutritional value. Ripening determines the essential appearance and taste qualities such as bright yellow-colored skin, flavors, consistency of pulp and starch-sugar transition of dessert bananas.

Bananas are an excellent source of potassium, in which a single banana provides 23% of potassium recommended for daily intake. Potassium is an important macronutrient that helps to maintain a proper muscles function in preventing muscle spasms and reduces risk of stroke (Singhal, 2002). In addition to this it is excellent source of vitamins including vitamin A which aids in healthy teeth, bones and soft tissue; vitamin B6-aids the body's immune system, promotes the health of brain and heart; vitamin C- aids in healing, growth of tissue and ligaments; Vitamin D- helps the body to absorb calcium and Vitamin B6 which plays a great role in the body's immune system, promotes brain and heart health. Banana is great source of energy and can provide the necessary energy to complete a longer workout (Kumar *et al*., 2012).

Banana has also a medicinal effect by being mild laxative for constipation problems in children, used to heal the intestine lesions, and it forms the part of diets of children suffering from malnutrition (Kumar *et al*., 2012).

2.2 Banana Production and Economic Importance

The export market of desert banana is mainly covered by Cavendish subgroup cultivars that are genetically very similar with respect to disease response (Gibert *et al*., 2009). Banana production in Ethiopia is mainly composed of different farming systems; small scale

plantations owned by subsistent farmers, medium-sized plantations producing up to 10 ha by local farmers who supply for local consumers, and large-scale plantations that cover above 20 ha of production area for local consumers and for export markets. CSA (2017) reported that in 2016/17 "meher" season (a production season from September up to February) bananas contributed about 58.59% with a production area of 63,212.97 ha from the total area of cultivable land covered for fruit production (107,890.60 ha).From the total fruits production that accounts 7,923,665.02 qt, banana production was 5,383,023.41 qt by contributing 67.94%for the same year reported above. SNNPR state of the country is the leading banana producer region which accounts 68.72% by covering 37,076.85 ha land for banana production, which accounts 77.53% (370,784.17 tones) of production by 22.38% (1,504,207) of the banana producers.

From this total production GamoGofa zone covered 70 % of the total banana market supply (2004). This has favored the region to benefit from increased food security, income generation, employment opportunities and the enhancement of local and regional economic developments (Woldu *et al*., 2015; CSA, 2014; CFC, 2004). Banana production in Arba Minch area of Gamo zone dates back to the early 1980s, where the then Arba Minch State Farm had about 62 hectares of land covered by the Dwarf Cavendish banana Cultivar. During that time the crop lands of the smallholder farmers were occupied by maize, cotton and sweet potato and there were frequent trials which were held to introduce the crop to the nearby Lante area, even though that effort was not successful at that time with the rationale banana was not perceived as an important income generating as well as nutritional crop.

The Arba Minch banana, as a result of its taste, is the most preferred cultivar of banana in the country and has the highest demand throughout the markets of the country at present. Irrigated banana production (Dwarf, Medium height and Giant Cavendish) presently covers about 11,000 ha of land in Arba Minch Zaria and Mirab Abaya woredas (Alemu, 2017).

2.3 Banana Export Characteristics

Banana is easily producible food crop with a number of useful properties which is consuming in both production and non-production areas of the world. For export purpose, the standards quality parameters for banana are like shape and size of the fruit, freeness from blemishes,

and uniformity in color development. The first class of fruit length packs usually have a minimum length of 19 – 20 cm, and other packs range down to 15 cm. Clusters with fruits less than 15 cm are not usually exported (Stover and Simmonds, 1987). The total number of fruits per bunch varies from 128 to 202 fruits, and the number of hands per bunch varied from 8-11 hands. The number of fruits per hand is always constant from the fourth to the last hand and range from 13-18 fruits (Astroga, 1998).

Banana usually harvested at the mature green stage and transported to distant markets, therefore evaluation of banana fruit in its green state is very important characteristics for export market. During transport, the fruits should remain firm, green and without any significant change in skin color, texture or composition for two to three weeks depending on the storage conditions during transit and stage of maturity at harvest. Consumers use visual quality to purchase fresh produce and market returns for banana in international markets are generally greatest for large fruit that are blemish-free (Shewfelt, 2009). The domestic markets can allow a degree of tolerance for superficial damage caused by insects. However, external blemishes caused by bunch pests are totally unacceptable for the discerning export market, where quality standards are strict. Several insects are primarily responsible for peel damage, including thrips, fruit scarring beetles, and the tar honey wasp.

2.4 Characteristics of Bunch Cover Materials

The color of bunch covers acts as a filter of photo synthetically active radiation (PAR), the wave lengths between 400 and 700 nm that are used during photosynthesis. PAR is essential for photosynthesis and fruit growth, and its transmission is controlled by colored plastic materials. Light interception and PAR are higher inside the transparent polythene bunch cover over blue polythene bunch cover (Sarkar, 2014). In comparison, Colors such as red, green and blue absorb a higher proportion of selected wave lengths from the PAR range, but white materials absorb all wavelengths equally and transmit a reduced uniform spectrum (Connellan *et al*., 1988). Blue covers receive 73% of the wavelengths of the PAR; whereas transparent ones receive 93%. Most of the banana production uses blue bunch covers that produce heavier bunches because it lets in the heat without causing burns because it blocks ultraviolet (UV) rays (Muchui *et al*., 2010).

2.4.1 Effect of different bunch covers on fruit yield characteristics

Banana fruit protection bags are used throughout the commercial banana growing areas of the world. These bags are mainly used to improve fruit production and quality, especially fruit intended for the export markets. Fruit protection bags of various colors, perforated and non-perforated, have been extensively used in both tropical and subtropical banana growing countries to improve yield and quality (Muchui *et al.*, 2010). Some of these quality and yield parameters include acceptable skin appearance and color, increase in fruit length, number of fruits per hand and bunch weight, increased total bunch weight as well as reduced fruit defects for example sunburn and fruit splitting (Amarante *et al.*, 2002).

Banana fruit components like total bunch weight, bunch length, number of fruits per bunch, fruits length and fruit weight significantly influenced by white polypropylene bunch cover treatment with the highest bunch weight of 15.25 kg. The use of transparent and blue polythene covers enhanced fruit yield by 20 and 16% respectively over the control (uncovered bunches) (Weerasinghe and Ruwapathirana, 2002). Robinson (1996) also reported that a 16.5% increase in bunch weight was recorded for the cultivar Williams cultivar due to a 10% increase in fruit length, and the author assumed that the increment might happened due to increased temperatures (0.5˚C) under blue covers that favored growth. There is also a research finding that state bagging bunches with transparent and blue polythene covers increase the size and weight of fruits (Weerasinghe and Ruwapathirana, 2002). Covered banana bunches in Dwarf Cavendish cultivar resulted a bunch weight of 14.5 kg as compared to uncovered bunches (11.50 kg)which showed a significant difference (Mukharjee, 2006).

Anon (2012) recorded the highest bunch weight (35.68 kg) and fruit weight (221.7 g) covered with blue polypropylene sleeves followed by white polypropylene bunch sleeves which recorded a bunch weight of 34.5 kg for Cavendish subgroup Cv. Grand Naine. In contrast, the uncovered bunch recorded the least bunch weight (32.88 kg) with average fruit weight of 198.5 g. In high density planting (1.2 x 1.2 m) Cavendish subgroup Cv. Robusta, the use of bunch covers significantly increases the fruit weight and fruit diameter of 234.9 g and 4.3 cm, respectively as compared with the uncovered bunches with a fruit weight and fruit diameter of 199.8 g and 3.8 cm, respectively (Reddy, 1989).

Sarkar *et al*. (2016) reported that nonwoven polypropylene skirt bag in comparison to the normal farmers' practice, without covering the bunch showed fruits under bunch cover revealed significantly lower scarring beetle infestation (1.8%) as compared to fruits of uncovered bunches (98.5%). Significant increase in fruit weight and bunch weight were recorded to the tune of 7.5% and 4.4%, respectively, whereas shooting-harvest interval was reduced by 8 days under cover as compared to control. Banana fruits grown under cover had minimal bruises (2-5%) and were significantly cleaner from dust, spider web, and bird drops at harvest over control (50%).

The influence of different bunch covers (blue non-woven polyethylene bag, transparent polyethylene bag, leno bag and gunny bag*)* on banana were showed significant difference over none cover bunches of fruit length, fruit girth and bunch weights; Length and weight of banana fruit contribute to the commercial worthiness of a banana fruit. Through this demonstration, the highest fruit length (17. 65cm) is recorded from blue non-woven polyethylene bag and the least fruit length 15.26 cm from control (none cover), similarly in the fruit girth or diameter was gained from white none-woven polypropylene bags (11.71 cm) and in the case of total bunch weight, the highest 18.5 kg was recorded from white none-woven polypropylene bags and the uncovered was 14.88 kg. (Pathak *et al*., 2017)

2.4.2 Effect of bunch cover on fruit post harvest quality characteristics

The visual appearance of foods is a major factor in their perceived quality by consumers. Consumer's first impression frequently determines the acceptance or rejection of foods, even before they enter the mouth. In general, total appearance of an object consists of visual structure, color, gloss, translucency and their patterns, and surface texture. In addition to these visual quality parameters there are basic quality determinant factors, such as green life, pulp and peel ratio, total soluble solids, sugar contents, moisture and dry matter contents are important in determining fruit maturation and quality (Dadzie and Orchard, 1997). Sugars are the main soluble solids in most ripe fruits including bananas. Since the amount of TSS in fruits usually increases as they ripen, they can be a useful index of stage of ripeness. A significant reduction in peel surface damage from insect pests may be obtained by covering the banana bunch shortly after pollination. The chaffing of fruit from leaves during growth

has also been reported to be eliminated by bunch covers (Weerasinghe & Ruwapathirana, 2002).

The net effect of bunch cover use is better fruit quality and increased marketable yield. Banana bunch covers allow for production of high quality banana fruits that are not bruised and hence have acceptable visual appearance. Export quality includes appealing skin color, reduced sunburn, reduced fruit splitting, and increased fruit length and bunch weight among others. High air temperatures (greater than 38 ^{0}C) and bright sunshine are associated with sunburn damage on exposed fruit, especially on the top hands of the bunch, so care is needed by using protective bags (Turner, 2013). Perforated covers are commonly used to reduce sunburn damage for export production overseas (Daniells & Lindsay, 2005). In addition, banana bunches were protected against the pests and diseases such as thrips, beetles, pitting, anthracnose, tip end rot, cigar end rot, brown spot and diamond spot (Amani and Avagyan, 2014). In respect to different bunch cover colors different results gained from different researchers. Muchui *et al*. (2010) reported that banana production areas mostly use the blue covers as they let in heat without causing sun scald, because it blocks UV rays. These bags allow faster & more trustworthy harvest with adequate ripening of the banana.

These also protect from external natural conditions (wind, rain, sun damage, etc.) and prevent mechanical injuries as marks and scratches. Transparent covers treated to block UV 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).Bunch covering had significant effect on the pulp/peel ratios of fruits of cv. Williams at harvest and during ripening. It was seen that in bananas, the pulp portion continues to grow even in the later stages of maturation, skin color development and other post-harvest qualities (Nakasone and Paul, 1998; Turner, 1997).

Muchui *et al*. (2010) reported that using perforated blue polypropylene bunch cover on cultivar Williams result showed that the bagged fruits had minimal bruises (2 to 5%) and were significantly cleaner from dust, spider webs and bird droppings at harvest compared to the un bagged fruits (>50%). The covered fruits were therefore more visually appealing, cleaner compared to the un-bagged fruit. Many authors have reported that the significances of banana bunches with covers on the effect of decreasing the physiological maturity period for

harvest; Santosh *et al*. (2017) 12 days; Sarkar *et al*. (2016) 8 days; Anon (2012) 7.5 days earlier harvested than bunches without cover. In Grand Naine cultivar fruit characters and fruit quality parameters like pulp-peel ratio (3.08) and TSS (27.8^{o}Brix) were the highest in bunches covered with blue sleeves (Anon, 2012).This significance result supported by Sarkar (2014) in Grand Nine cultivar that showed covered bunches have more TSS than the uncovered bunches.

Choudhury *et al.* (1997) work in Dwarf Cavendish reported, best quality fruits (21.67% TSS, sugar-acid ratio of 71.33, ascorbic acid content of 0.43 mg per fresh weight and protein content of 2.03%) were obtained from the bunch covered with white polyethylene as compared to uncovered bunches (16.33% TSS, sugar-acid ratio of 65.82, ascorbic acid content of 4.25 mg per 100 g fruit weight and protein content of 1.92%).

3 METHODOLOGY

3.1 Description of the Study Area

The study was conducted in Gamo zone,Arba Minch Zuriya district (woreda) of SNNPRS at "Chano Mile Nursery and Training center" .The Woreda was located about 505 km south west of Addis Ababa and has a total of 29 rural Kebeles (the smallest administration unit in the country). Four of the kebele found in highlands agro ecologically, 15 of them found in mid-altitude and the rest 10 in the low land zone. The district has a total area of 168,172 hectares of land and a total population of 239,408 (including Arba Minch city) with specific geographic location of $37^{0}36'32.56"$ East longitude and $6^{0}6'44.716"$ North latitude at 1186 m.a.s.l..The altitude of the district ranges from1500 – 3300m.a.s.l. with bimodal annual rainfall amount from 600 - 1200 mm and temperature from 16- 37˚C with a relative humidity of 50-90 %. The soil black vertisols and clay loam in textures.The district had located surrounding the two Rift Valley lakes namely Chamo and Abaya lakes that have a great economic as well as ecological values to the area.

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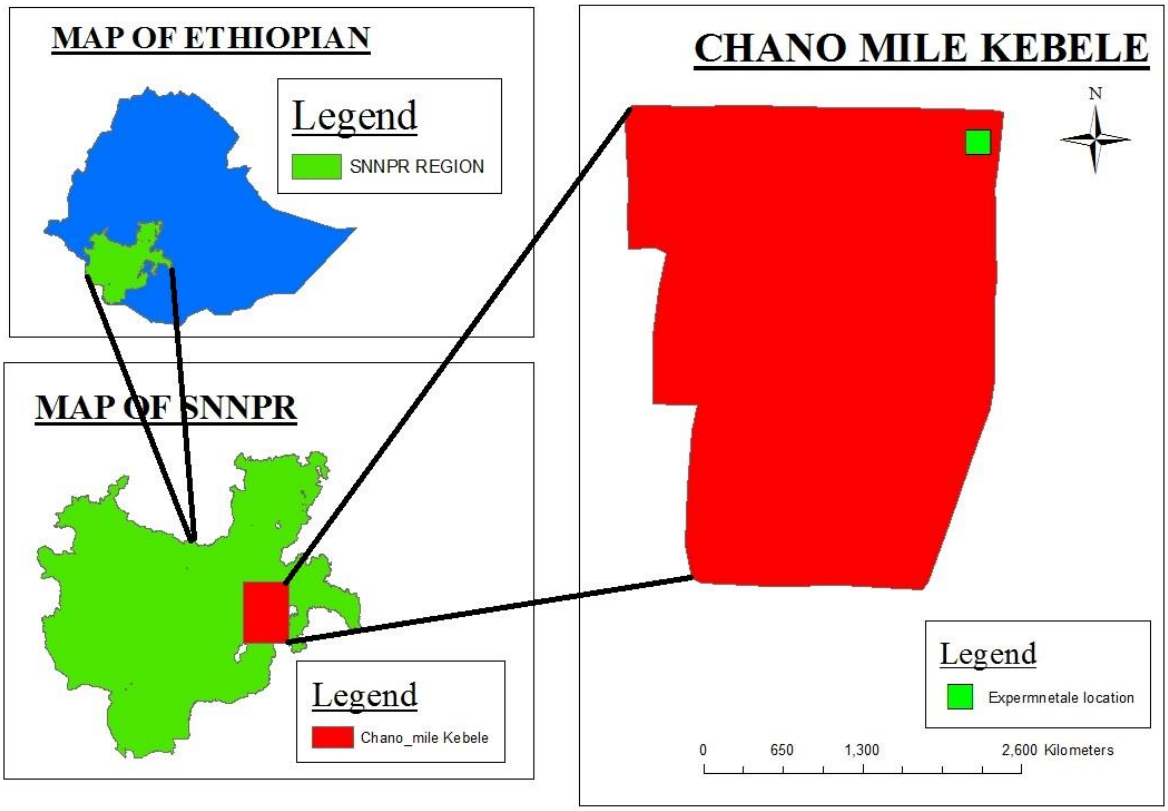

Figure 1 Map of the study site

3.2 The Experimental Design

The experiment was conducted using randomized completed block design (RCBD design) in factorial arrangement using four covering materials (blue polyethylene, green polyethylene, white polyethylene, gunny bag along with control without cover (control)) applied on two banana cultivars with three replications. For each treatment three plants or bunches were selected from the already newly established banana orchards of two Grand Naine and Williams banana cultivars. The orchard is plant crop i.e. the first cycle not ratoon crop. The reason for selecting these two cultivars was due to the availability, known and well organized of these cultivars in the nursery site rather than the others. The experimental treatment arrangements were as follow

Factors 1: Four different cover types (blue, Green, white polyethylene and Gunny bag) with control

T1- Blue polyethylene bunch cover plastic

T2- yellow polyethylene bunch cover plastic

T3- white polyethylene bunch cover plastic

T4- gunny bag

T5- Control (no bunch cover)

Factor2: banana cultivars (Grand Naine and Williams)

V1 - Grand Naine

V2- Williams

Total treatment combinations are:

T1V1- Blue polyethylene bunch cover in Cv. Grand Naine

T2V1- Green polyethylene bunch cover in Cv. Grand Naine

T3V1- white polyethylene bunch cover Cv. Grand Naine

T4V1- Gunny bag cover in Cv. Grand Naine

T5 Control (No bunch cover in Cv. Grand Naine)

T1V2- Blue polyethylene bunch cover in Cv. Williams

T2V2- Green polyethylene bunch cover in Cv. Williams

T3V2- White polyethylene bunch cover in Cv. Williams

T4V2- Gunny bag bunch cover in Cv. Williams

T5 – control (no cover) in Cv. Williams

Design = RCBD (factorial)

Number of treatments = 10

Number of replications = 3

For this experiment three colored types of polyethylene bags and one gunny bag were used with the height of 1.5m height and 40 microns density. The gunny bags (sacks) were obtained from local markets.

3.3 Experimental Management

The spacing for banana orchard was established using a total area of 30m by 50m having gentle slope (<5%) and spacing of 2m (between plants) by 3m (between rows). Banana plants

with similar stages of flowering were randomly selected by counting the number of each plant in the row from each cultivar. To each treatment three plants that start blooming (opening of the first hand) were tagged by taking the row number and the number of the plant in the row in paper. Selecting plants was caring to get the same stage (not over a week difference to flower).

Mechanically, weed control was done by proper cultivation and hand picking throughout the field. Regular, routine removal or detrashing of the dead leaves was done to encourage growth and vigor of the plant and reduce the incidence of leaf and fruit diseases.

Desuckering, which is the removal of unwanted suckers was done by leaving only two suckers with one mother plant for all.

Debelling, was done after filling the last hand and removal of floral remnants which could help to increase bunch weight by preventing further meristem growth and to direct the plant photosynthetic energy. The bell also is a potential center for thrips and mites.

Propping (Bunch support), was done by a strong stick to prevent the bunched plant from toppling during windy conditions and over weighted bunches.

Banana cultivars, Grand Naine and Williams were taken from the already existed banana orchard in Chano Mile nursery and training center in Arba Minch area. The source of planting, selected banana cultivars was first established by the then Ethiopian Horticulture Authority in 2012 by taking tissue cultured planting materials from Melkasa Agricultural Research Center to the center. From both banana cultivars (Grand Naine and Williams) 90 bunch (45 bunches from each) was randomly selected and tagged (that selected plant were recorded in a paper by its number with intra and inter row number). Two to three weeks after flowering (the time at which fruit curled upward and the flower remnants at the base of the fruit become hard and dry), the flower bud was cut down and the bunch covers slide up from the bottom of the stalk and securely tied above the first hand of fruit until harvested

3.4 Data Collection

Data collection was done by randomly selected one bunch from each treatment (total 30) when the banana fruits reached three-quarter of its maturity; in which the fruit in the upper

hand were changed to light green and the flower remnants were easily rubbed off the tips. To reduce variation and to obtain consistent data, all measurements were taken on the fruits of the second hand (cluster) (Amin *et al.*, 2015). From each selected treatments data were taken to measure physical yield characteristics such as; evaluation of visual appearance (degree of cleanness and bruise) in percentage and in scale, days taken from the time of flowering to physiological maturity (NDM), bunch weights (in kg), bunch length (in cm), number of hands per bunch, number of fruit per hand, fruit length in cm and weight in kg, fruit girth (circumference) in cm, as well as yield in tha^{-1}andand data of chemically (post harvest) quality aspects recorded after repining; pulp to peel ratio, total titrable acid percentage (TTA) and total soluble solids (TSS) in ^{o}brix. For all parameters tested in the experiment five fruits for each was taken from the second hand of the bunch (Dadzie and Orchard, 1997).

3.4.1 Evaluation of visual appearance

After harvest the fruit were checked for the incidences of different dirt's like dust, bird droppings, spider webs and injuries (blemishes). Percentage surface area covered was rated based on the Merz 0 to 6 scale (Merz, 2000), adopted for surface area covered by dirt instead of lesions where, 1=0 to 2%, 2=2 to 5%, 3=5 to 10%, 4=10 to 25%, 5=25 to 50% and 6=>50% of the surface area covered by the blemishes, dust and spider webs.

3.4.2 Days taken from flowering to maturity

The total number of days required from the time of flowering (opening of the first hand) to physiological maturity of bunch (when the color changes from dark green to light green) was recorded and expressed in number of days.

3.4.3 Fruit weight (gm)

Randomly selected five sampled fruits taken from the second hand of bunch were weighed and reported the average weight in grams.

3.4.4 Fruit length (cm)

Five fruit samples for fruit grade (length, weight and girth) from the second hand of the bunch were taken (Dadzie and Orchard, 1997). From each bunch of the samples, fruit length was

determined by measuring the outer curve of individual fruit from the distal end to the point at the end where the pulp judged to terminate.

3.4.5 Fruit girth (cm)

The fruit girth (circumference) also taken five fruits randomly from the second hand was measured from the in the midpoint by a thread with one small pin attached to it at its one end, and then the circumference or girth of the banana was recorded by measuring the length of the thread and expressed in centimeter.

3.4.6 Number of fruits per hand

The number of fruits (single fingers) in each hand was counted and expressed in average number of fruits per hand.

3.4.7 Number of hands per bunch

The total hands (cluster of fruits) per bunch was counted and expressed in number.

3.4.8 Bunch weight (kg)

Immediately after harvest bunches were dehanded and weighed to obtain the bunches weight in kilograms.

3.4.9 Bunch length (cm)

The length of each bunch (from the point of the first hand to the end point of the last hand) was recorded after harvesting of the bunch and expressed in centimeter.

3.4.10 Productivity (ton/ha)

The recorded weight of each bunch was calculated by the number of plants found in one hectare and expressed in tons per hectare.

3.4.11 Pulp to peel ratio

To determine the pulp to peel ratio five ripened fruits were taken from the second-hand bunch and the average pulp weight divided by the average peel weight were recorded for each treatment.

3.4.12 Total soluble solids (TSS)

The total soluble solids (TSS) of banana fruit pulp which consists of acids, sugars, vitamins, amino acids and other soluble solids were measured by Atago's hand refractometer and expressed in ^{o}brix. Sample was taken from five ripened fruits to make a juice and a drop of banana juice was used to read the TSS content on the prism of the refractor meter and the percentage were recorded as ^{o}brix and the observation recorded separately for each treatment in all replication. The prism of the refract meter has properly washed and dry before each test of observation (Dadzie and Orchard, 1997) (Appendix 3).

3.4.13 Total titratable acidity (TTA)

Total titratable acidity was measured at fruit ripening using the Association of official analytical chemists (AOAC) method. It was determined by titration with 0.1N NaOH in the presence of phenolphthalein indicator and expressed as percentage of malic acid (Josylin, 1970). (Appendix 4)

Using the following formula;

$$\% \text{ acid concentration} = \frac{[\text{mlsNaOH used}] \times [0.1 \text{ N NaOH}] \times [\text{milliequivalent factor}] \times [100]}{\text{Grams of sample}}$$

3.5 Data Analysis

The data collected from various parameters considered in the experiment were statistically analyzed following the procedure in Analysis of Variance (ANOVA) using SAS version 9.1statistical software in RCBD factorial. The significance differences between treatments were tested using LSD (List significant Difference) at 5% significance level.

4 RESULTS AND DISCUSSION

The result obtained from this study on fruit yield and post-harvest quality aspects for the combined main effects of cultivar and cover types were presented and discussed in this chapter as follows but at all tested parameters it didn't record significant ($p > 0.05$) variation on the interaction effect of cultivars and the bunch cover types .

4.1 Weather Condition of the Study Area

The area has two (bimodal) rain seasons; that is, that is a'Belg' season from February to May and 'Meher' from June to September. The aggregate average annual rainfall that the region gets from these two seasons is about 700 mm. As indicated in table 1 the long term of total rainfall exceeds by 23 mm, the highest rainfall month from long term and growing season was at September (125 mm and 112 mm respectively), as in the behavior of banana, at high rainfall time, its production becomes extended because of increasing vegetative growth.

Table 1 Average rainfall data of long term (2008-2018) and growing season of the study area

Month	Long term rainfall (mm)	Growing season rainfall (mm)
June	98	65
July	71	81
August	92	105
September	125	112
Total	386	363 (23)

Source: Hawassa meteorology station

4.2 Phonological Parameter

4.2.1 Days from flowering to maturity

The analysis of variance showed that the main effect of cultivars significantly ($p < 0.05$) influenced number of days from starting of flowering to physiological maturity (to harvest). But, did not record significant ($p > 0.05$) difference due to the main effect of bunch cover type and interaction effects of cultivar and cover type (Appendix 2.1).

The minimum days (108.2) taken from flowering to maturity was recorded in Williams than days (114.2) taken in Grand Naine cultivar (Table 1).

The above variation recorded in 8 days earlier taken from flowering to physiological maturity in Williams cultivar could be due to the cultivar genetic makeup or nature.

4.3 Effect of Bunch Covers and cultivars on Fruit Yield Characteristics

4.3.1 Evaluation of visual appearance (cleanness)

Covered bunches had shown significantly ($p < 0.001$) cleaner fruits than that of uncovered bunches of both cultivars. However, neither the cultivars nor the interaction of cultivar type and cover type didn't record significant ($p > 0.05$) difference (Appendix 2.2).

Covered bunches of both cultivars showed with minimal (less than 5%) bruises, dust and birds drop at harvest and more visually appealed than the uncovered bunches (greater than 50 % of affected surface area) (Table 1). This result agrees with the findings of Weerasinghe and Ruwapathirana (2002) that banana fruits grown under covers had no bruises or blemishes and was attractive to consumer where as those of uncovered fruits showed physically injured fruits. Muchui *et al.* (2010) and Sarkar *et al.* (2016) also reported that the covered bunches observed minimum (2-5%) blemishes than the uncovered (>50) bunches and fruits of covered bunches creates consumer acceptance throughout the banana market.

4.3.2 Fruit weight (gm)

The analysis of variance revealed that the main effect of cultivar and cover type were significantly influenced fruit weight at probability of $p<0.05$ and $p<0.001$ respectively. However, interaction effect of cultivar and cover type didn't recorded significant influence ($p > 0.05$) (Appendix 2.3).

As indicated in Table 1 maximum fruit weight 160.75gm followed by 150.67 gm was recorded from bunches covered by blue and green polyethylene bags respectively; whereas minimum fruit weight (134.83 gm) was recorded from bunches without cover (control). This data indicates 25.92 gm (19.22%) showed an individual increment of fruit weight by using blue polyethylene bunch covers. Among the cultivars, Grand Naine recorded significantly higher (148.63 gm) fruit weight than Williams cultivar (141.23 gm).

Fruit weight is the sum result of the fruit length, fruit girth and also density. Due to the created regulated microclimate and increased temperature around the covered fruits which could be favored the fruit size without causing sunscald and the blue color acts as a filter of PAR , in which PAR is responsible for light intensity required in growth and development of fruits becomes filtered through various bunch cover colors (Chouldhury *et al*., 1997). Blue followed by green polyethylene allows the shortest wavelengths of naturally flows the visible light of radiation energy from 400 nm-700 nm then the lowest wavelength transfers the highest energy, so that the blue cover cannot hinder the energy comes from sunlight but protects the fruit from direct heat damage. Consistent findings by Weerasinghe and Ruwapathirana (2002) in Sri Lanka indicated that blue polyethylene bagging enhanced fruit weight by 16 % over the control (uncovered bunches). Similarly banana production regions mostly use blue covers which favors the fruit size due to compiled effect of length and girth (Muchui *et al*., 2010). In contradictory, Rodrigues *et al*. (2001) report showed that polyethylene bunch covers had no significant variation in fruit yield characters.

4.3.3 Fruit length

Cultivar and cover type was significantly influenced at $p < 0.05$ and $p < 0.001$ fruit length respectively. But, didn't record significant variation ($p > 0.05$) due to the interaction effect of cultivar and cover type (Appendix 2.4).

The highest fruit length (18.42 cm) followed by (17.18 cm) were recorded from bunches covered by blue polyethylene and green polyethylene cover respectively than any other cover types tested in the experiment and the lowest (15.58 cm) from bunches without cover and from bunches covered by gunny bag each (Table 1). From individual fruits 2.84 cm (18.22%) gained an increment of fruit length.

The higher fruit length (16.91 cm) was significantly recorded from Grand Naine cultivar than recorded (16.3 cm) from Williams cultivar (Table 1).

This might be due to better filling of fruit under the bunch cover treatments which had more temperature than that of uncovered bunches (Pathack, 2017).

Table1. Fruit weight (gm), Fruit length (cm), visual appearance and days from flowering to maturity as influenced by the main effect cultivars and bunch cover types.

Treatments	Fruit weight (gm)	Fruit length (cm)	Visual appearance (scale)	Days from flowering to maturity
Cultivars				
Grand Naine	148.63[a]	16.91[a]	2.67	114.2[a]
Williams	141.23[b]	16.3[b]	2.60	108.2[b]
LSD	5.57	0.55	NS	4.71
Type of cover				
Blue	160.75[a]	18.42[a]	2.17[b]	109[a]
Grean	150.67[b]	17.18[b]	2.00[b]	110.50
White	141.92[bc]	16.25[c]	2.00[b]	112.67
Gunny	136.50[c]	15.58[c]	2.00[b]	109.83
No cover	134.83[c]	15.58[c]	5.00[a]	114.00
LSD	8.80	0.86	0.22	NS
CV	5.04	4.31	6.93	5.56

Means of the same main effect within a column followed by the same letter are not significantly different from each other at 5%level of significant (LSD test)

4.3.4 Fruit girth

The analysis of variance revealed that the main effects of cultivar and cover type significantly ($p < 0.01$) affect the fruit girth. But did not significantly ($p > 0.5$) influence the fruit girth due to the interaction effect of cultivar and bunch cover type (Appendix 2.5).

The maximum fruit girth (11.5 cm) was recorded from bunches covered by blue cover, which was at statistical similarity (11.08 cm) with bunches covered by green cover and the minimum fruit girth (9.83 cm) recorded from bunches without cover (control) (Table 2). This data indicated 1.67 cm (16.98%) of individual fruit girth showed increment due to the use of blue polyethylene bunch cover over the control.

The highest fruit girth (10.93 cm) was recorded from Grand Naine cultivar than Williams cultivar (10.27 cm) (Table 2). Similar finding from Santosh *et al*. (2017) in india showed that covered bunches recorded higher (13.75 cm) fruit girth than uncovered (12.88 cm) fruits.

4.3.5 Fruit per hand and hand per bunch

The analysis of variance indicated in Appendix 2.6 and 2.7 showed that the main effect of cultivar and cover type as well as their interaction did not record significant ($p > 0.05$) difference on fruit per hand and hand per bunch (Table 2).

Similar finding from Santosh *et al*. (2017) and Amani and Avagyan (2014) records showed that no significant variation in both parameters and SREE (2015) in number of hands per bunch due to polyethylene cover types. But, contradictory results shown bunch covering materials recorded significant variation in the number of fruits per hand (SREE, 2015).

Table2. Fruit girth (cm), fruit per hand and hand per bunch as influenced by the main effects of two cultivars and bunch cover types.

Treatments	Fruit girth (cm)	Number ofFruit per hand	Hand/bunch
Cultivars			
Grand Naine	10.93[a]	15.87	9.53
Williams	10.27[b]	15.73	9.40
LSD	0.41	NS	NS
Type of cover			
Blue	11.50[a]	16.17	9.83
Grean	11.08[ab]	16.33	9.83
White	10.5[bc]	15.33	9.17
Gunny	10.08[c]	15.33	9.33
No cover	9.83[c]	15.83	9.17
LSD	0.64	NS	NS
CV	5.02	6.22	6.95

Means of the same main effect within a column followed by the same letter are not significantly different from each other at 5% level of significant (LSD test)

The inconsistent results found from different researches may be from the consequence of difference agro ecological zones.

4.3.6 Bunch weight (kg)

The analysis of variance revealed that the main effect of cultivar ($p < 0.05$) and cover type ($p< 0.001$) recorded significant variation on Bunch weight. However, the interaction effect of cultivar and cover type did not show significant ($p > 0.05$) variation (Appendix 2.8).

The result on Table 3 showed that the highest (18.92 kg) bunch weight was recorded from bunches covered by blue cover and the lowest (15.83 kg) bunch weight was recorded from bunches without cover, statistically similar (16 kg) with bunches covered by gunny bag. This data showed 3.09 kg (19.51%) individual increment of bunch weight by using blue poly ethylene bunch cover over the control.

The bigger bunch weight (17.4 kg) was recorded from Grand Naine than bunch weight (16.7 kg) recorded from Williams cultivar (Table 3).The significant variation of bunch weights is come from the combined effects of increased fruit weight, fruit girth and fruit height.

4.3.7 Bunch length (cm)

The main effects of cultivars and different types of cover types as well as their interaction effect were not significantly ($p > 0.05$) influence the bunch length (Appendix 2.9) (Table 3). This result confirms with findings of Santosh (2017) in India that covered bunches didn't shown significance difference in the case of bunch length.

4.3.8 Productivity (ton/ha)

The main effects of cultivar and cover type showed significant effect on fruit productivity at ($p < 0.05$, $p<0.001$ respectively, but the interaction effect of the main effects did not shown significant ($p > 0.05$) difference on fruit productivity (Appendix 2.10).

The maximum fruit productivity (31.53 ton/ha) of banana was recorded from bunches covered by blue cover and the minimum productivity (26.67 ton/ha) obtained from bunches covered by gunny bag, which was at similarity (26.79 qt/ha) with bunches without cover. this data showed an increased 4.86 kg (18.22%) productivity on using blue poly ethylene bunch covers over non covered bunches.

Higher yield per hectare (29 tont/ha) was recorded from Grand Naine cultivar than productivity (27.84 tont/ha) recorded from Williams cultivar (Table 3). The greater productivity of Grand naine than Williams could be due to genetic potential. Similar finding by Mohammed *et al.* (2014) who reported that genetic variation in local and introduced dessert banana and Tekle *et al.* (2014) adaptability of banana cultivars result shown Grand naine cultivar exceeds the fruit productivity (ton/ha) than the Williams cultivar.

The influence of different bunch covers in AAA genome showed significant variation in fruit length, fruit girth and total yield over none covered bunches and bunches covered by leno bag, gunny bag and leaves (Pathak *et al*., 2017). Several other findings also reported on the effect of different bunch covering material such as Kutinyu (2013) have shown perforated and non-perforated blue and green cover materials recorded significantly higher yield (ton/ha) than the uncovered bunches in Mozambique; Muchui (2010) reported that blue covered bunches of Grand Naine had significant variation in the case of bunch weight (kg) and fruit length (cm) which are the components of a given fruit productivity over uncovered bunches; Santosh *et al*. (2017) also mentioned that a significant variation in yield (ton/ha), fruit girth (cm) and bunch weight (kg)were observed in blue covered bunches compared to the control. In addition, Ogunsua *et al*. (2018) report showed that from bunches covered by brown paper and perforated blue polyethylene recorded significant effect in fruit diameter (cm) over other cover materials. On the other finding, bunches covered by polyethylene bags showed significantly longest, widest, heaviest fruits and significantly higher productivity over bunches covered by gunny bags and uncovered bunches of Grand Naine (SREE, 2015).

Sarkar *et al*. (2016) similarly reported that bunches covered by polyethylene covers showed significant variation in bunch weight, fruit weight and yield t/ha over the uncovered bunches, however from this experiment some fruit yield characteristics such as fruit per hand, hand per bunch and length of bunch did not show significant variation in any of the treatments which is in agreement with the findings of Santosh *et al*. (2017) that revealed no significant variation on bunch length, number of hands per bunch and number of fruits per hand.

Amani and Avagyan (2014) reported that in Iran the covered bunches recorded significant higher average bunch weight than uncovered bunches due to the compiled contribution of

fruit grades as weight, length and girth of individual fruit. In addition, they recorded visually appealed fruits and decreased fungal infestation.

Table3. Bunch weight (kg), bunch length (cm) and productivity (ton/ha) as influenced by the main effect of two cultivars and bunch cover types.

Treatments	Bunch weight (kg)	Bunch length (cm)	Fruit yield(ton/ha)
Cultivars			
Grand Naine	17.40[a]	70.33	29.00[a]
Williams	16.70[b]	69.60	27.84[b]
LSD	0.67	NS	1.12
Type of cover			
Blue	18.92[a]	70.40	31.53[a]
Grean	17.67[b]	70.33	29.45[b]
White	16.83[bc]	69.92	28.06[bc]
Gunny	16.00[c]	69.08	26.67[c]
No cover	15.83[c]	70.08	26.79[c]
LSD	1.07	NS	1.78
CV	5.19	4.23	5.19

Means of the same main effect within a column followed by the same letter are not significantly different from each other at 5% level of significant (LSD test)

4.4 The Effect of Bunch Cover Types on Quality Characteristics

4.4.1 Pulp to peel ratio

The analysis of variance revealed Pulp to peel ratio significantly affected by cultivars ($p<0.05$) and bunch cover types (< 0.001). But, did not show significant difference ($p > 0.05$) due to the interaction effect of cultivar and cover types (Appendix 2.11).

The highest proportion of pulp to peel ratio (2.68) was recorded from bunches covered by Blue cover and the lowest proportion (2.26) was recorded from bunches covered by gunny bag, which was at parity (2.29) with bunches without cover (Table 4).

The highest proportion of pulp to peel ratio (2.47) was recorded from Grand Naine and the lowest (2.35) from Williams cultivar (Table 4). This indicates bunches covering by blue followed by green and white covers increased the proportion of pulp to peel ratio. Similarly, Muchui *et al.* (2010) also shown shiny blue cover significantly increased the proportion of pulp to peel ratio. In addition to this finding, Sree (2015) reported that pulp to peel ratio and TSS recorded higher in bunches covered by polyethylene bags than those uncovered bags and this might be due to proportional increased fruit of blue covered bunches.

4.4.2 Total soluble solids (^{0}Brix)

The analysis of variance result on the bunch cover types showed significant ($p < 0.001$) influence on total soluble solids, but did not recorded significant ($p > 0.05$) difference from the main effect of cultivar and interaction effect of cultivar and bunch cover types (Appendix 2.12).

The maximum TSS (22.33^o brix) was recorded from bunches covered by blue polyethylene bunch cover followed by bunches covered by green polyethylene cover (22° brix) and the minimum (18.5 ^{o}brix) was recorded from bunches without cover, which was at parity (19.83) with bunches covered by gunny bag and white polyethylene cover each (Table 4). The high amount of TSS has positive correlation with sweetness and indicates more sugar content in the pulp (Mrriot, 1980; Sajib *et al.*, 2014). In agreement to this finding various research findings reported that due to the significant positive association of covers with increased temperature inside the covered bunches, more TSS was observed (Santosh *et al.*, 2017; Surajit, 2014).

4.4.3 Total titrable acidity (TTA)

The analysis of variance indicated in Appendix 2.13 did not showed significant ($p > 0.05$) variation on any of the main effects of cultivar and cover type and the interaction effect of cultivar by cover type in total titrable acid percentage (Table 13).

Similar finding from Rajametov (2017) who reported that the amount of acid percentage was not shown significant variation among the treatments due to covering materials in other fruits as pear. Comparatively reduced amount of the acid percentage in any type of fruit is crucial for the testy of that produce.

Table4. Pulp to peel ratio, titrable acid (%), total soluble solids (TSS) (^{0}Brix) as influenced by the main effect of two cultivars and bunch cover types.

Treatments	Pulp to peel ratio	TTA (%)	TSS (^{O}Brix)
Cultivars			
Grand Naine	2.47[a]	0.29	22.67
Williams	2.35[b]	0.28	22.33
LSD	0.09	NS	NS
Type of cover			
Blue	2.68[a]	0.27	22.33[a]
Grean	2.49[b]	0.28	22.00[b]
White	2.35[bc]	0.29	19.83[c]
Gunny	2.26[c]	0.31	19.83[c]
No cover	2.29[c]	0.30	18.50[c]
LSD	0.1485	NS	1.425
CV	5.11	9.83	5.25

Means of the same main effect within a column followed by the same letter(s) are not significantly different from each other at 5% level of significant (LSD t

5 SUMMARY AND CONCLUSION

Banana is an important food and cash crop of the Arba Minch area farmers. However, its productivity and quality are low owing to a number of constraints. In this area and elsewhere in the country improving the yield and quality of banana is limited by the lack of knowledge on the management practices. Therefore, field experiment was conducted at Arba Minch in Chano Mile nursery and training center during 2018 cropping season with the objective of determining the effect of pre-harvest bunch cover technology on production and quality status of two banana (Grand Naine and Williams) cultivars.

Four types of bunch covering materials (blue, green, white polyethylene bags and gunny bag) along with a control (no bunch covering) were tried in two popular cultivars (Grand Naine and Williams) with 10 treatments replicated 3 times following the randomized complete block design (RCBD). Fruit yield characteristics and post harvest quality parameters including days taken from flowering to physiological maturity, Visual appearance, fruit weight, fruit length, fruit girth, fruit per hand, hand per bunch, bunch weight, bunch length, productivity, pulp to peel ratio, TSS and TTA were evaluated.

Most of the parameters tested were recorded significant variation as indicated in the analysis of variance. All revealed significant variations was due to the main effects of Cultivar and bunch cover type but didn't record any of the parameters due to the interaction effect of cultivar and bunch cover type.

The investigation showed that the average fruit weight was maximum in bunches covered by blue polyethylene bag (160.75 gm) and the minimum fruit weight was from bunches covered by gunny bag (136.5 gm), which was at par with bunches without cover (136.5 gm).

In the case of two cultivars maximum fruit weight (148.63 gm) was recorded from Grand Naine and the minimum fruit weight (141.23 gm) from Williams.

Length of fruit was maximum in bunches covered by blue polyethylene bunch cover (18.42 cm) and the minimum was from bunches without cover and bunches covered by gunny bag (15.58 cm each).

In the case of cultivars maximum fruit length (16.91cm) recorded from Grand Naine and the lower fruit length (16.3 cm) was from Williams.

Bunches covered by blue polyethylene bunch covers as par with bunches covered by green polyethylene showed significance difference in Fruit girth (11.5 gm cm and 11.08 cm respectively) and the lowest fruit girth was recorded from bunches without cover (9.83 cm), which was at par with bunches covered by gunny bag (10.08 cm).

From the cultivars the average highest fruit girth (10.93 cm) and the lowest fruit girth (10.27 cm) was recorded from Grand Naine and Wlliams respectively.

Significantly maximum Bunch weight (18.92 kg) was recorded from bunches covered by blue polyethylene bags and the lowest (15.83 kg) bunch weight was recorded from bunches without cover at par with bunches covered by gunny bag (16 kg).

In case of cultivars the highest (17.4 kg) bunch weight was recorded from Grand Naine and the lowest (16.7 kg) was recorded from Williams.

The analysis of variance revealed that the significantly highest average productivity (31.53 tone/ha) was recorded from bunches covered by blue polyethylene bags and the lowest (26.67, 26.79 tone/ha) was recorded from bunches covered by gunny bag and bunches without covers respectively.

In the case of cultivars the highest (29 tone/ha) was recorded from Grand Naine and the lowest (27.84 tone/ha) from Williams.

The lowest number of days (108.2 days) covered from flowering to maturity was recorded from Williams and the highest number of days (114.2 days) was recorded from Grand Naine.

Significantly highest pulp to peel ratio (2.68) was recorded from bunches covered by blue polyethylene bunch covers and the lowest pulp to peel ratio (2.26 and 2.29) from bunches covered by gunny bag as par with bunches without cover respectively.

Grand Naine as a cultivar recorded highest (2.47) pulp to peel ratio and the lowest (2.35) was recorded from Williams.

Significantly maximum TSS (22.33 ^{0}Brix) was recorded from bunches covered by blue polyethylene and the lowest TSS (18.5) from bunches without cover as par from bunches covered by gunny bag and covered by white polyethylene bag (19.83 and 19.83 respectively).

Bunches covered by all of the tested covering types showed significantly lower fruit bruises and existence of dirties than bunches without covers.

In conclusion, most the basic fruit grades and quality characteristics of the tested parameters of the banana fruit had shown significant influence due to cover type of blue poly followed by green polyethylene bags.

Due to the fact that from this experiment, it can be recommended that, from the two cultivars used the Grand Naine and from the cover types tested blue polyethylene followed by green polyethylene bags were preferable and superior for the yield and quality attributes of Banana in Arba Minch area that growers or farmers can be used. However that this experiment was tested in limited location, in only two cultivars and growing season, further researches up on other growing areas, other cultivars and in different growing seasons needed to fully recommend. As a limitation, using more plastic bags can be harmful for the environment protection aspects then manufacturing degradable covering materials could be in consider.

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APPENDIX

Appendix 1 Weather data for CMNTC from January /2018 September /2018

Year	Rain fall (mm)	Temperature (^{0}C)		RH (%)	
		Min	Max	Min	Max
January 2018	23	17	31	26	65
February 2018	65	19	29	36	63
March 2018	35	19	31	31	65
April 2018	95	17	31	32	71
May 2018	135	17	30	34	81
June 2018	65	16	30	34	76
July 2018	81	17	31	31	90
August 2018	105	16	30	32	71
September 2018	112	19	31	31	67

Source: MinikinERi&MinikinTHi digital weather sensor from the center

Appendix 2 ANOVA Tables

Appendix 2.1 ANOVA table for days from flowering to harvesting, visual appearance and fruit weight

	DFH			VA			FW		
Source	DF	MS	P-value	DF	MS	P-value	DF	MS	P-value
Cultivar	4	27.78	0.6175	4	10.53	<.0001	4	697.90	<.0001
Cover	1	270.00	0.0151	1	0.03	0.3293	1	410.70	0.0118
Cul*Cov	4	13.75	0.8343	4	0.03	0.4307	4	52.47	0.4397
Error	20	38.23		20	0.03		20	53.43	
Total	29			29			29		

Appendix 2.2 ANOVA table for Fruit length, Fruit girth and fruit per hand

	FL			FG			FH		
Source	DF	MS	P-value	DF	MS	P-value	DF	MS	P-value
Cultivar	4	8.74	<.0001	4	2.86	0.0001	4	1.28	0.2940
Cover	1	2.76	0.0312	1	3.33	0.0027	1	0.13	0.7143
Cul*Cov	4	0.87	0.1915	4	0.06	0.9238	4	0.05	0.9946
Error	20	0.51		20	0.28		20	0.96	
Total	29			29			29		

Appendix 2.3 ANOVA table for hand per bunch, bunch weight and bunch length

	HB			BW			BL		
Source	DF	MS	P-value	DF	MS	P-value	DF	MS	P-value
Cultivar	4	0.70	0.2094	4	9.74	<.0001	4	1.68	0.9401
Cover	1	0.13	0.5853	1	3.68	0.0426	1	3.96	0.5092
Cul*Cov	4	0.96	0.1021	4	0.71	0.4745	4	9.00	0.4175
Error	20	0.43		20	0.78		20	8.77	
Total	29			29			29		

Appendix 2.4 ANOVA table for productivity, pulp to peel ratio and TSS

	P			PTP			TSS		
Source	DF	MS	P-value	DF	MS	P-value	DF	MS	P-value
Cultivar	4	27.06	<.0001	4	0.17	<.0001	4	15.75	<.0001
Cover	1	10.21	0.0426	1	0.11	0.0135	1	0.83	0.4494
Cul*Cov	4	1.99	0.4756	4	0.02	0.2681	4	0.92	0.6304
Error	20	2.18		20	0.01		20	1.40	
Total	29			29			29		

Appendix 2.5 ANOVA table for TTA

TTA			
Source	DF	MS	P-value
Cultivar	4	0.0013	0.2160
Cover	1	0.00027	0.5733
Cul*Cov	4	0.0011	0.2665
Error	20	0.0008	
Total	29		

Appendix 3 Measurement of Total Soluble Solids (TSS)

Using the most popular of measuring the refractive index of the juice using a refractometer.

A. materials used

Hand held refractometer with 0-32 degrees scale Brix, distilled water

B. Procedures

1/ Bring juice samples from ripened banana fruit samples taken from the second hand of the banch

2/ Clean the prisms of the refractometer before each reading with distilled water

3/ Apply a drop of juice from the sample in to the prism, by avoiding bubbles and large pulp particles and cover with fogged glass and position and position the light beam to shine through the fogged glass.

4/ adjust the shadow to the cross hairs

5/ Read the degree brix.

Appendix 4 Measurement of Titratable acidity (TTA)

A. Materials used;

pH meter, burrette, magnetic stirrer, burrette stand, conical flask, sensitive balance, juice extractor, 0.1N NaOH solution, beakers, graduated cylinder.

B. Procedure followed;

1/ Cut sampled fruits and make juice using juice maker

2/ measured 4g of juice and 100ml distilled water

3/ Mix the sampled and stirred using the magnetic stirrer

4/ Titrated the sample with 0.1N NaOH up to the end point of 8.1 (measured with pH) and recorded the milliliters (mls) of NaOH used.

% acid = [mlsNaOH used] x [0.1 N NaOH] x [milliequivalent factor] x [100] grams of sample

grams of sample

Appendix 5 Figures



Figure 1 The time of clearing the flower remnants and cutting the male bud



Figure 2 Bunch covered by blue poly bag in Grand Naine



Figure 3 Bunch covered by green poly bag in Grand Naine



Figure 5 Bunch covered by gunny bag in Grand Naine



Figure 4. Bunch covered by white poly bag in Williams



Figure 6 Bunch covered by blue bag in Grand Naine



Figure 7 Bunch covered by green bag in Williams



Figure 8 Bunch covered by white bag in Williams



Figure 9 Bunch covered by gunny bag in Williams



Figure 10 Fruits after harvest for measuring grades (length, weight, girth)



Figure 11 Measuring the amount of TSS using hand refractometer



Figure 13 Acid titration



Figure 12 Measuring the peels and fruits for pulp to peel ratio