

**STUDIES ON EFFECT OF PRE-HARVEST BUNCH  
TREATMENT AND BAGGING ON YIELD AND  
POST HARVEST QUALITY OF BANANA**

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**JUNE, 2016**

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**Thesis submitted to the**  
*University of Horticultural Sciences, Bagalkot*  
*in partial fulfillment of the requirements for the*  
*Degree of*

**DOCTOR OF PHILOSOPHY (HORTICULTURE)**

*In*

**HORTICULTURE**

By  
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**CERTIFICATE**

This is to certify that the thesis entitled “**STUDIES ON EFFECT OF PRE-HARVEST BUNCH TREATMENT AND BAGGING ON YIELD AND POST HARVEST QUALITY OF BANANA**” submitted by **RAVISHANKAR M. PATIL, I.D. No. UHS10PGD04** for the degree of **DOCTOR OF PHILOSOPHY** in **HORTICULTURE** of the University of Horticultural Sciences, Bagalkot, is a record of research work carried out by him during the period of his study in this university, under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associate ship, fellowship or other similar titles.

**Place:** Arabhavi

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## ACKNOWLEDGEMENT

*With the kind blessings of my parents and the omnipresent lord as I proceed towards the completion of my Ph.D. degree, I am recalling the valuable support and guidance received by me throughout the period of my research work.*

*I owe a deep sense of gratitude to **Dr. S. L. Jagadeesh** for continuous support during my degree programme and research, for his motivation, enthusiasm, and immense knowledge. I have been amazingly fortunate to have an advisor who gave me the freedom to explore on my own and at the same time the guidance to recover when my steps faltered. He taught me how to question thoughts and express ideas. His patience and support helped me overcome many crisis situations and finish this manuscript. I could not have imagined having a better advisor and mentor for my doctoral study.*

*I am sincerely thankful to **Dr. G.S.K. SWAMY**, Professor of Fruit science, for his motivational support, excellent guidance, continued calm endurance and inspiring encouragement during the course of investigation and preparation of the manuscript.*

*I am extremely grateful to **Dr. G. J. Suresha**, Asst. Professor, Dept. of Post Harvest Technology and **Mrs. Sandhyarani Nishani**, Asst. Professor, Dept. of Crop improvement and Biotechnology; **Dr. N. Thammaiah**, Professor, Dept. of Horticultural Plant Pathology, UHS, Bagalkot, The members of my Advisory Committee for their edifying comments, advice and evaluation of the manuscript during the course of investigation. I am highly thankful to them for the long discussions that helped me sort out the technical details of my work. I extend my sincere thanks to all other teachers of **KRCCH, ARABHAVI** for their help rendered during the study.*

*I am highly thankful to **Dr. M. S. Kulkarni** , Dean KRCCH, Arabhavi , **Dr. R. C. Jagadeesh**, Professor and Head, Dept. of BCI, **Dr. P. M. Gangadharappa** Professor and Head, Dept. of PMA, **Dr.Lakshman Kukanoor**,*

*Professor and Head, Dept. of Post harvest technology, UHS, Bagalkot and Late Dr. V. Chikkasubanna Professor, UAS Bangalore for their kind support and guidance.*

*I take this opportunity to extend my heartfelt thanks to my junior friends **Abhi, Udachappa, Raveendra, Chandan, Scienti, Ravi Pujari, Chethan, Phatak, Nagraj Gokavi, Prashant, Kitty, Kumar Bhavi, Kashi, Erage, Santu, Mahaveer, Shashi, Jayanna, Pavalya, Sanjiv and Yograj** and all my juniors and classmates, who have been with me in all ups and downs that I confronted during this period.*

*I am extremely thankful to Mr, Bharatesh, B. M. for providing his field to carry out the research work*

*I express my heartfelt love and affection from the inner core of my heart to my beloved parents **Late Sri Mallikarjuna Gowda & Smt Jayashree** and my wife **Ashwini** for their constant encouragement, moral support and inspiration.*

*I also have been highly fortunate in having many affectionate friends I am ever grateful to my friends **Amith, Deepak, Madhu, Chandu, Tej, Balu, Nitu, Kanta** I am ever grateful to my cousins **Gatu, Ganu, Rudra, Ani, Suma, Deepa, Rakshi and Prabhu**. I have no words for the love, support and encouragement given to me by **my family, cousins** and my best pals.*

*Finally, I would like to thank all those who helped me directly or indirectly in completing the doctors degree programme.*

*.....any omission in this brief acknowledgement does not mean lack of gratitude.*

**Arabhavi,**

**June, 2016**

**(Ravishankar M. Patil)**



Affectionately dedicated to

**My Beloved  
Parents and My  
Family**

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## LIST OF ABBREVIATIONS AND SYMBOLS

SOP	Sulphate of potash
2,4D	2, 4 dichloro phenoxy acetic acid
cm	Centimetre
C*	Chroma
C.D	Critical difference
<sup>o</sup> C	Degree centigrade
et al.	Et alii (and other)
g	Gram
ha	Hectare
h	Hour
<i>h</i> <sup>o</sup>	Hue angle
kg	Killogram
L*	Lightness
L	Litre
mg	Milligram
ml	Millimetre
Viz.,	Namely
N	Normality
ppm	Parts per million
%	Per cent
PLW	Physiological loss in weight
a*	Redness
S.Em	Standard mean error
t	Tonnes
TSS	Total soluble solids
b*	Yellowness

# 1. INTRODUCTION

Banana (*Musa* spp.), cultivated by man since prehistoric times, is considered as a “queen of tropical fruits”. The fruit provides nutrition and well-balanced diet to millions of people around the globe and also contributes to livelihood through crop production, processing and marketing (Singh, 2002). Banana grows well in humid tropical low lands. It belongs to the family *Musaceae*. South-East Asian countries, especially eastern Malaysia is believed to be the center of origin of banana (Saucer, 1952). Its cultivation is distributed throughout the warmer countries and is confined to the region between 30° North and 30° South of the equator (Tai, 1977).

Banana provides dessert fruit or starch staple to millions of people in the world. It is easy to digest, nearly fat free with high nutritive value and relatively cheaper than other fruits. The total energy provided by 100g edible ripe pulp is 116 K calories. The fruit is composed of 1.2 g protein, 0.3 g fat, 27.2 g carbohydrates, 0.4 g fibre, 7 mg vitamin C and 0.8 g of minerals (Gopalan *et al.*, 1989).

Banana is popular among the people of India in that it is liked by both poor and rich alike. Banana is also called ‘poor man’s apple’ as it is the cheapest among fruits grown in the country with good energy and nutritive values. It is also popular on account of its year round availability as compared to seasonal availability of other fruits (Chadha, 2001).

Banana ranks first in production among the fruit crops grown in India with production of 297.24 lakh MT annually from an area of 8.02 lakh hectares. In Karnataka, it is grown in an area of 1.02 lakh hectares with the production of 26.57 lakh MT. In India the productivity of banana is highest in Madhya Pradesh (66.0 MT/ha) followed by Gujarat (53.6 MT/ha) (Anon., 2015). The important cultivars of banana grown in different parts of India are Dwarf Cavendish, Robusta, Poovan, Nendran, Monthan, Borjahaji, Elakki Bale, Rasabale, Mitli and Sakkarebale (Chadha, 2001).

Grand Naine is a popular variety grown mostly in all the banana growing countries of Asia, South America and Africa. This is a superior selection from Giant Cavendish which was introduced from Australia to India in 1990's and is a tall mutant

of Dwarf Cavendish. Due to many desirable traits like excellent fruit quality, immunity to *Fusarium* wilt *etc.*, it has been proved as better variety (Singh and Chundawat, 2002).

Ney Poovan, (Elakkibale) once a delicate backyard cultivar of choice, now assumes commercial monoclonal cultivation. It is a slender, medium tall cultivar taking 12-13 months for its crop cycle and occupies large area in Karnataka. Average bunch weight is 18-20 Kg with small fruits packed closely having a wind-blown appearance. Pulp is ivory coloured, firm sweet, with good aroma and conspicuous ovules. Fruits attain yellow colour after ripening and are bequeathed with good-keeping quality and flavor.

Banana generally requires high amount of mineral nutrients for proper growth and fruit production. To ensure high yield and quality of banana, application of adequate nutrients is of paramount importance.

About 16 elements are considered essential for plant growth, some of which are required in large quantities (macronutrients *viz.*, N, P & K) while a few others are required in smaller quantities (secondary nutrients *viz.*, Ca, Mg & S) and still others are required in micro quantities (micronutrients *viz.*, Fe, Cu, Zn, Mn, B, Mo & Cl). Some of the beneficial elements (Co, Si, Va, *etc.*) are also required for the growth and development of the crop.

Silicon is the most abundant element in the earth's crust region next to oxygen and comprises 28% of its weight, 3-17% in soil solution (Epstein, 1999). It is most commonly found in soils in the form of solution as silicic acid ( $H_4SiO_4$ ) and is taken up directly as silicic acid (Ma *et al.*, 2001). Being a dominant component of soil minerals it has many important functions in environment, although silicon is not considered as an essential plant nutrient because of its ubiquitous presence in the biosphere and most plants can be grown from seed to seed without its presence. Many plants can accumulate Si concentrations higher than essential macronutrients (Epstein, 1999).

Silicon is deposited in the walls of epidermal cells after absorption by plants and contributes considerably to stem strength. Silicon is not much mobile element in plants (Savant *et al.*, 1999). The role of silicon in plant biology is to reduce multiple

stresses including biotic and abiotic stresses. It is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels under high transpiration rates (Melo *et al.*, 2003). Gong *et al.* (2003) observed improved water economy and dry matter yield by silicon application and the element enhanced leaf water potential under water stress conditions, reduced incidence of micronutrient and metal toxicity (Matoh *et al.*, 1991). It is most commonly applied as foliar spray to correct the deficiency of specific element rather than complete requirement of that element. Silicon is essential for many enzymatic reactions.

Banana takes up major nutrients in greater quantities during peak growth phases but after shooting the rate of nutrient uptake slows down. Banana plant is supplied with nutrients through soil and foliage, de-navelling (removal of male inflorescence for nutrient diversion) and post-shoot feeding nutrients through the distal stalk-end of rachis to achieve high yields. During fruit development, the plant nutrient status and uninhibited flow of nutrients to the developing bunch influence the bunch size and quality of fruits. Soil characters and environmental factors may cause considerable loss to the soil applied nutrients leading to insufficient supply of nutrient after shooting to meet the nutrient demand of developing bunch. Hence, bunch feeding of nutrients provides a considerable scope not only for the effective utilization of nutrients but also to safeguard the economy of the farmer by improving the yield potential and quality of the produce (Veerannah *et al.*, 1976) there by little research has been conducted on bunch feeding of nutrients in banana crop.

The use of bunch covers is widespread throughout the commercial banana growing regions of the world. They are also commonly used to protect export market intended plantain fruit during development. The practice is regarded as essential to improve the market quality and yield of the fruit. Bunch covers provide protection to the fruit surface against wind damage, leaf and petiole scarring, dust, light hail, sunburn, bird feeding and handling damage during harvest and transport. Pre-harvest fruit bagging is a simple, grower-friendly technology which is safe to use and has several beneficial effects on the physical appearance and quality of fruit. Furthermore, it is the safest approach to protect fruit from insect pests, diseases and other disorders. This approach is an integral part of fruit production in some parts of the World (Sharma *et al.*, 2014).

In view of possible benefits of silicon, bunch feeding and bagging on banana bunches the present study was carried out to know the effect of bunch treatment on yield and quality of banana cv. Ney Poovan (Elakkibale) and variety Grand Naine with the following objectives:

1. To study the effect of pre harvest bunch treatment (potassium silicate) and bagging on bunch and finger characters of banana fruits var. 'Grand Naine' and cv. Ney Poovan (Elakkibale)
2. To study the effect of bunch treatment (urea, ammonium sulphate, SOP and 2,4-D) and bagging on bunch and finger characters of banana fruits var. 'Grand Naine' and cv. Ney Poovan (Elakkibale)
3. To study the influence of pre harvest bunch treatment and bagging on physico-chemical, sensory qualities and shelf life of var. Grand Naine and cv. Ney Poovan (Elakkibale) of banana.

## 2. REVIEW OF LITERATURE

Banana is one of the important commercial fruit crops of south India, known to receive higher quantities of nutrients than any other fruit crops cultivated in India. Supply of nutrients at critical growth stages of plant is very important to attain good yield and quality. It is a nutrient loving plant and requires proper amount of nutrient especially major nutrients during its growth and development stage. Any limitation in supplementing nutrients during the growth stages affects the yield and quality of produce. In addition to the regular application of nutrients foliar spraying, bunch spraying, bunch feeding with major and minor nutrients *etc.*, will help to improve the yield and quality of the produce and also corrects the deficiency if any.

Of the mineral elements essential for plant growth, silicon (Si) is a non-essential element with beneficial effects reported in several crops. It has been characterized as an 'agronomically essential' for rice in Japan, since it is used for obtaining higher yield. 'Quasi essential' is another term used to describe silicon for its prophylactic role against several stresses observed in a variety of plant species (Epstein & Bloom, 2005). Silicon can benefit plant growth and development in many ways. Some of these benefits include increased plant growth and crop quality, stimulate photosynthesis, reduced transpiration rate and increased plant resistance to abiotic and biotic stresses (Ma and Takahashi, 2002). Silicon contributes to greater stalk strength and resistance to lodging by contributing to the structure of cell wall. Silicon impregnates the walls of epidermal and vascular tissues where it appears to strengthen the tissues, retards fungal infection and reduces water loss. It increases photosynthesis because of better light interception (Tisdale *et al.*, 1993). Most of the research conducted on the benefits of Si has been conducted on field crops, but the role of silicon in the nutrition of plant species especially in horticulture crops has not been investigated in comparison to agricultural crops like rice (Iler, 1979).

Under traditional farming system, banana crop receives its last dose of fertilizers (nitrogen and potassium) at 7<sup>th</sup> month after planting *i.e.* just before shooting, This dose has to support the requirement of nutrients until harvest since large quantity of photosynthates are to move from the source to the sink *i.e.* to developing bunches at this phase. Any limitation in the supply of nutrients at this

crucial stage affects the bunch size and quality. Because of this problem, poor filling and development of fingers is often reported. Hence, an additional dose of fertilizer after shooting has become imperative. However, it is not advisable to go for soil application of fertilizers at finger development stage, since the uptake is slow and low at this stage (Veerannah *et al.*, 1976). Many reports have indicated the usefulness of post shoot application of various nutrients during fruit development in influencing the fruit yield, shelf life and quality (Kannan, 1980).

The present review emphasizes the work on banana particularly on use of potassium silicate and 2, 4-D for bunch spraying and use of urea, ammonium sulphate and sulphate of potash for bunch feeding with or without skirting materials (bunch covers) in influencing the quality and yield of banana variety Grand Naine and cultivar Ney Poovan.

Hence, an attempt has been made in this chapter to compile the available literature on these aspects and present it under appropriate headings.

- 2.1 Influence of silicon on yield and quality parameters of horticultural crops
- 2.2 Influence of foliar sprays and bunch feeding on yield and quality parameters of banana and other horticultural crops
- 2.3 Influence of skirting materials on yield and quality parameters of banana and other horticultural crops

## **2.1 Influence of silicon on yield and quality parameters of horticultural crops**

Silicon nutrition has several beneficial effects on growth, yield and quality largely due to its unique physiological role.

### **2.1.1 Fruit plants**

Strawberry plants continuously received 50 ppm SiO<sub>2</sub> and recorded increased top weight, fruit weight and fruit yield and also showed increased pollen fertility (Miyake and Eiichi, 1986).

Potassium silicate ( $K_2SiO_3$ ) applied to grapes cv. Bacchus resulted in higher yield compared to control (without silicon) and in addition, grape berries also utilized the endogenous silicon to fight against diseases (Reynolds *et al.*, 1996).

Voogt and Sonneveld (1997) showed increased yield up to 10 per cent in courgettes and a clear reduction was observed in the incidence of powdery mildew in strawberry. This improved crop yield and quality was attributed to be due to Si ( $1 \text{ mM Si L}^{-1}$ ) amendment.

Cai and Qian (1995b) reported that apple tree receiving Si fertilizer at 15 Kg per tree to soil with a concentration of 314 to 404 mg  $SiO_2 \text{ Kg}^{-1}$ , enhanced yield (10%) and fruits from such trees became red 3 to 5 days earlier and ripened about 10 days earlier with bright appearance. Nevertheless, fruit freshness was retained for longer period during storage and transportation. Cai and Qian (1995a) reported that silicon fertilization to peacanut tree could increase the nut yield percentage.

Stamatakis *et al.* (2003) studied the effect of silicon and salinity on fruit yield and quality of tomato. The firmness, TSS,  $\beta$ -carotene, vitamin- C and lycopene contents of fruits were significantly increased by application of silicon. Further, the addition of silicon significantly restricted the occurrence of blossom end rot in tomato fruit when the plants were not exposed to salinity.

Anderson *et al.* (2005) investigated the possible use of silicon for the control of post-harvest anthracnose of 'Hass' avocado. Injecting soluble silicon into trees prior to harvest significantly decreased the severity and incidence of anthracnose.

According to Ochmian *et al.* (2006) foliar application of 0.2% calcium silicate keeps plum fruit more firm during fruit picking and they lose their firmness slowly compared to other two treatments as foliar sprays involving calcium chloride solution at 0.5% and lime sulphate solution at 0.5% concentration.

Reaple and Laane (2008) investigated the effects of foliar sprays with Agro force (oligomeric silicic acid + boric acid) at different concentrations on plant development, production and quality of papaya fruit. Application of 2.7 litres/ha, 5.4 litres/ha and 2.7 litres/ha with trace elements enhanced growth, production and quality compared to control.

Abraham *et al.* (2008) reported that application of potassium silicate reduces the disease lesion caused by *Penicillium digitatum* and also reduces the post harvest loss and fruit decay at 100 mg L<sup>-1</sup> in citrus fruit.

According to Mathaba *et al.* (2009), silicon at 0.5 ppm had greater potential in mitigating chilling injury with less weight loss and membrane damage in citrus fruits.

Bertling *et al.* (2009) placed 'Hass' avocado fruit into 5000, 13000 and 25000 ppm Si (as potassium silicate) solutions for 20 min to allow penetration of the solution. Thereafter, fruits were allowed to air-dry on the bench and stored at 5.5°C for 16 days. All Si-treatments (5.000, 13.000 and 25.000ppm Si) showed correspondingly elevated Si concentrations in fruit. Fresh weight declined significantly faster in control than in Si-treated fruit, with the highest Si application maintaining the highest weight.

Bhavya (2010) conducted an experiment to examine the response of Bangalore Blue grape vines to foliar Silicic acid (SA) and Boron (B) spray. Application of 4 ml and 6 ml L<sup>-1</sup> foliar SA at 10 days interval (6 sprays) and 6ml L<sup>-1</sup> foliar SA at 20 days interval (3 sprays) significantly influenced yield and quality parameters over control.

Kaluwa *et al.* (2010) experimented different sources of silicon (potassium silicate, non toxic-silica, calcium silicate, sodium meta silicate and bio silicate) as post-harvest dips and pre-harvest soil drenches. Among different Si sources, post-harvest applications of Si in the form of potassium silicate seem to be the most beneficial to maintain 'Hass' avocado fruit quality, probably due to a suppression of respiration and a reduction in ethylene evolution.

Simone *et al.* (2011) studied the sources of silicon in the development of micro propagated seedlings of banana in *in-vitro* condition. The study revealed that there was an increase in levels of chlorophyll a, b and total chlorophyll in the presence of calcium silicate. Supplementation of culture medium with sodium silicate promoted increase in length, fresh and dry weight of shoots. The silicon provides adequate seedling development.

Magno *et al.* (2012) noted the modifications in leaf anatomy of banana plants cultivar Maca that was subjected to different silicon sources under *in vitro* condition,

where the addition of calcium silicate resulted in greater thickness of upper and lower epidermis, mesophyll, palisade parenchyma and with increased photosynthetic rate. The use of silicon improved micro propagated anatomy of banana plant cultivar Maca leaves.

Roshdy *et al.* (2014) elucidated the single and combined applications of potassium silicate and seaweed extract each at 0.05 to 0.1% was significantly responsible for stimulating the four growth characters namely, height and girth of pseudostem, leaf area and number of green leaves at bunch shooting of Grand Naine banana plants in comparison to the check treatment.

Kumbargire *et al.* (2015) conducted an experiment to examine the response of banana cv. Grand Naine to Diatomaceous Earth used as a source of silicon. Basal dose application of Diatomaceous Earth at 750kg/ha along with package of practice significantly influenced the yield attributing characters, quality parameters and minimum per cent of whitefly and sigatoka incidence over the control.

### **2.1.2 Flower crops**

Gillman *et al.* (2003) revealed that, with application of 100 and 150 mg silicon per litre resulted lesser incidence of black spot disease and thus helped in improving the quality of rose flowers. Application of potassium silicate proved to have beneficial effects on yield and quality of cut flower miniature rose *Rosa hybrida* 'Finocchio' in the rock wool culture system compared to control (Hwang Seungjae *et al.*,2005).

Tesfagiorgis *et al.* (2008) reported increased plant yield with the application of 50 to 100 mg L<sup>-1</sup> of silicate fertilizer by limiting disease incidence and maximizing growth in Zucchini and Zinnia.

Kamenidou *et al.* (2009) studied the effect of different source of silicon (KSiO<sub>3</sub> substrate incorporation as weekly substrate drench, NaSiO<sub>3</sub> foliar application and rice husk ash substrate) on the quality traits in Zinnia and ornamental sunflower. The results showed that application of KSiO<sub>3</sub> as five weekly drenches increased the diameter of stem and flower. Similarly, treatment of ornamental sunflower with 200 mg L<sup>-1</sup> Si applied as KSiO<sub>3</sub> substrate drench resulted in plants with larger flower diameter.

Saeed *et al.* (2009) observed an increase in flower diameter, flower number and improved colour intensity or saturation of petals in *Rosa hybrida* Var. 'Hot lady' with the application of 150 ppm silicon under salt stressed condition.

In the study of Kamenidou *et al.*, (2010), gerbera plants were supplemented with several silicon sources ( $\text{KSiO}_3$  substrate incorporation or weekly substrate drench,  $\text{NaSiO}_3$  foliar application and rice husk ash substrate) at different combinations. Among all,  $\text{NaSiO}_3$  as foliar spray recorded thicker flower peduncle, increased flower diameter, height and early flowering than control.

Application of calcium silicate at 7.3 g Si per plot showed increased flower number, height, flower diameter and stem diameter in gerbera (Moyer *et al.*, 2010).

According to Babak and Majid (2011), the use of ethylene production inhibitors such as nickel (Ni) or cobalt (Co) and silicon (Si) might have possessed positive impact on post-harvest life of cut flowers of carnations with climacteric respiration. Nickel sulphate, cobalt chloride and potassium silicate caused higher vase life with lower ethylene production.

### **2.1.3 Vegetables**

Adatia and Besford (1986) reported an increase in number of fruits and average fruit weight with the application of silica solution at 3 mM concentration in cucumber plants. The yield increase caused by Si application differed from 6 to 16 per cent for number of fruits and from 11 to 33 per cent for the total yield.

Liang *et al.* (1993) reported an increase in tomato yield by 42 per cent in a solution culture trail, where 50 mg silicic acid  $\text{ml}^{-1}$  was added to a nutrient solution.

Liu (1997) showed that application of silicate and calcium fertilizers increased fruit size and subsequently increased yield up to 20 per cent and improved the flavour of the tomato fruits by increasing sugar concentration in the fruit. In another study it was found the combination of silicon amendment plus fungicide application as more effective in reducing powdery mildew severity than either silicon or fungicide alone. Silicon amendment resulted in a 5-fold increase in plant Si concentration. Thus, Si amendment resulted delay in foliage senescence and increased pumpkin yield by 60% without increasing the cost of production (Heckman *et al.*, 2003).

The  $\beta$ -carotene and lycopene contents of fruit were significantly increased by Si and nutrient-induced salinity. Both Si and EC enhanced the fruit firmness and the contents of total solid solutes and vitamin C in the tomato fruit and significantly restricted the occurrence of blossom end rot in tomato fruit when the plants were not exposed to salinity (Stamatakis *et al.*, 2003).

Carlor *et al.* (2008) reported that application of silicon resulted in the reduction of stalk lodging and increased mean tuber weight and consequently tuber yield of potato. As reported by Luz (2008), application of 1%  $K_2SiO_3$  in potato plants increased the yield up to 22.4%.

Cucumber plants were cultivated in 12 litre containers filled with substrates amended with sodium silicate, potassium silicate, calcium silicate and ammonium silicates at rates of 2 or 4 g per litre. The results indicated that slow-release calcium silicate and ammonium silicate contributed to increase in yield and elevated Si content in cucumber leaves and fruits. Water-soluble sodium and potassium silicates increased Na or K concentration and raised pH of substrates and resulted in increased yield of cucumber (Gorecki and Busch, 2009).

Production of peruvian carrot clones was evaluated in response to calcium-magnesium silicate. Commercial yield was increased with application of calcium magnesium silicate (Sediyama *et al.*, 2009). In another study, Trazilbo *et al.* (2009) applied that both  $CaCl_2$  and  $CaSiO_3$  were applied at 45 days after emergence of common bean. Application of  $CaCl_2$  and  $CaSiO_3$  significantly reduced both incidence and severity of white mold and yield was also increased.

Rodrigues *et al.* (2010) stated that in bean plants, lesser plant defoliation were found at the highest potassium silicate rate with pH 5.5 compared to the control. Yield increased by 30 and 43% respectively, as the potassium silicate rates increased from 0 to 60 g L<sup>-1</sup> with p<sup>H</sup> 5.5 and 10.5.

Dimitrios *et al.* (2011) reported that silicon increased the ascorbic acid content of Zucchini squash fruit from plants exposed to higher salinity and had significant effect on fruit quality characteristics like weight loss, total soluble solids content and

mineral content during storage. According to Joseph (2011), calcium silicate used as amendment in soil resulted in fewer fungicide applications and reduced the cost of production in pumpkin.

Kayaa *et al.* (2011) studied the effects of silicon and high boron on growth and yield of tomato (*Lycopersicon esculentum* cv. '191F1') plants. Supplementing the nutrient solution containing high B with 2 mM Si increased both nutrients in the leaves. These results indicate that supplementary silicon can mitigate the adverse effects of high B on fruit yield and whole plant biomass in tomato plants.

Lebedeva *et al.* (2011) revealed the effect of low rates of LSi (lignosilicon) application (10 kg/ha, 20 kg/ha and 40 kg/ha) on potato plant tuberization and productivity, improvement of the quality and biochemical composition of tubers. It was shown that LSi used for treatment of potato tubers before sowing at low application rates of 20-40 kg/ha, had a favorable action on the yield and quality of the tubers. In comparison with the control, the additional yield achieved due to application of LSi (20-40 kg/ha) was 18-20 per cent. The dry matter content and starch increased by 16 per cent and 18 per cent respectively, in the tubers wetted with water and LSi- treated before sowing. However, the content of nitrates in the tubers decreased 1.6 times. LSi can be recommended for potato cultivation under conditions of conventional and organic agriculture.

Miyake and Eiichi (2012) studied the effect of silicon on reproductive growth of tomato plant. The plant which was supplied with 100 ppm of silicon was showed maximum reproductive growth as compared to that of control.

Toresano *et al.* (2012) studied the effect of the application of mono silicic acid fertilizer on yield and quality of greenhouse triploid watermelon. The monosilicic acid fertilizer had a positive impact on the parameters of fruit quality (°Brix and pulp firmness).

Fernando *et al.* (2012) studied the effect of the application of silicon hydroxide on yield and quality of cherry tomato. Significant differences were observed, including a higher number of fruits (fruits/plant) and a larger yield (kg/m<sup>2</sup>) in the plots that were fertilized with silicon.

## **2.2 Influence of foliar sprays and bunch feeding on yield and quality parameters of banana and other horticultural crops**

### **2.2.1 Effect of silicon spray on fruit crops**

Single and multiple foliar sprays of a commercial formulation Apasil containing silicon dioxide on Golden Delicious apple trees, starting at the petal fall stage, significantly reduced fruit rosetting (Edgerton, 1976). Strawberry plants that received 50 ppm SiO<sub>2</sub> recorded higher top weight (shoot weight), fruit weight, fruit yield and improved pollen fertility (Miyake and Eiichi, 1986). Silicon uptake is related to the development stages of the plant and in the soil system, the silicate ion can replace and release the phosphate ion fixed in the soil, thus increasing the amount of phosphate available to the plant, and helps to promote the translocation of phosphorus (Takahashi *et al.*, 1990).

Potassium silicate suppressed respiration rate, ethylene evolution and maintained quality of 'Hass' avocado (Stamatakis *et al.*, 2003). The application of potassium silicate (125, 250 and 500 mg/l-1) increased the silicon and calcium concentration in the leaf tissue of *Rosa chinensis minima* 'Sonja' (Mary, 2005). Simultaneous application of Mn and Si both with the dosages of 400 mg/kg effectively prevented Fuji apple trees from developing the internal breakdown (Gao *et al.*, 2006). Foliar sprays of calcium silicate (ActiSil) at 0.2 per cent resulted in maximum firmness of plum fruit during fruit picking and further delayed its softening (Ochmian *et al.*, 2006).

Foliar sprays with Agro force (oligomeric silicic acid + boric acid) at different concentrations (2.7 litres/ha and 5.4 litres/ha) enhanced growth, production and quality of papaya compared to control (Realpe and Laane, 2008). Increase in the fresh fruit weight of 'Hass' avocado fruits were observed when fruits were dipped in 5, 13 and 25 x 10<sup>3</sup> ppm of potassium silicate after harvest and subsequently stored at room temperature (25°C) (Bertling *et al.*, 2009). Silica at 0.5 ppm reduced membrane damage, weight loss and mitigated chilling injury of citrus fruits (Mathaba *et al.*, 2009). Tomatoes treated with silicon as post harvest dip had significantly higher

firmness, TSS,  $\beta$ -carotene, vitamin-C and lycopene (Kaluwa *et al.*, 2010). Weak neck, a physiological weakening at the pedicel of *Musa sp. cv. Rastali* can be controlled by applying silicon, boron and magnesium (Putra *et al.*, 2010).

Sodium silicate ( $10\text{mmol L}^{-1}$ ) increased the flesh firmness of apricot fruits during storage (Zhang *et al.*, 2011). Longan fruit coated with nano-silica witnessed reduced browning index and polyphenoloxidase activity, decreased weight loss and extended shelf life (Shi *et al.*, 2012).

In the experiment of Lalithya *et al.* (2014) showed an increased leaf nutrient status of sapota with respect to macro nutrient and silicon content in response to soil and foliar application of silicon and micro nutrients. The treatment with foliar application of potassium silicate at 8 ml per litre resulted in more yield and quality of fruits.

Roshdy *et al.* (2014) reported that single and combined applications of potassium silicate and seaweed extract each at 0.05 to 0.1 per cent significantly improved bunch and hand weights, and had no significant effect on number of hands per bunch and number of fingers per hand. Further, the treatment was found very effective in improving fruit quality in terms of increasing weight, length and diameter of finger, pulp, TSS and total sugars percentage and reducing both fruit peel and total acidity percentage relative to the check treatment.

## **2.2.2 Effect of Nitrogen compounds on yield and quality on fruits crops**

### **2.2.2.1 Banana**

Post-shooting application of urea in *cv. Giant Cavendish* bananas has been reported to promote the yield (Venkatarayappa *et al.*, 1976). In banana *cv. Nendran*, foliar application of one liter solution of 4 per cent urea per plant on both the surfaces of leaves recorded maximum bunch weight (20.57 kg) and fruit weight (113.17 g), whereas 2 per cent urea spraying increased the TSS (18.90%). On the other hand, increased total sugar (15.01%) and decreased acidity (0.172%) was noted in urea spray at 1 per cent (Patel and Patel, 1987).

The translocation of nutrients into the inflorescence from exogenous feeding in 'Poovan (AB)', 'Monthan (AAB)' and 'Nendran (AAB)' varieties has been reported (Buragohain and Shanmugavelu, 1986; and Sobhana and Arvindakshan, 1989). Foliar application of nitrogen and phosphorus as di-ammonium phosphate (2%) in the 4<sup>th</sup> month recorded the highest bunch weight (18.72 kg) and number of fruits (52.00) in banana cv. Nendran (Selvarajan and Azhakiyamanavalan, 1992).

In a study, banana cv. Harichhal with 2 types of suckers (sword and water) were treated with foliar sprays of urea in the concentrations of 0, 1, 2 or 3 per cent. Sword suckers sprayed with 2 per cent urea produced fruits with the highest TSS (18.90%), sugar (18.66%), ascorbic acid (5.49 mg/100 g), protein (1.64%), ash (0.81%), P (32.93 mg/100 g), K (359.23 mg/100 g), Ca (6.76 mg/100 g) and Mg (44.90 mg/100 g) contents (Singh, 1992). Smith and Hoffman (1998) tested fertigation (N and K) by drip and micro-spray irrigation. Stem circumference and number of hands per bunch were greater for the micro-spray method and were also greater with monthly applications for both methods. Mean bunch mass for weekly and monthly irrigations was 23.9 kg and 29.2 kg, respectively, for drip irrigation, and 30.1 kg and 33.3 kg, respectively for micro-spray irrigation.

Combination of 2<sup>nd</sup> week pruning of male bud after its emergence and placement of 30 g urea to cut stalk end, resulted in maximum bunch weight (12.49 kg) with excellent finger characteristics viz., weight (248.13 g) and girth (14.06 cm) in comparison to control (8.04 kg) plants, whereas finger length (24.08 cm) was maximum in combination of 2<sup>nd</sup> week pruning with 10 g urea placement (Ancy *et al.*, 1998).

The influence of urea feeding at the cut end bunch stalk of the rachis of banana in tissue cultured plants of 'Nendran' variety was studied by Ancy and Kurien (2000). The study revealed that placing 30 g urea on the cut stalk end at 2 weeks or 4 weeks after complete emergence of the bunch resulted in maximum yield and yield attributes. There were significant differences in finger weight and size in favour of urea treated plants. Maximum bunch weight (7.02 kg), finger weight (186.79 g) and girth (14.00 cm) were observed in the treatment with 30 g urea placement and it differed significantly over all other treatments. Finger length (24.50 cm) was maximum with 70 g urea placement. Premature ripening and blackening of the terminal fingers and hand (proximal to the treatment) was observed in treatment with more than 50g.

Urea spray (4%) was observed to hasten ripening of banana fruits and high non-reducing sugars content (7.55%). Foliar spray of urea either alone or in combination with Potassium di hydrogen phosphate ( $\text{KH}_2\text{PO}_4$ ) appeared to hasten fruit ripening (Kumar and Bangarusamy, 2006). Application of 15 g of ammonium sulphate and 7.5 g of sulphate of potash in 500 g of fresh cow dung to distal stalk-end of the bunch of 'Robusta' banana was found to be promising to boost the bunch weight (29.71 kg) by 41.5 per cent without affecting the fruit quality in banana cv. Robusta (Kottur and Murthy, 2008).

De-navelling and bunch feeding of ammonium sulphate (5g) and sulphate of potash (2.5 g) blended in fresh cow dung (500 g) resulted highest bunch weight (9.36 kg), highest Ca (1.44%), Mg (0.12%), S (0.03%) and Fe (139 mg kg<sup>-1</sup>) compared to control (5.25kg) and Ca, Mg, S and Fe (0.94, 0.096, 0.024, and 51 mg kg<sup>-1</sup> respectively) in banana cv. Ney Poovan (Kotur and Murthy, 2010).

Urea 2 per cent was sprayed on banana cv. Nanjangudu rasabale (AAB) twice on bunch immediately after bunch emergence resulted in better finger length (Nandan *et al.*, 2011).

A Field experiment was conducted by Shetty *et al.* (2015) to determine the effect of foliar spray on improvement of yield of tissue culture banana cv Grand Naine (AAA). Urea (1%, 2% and 3%), SOP (1%, 2% and 3%) and combination of urea and SOP were sprayed thrice after emergence of flag leaf. The results revealed that bunch sprayed in combination with SOP (2%) and urea (1%) reduced the days taken from shoot initiation to complete shooting and shooting to harvest (12.17 and 122.92 respectively), increased bunch length (90.93 cm), intermodal length between hands (11.67 cm), weight of hand (4.41 kg), length of finger (25.17 cm), girth (13.67 cm), weight of finger (221.0 g), also highest weight of bunch and total yield per hectare (40.67 kg and 102.70 tonnes, respectively).

#### **2.2.2.2 Mango**

Gill and Mukherjee (1967) studied the effect of spraying urea (2%) and 2, 4-D (15, 20 and 60 ppm) on fruit retention and fruit size of mango and found an increase in yield by the application of urea (2%).

Sharma *et al.* (1990) experimented with different combination of treatments using potassium nitrate ( $\text{KNO}_3$ ) and NAA on mango cultivar Langra. Among these different treatments, the maximum number of fruits/plant, highest non reducing sugars (14.15%), ascorbic acid content (68.5 mg/100 g pulp) and lowest acidity (0.27%) were obtained with urea (4%) +  $\text{KNO}_3$  (3%) and highest TSS (20.22%), reducing sugars (4.6%) and total sugars (18.22%) were obtained with the combination of urea (4%) + NAA (40 ppm).

Shinde *et al.* (2002) reported significant control of fruit drop and higher yield in Alphonso mango for three consecutive seasons with the foliar feeding of urea (2%), NAA (20 ppm) and a micronutrient mixture (50 ppm) followed by combined application of urea + triacontanol + micronutrient.

### **2.2.2.3 Grapes**

Kumar and Pathak (1992) reported spraying of 1.0 per cent urea proved most effective in improving the size and weight of bunches (325 g/bunch) in grapes cv. Perlette. The highest yield (8.45 kg/ vine) was recorded with application of urea followed by 0.4 per cent foliar spray of  $\text{ZnSO}_4$  (8.3 kg/vine). Further, the best quality berries were also obtained with 0.2 per cent  $\text{ZnSO}_4$  application.

Beniwal *et al.* (1992) revealed that 1.5 per cent foliar spray of urea in Perlette grapes was found to be effective for increasing bunch weight, bunch volume, berry characteristics and yield.

### **2.2.2.4 Pomegranate**

Ramezani *et al.* (2009) conducted an experiment by applying aqueous solutions of urea and calcium chloride on two branches of pomegranate (*Punica granatum* L. cv Malase-Yazdi) at full bloom and one month after full bloom stages and found urea at 1 per cent and 2 per cent significantly increased aril size, fruit length, fruit diameter also soluble solid content.

### **2.2.3 Effect of potash on yield and quality of fruits crops**

Banana is a potassium loving crop; it requires more potassium for its growth, production and quality compared to nitrogen and phosphorus. Potassium is often referred as the quality element for crop production (Usherwood, 1985).

Potassium appears to have profound influence on fruit quality through its influence on size, appearance, colour, soluble solids, acidity and vitamin contents. Potassium deficiency in fruits is often observed even in K-rich soils. Fruits like banana, grapes, peach and passion fruit require high potassium. Although potassium does not form part of the structure of plant constituents, it regulates many vital functions like carbon assimilation, translocation of proteins and sugars, maintaining water balance in plants, maintaining turgor pressure in the cell, root development, improving quality of the fruits by maintaining desirable sugar to acid ratio, ripening of fruit and many other processes. Thus, it is the most important nutrient regulating the quality of fruits. Potassium is involved in many aspects of plant physiology *viz.*, activation of more than 60 enzymes, aiding in photosynthesis, favouring high energy status, regulation of stomata opening *etc.* With the changing cropping patterns, need for potassium nutrition has become pertinent to obtain high yield and quality fruits (Kumar *et al.*, 2006).

Potassium requirement by plants is much greater than other mineral nutrients, with the exception of N. Potassium uptake by plants from soil solution is influenced by several factors, including soil moisture conditions, pH, texture, aeration, temperature, and balance with other nutrients. Plant development stage also influences the capacity for K uptake. More K is taken up during the vegetative growth stages when roots are actively growing than in fruit growth (reproductive) stages when root growth is inactive. Developing fruits are stronger sinks for photo assimilates than roots and other vegetative tissues. This competition for photo assimilates reduces root growth and energy supply for nutrient uptake (Lester *et. al.*, 2007).

#### **2.2.3.1 Banana**

In a high value crop species like banana, role of potassium is involved in carbohydrate synthesis, translocation and synthesis of protein and neutralization of physiologically important organic acids (Tisdale and Nelson, 1966). Banana responds

positively to potassium application. However, demand for potassium increases rapidly after flowering because of developing bunches (Hedge and Srinivas, 1991). Hence there is a need to supply potassium for better growth and development of fruits. In order to meet this extra demand for potassium after flowering, spraying of potassium on foliage and bunches and stalk end feeding with potassium is practiced.

Spraying of 50 ppm Potassium di hydrogen phosphate ( $\text{KH}_2\text{PO}_4$ ) and 10,000 ppm urea on banana cv 'Ney Poovan' delayed the maturity of fruit (11 days) (Kumar and Reddy, 1998). In an experiment  $\text{GA}_3$ , 2, 4-D, urea and Potassium di hydrogen phosphate ( $\text{KH}_2\text{PO}_4$ ) were sprayed to banana bunches at 7 days and 15 days after shooting. Results showed that bunch weight varied significantly among the different treatments. Bunch weight was significantly higher in urea and potassium di hydrogen phosphate ( $\text{KH}_2\text{PO}_4$ ) treated plants when compared to control (water spray) (Athani and Hulamani, 1999). The foliar application of 2 per cent sulphate of potash on banana gave the highest yield but decreased by further increase in concentration (3 and 4%). The interaction effect between irrigation and potassium were not significant. The total soluble solids were also found to be non- significantly different in either irrigation levels or by potassium spray (Srinivas, 2004).

Pre harvest treatments on Nendran cultivar of banana revealed that potassium sulphate (2%) as two sprays found to be best among the treatments and recorded significantly highest bunch weight (9 kg), number of fingers (55.8), finger length (22.13 cm) and finger girth (13.6 cm), followed by 1 per cent potassium sulphate spray (Mustaffa *et al.*, 2004).

Sateesh and Bangarusamy (2006) reported that pre-harvest foliar spray of urea (4%), potassium di hydrogen phosphate ( $\text{KH}_2\text{PO}_4$ ) (2 per cent), calcium chloride ( $\text{CaCl}_2$ ) (0.5%) and boric acid (0.2%) after shooting was found to be the best combination for enhancing total soluble solids (25.05 °Brix), reducing sugar (19.48%) and better shelf life in banana cv. Rasthali.

Ramesh and Kumar (2007) evaluated the effect of foliar spray of Sulphate of potash (SOP) on banana cv. Ney Poovan and reported that SOP at 1.5 per cent spray had highest bunch weight (14.27 Kg) with better bunch traits such as number of hands (13.00), total number of fingers (233.30), finger weight (75.10 g), finger length (14.37

cm) and finger girth (13.77 cm). Further, quality traits such as maximum TSS (28.9%), total sugars (22.36%), less acidity (0.16%) and maximum shelf life (8.7 days) with less number of days to harvest from shooting (89.90) were also reported.

Ramesh *et al.* (2008) reported that foliar spray of sulphate of potash (SOP) at 1.5 per cent twice *i.e.*, first immediately after opening of the last hand and second 30 days after the first spray increased bunch weight (31.97 kg) with better bunch traits such as number of hands (10.00), total number of fingers (188.7), finger weight (167.3 g), pulp to peel ratio (5.37) and quality traits such as higher TSS (22.62%), total sugars (19.80%), less acidity (0.16%), maximum shelf life (8.7 days) and with less number of days to harvest (103.7) from shooting. Further, SOP at 1.5 per cent concentration produced heavier bunches which were on par with SOP at 1.0 per cent in cultivar Robusta (AAA- Cavendish).

Post shooting foliar spray twice, first at the time of last hand emergence and repeated after 30 days after first spray with potassium di hydrogen phosphate (0.5%) + urea (1%) + 2, 4-D (20 ppm) and sulphate of potash (SOP) at 1.5 per cent resulted in higher bunch weight (14.33 Kg) with better bunch traits such as number of hands (13.00), total number of fingers (219.1), finger weight (76.7 g), Pulp:peel ratio (7.62) and better quality traits such as TSS (27.90%), reducing sugars (19.96%), non-reducing sugars (3.04%), total sugars (23.00%), acidity (0.26%), green life (5.3 days) and maximum shelf life (9.0 days) with less number of days to harvest from shooting (103.3) in banana cv. Ney Poovan (Ramesh and Kumar, 2010).

Sulphate of potash (SOP) at 2 per cent sprayed on banana bunch cv. Nanjangudu rasabale (AAB) immediately after bunch emergence resulted in better finger girth (13 cm), green life (5.15 days), shelf life (5.6 days), total sugars (25.89%), TSS (26.1 °B) and lowest physiological loss in weight (11.80). Meanwhile, maximum pulp to peel ratio (4.12) and reduced titratable acidity (0.31%) were recorded in 3 per cent SOP sprayed fruits (Nandan *et al.*, 2011).

According to Shetty *et al.* (2015), foliar application of urea (1%, 2% and 3%), SOP (1%, 2% and 3%) and their combination applied at emergence of flag leaf stage on tissue culture banana cv. Grand Naine (AAA) improved yield and quality. While, the best results were obtained from combination of SOP (2%) and urea (1%) in terms of bunch weight and total yield per hectare.

### 2.2.3.2 Mango

Oosthuysen (1997) studied the effect of potassium nitrate ( $\text{KNO}_3$ ) spray on fruit retention, fruit size, tree yield and fruit quality of six mango cultivars and reported that two sprays of  $\text{KNO}_3$  (2%) retained higher fruits till harvest with an increase in yield in all the six cultivars. There was no apparent effect of  $\text{KNO}_3$  sprays on fruit quality such as TSS, pH or skin colour.

Ghosh and Chattopadhyay (1999) studied the effect of foliar applications of urea at 3 different levels (2, 3 and 4%) at three different stages *viz.*, panicle emergence, pea stage and marble stages on yield and physico-chemical characters of mango cv. Himasagar. Among the three applications, urea (4%) resulted in higher fruit yield (41.7 kg/tree), TSS and total sugar contents. However, the fruit weight was found to be maximum (259 g) with urea (3%).

Burondkar *et al.* (2002) investigated the effect of different sources and doses of potassium on yield and quality of 'Alphonso' mangoes and reported that trees receiving recommended dose of K through SOP as soil application and supplemented with  $\text{KNO}_3$  (1%) as foliar spray registered maximum yield (74.59 kg/tree) over rest of the treatments including control (39.38 kg/tree) and the treatment improved the TSS of fruits.

### 2.2.3.3 Grapes

The Perlette grapevines, sprayed with 1 per cent sulphate of potash (SOP) at weekly intervals after setting of berries significantly improved the average berry weight, juice percentage, reducing sugars, TSS and berry firmness while, total acidity also increased as a result of sprays with SOP (Singh *et al.*, 1979). Beniwal *et al.* (1992) revealed that 0.5 per cent urea and 1.0 per cent potassium sulphate as foliar spray in Perlette grapes was proved to be effective in increasing total soluble solids and reducing sugars. Interestingly, acidity increased with urea spray, whereas it decreased with spray of potassium sulphate.

#### **2.2.3.4 Guava**

Weekly sprays of potassium (1% aqueous SOP solution) for seven weeks improved the quality of guava with respect to TSS and total sugars (Ahlawat and Yamdagni, 1981). In an experiment conducted by El-Sherif *et al.* (2000), potassium sulphate (1%, 2% and 3%) and zinc sulphate (0.5%, 1% and 2%) sprayed to Montakhab El-Kanater guava trees at full bloom stage in both seasons resulted in higher yield and maximum number of fruits per tree with 1 and 2 per cent potassium sulphate as well as 0.5 and 1 per cent zinc sulphate sprays. The fruit quality was also improved in trees treated with potassium and zinc fertilizers.

#### **2.2.3.5 Pomegranate**

Potassium nitrate (250 mg/L) sprayed on pomegranate fruits resulted in higher fruit diameter (30 mm), TSS (16.18 °Brix) and titrable acidity (1.11 mg citric acid $100^{-1}$  mL juice) in 'Malas Yazdi' pomegranate (Khayyat *et al.*, 2012).

#### **2.2.3.6 Ber**

Gill and Bal (2009) reported that foliar spray of KNO<sub>3</sub> (1.5%) recorded maximum fruit length (4.71 cm), fruit breadth (3.09 cm), fruit weight (24.0 g) and fruit characteristics like TSS (16.9%) and maximum TSS to acid ratio (49.5) and foliar spray of KNO<sub>3</sub> (1.0%) resulted in lower acidity value (0.32%).

#### **2.2.3.7 Olive**

According to Hegazi *et al.* (2011), foliar application of potassium nitrate at 4 per cent after final fruit set (mid May) improved the yield (25.67 kg/tree and 21.67 kg/tree), while KNO<sub>3</sub> (4%) spray after pit hardening (first week of August) improved the fruit length (3.03 and 3.09 cm), fruit diameter (2.42 and 2.46 cm), fruit weight (11.01 and 12.08 g) and flesh weight (9.78 and 10.76 g) in two successive seasons of 2009 and 2010 in Olive cv. Picual.

## 2.2.4 Effect of 2, 4-Dichlorophenoxyacetic acid on quality and yield on fruit crops

### 2.2.4.1 Banana

Banana var. Giant Governor bunches drenched once completely at 55 days after flowering with 300 ml solution of 2,4-D (25 ml/l) increased the fruit length (17.9 cm), reduced peel weight (41.7 g), while 2,4-D (10 ml/l) increased TSS (23.2 ° Brix) and reducing sugar (6.7%) concentration (Pradhan *et.al.*, 1988). Interaction effect between three split application of fertilizers on 3<sup>rd</sup>, 5<sup>th</sup> and 6<sup>th</sup> month and foliar application of 2,4-D at 25 ppm four times at bimonthly intervals from third to ninth month increased the yield (37.64 t/ha) compared to control (22.33 t/ha) in banana variety Nendran (Selvarajan and Doraipandian, 1996).

Athani and Hulamani (1999) reported shorter ripening period (125 days in comparison with 151 in the control) and higher yield (21.2 tonnes/ha in comparison with 11.3 t/ha in the control) with 2, 4-D 30 ppm sprayed at 7 days after shooting in banana cv. Rajapuri. Spraying with 2, 4-D at 7 days after shooting on banana cv. Rajapuri (*Musa* AAB) also resulted in significant increase of bunch circumference (Athani and Hulmani 2001).

With plant growth substances *viz.*, GA<sub>3</sub> (100, 200 and 300 ppm), 2, 4-D (10, 20 and 30 ppm) and KH<sub>2</sub>PO<sub>4</sub> (0.5%) + urea (1%) an experimental trial was conducted. The chemicals applied as foliar spray at 5<sup>th</sup> month after planting and immediately after the last hand opening of the bunch in banana cv. Borjahaji resulted in the highest bunch weight and yield (15.78 kg and 48.70 t/ha). While, the lowest bunch weight and yield (8.50 kg, 26.23 t/ha) were observed in the control plot (Barman and Das, 2002). Spraying of 2, 4-D to the fruits at 15, 30, and 45 ppm on banana cv. Nendran significantly improved fruit length, fruit girth, bunch weight, yield, pulp-peel ratio, total soluble solids, total sugar and reducing sugar. While, ripening period and shelf life were reduced with 2, 4-D application. Among all 2, 4-D at 30 ppm was found to be most beneficial treatment (Geetha and Nair, 2002).

Foliar application of 2,4-D at 20 and 10 ppm at 5 months after planting and immediately after the last hand opening of the bunch in banana cv. Barjahaji (*Musa*

AAA group) found beneficial compared to the other treatments in terms of positive effects on TSS (23.22%), total sugar (20.42%), highest bunch weight (15.78 kg) and highest yield (48.70 t/ha) (Barman and Baruah, 2003). Spraying with 2, 4-D at 25 ppm on the Musa (AAB group) cv. Malbhog bunches at the opening of the last hand had the longest fingers compared to control (Bhaskarjyoti and Chakrabarty, 2003).

A differential activity was observed with respect to peak of pectate lyase (PEL) during ripening of banana fruits (*Musa acuminata* var. Harichhal) receiving different hormone treatments. Exposure of fruits to 25 ppm ethylene for 24 hours, as well as dipping of *M. acuminata* fruits in 1 mM 2,4-dichlorophenoxy acetic acid (2,4-D) for 4 hours, hastened fruit ripening. Both PEL activity peak and climacteric peak were observed on the 4<sup>th</sup> and 10<sup>th</sup> days of treatment with ethylene and 2, 4-D, respectively, compared to the 16<sup>th</sup> day in control fruits. Treatment of fruits with ethylene or 2, 4-D also advanced the appearance of a polygalacturonase (PG) peak (Anurag *et al.*, 2004).

#### **2.2.4.2 Mango**

According to Maurya *et al.* (1973) foliar spray of NAA, 2, 4-D or 2, 4, 5-T each at 20, 40 and 60 ppm at fortnightly interval from pea-sized stage in Dashehari mango until harvest improves fruit size and quality in terms of TSS, sugars, ascorbic acid and reduced the total acidity. The most effective treatment was found to be 2, 4-D at 20 ppm.

#### **2.2.4.3 Citrus**

Jose *et al.* (1984) reported that dilute spray of 10 or 20 ppm of 2, 4-dichlorophenoxyacetic acid (2, 4-D) at 5 weeks after mid bloom increased the yield in Navel Oranges. Rattanpal *et al.* (2005) experimented with potassium nitrate (2.5% and 5%) and potassium sulphate (2.2% and 4.4%) alone and in combination with 2, 4-D (20 ppm) sprays at 30, 45, 60 and 75 days after full bloom on six year old Kinnow trees and the results indicated that KNO<sub>3</sub> at 5.0 per cent + 2, 4-D at 20 ppm sprayed 60 days after full bloom proved to be the best for maximum increase in fruit size.

Exogenous application of 20 ppm 2, 4-D on Blood Red sweet orange trees two months after fruit set recorded maximum reducing sugars (3.13%) in fruit (Basharat *et*

*al.*, 2007). Similarly, exogenous application of growth regulators (2, 4-D, GA<sub>3</sub> and NAA) in Kinnow mandarin (*Citrus reticulata* Blanco) significantly decreased percentage of preharvest fruit drop, leading to increase in total number of fruits per plant, fruit weight, juice percentage, total soluble solids, acidity, reducing sugars and non reducing sugars. Among them, auxins (2, 4 - D and NAA) performed better compared to gibberellins (Azher *et al.*, 2008).

### **2.3 Influence of skirting materials on yield and quality parameters of banana and other horticultural crops**

Bagging is a physical protection technique, commonly applied to many fruit, which not only improves their visual quality by promoting peel colouration and reducing the incidence of fruit cracking and russeting, but it can also change the microenvironment for fruit development (Fan and Mattheis, 1998).

During growth and development, fruit undergo several physical and chemical changes and are susceptible to insect pest infestations, bird attack, various pathogens, and mechanical damage, all of which can reduce their commercial value and thereby cause significant yield and economic losses. To prevent the losses caused by biotic and abiotic factors, several good agricultural practices (GAP) are becoming popular throughout the World (Sharma, 2009). Furthermore, the development of alternative techniques to improve the appearance and quality of fruit and to reduce disease and insect infestations is becoming increasingly important as consumer anxiety over the use of manmade agro-chemicals and environmental awareness increases. Thus, more emphasis is being placed on reducing the use of pesticides to ensure worker safety, consumer health, and environmental protection (Sharma, 2009). Among several such alternatives, pre-harvest fruit bagging has emerged as an effective approach in different parts of the World. In this technique, individual fruit or fruit bunches are bagged on the tree for a specific period.

Bagging has been used extensively in several fruit crops to improve skin colour and to reduce the incidence of disease, insect pests, mechanical damage, sunburn of the skin, agrochemical residues on the fruit, and bird damage (Bentley and Viveros, 1992; Kitagawa *et al.*, 1992; Hofman *et al.*, 1997; Amarante *et al.*, 2002; Xu *et al.*, 2010). Preharvest bagging of fruit is practiced in Japan, Australia, and China

during peach, apple, pear, grape, and loquat cultivation in order to optimise fruit quality by reducing physiological and pathological disorders and to improve fruit colouration to increase market value leading to an improved appearance (Amarante *et al.*, 2002). Some countries such as Mexico, Chile and Argentina do not import apples unless they are bagged.

### **2.3.1 Effect on maturity**

‘Repol’ a polypropylene based non-woven fabrics used as bunch sleeves to study the effect on bunch characteristics and fruit quality in banana *var.* Grand Naine produced more encouraging results on bunch maturity. Early maturity of fruits (100.6 days) was obtained in blue polypropylene sleeves cover which was followed by polythene with 6% ventilation (102.5 days) as compared to the control (109.3 days) (Anonymous, 2013).

Abbasi *et al.* (2014) reported that guava fruits bagged in news paper took 98 days after fruit set to commercially mature, whereas, the fruits packed with other treatments *viz.* perforated polyethylene bags, muslin cloth, netting bags and control took 91 days to mature. The study indicates the difference in period required for fruit maturity due to different bagging treatments.

### **2.3.2 Effect on yield**

Turner (1984) studied the effect of bunch covers on bananas and reported that bunch covers increased yield by increasing the size and appearance of the fruits. Justus *et al.* (2006) studied the influence of net and cheesecloth cover on growth, yield and fruit quality of peach and reported maximum fruit yield in net covers followed by cheesecloth cover, while lowest number was reported in control. Further, the difference between the control and the treatments was observed significant implying that covering with nets or cheesecloths can be of commercial importance in peach orchards.

In banana *var* Williams, maximum bunch weight (10.44 kg) was obtained in dull blue colour bags followed by shiny blue colour bags (9.16 kg), while, the lowest bunch weight (8.62 kg) was in control of under central Kenya condition (Muchui *et al.*, 2010). Field demonstrations in Jalgaon district on use of plastic skirting bags for

production of export quality banana fruits indicated that the use of skirting bags helped in production of spotless yellowish green fruits which had high demand in the market (Anonymous, 2011a). Demonstrations were conducted on use of skirting bags in banana in 10 different orchards of Buldhana district. The results indicated that the use of skirting bags had significant effect on weight of bunch. The average bunch weight with skirting bags was 19.10 kg, while it was 17.44 kg without skirting bags. The highest yield of 82.30 tons/ha was obtained by using skirting bags, while the average yield of control was 74.81 tons/ha (Anonymous, 2011b).

Bagging with different polythene materials influenced productivity, ripening and quality of Zaghoul date palm. Maximum yield (202 kg/palm) was obtained in blue polythene bags followed by transparent polyethylene bags (197 kg/palm), while the lowest yield (161 kg/palm) was recorded in control (Kassem *et al.*, 2011).

Mohamed and Quarshi (2012) studied the effect of gibberellic acid spray and bunch bagging on fruit quality of 'Barhee' date palm cultivar under hot arid conditions and reported that bunch bagging significantly increased bunch weight than the control but the effect was lower than the GA<sub>3</sub> treatments. The maximum bunch weight of fruit (9.4 kg) was obtained in bagging + 50 ppm GA<sub>3</sub> followed by bagging (7.5 kg), while the lowest (6.7 kg) bunch weight was noted in control. Further, GA<sub>3</sub> application and bunch bagging also delayed fruit ripening.

Fruit bagging for lychee in commercial orchards as well as for home growers eliminates the pesticide use, improves overall fruit colour, increases fruit yield, reduces culling time of damaged fruit and provides uniform ripening (Andrea and Nakamoto 2013).

Maximum bunch weight (37.30 kg) in banana fruit was obtained in blue polypropylene sleeves cover while lowest bunch weight (34.46 kg) was recorded in control. The control fruits without bunch sleeves had blemishes and injuries on the fruit surface and also recorded lesser fruit weight and yield which in turn reduced the profitability of the farmers (Anonymous, 2013).

Abbasi *et al.* (2014) studied the economics of different types of bagging materials (control/no bagging, newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags) in guava during summer season under Pakistan

condition and recorded four times increase in yield due to different bagging treatments. The yield of fruits in different bagging treatment was (56.25 kg/tree), while the control recorded the lowest (14.08 kg/tree) yield.

### **2.3.3 Effect on quality**

#### **2.3.3.1 Effect on physical attributes**

Use of banana bunch covers resulted in obtaining large-grade fruits with more uniform fruits within the bunch and offered protection from mechanical damage to the fruits while hanging in the plantation and during transport to the shed (Turner *et al.*, 1984). Walter and Mario (1992) studied the effect of bagging on granny smith apples and stated that brown paper bags significantly reduced sunburned fruits as well as improved fruit firmness and sweetness.

Bagging in 'Fuji' apples during fruit development, colour development and storage period increased temperature at the apple surface by 3 to 5<sup>0</sup>C in the middle of a sunny day, in addition, bagging delayed and reduced red colour development especially on the blush side. Bagging during fruit development increased superficial scald but eliminated stains during cold storage Xuotong and James (1998). Banana bunch covering increased finger length, girth and weight of covered bunches by 11, 13, and 37% respectively (Johns and Scott, 1989).

Amarante *et al.* (2002) studied the effect of pre-harvest bagging on fruit growth in pears (*Pyrus communis*) and found that bagging increased the air temperature within the bags (32 <sup>0</sup>C) compared to ambient air temp (27 <sup>0</sup>C). But there was no significant difference in fruit growth, final fruit weight, density and fruit maturity at commercial harvesting stage. Justus *et al.* (2006) reported maximum weight of peach fruit (148 g) in net cover followed by cheesecloth cover (143 g), while the least (129 g) in control.

A study revealed the effect of pre-harvest bagging on fruit quality of peach (*Prunus persica Batsch cv. Hujingmilu*). Length of un-bagged fruit was smaller than triple layer bagged fruits when measured at 117 and 124 days after full bloom. Skin colour was significantly influenced by fruit bagging, while the brightness of skin was minimum in un-bagged fruit (Bin *et al.*, 2006). According to Muchui *et al.* (2010)

bunch bagging had no significant effect on grade, finger length and bunch weight under central Kenya condition.

Harhash and Al-Obeed (2010) studied the effect of colour of bagging materials on yield and fruit quality of date palm and reported maximum length of fruit (3.17 cm) in blue colored bags which was followed by white bags (3.48 cm), while the lowest was in control (3.20 cm). Similarly, Kassem *et al.* (2010) reported that polythene bagging increased the fruit length, diameter and weight in Zaghoul date palm. Further, fruit cracking percentage was also decreased as compared to un-bagged control. Blue coloured bagging had greater influence than the transparent polythene bagging but the differences were not significant. Bagging had no effect on the fruit skin hardness, total soluble solids, total titratable acidity, edible portion, length of fruit, fruit diameter, age of harvest in *Musa paradisiaca* var. *Typica*, (AAB group) (Ani *et al.*, 2011). Alfonso and Henry (2011) studied effect of two types of banana bunch covers (1-blue Santa Lucia and 2-transparent photosensitive) on fruit quality. Results revealed no differences between bunch cover in bunch appearance or in the peel firmness in grade-I of maturation for fruit colour appearance except for  $L^*$  value which was found to be higher (56.48). However, the transparent photosensitive cover in comparison to the blue Santa Lucia covers did not result in increased production or an improvement in bunch and fruit appearance.

Junhui *et al.* (2012) studied the effects of bagging on fresh fruit quality of *Canarium album* for two years and reported that colour and smoothness were better, the edible pulp and ascorbic acid concentration were higher after bagging than in the control. But the soluble solids in fruit decreased. Bagging showed golden yellow colour, more smoothness, higher single fruit weight and more delicate flesh. However, the bag needs size specifications and modification with a few holes at the bottom. According to EL-Alakmy (2012) combination of calcium application and wrapping treatment on fruit quality of Earli Grande Peach trees had significant difference in fruit weight. Peach fruit weight averaged for treated (85.55 g) were significantly higher compared to control (52.87 g). Further,  $\text{CaCl}_2$  with polyethylene wrapping treatment was effective in increasing fruit weight, flesh weight, flesh thickness.

Maximum fruit length (23.5 cm) and girth (14.5 cm) was obtained in blue polypropylene sleeves cover, while the lowest fruit length (20.7 cm) and girth (13.7 cm) in control in Grand Naine banana under Trichi conditions (Anonymous, 2013).

An investigation was undertaken in 2013 and 2014 for two consecutive fruiting seasons to study the influence of bagging on physical quality of mango *cv.* Alphonso. The fruits were bagged at marble stage (30 days from fruit set) with different types of bags. Bagging with newspaper bag and brown paper bag improved fruit retention, weight of fruit, diameter of fruit, pulp weight (Haldankar *et al.*, 2015)

### **2.3.3.2 Effect on chemical attributes**

Johns and Scott (1989) studied the effect of bunch covers on fruit yield and quality of banana and reported that the flavour of sealed cover fruit was insipid than that of their counterparts and less sweetness. However, the sealed cover treatment, when harvested at the normal time, produced the most fruits with green life greater than 30 days.

An investigation was undertaken by Sujitra *et al.* (2005) to studied the effect of bagging and storage temperature on anthocyanin content and phenylalanine ammonialyase (PAL) activity in mangosteen (*Garcinia mangostana* L.) fruit pericarp. Reports suggested elevated anthocyanin content during maturation of fruit was observed in bagged fruits while PAL activity was not significantly influenced by bagging but activity was slightly decreased in unbagged fruits compared to bagged fruits.

Covering of peach fruits with cheese cloth led to increased brix value of fruit (12.46%) followed by net cover (12.15%) and the lowest brix value (11.93%) was noted in control. While, maximum acidity per cent observed in control fruits (0.23%) was followed by net cover (0.17%) and cheesecloth cover (0.15%) (Justus *et al.*, 2006). Bin *et al.* (2006) reported that TSS concentration in juice of peach fruit was higher in single-layer bagged fruit than in other double-layer bagged fruit and un-bagged fruit at the full-ripe stage. Flesh firmness of un-bagged fruit was a little higher than that of bagged fruit from 114 DAFB (Days after full bloom) to 120 DAFB. However, at the full-ripe stage (124 DAFB) flesh firmness of bagged fruit, especially in triple-layer bagged fruit was higher than that of un-bagged fruit.

Signes *et al.* (2007) observed the effects of pre-harvest bagging on quality of black table grapes and opined that pre-harvest bagging provided a more uniform colour of perla grapes than non-bagged samples. Further, the scientists witnessed higher soluble solids, titratable acidity, maturity index, sugars and organic acids composition, colour coordinates and high volatile compounds with leafy aroma in bagged grapes as compared to non-bagged grapes with delayed ripening of fruits by bagging operation. Chunhui *et al.* (2009) studied effect of fruit bagging on colouring and related physiology, and qualities of red chinese sand pear during fruit maturation and reported that, bagging treatments significantly affected the concentration of anthocyanin and the visual qualities of pear fruit compared to control.

Yang *et al.* (2009) conducted an experiment with three different types of bags *viz.* perforated translucent plastic bag (TPB), white adhesive-bonded fabric bag (WAFB) and black adhesive-bonded fabric bag (BAFB) on fruit development and quality in cross-winter off-season longan (*Dimocarpus longan* Lour.). The authors reported that sugar content was not significantly affected by bagging but organic acids including vitamin C were considerably affected. Concentration of malic acid, the dominant organic acid in longan aril, was 605.6, 830.0, 1161.0 and 1428 mg/g FW in TPB, BAFB, WAFB and the control. Vitamin C in the aril was significantly reduced by BAFB (108.4 mg/g FW), slightly increased by WAFB (183.9 mg/g FW) and significantly increased by TPB (264.5 mg/g FW) as compared with the control (174.7 mg/g FW). Pericarp of fruit bagged with TPB had a slightly higher content of Vitamin C (1337 mg/g FW), while those bagged with BAFB (873.6 mg/g FW) and WAFB (787.4 mg/g FW) had significantly lower vitamin C contents than the control (1243 mg/g FW).

Muchui *et al.* (2010) reported that the bunch covers did not influence starch, TSS, moisture content and weight loss during storage, chlorophyll content, peel and pulp firmness, total sugars and shelf life. However, perforated dull and shiny blue bunch covers may be used in commercial banana orchard in Kenya to produce high quality fruits especially in cooler areas.

Kassem *et al.* (2011) reported higher fruit acidity with bagging treatments than no bagging in Zyghloul date palm. Blue polythene bagging significantly decreased fruit total soluble solids, dry matter, reducing and total sugar and increased fruit

moisture contents compared to no bagging treatment. Generally, no significant differences were found between bagging with transparent polythene and no bagging in fruits with respect to TSS, dry matter, moisture, reducing sugars and total sugar content. According to Mohamed *et al.* (2012), the highest TSS concentration (34.8%) was recorded in bunch bagging treatment in date palm cv. Barhee followed by bagging + 50 ppm GA<sub>3</sub> (34.7%) treatment, while the lowest (31.3%) was in control. Bagging did not significantly affect the fruit diameter as well as total phenols concentration but increased fruit and flesh weight, fruit length, fruit/seed ratio acidity, vitamin C than control.

Banana bunches covered with blue polypropylene sleeves produced maximum TSS (21.84 °Brix), acidity (0.34%) and pulp: peel ratio (2.38). The lowest TSS (20.90 °Brix) and acidity (0.32%) were recorded in control. The highest total sugars (15.28%) and lowest pulp: peel ratio (2.22) was observed in white polypropylene sleeves (Anonymous, 2013).

Pre-harvest fruit bagging in apple cv. Delicious significantly influenced the colour development in apples, bagged apples with light-yellow bags resulted in the development of attractive red colour (Hunter *a* values) over non-bagged apples, conversely yellow/green colour development was suppressed by bagging. Further they reported that, bagging is an effective way to promote anthocyanin synthesis and improve fruit coloration in apples. Bagging also increased light sensitivity of fruit and stimulated anthocyanin synthesis when fruits were re-exposed to light after bag removal (Ram *et al.*, 2013).

Abbasi *et al.* (2014) studied the effect of fruit bagging treatments (control/no bagging, newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags) on quality of guava harvested at different maturity stages during summer. The authors reported the highest total soluble solid, non-reducing sugar and total sugar contents in case of fruit covered with perforated polyethylene bags on trees, while the lowest values were observed in control.

Bagging with newspaper bag and brown paper bag improved total soluble solids and reducing sugars at ripe stage and produced spongy tissue free fruits. The brown paper bag with polythene coating improved the fruit quality. Other bags such as butter paper bag, muslin cloth bag and scurting bag also improved fruits chemical

attributes compared to control. While, bagging with different types of bag did not change the sensory qualities of ripe fruits mango cv. Alphonso (Haladankar *et al.*, 2015).

#### **2.3.4 Effect on physiological behavior**

A delay in softening of mangoes and yellowing of their skin has been reported in fruits bagged with white paper bags in comparison to non-bagged fruit (Hofman *et al.*, 1997). Pre-harvest bagging of pear fruit (*Pyrus communis*) with micro-perforated polyethylene bags 30 days after full bloom did not affect maturity and flesh content of N, P, K, Ca, and Mg, but fruits had a greener and lighter skin colour than non-bagged fruits, Even respiration rate had no difference between treatments, but bagged fruits had slightly and consistently lower respiration rate than non-bagged fruits (Amarante *et al.*, 2002). A-Shiaran *et al.* (2004) studied effect of bagging with black paper on coloration and fruit quality of 'ruby' grapefruit and reported that bagging increased chroma and lightness values compared to control fruits.

Baiyeri *et al.* (2005) studied variable light transmission through four polyethylene colours used for plantain (*Musa sp. AAB*) fruits storage to know their influence on postharvest and culinary qualities. Their study revealed that, colourless polyethylene permitted higher light intensity ( $706.8 \text{ Wm}^2$ ), while the yellow polyethylene transmitted the least intensity ( $479.5 \text{ Wm}^2$ ). However, the light intensity passing through yellow and blue ( $513.7 \text{ Wm}^2$ ) polyethylene was statistically similar. Whereas, the reduction in light intensity by the colourless polyethylene was as low as 3.6%, reduction by blue and yellow polyethylene ranged between 30-35%. Weight loss from fruits stored in blue polyethylene was significantly lowest about 7%. They further reported that, 67% of fruits stored in colourless, yellow and red polyethylene without the inclusion of sawdust were still green after two weeks of storage as against only eight per cent of the control samples.

Different-colored coverings have different effects on the ripening of fruit. Brown paper bags have been recognized as a tool for delaying fruit maturation, thereby extending the harvest season of some fruits (Debnath and Mitra, 2006).

Oosthuysen *et al.* (2008) conducted an experiment to know the effect of time of placing paper sleeves over 'fuerte' or 'rayan' avocados prior to harvest on

physiological disorder incidence. The results indicated that the sleeves were entirely effective in preventing the solar injury when applied prior to 20<sup>th</sup> November. The severity and incidence of physiological disorder occurring was also low and thus extended the shelf life.

Effects of three different types of bags *viz.* perforated translucent plastic bag (TPB), white adhesive-bonded fabric bag (WAFB) and black adhesive-bonded fabric bag (BAFB) were studied on fruit development and quality in cross-winter off-season longan (*Dimocarpus longan* Lour.) and indicated that, bagging with different materials showed differential effects on incidence of fruit cracking. WAFB and BAFB reduced the cracking incidence and were significantly firmer as compared to the control (5.1 and 11.6% vs. 32.8%) (Yang *et al.*, 2009).

Pre harvest bagging (cellulose bags) in black variety of table grapes (Perla) provided more uniform colour of grapes than non bagged samples, while data on soluble solids, titratable acidity, maturity index, sugars, organic acid compounds,  $L^*$   $a^*$   $b^*$  color coordinates and volatile aroma composition supported the fact that bagging increases quality, brings in colour uniformity and delays ripening process (Signes *et al.*, 2007). Similarly, red Chinese sand pears (*P. pyrifolia* Nakai) bagged until harvest had a yellow tinge with a higher lightness value ( $L^* = 72.6$ ) and a higher hue angle ( $h^\circ = 96.2$ ) than control fruits (Chunhui *et al.*, 2009).

Bagged fruit had a prolonged postharvest life and reduced physiological loss of weight, in addition bagging produced an unblemished, attractive and high quality fruit at harvest and on ripening, leading to improved exports and better prices for mango fruit farmers. Fruit bagging during growth phase had beneficial effects on fruit quality when bagged during 70 days after bloom (DAB). In addition to this bagged fruit also had significantly higher peel hue angle ( $H^\circ$ ) and  $L^*$  values when compared to unbagged fruits. Sensory analysis also rated bagged fruit superior in terms of appearance, color and overall acceptance at harvest and on ripening (Mathooko *et al.*, 2011).

An attempt was made to observe the effect of pre-harvest bagging with spun-bound fabric bags on color and quality of Delicious apple. Bagging was done about a month before harvesting and removed 3-day before harvesting and the harvested

apples were stored at  $2^{\circ}\text{C} \pm 1^{\circ}\text{C}$  and 90 - 95 per cent RH. Observations were recorded on color and fruit quality attributes such as total phenolics, AOX activity, fruit Ca contents, LOX activity, SSC and ascorbic acid contents at harvest and during storage. Results indicated that bagged fruits have better color development (Hunter “a” = 52) than non-bagged fruits at harvest (Hunter “a” = 38) which declined slightly during storage. Similarly, at harvest, bagged fruits contained high amounts of Ca (5.38 mg/100g) and total phenolics (9.3 mg GAE/100g pulp) exhibited higher AOX activity (12.6  $\mu\text{moles Trolox g}^{-1}$ ), and had better SSC and ascorbic acid contents than non-bagged fruits and there was a decline in all recorded parameters during storage (Ram *et al.*, 2013).

An investigation was undertaken in 2013 and 2014 for two consecutive fruiting seasons to study the influence of bagging on quality of mango *cv.* Alphonso. The fruits were bagged at marble stage (30 days from fruit set) with different types of bags. This pre harvest bagging altered period required for harvesting after bagging, shelf life and occurrence of spongy tissue. Bagging with newspaper bag and brown paper bag improved fruit retention and produced spongy tissue free fruits. Brown paper bags with polythene coating improved fruit retention and decreased occurrence of spongy tissue with an extended shelf life of the fruits (Haladankar, *et al.*, 2015).

### **2.3.5 Effect on pest and disease incidence**

According to Turner *et al.* (1984) extra long bunch covers assist in preventing flying foxes and birds from climbing on to bunches and produce the fruits with better appearance leading to more profit to the growers. Walter and Mario (1992) reported that use of brown-bagging on granny smith apples trees reduced the damage due to codling moth as compared with fruits hand-thinned and left unbagged (Bentley and Viveros, 1992).

Hofman *et al.* (1997) studied the effect of period of bagging (at 131, 105, 82, 56 and 31 days before harvest) on incidence of anthracnose and stem end rot of mango. The authors reported that bagging of mango fruits with white paper bags reduced the anthracnose and stem end rot. The severity of stem end rot continued to decline with increasing bagging duration, but there was no further consistent reduction in anthracnose severity with bagging durations longer than 56 days.

However, the study indicated that the bagging of fruits can improve fruit quality through reduction in disease.

A study on the effect of different treatments of bagging for managing fruit-borer with cellophane paper in litchi reported minimum incidence of stone-borer (3.98%) in the treatment of bagging at 1 week after fruit setting and de-bagging at 1 week before harvesting (Debnath *et al.*, 2006). Affandi *et al.* (2008) studied the effect of application of fruit bagging, sanitation (SNT) and yellow sticky trap (YST) on control of thrips on mangosteen and reported that early bagging, just after the calyx falling down resulted in low scar intensity (2.79), application of YST reduced thrips population by 1.92 thrips per trap and single treatments of SNT or YST reduced the percentage of scarring by 16.44 per cent and 21.63 per cent respectively, compared to control. However, combination of SNT+YST on the other hand was able to reduce the percentage of scarring to as much as 41.82 per cent.

Oosthuysen *et al.* (2008) conducted an experiment to know the effect of time of placing paper sleeves over 'fuerte' or 'rayan' avocados prior to harvest on disease incidence, fruit appeal and disease incidence at harvest or after extended cold-storage. Sleeving prior to onset of rain was found an effective measure to control cercospora spot and anthracnose. Sleeve impregnation with a pesticide prior to covering may limit insect activity under the sleeve.

According to Muchui *et al.* (2010), bagging of banana fruits resulted in minimum bruises (2 to 5%) and was significantly clear from dust spider webs, bird dropping at harvest as compared to un-bagged fruits. The fruit grown under cover were more visually appealing, cleaner compared to un-bagged fruits.

Ani *et al.* (2011) reported that bagging treatment in banana reduced the intensity of pest attacks by 20 per cent, whereas the control treatment produced the severity of the infestation of (84.81%). These results indicate the importance of bagging to protect bananas from pests. Germano *et al.* (2012) studied the effect of bagging on *Annona crassiflora* fruits to control fruit borers and reported that the fruit bagged with transparent plastic bags showed fewer attack by the borers than the control. They further reported that, bagged fruits of less than two cm in diameter were not attacked by *Cerconota sp.*, whereas 5 per cent of the non-bagged fruits were attacked by this pest.

Sharma *et al.* (2014) reported that the pre-harvest bagging of fruit can reduce the incidence of disease, insect pest and mechanical damage. It also reduces the fruit cracking, sunburn of the skin, agrochemical residues on the fruit and bird damage. Hence, fruit bagging has become an integral part for peach, apple, grape and loquat cultivation in Japan, Australia, China and USA. Moreover, countries such as Mexico, Chile and Argentina do not import the fruits like apple unless they are bagged.

According to Haldankar *et al.*, (2015) brown paper bag with polythene coating decreased incidence of mealy bag from an investigation undertaken in 2013 and 2014 fruiting season of Mango cv. Alphonso. The results also suggested, butter paper bag, muslin cloth bag and scurting bag also improved fruit retention and reduced incidence of mealy bag without affecting in quality of mango fruits cv. Alphonso.

### 3. MATERIAL AND METHODS

The present investigation entitled “Studies on effect of pre-harvest bunch treatment and bagging on yield and post harvest quality of banana” was conducted in four different experiments which included two each different field trials in *cv.* Ney Poovan and *var.* Grand Naine. The field experiments were carried out in a private orchard owned by Mr. Bharathesh, B. M., a progressive farmer of Kadur taluk in Chikmagalur district. The laboratory analysis of the experimental material was performed in the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, Gokak taluk, Belgaum district, Karnataka during 2014 to 2016. The experimental details pertaining to material and methods adopted in the investigations are presented in this chapter.

#### 3.1 Geographical location and climate

Field experiments were undertaken in a private orchard of Kadur taluk which is located 40 km away from Chikmagalur, which comes under Central dry zone (zone 4) of Karnataka. It lies between 13<sup>0</sup> 55'N latitude and 76<sup>0</sup> 01' E longitudes, at an altitude of 763 m from mean sea level. The average annual rainfall at Kadur is 600-700 mm and it is distributed over a period of eight months from May to December. The mean maximum temperature goes up to 33.75 °C (April) and mean minimum temperature drops down to 12.10 °C (January). The relative humidity reaches its peak (81.55%) in October (Appendix I).

The resultant fruits from plants of experiment No. 1, 2, 3 and 4 were brought to the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi for further studies. The place Arabhavi is situated in northern dry zone (zone 3) of Karnataka. It lies between 16<sup>0</sup> 12'N latitude and 75<sup>0</sup> 45' E longitudes, with an altitude of 640 m from mean sea level. The average annual rainfall at Arabhavi is 530 mm and it is distributed over a period of seven months from May to November. The mean maximum temperature goes up to 38.24 °C (April) and mean minimum temperature drops down to 9.3 °C (January). The relative humidity reaches its peak (95%) in January.

### **3.2 Soil characteristics of experimental site**

The texture of the soil was sandy clay loam with moderate fertility level having an slightly acidic pH of 5.90. The physical properties and chemical composition of the soil of experimental site are furnished in Appendix-III. The crop was irrigated through drip irrigation method.

### **3.3 Cultural practices**

The plots were kept free from weeds by regular hand weeding. Irrigation schedule was followed according to the requirements. Earthing up was followed whenever, soil became compact. De-suckering was done regularly till shooting and a single sucker was allowed to grow after shooting. Along with de-suckering other cleaning activities were also carried out accordingly. Before a week of planting, 20 kg of well decomposed farm yard manure (FYM) was added to each pit. Inorganic fertilizers were applied at 2<sup>nd</sup>, 4<sup>th</sup> and 6<sup>th</sup> months after planting with recommended dose per plant (180: 108: 225 g NPK).

### **3.4 Experimental details and planting**

The land was ploughed twice and harrowed to bring it to a good tilth. The variety Grand Naine belonging to Cavendish group was selected. Uniform sized two months old tissue cultured banana plants of variety Grand Naine were planted at a spacing of 1.8 m x 1.8 m. Protective irrigation was given at weekly intervals. The experiment was laid out in a randomized complete block design (RCBD) with eight treatments, replicated thrice. Total number of plants was maintained at 5 per each replication. The details of different treatments imposed in the present investigation are presented below in section 3.4.1.

Similarly for cv. Ney Poovan, the experiment was carried on newly planted banana plants spaced at 2 m x 2 m. The experiment was laid out in a randomized complete block design (RCBD) with eight treatments, replicated thrice. Total number of plants was 5 per each replication. The uniform sized sword suckers from healthy and vigorous banana plants of cv. Ney Poovan free from viruses and other diseases were selected for planting. The suckers were trimmed and the rhizome had been applied with carbofuran (3%) granules to prevent the rhizome weevil and other pests.

Protective irrigation was given at weekly intervals and the treatments were imposed as per the experiment.

The treatment details of the experiment are mentioned below. Each treatment consisted of fifteen plants.

The present investigation was carried out by using sources of silicon and 2,4D for spaying with different concentrations and use of urea, ammonium sulphate and sulphate of potash for bunch feeding with or without skirting materials (bunch covers) to study their influence on the quality and yield of bananas variety Grand Naine and cv. Ney Poovan. As already mentioned before, the experiment was laid out with eight treatments in Randomized Complete Block Design (RCBD) and replicated thrice. The details of different treatments are mentioned below.

### **3.4.1 Treatment details of the experiment:**

Banana plants under the experimental plots of all the four experiments were supplied with recommended dose of fertilizers and cultural operations were followed similarly and uniformly till the emergence of inflorescence. The treatments were imposed after the emergence of inflorescence in experiment 1 and 2 and after pistillate flowers had formed into fruits in experiment 3 and 4 as per the experimental details given below.

#### **Experiment-I: Effect of bunch treatment (potassium silicate) and bagging on yield, post harvest quality and shelf life of banana fruits var ‘Grand Naine’ (AAA)**

Pre-harvest sprays as given below were taken up at monthly interval (3 sprays) from the time of emergence of flowers (inflorescence). The experiment was carried out for two different seasons 2014 and 2015.

#### **Treatment details of the experiment**

- T<sub>1</sub>: Control (No silicon application + No bagging)
- T<sub>2</sub>: Only bagging (No silicon application)
- T<sub>3</sub>: Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

- T<sub>4</sub>: Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/ bunch at 30 days interval
- T<sub>5</sub>: Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/ bunch at 30 days interval
- T<sub>6</sub>: Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/ bunch at 30 days interval+ polyethylene bagging of bunches
- T<sub>7</sub>: Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/ bunch at 30 days interval+ polyethylene bagging of bunches
- T<sub>8</sub>: Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**Experiment-2: Effect of bunch treatment (potassium silicate) and bagging on yield, post harvest quality and shelf life of banana fruits cv. ‘Ney Poovan’ (Elakkibale) (AB)**

Pre-harvest sprays as given below were taken up at monthly interval (3 sprays) from the time of emergence of flowers. The experiment was carried out for two different seasons 2014 and 2015.

**Treatment details of the experiment**

- T<sub>1</sub>: Control (No silicon application + No bagging)
- T<sub>2</sub>: Only bagging (No silicon application)
- T<sub>3</sub>: Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/ bunch at 30 days interval
- T<sub>4</sub>: Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/ bunch at 30 days interval
- T<sub>5</sub>: Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/ bunch at 30 days interval
- T<sub>6</sub>: Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/ bunch at 30 days interval+ polyethylene bagging of bunches.
- T<sub>7</sub>: Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/ bunch at 30 days interval+ polyethylene bagging of bunches.
- T<sub>8</sub>: Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/ bunch at 30 days interval+ polyethylene bagging of bunches.

**Experiment-3: Effect of bunch treatment (urea, ammonium sulphate, SOP and 2, 4-D) and bagging on yield, post harvest quality and shelf life of banana fruits var. ‘Grand Naine’ (AAA)**

Treatments (except T<sub>5</sub> and T<sub>8</sub>) involved dissolving the nutrients as per treatments given below in 100 ml water and the slurry was made by mixing it in 500 g of fresh cow dung. The slurry so prepared was applied to the de-navelled stalk-end of bunch. At the similar stage of bunch, 2, 4-D treatment (T<sub>5</sub> and T<sub>8</sub>) was undertaken in the form of spray.

**Treatment details of the experiment:**

T<sub>1</sub>: Control (No bunch treatment + No bagging)

T<sub>2</sub>: Only bagging (No bunch treatment)

T<sub>3</sub>: Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture

T<sub>4</sub>: Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture

T<sub>5</sub>: Application of 20 ppm of 2, 4-D

T<sub>6</sub>: Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches

T<sub>7</sub>: Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches

T<sub>8</sub>: Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches

**Experiment-4: Effect of bunch treatment (urea, ammonium sulphate, SOP and 2, 4-D) and bagging on yield, post harvest quality and shelf life of banana fruits cv. ‘Ney Poovan’ (Elakkibale) (AB)**

Treatments (except T<sub>5</sub> and T<sub>8</sub>) involved dissolving the nutrients as per treatments given below in 100 ml water and the slurry was made by mixing it in 500 g

of fresh cow dung. The slurry so prepared was applied to the de-navelled stalk-end of bunch. At the similar stage of bunch, 2, 4-D treatment (T<sub>5</sub> and T<sub>8</sub>) was undertaken in the form of spray.

**Treatment details of the experiment:**

T<sub>1</sub>: Control (No bunch treatment + No bagging)

T<sub>2</sub>: Only Bagging (No bunch treatment)

T<sub>3</sub>: Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture

T<sub>4</sub>: Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture

T<sub>5</sub>: Application of 20 ppm of 2, 4-D

T<sub>6</sub>: Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.

T<sub>7</sub>: Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.

T<sub>8</sub>: Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches.

**3.4.2 Preparation of potassium silicate solution**

Oligometric potassium silicate solution was added in fresh water at 1:5 ratio and left for 60 minutes for dissolution. Required quantity of diluted potassium silicate solution (soluble silicic acid) was drawn and mixed with one litre of water per plant for foliar spray as per treatment. Spray was given to treatment plants along with the wetting agent (Intradon, AE sticker, spreader and an activator) till the entire inflorescence got wet and dripped down. The spray was under taken using knap back hand sprayer.



**Plate 1: General view of plot during treatment imposition at different growth stages**

### **3.4.3 Preparation of 2, 4-Dichlorophenoxyacetic acid (2, 4-D) solution**

The 2, 4-D solution was prepared by weighing 20 milligram of 2, 4-D accurately and dissolving in little volume of 95 per cent ethyl alcohol. The volume made up to 1000 ml by adding water to prepare 20 ppm solution.

### **3.4.4 Preparation of solution for bunch stalk feeding**

Nutrient fertilizers as per the treatment (7.5 g of ammonium sulphate/7.5g of urea+ 7.5 g of sulphate of potash) were dissolved in 100 ml water. To this solution, 500 g of fresh cow dung was thoroughly mixed to make slurry. The blend so prepared was placed in a polythene bag and tied securely to dip the excised rachis into the slurry.

#### **3.4.4.1 Bunch feeding**

For bunch stalk feeding, uniform bunches from each treatment were selected. Rachis at the distal end of the bunch was excised along with male bud giving a slant cut immediately after all pistillate (Female) Flowers had formed into fruits and after 4 bracts were shed. The prepared 500 ml solution was placed in a thick polythene bag according to the treatments and tied securely by dipping the excised rachis and maintained till harvest.

### **3.4.5 Harvesting**

Even though, all the plants did not reach harvest maturity at the same time, the harvesting process was spread over for a period of 15 days. Perfectly filled fingers with clear fullness of the angles in the fingers were kept in mind for deciding the stage for harvesting. Bunches were harvested by leaving 15-20 cm peduncle from base for easy handling of bunches.

## **3.5 Observations recorded**

### **3.5.1 Bunch characters**

The observations on bunch characters *viz.*, bunch weight, number of hands per bunch, number of fingers per hand (representative) and total number of fruits per bunch were recorded by counting for all the treatments.

### **3.5.1.1 Bunch weight (kg)**

The weight of bunches was recorded using a weighing scale after harvest of fully matured bunches and the bunch weight was expressed in kilogram.

### **3.5.1.2 Number of hands/bunch**

Total number of hands per bunch was counted and the mean was worked out.

### **3.5.1.3 Number of fingers in third hand**

Third hand from the proximal end of the bunch was used for counting number of the fingers. Mean number of fingers in third hand was recorded.

### **3.5.1.4 Total number of fruits**

Total number of fingers in a bunch was physically counted and the mean number of fingers per bunch was recorded.

## **3.5.2 Fruit characters**

Fruit characters were recorded at two stages *i.e.* first at mature stage for characters like fruit weight, fruit length and fruit diameter, and at ripe stage for characters like fruit weight, pulp weight, peel weight and pulp percentage. Five ripe fingers from third hand were used for recording all the fingers characteristics.

### **3.5.2.1 Finger weight at mature stage (g)**

Fingers were weighed by using electronic balance and the mean weight of fingers was recorded and expressed in grams.

### **3.5.2.2 Finger length (cm)**

Finger length was measured by using foot scale from the top of a finger to the pedicel; the mean length of finger was recorded and expressed in centimeters.

### **3.5.2.3 Finger diameter (cm)**

Finger diameter was measured at the centre of finger by using vernier calipers and mean diameter of finger was recorded and expressed in centimeters.

### **3.5.2.4 Finger weight at ripe stage (g)**

Fingers were weighed by using electronic balance and the mean weight of fingers was recorded and expressed in grams.

### **3.5.2.5 Pulp weight (g)**

Pulp weight of ripened fruit was weighed after removing the peel using an electronic balance and the mean weight of pulp was recorded and expressed in grams.

### **3.5.2.6 Peel weight (g)**

Peel weight of respective ripe fruit was weighed using electronic balance, the mean weight of peel was recorded and expressed in grams.

### **3.5.2.7 Pulp percentage (per cent)**

The pulp recovery from the ripe fruits was determined by the following formula.

$$\text{Pulp percentage (\%)} = \frac{\text{Pulp weight (g)}}{\text{Fruit weight (g)}} \times 100$$

## **3.5.3 Pest incidence (Incidence of thrips)**

The observations on total number of nymphs/adults of thrips per bunch at harvesting stage were observed visually and the average population of thrips per bunch for each treatment was worked out for its statistical analysis.

## **3.5.4 Post harvest behaviour of the fruit**

### **3.5.4.1 Respiration rate (ml CO<sub>2</sub>/kg/h)**

Respiration rate was measured with a CO<sub>2</sub> gas analyzer in static method, wherein whole fruit was weighed and incubated in a hermetically sealed container of 1250 ml capacity for 20 minutes. At the end of incubation period, gas sample was drawn from the container head space using a gas tight syringe and measured in the analyzer. The change in CO<sub>2</sub> concentration in the head space and time was recorded.

The respiration rate of the fruit was calculated using the following formula and expressed as ml CO<sub>2</sub>/kg/h.

$$\text{Respiration rate (ml CO}_2\text{/kg/h)} = \frac{\text{CO}_2 \text{ (\% in the sample) x Volume of container (ml)}}{100 \times \text{Weight of the sample (kg) x Time (h)}}$$

#### 3.5.4.2 Physiological loss in weight (PLW%)

The fruits in each replication of respective treatment were weighed at the beginning of storage which was recorded as initial weight at mature green stage and later at ripe stage or senescence stage as final weight. Per cent physiological loss in weight was calculated using the formula given below.

$$\text{Physiological loss in weight (\%)} = \frac{(P_0) - P_1 \text{ or } P_2}{P_0} \times 100$$

Where,

P<sub>0</sub>- initial weight

P<sub>1</sub>- Fruit weight at ripe stage

P<sub>2</sub>- Fruit weight at senescence stage

#### 3.5.4.3 Instrumental colour measurement (*L\**, *a\**, *b\**)

The colour of samples was measured using a Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) fitted with 8mm diameter aperture. The instrument was calibrated using the black and white tiles provided. Colour was expressed in Lovibond units *L\** (Lightness/darkness), *a\** (redness/greenness) and *b\** (yellowness/blueness). Banana fruits were directly placed under the aperture of the colour meter and measured on two sides per fruit for colour analysis and the values were averaged.

#### 3.5.3.4 Shelf life (days)

The shelf life of fruits was determined by counting the number of days from ripening till the fruits remained edible without spoilage.

### **3.5.5 Chemical parameters of fruits**

The following chemical parameters were observed at mature green, ripe and senescent stage of banana fruits (Appendix IV).

#### **3.5.5.1 Total soluble solids (<sup>0</sup>B)**

The juice extracted by squeezing the homogenized fruit pulp through muslin cloth was used to measure the TSS. It was determined by using ERMA hand refractometer, replicated three times and the mean was expressed in <sup>0</sup>B.

#### **3.5.5.2 Titrable acidity (%)**

A known weight of fruit pulp (5g) was homogenized with distilled water and filtered using muslin cloth followed by Whatman No. 1 filter paper. An aliquot of 10 ml was taken and titrated against standard 0.1N NaOH using phenolphthalein indicator. The appearance of light pink colour was marked as the end point. The value was expressed in terms of malic acid as per cent titratable acidity of juice (Anon., 1984).

#### **3.5.5.3 Total sugars (%)**

Non-reducing sugars were first hydrolyzed with hydrochloric acid to reducing sugars. Then, the total sugar was estimated using Dinitrosalicylic acid (DNSA) method (Anon., 1984) and values were expressed as per cent.

#### **3.5.5.4 Reducing sugar (%)**

Reducing sugars in the samples were estimated as per the Dinitrosalicylic acid method (Miller, 1972). The values obtained were expressed as per cent.

#### **3.5.5.5 Non-reducing sugar (%)**

The per cent non-reducing sugars were obtained by subtracting the value of reducing sugars from that of total sugars. The resultant value was multiplied by the factor 0.95.

$$\text{Non-reducing sugar (\%)} = [\text{Total sugar (\%)} - \text{reducing sugar (\%)}] \times 0.95$$



**Plate 2: Harvesting of fruits**



**Plate 3: Estimation of respiration rate and colour values of harvested fruits**



**Plate 4: Organoleptic evaluation of fruits by semi-trained panel of judges**

### 3.5.5.6 Sugar-acid ratio

Sugar-acid ratio of fruit pulp was computed as the ratio of total sugars to the titrable acidity.

### 3.5.5.7 Starch (%)

Starch content in the fruit samples was estimated using anthrone reagent method (Hodge and Hofreiter, 1962). The values obtained were expressed in percentage.

### 3.5.6 Organoleptic evaluation of fruits

Organoleptic evaluation of ripe fruits was carried out by a panel of 10 semi-trained judges. The sensory characters like skin colour, pulp colour and appearance, pulp texture, taste and flavour and overall acceptability were evaluated on a 9 point Hedonic scale using the score card mentioned below. The mean of scores given by the judges were used for statistical analysis.

Scale	Peel colour and appearance	Pulp Colour and appearance	Pulp Texture	Pulp taste and flavour	Overall acceptability
1	Poor	Poor	Poor	Poor	Poor
3	Fair	Fair	Fair	Fair	Fair
5	Good	Good	Good	Good	Good
7	Very good	Very good	Very good	Very good	Very good
9	Excellent	Excellent	Excellent	Excellent	Excellent

### 3.6 Statistical analysis

Statistical analysis was performed using Web Agri Stat Package (WASP) Version 2.0. All the data collected were analysed by one-way analysis of variance (ANOVA). Significant differences among means at  $P = 0.05$  were determined by post hoc tests using Duncan's multiple range test.

## **4. EXPERIMENTAL RESULTS**

The present investigation entitled “Studies on effect of pre-harvest bunch treatment and bagging on yield and post harvest quality of banana” was conducted in four different experiments which included two different field trials for cv. Ney Poovan and var. Grand Naine. The field experiments were carried out in a private orchard and the laboratory analysis was performed in the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, Gokak taluk, Belgaum district, Karnataka during 2014 to 2016. After imposition of the treatments, fruits were harvested and physical characters of bunches were recorded. Then the fruits were brought to the laboratory and kept under ambient conditions to study the initial quality and storage behaviour of banana fruits for various parameters *viz.*, physiological, physico-chemical and organoleptic changes during storage. The results obtained from these investigations are presented in this chapter.

### **4.1 Experiment-1: Effect of bunch treatment (potassium silicate) and bagging on yield, post harvest quality and shelf life of banana fruits var. ‘Grand Naine’ (AAA)**

#### **4.1.1 Bunch characters**

##### **4.1.1.1 Bunch weight (kg)**

Significant differences were observed with respect to bunch weight of the banana plants imposed with different pre-harvest bunch treatments (Table 1). During 2014, 2015 and in pooled analysis, the bunch weight showed significant increase in all the treatments over T<sub>1</sub> (Control) (24.04 kg/plant, 25.39 kg/plant and 24.71 kg/plant). Maximum bunch weight (32.05 kg/plant) was observed in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014 and it was on par with T<sub>7</sub> (31.19 kg/plant) and T<sub>5</sub> (30.40 kg/plant). During 2015 also, the treatment T<sub>8</sub> significantly enhanced bunch weight (33.34 kg/plant) followed non significantly by T<sub>7</sub> (31.19 kg/plant). Interestingly, in the pooled data, the treatment T<sub>8</sub> showed significant difference for bunch weight (32.69 kg/plant) over all the treatments except T<sub>7</sub>.

#### **4.1.1.2 Number of hands per bunch**

Pre-harvest treatments resulted in non-significant differences with respect to number of hands per bunch in var. Grand Naine at harvest during both the seasons and even in the pooled data (Table 1). During 2014, 2015 and in pooled analysis, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (12.83, 12.67 and 12.75) recorded maximum number of hands per bunch and treatment T<sub>1</sub> (control) recorded minimum number of hands for both the years and for pooled data (11.00, 11.33 and 11.17).

#### **4.1.1.3 Number of fingers in third hand**

The data pertaining to number of fingers in third hand showed non-significant differences among the treatments during analysis of individual years (Table 1). The least number of fruits were observed in T<sub>2</sub> (control +bagging) during 2014 (15.33) and in T<sub>1</sub> (control) during 2015 (15.33). The maximum number of fingers were observed during 2014 in T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) (18.33), while in 2015 the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) had maximum fingers (19.00). Pooled analysis of two years data revealed least number of fruits (15.67) in control treatment (T<sub>1</sub>) which remained statistically non-significant with T<sub>2</sub>. On the other hand, the treatment T<sub>8</sub> recorded maximum number of fruits (18.50) followed by T<sub>7</sub> and T<sub>5</sub>. These three treatments did not differ significantly among themselves.

#### **4.1.1.4 Total no. of fingers per bunch**

The fruits under the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded significantly maximum number of fruits in 2014 (201.67), 2015 (206.00) and in pooled analysis (203.83) followed by T<sub>7</sub> and T<sub>5</sub> in both the years. The treatment T<sub>1</sub> (control) with least number of fruits per bunch during both the years (2014-153.30; 2015-166.0 and 159.67) and also when subjected for pooled analysis exhibited statistical parity with the treatment T<sub>2</sub>.

**Table 1: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on bunch weight and bunch characters of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Bunch weight (kg)			No. of hands /bunch			Fingers in third hand			Total no. of fruits/bunch		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	24.04d	25.39d	24.71d	11.00	11.33	11.17	16.00	15.33	15.67c	153.33e	166.00d	159.67e
T <sub>2</sub>	25.30cd	26.46cd	25.88d	11.33	11.00	11.17	15.33	16.33	15.83c	163.67de	168.33cd	166.00e
T <sub>3</sub>	27.77bc	29.29bc	28.53c	11.67	11.33	11.50	16.33	17.00	16.67bc	169.33cd	182.00bc	175.67d
T <sub>4</sub>	28.30bc	29.98b	29.14c	12.00	12.67	12.33	16.67	16.67	16.67bc	178.33abc	183.67b	181.00cd
T <sub>5</sub>	30.24ab	30.08b	30.16bc	12.33	12.67	12.50	17.67	17.33	17.50ab	196.33ab	190.67b	193.50b
T <sub>6</sub>	28.49bc	30.67ab	29.58bc	11.83	10.67	11.25	17.00	17.67	17.33ab	181.67bc	175.67bcd	178.67cd
T <sub>7</sub>	31.19ab	31.19ab	31.19ab	12.50	11.33	11.92	18.33	18.00	18.17a	184.00bc	186.33b	185.17c
T <sub>8</sub>	32.05a	33.34a	32.69a	12.83	12.67	12.75	18.00	19.00	18.50a	201.67a	206.00a	203.83a
<b>S.Em±</b>	1.16	0.98	0.61	0.56	0.69	0.44	0.69	0.71	0.41	4.89	4.95	2.48
<b>C.D @ 5 %</b>	3.52	2.97	1.86	NS	NS	NS	NS	NS	1.24	14.83	15.01	7.53

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

## **4.1.2 Fruit characters**

### **4.1.2.1 Fruit characters at mature stage**

#### **4.1.2.1.1 Fruit weight (g)**

Pre-harvest treatments resulted in significant differences with respect to fruit weight at harvest during two seasons and after pooling the two season's data (Table 2). During 2014, 2015 and in pooled analysis, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (150.42 g, 151.0 g and 151.71 g) resulted in maximum fruit weight and it was found significant with T<sub>5</sub> (143.10 g, 145.69 g and 144.40 g). Both the treatments were significant with each other and differed significantly over all other treatments.

Significantly minimum fruit weight during 2014, 2015 and in pooled data was associated with T<sub>1</sub> (Control) (122.37 g, 121.08 g and 121.72g respectively) followed by T<sub>2</sub> (127.78 g, 129.78 g and 128.78g respectively).

#### **4.1.2.1.2 Fruit length (cm)**

In both the years, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded maximum fruit length (2014 – 19.53 cm and 2015 - 20.33 cm) (Table 2). This treatment was found to be significant with T<sub>5</sub> (2014 - 18.37 cm; 2015 - 19.27 cm). Conversely, the minimum fruit length was associated with T<sub>1</sub> (Control) both during 2014 (13.87 cm) and 2015 (14.10 cm). Pooled analysis of two years data showed significant increase in fruit length (19.93 cm) in T<sub>8</sub> over all other treatments. On the other hand, control treatment (T<sub>1</sub>) continued to record least fruit length (13.98 cm) and it exhibited significant differences over rest of the treatments.

#### **4.1.2.1.3 Fruit diameter (cm)**

Influence of pre-harvest treatments on fruit diameter of banana fruits followed similar trend as fruit length (Table 2). In the year 2014, T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (3.78 cm) recorded significantly maximum fruit diameter over all the treatments. The least fruit diameter observed in T<sub>2</sub> (Control + bagging) (3.30 cm) was found to be at parity with T<sub>3</sub>. In 2015, the maximum fruit diameter was associated with T<sub>8</sub> (3.82 cm). The treatment T<sub>1</sub> showed

**Table 2: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on fruit characters of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Mature fruit weight (g)			Ripe fruit weight (g)			Fruit length (cm)			Fruit diameter (cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	122.37f	121.08g	121.72g	116.26f	114.93g	115.59g	13.87g	14.10g	13.98h	3.35e	3.34e	3.35f
T <sub>2</sub>	127.78e	129.78f	128.78f	121.96e	123.84f	122.90f	14.07g	14.50g	14.28g	3.30de	3.34e	3.32cf
T <sub>3</sub>	130.97d	132.62ef	131.79e	124.89de	126.88ef	125.88e	14.93f	15.50f	15.22f	3.32d	3.41d	3.37e
T <sub>4</sub>	134.27c	135.33de	134.80d	128.39cd	129.78de	129.09d	15.80e	16.13e	15.97e	3.44c	3.47d	3.46d
T <sub>5</sub>	143.10b	145.69b	144.40b	137.06b	139.76b	138.41b	18.37b	19.27b	18.82b	3.67b	3.73b	3.70b
T <sub>6</sub>	136.54c	137.00cd	136.77d	131.23c	130.07d	130.65d	16.43d	17.00d	16.72d	3.48c	3.55c	3.52c
T <sub>7</sub>	141.02b	139.81c	140.42c	135.32b	134.13c	134.73c	17.30c	18.10c	17.70c	3.70b	3.75b	3.73b
T <sub>8</sub>	150.42a	151.00a	150.71a	144.17a	145.12a	144.65a	19.53a	20.33a	19.93a	3.78a	3.82a	3.80a
<b>S.Em±</b>	1.05	1.08	0.66	1.22	1.04	0.65	0.09	0.15	0.09	0.01	0.02	0.01
<b>C.D @ 5 %</b>	3.17	3.28	2.00	3.69	3.16	1.98	0.29	0.45	0.29	0.04	0.06	0.04

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

T<sub>1</sub>- Control  
T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

minimum fruit diameter (3.33 cm) and it did differ statistically with all other treatments except T<sub>2</sub>. Analysis of pooled data followed a similar trend as in 2014. Significantly higher overall fruit diameter was recorded in the treatment T<sub>8</sub> (3.80 cm), while it was lower in control + bagging of fruits (T<sub>2</sub>) (3.32 cm) which was on par with T<sub>1</sub> and T<sub>3</sub> treatments (Table 2).

#### **4.1.2.2 Fruit characters at ripe stage**

##### **4.1.2.2.1 Ripe fruit weight (g)**

Banana fruits exhibited significant differences for ripe fruit weight during both the years of experimentation (2014 and 2015) (Table 2). In 2014, significantly maximum fruit weight after ripening was noticed in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (144.17 g) in comparison to all the treatments. On the other hand, minimum fruit weight at ripe stage observed in T<sub>1</sub> (control) (116.26 g) significantly differed with T<sub>2</sub> (121.96 g) and T<sub>3</sub> (124.89 g). During 2015, fruits of the treatment T<sub>8</sub> (145.12 g) had higher ripe weight and it was significantly followed by T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (139.76 g). Minimum ripe fruit weight (114.93 g) was found associated with T<sub>1</sub> (control) and it showed statistical significance to T<sub>2</sub> (123.84 g). The combined data of two years was also significantly higher ripe fruit weight in T<sub>8</sub> (144.65 g). While, minimum ripe weight of fruit observed in T<sub>1</sub> (control) (115.59 g) was significantly followed by T<sub>2</sub> (122.90 g).

##### **4.1.2.2.2 Pulp weight (g)**

Significantly higher pulp weight was recorded in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (111.43 g) during 2014 when compared to all other treatments (Table 3). The pulp weight was significantly lower in T<sub>1</sub> (control) (82.92 g) followed by T<sub>2</sub> (Control + bagging) (89.18 g) and T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/l) (91.49 g) respectively. During 2015, fruits showed higher pulp weight in the treatment T<sub>8</sub> (112.21 g) which was closely and significantly followed by T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (106.99 g). On the other hand, control treatment (T<sub>1</sub>) (82.42 g) with minimum pulp weight was significantly different from rest of the treatments. However, it was followed by T<sub>2</sub> (90.41 g). Two years pooled data showed significantly higher pulp weight in T<sub>8</sub> (111.82 g) over rest of the treatments. Fruits in control (82.67 g) recorded minimum

**Table 3: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on pulp weight, peel weight and pulp percentage of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Pulp weight (g)			Peel weight (g)			Pulp percentage (%)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	82.92f	82.42f	82.67g	32.25d	30.54d	31.40c	71.33d	71.71e	71.52e
T <sub>2</sub>	89.18e	90.41c	89.80f	33.62b	32.02cd	32.82b	73.12cd	73.01d	73.06d
T <sub>3</sub>	91.49e	94.26d	92.87e	30.92e	31.88cd	31.40c	73.29c	74.27c	73.78cd
T <sub>4</sub>	94.96d	96.52d	95.74d	35.05a	33.85ab	34.45a	73.96bc	74.37c	74.16c
T <sub>5</sub>	106.32b	106.99b	106.66b	33.25bc	32.92bc	33.09b	77.57a	76.55a	77.06a
T <sub>6</sub>	96.35d	97.25d	96.80d	32.57cd	33.00bc	32.79b	73.42bc	74.76bc	74.09cd
T <sub>7</sub>	101.73c	101.33c	101.53c	33.89b	35.03a	34.46a	75.17b	75.54b	75.36b
T <sub>8</sub>	111.43a	112.21a	111.82a	33.20bc	34.13ab	33.67ab	77.29a	77.32a	77.31a
<b>S.Em±</b>	0.83	1.10	0.65	0.31	0.45	0.30	0.61	0.30	0.36
<b>C.D @ 5 %</b>	2.52	3.32	1.98	0.93	1.38	0.90	1.85	0.92	1.10

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

T<sub>1</sub>- Control  
T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

pulp weight followed by T<sub>2</sub> (89.90 g). Nevertheless, both the treatments differed significantly between each other.

#### **4.1.2.2.3 Peel weight (g)**

During 2014 peel weight was maximum in the treatment T<sub>4</sub> (Bunch spraying of potassium silicate at 4 ml/l) (35.05 g) followed by T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) (33.89), where the treatments remained significant with each other (Table 3). The maximum peel weight during 2015 was linked with T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) (35.03 g) and it was on par with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (34.13 g). In pooled data, maximum peel weight was recorded in T<sub>7</sub> (34.46 g) which exhibited statistical similarity with T<sub>4</sub> (34.45 g). Minimum peel weight during 2014 and 2015 was observed in T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/l) (30.92 g) and T<sub>1</sub> (control) (30.54 g) respectively. However, pooled analysis revealed a similar peel weight of 31.40 g in the treatments T<sub>1</sub> and T<sub>3</sub>.

#### **4.1.2.2.4 Pulp percentage (%)**

Both during 2014 and 2015, significant differences were observed with respect to pulp recovery (Table 3). Maximum pulp recovery during 2014 was associated with the treatment T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (77.57%). It was closely and non-significantly followed by T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (77.29%). During 2015, T<sub>8</sub> and T<sub>5</sub> recorded maximum pulp recovery of 77.32 per cent and 76.55 per cent respectively. Both these treatments were on par with each other, but differed significantly over all other treatments. Pooled data analysis revealed maximum pulp recovery in T<sub>8</sub> (77.31%) followed by T<sub>5</sub> (77.06%) and T<sub>7</sub> (75.36%), where T<sub>8</sub> and T<sub>5</sub> did not show significant difference between them.

### **4.1.3 Pest incidence**

#### **4.1.3.1 Incidence of thrips at harvest (numbers)**

There was no incidence of thrips (Table 4) in all the bagged treatments *viz.*, T<sub>2</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub> when the banana bunches observed at the time of harvest during 2014, 2015 and for pooled analysis. However, maximum number of thrips was

**Table 4: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on thrips incidence of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Thrips incidence (numbers)		
	2014	2015	Pooled
T <sub>1</sub>	17.67 (24.78)a	12.33 (20.49)a	15.00 (20.73)a
T <sub>2</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
T <sub>3</sub>	13 (20.98)b	8.33 (16.75)b	10.67d (18.97)b
T <sub>4</sub>	6.67 (14.85)c	9.67 (17.62)ab	8.17 (16.37)bc
T <sub>5</sub>	6.00 (13.87)c	6.33 (14.00)b	6.17 (13.98)c
T <sub>6</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
T <sub>7</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
T <sub>8</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>S.Em±</b>	1.11	1.30	0.96
<b>C.D @ 5 %</b>	3.37	3.93	2.92

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

Figures in parentheses are the arc sin transformed values

- |  |  |
|--|--|
| T <sub>1</sub> - Control   | T <sub>5</sub> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| T <sub>2</sub> - Only bagging (No silicon application)   | T <sub>6</sub> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| T <sub>3</sub> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | T <sub>7</sub> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| T <sub>4</sub> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | T <sub>8</sub> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

T<sub>1</sub>T<sub>3</sub>T<sub>4</sub>T<sub>5</sub>T<sub>2</sub>T<sub>6</sub>T<sub>7</sub>T<sub>8</sub>

**Plate 5: Images showing fruits (Grand Naine) of different treatments at green stages**

noticed in control (T<sub>1</sub>) treatment during 2014, 2015 and for data analysed after pooling (17.67, 12.33 and 15.00 respectively).

#### **4.1.4 Post harvest behaviour of fruit**

##### **4.1.4.1 Respiration rate (ml CO<sub>2</sub>/kg/h)**

Respiration rate of banana fruits (var. Grand Naine) at mature green stage, ripe stage and senescence stage showed significant differences among the treatments. Respiration increased from green stage reaching peak at ripe stage and exhibited a decline towards senescent stage. The mean values of pooled data at green stage showed a range from 75.40 (ml CO<sub>2</sub>/kg/h) (T<sub>8</sub>) (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) to 101.72 ml CO<sub>2</sub>/kg/h (T<sub>1</sub>) (Control) (Table 5).

At ripe stage, fruits under the treatment of T<sub>1</sub> (control) had significantly higher respiratory peak in both the seasons (2014, 2015) and in pooled analysis (356.50 ml CO<sub>2</sub>/kg/h, 324.91 ml CO<sub>2</sub>/kg/h and 340.70 ml CO<sub>2</sub>/kg/h respectively). Minimum values of respiratory peak during 2014, 2015 and in pooled data were noted in T<sub>8</sub> (210.19 ml CO<sub>2</sub>/kg/h, 182.71 ml CO<sub>2</sub>/kg/h, 196.45 ml CO<sub>2</sub>/kg/h respectively) which were found to be significant over all other treatments.

At senescence stage, the highest respiration rate was signified in the treatment T<sub>1</sub> during 2014 (248.99 ml CO<sub>2</sub>/kg/h), 2015 (208.04 ml CO<sub>2</sub>/kg/h) and in pooled analysis (228.51 ml CO<sub>2</sub>/kg/h) over rest of the treatments. The least respiration rate during 2014, 2015 and pooled analysis was noticed in T<sub>8</sub> (181.87 ml CO<sub>2</sub>/kg/h, 165.63 ml CO<sub>2</sub>/kg/h and 173.75 ml CO<sub>2</sub>/kg/h respectively). This treatment was significantly followed by T<sub>5</sub> (188.99 ml g CO<sub>2</sub>/kg/h, 185.35 ml CO<sub>2</sub>/kg/h and 187.17 ml CO<sub>2</sub>/kg/h respectively).

##### **4.1.4.2 Physiological loss in weight (PLW) (%)**

During 2014, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) with minimum PLW both at ripe (6.05%) and senescence stage (10.17%) was closely and significantly followed by T<sub>7</sub> (7.79% - ripe stage; 12.56% - senescence) at both stages (Table 6). Similar trend was followed in 2015 and for pooled data analysis PLW was recorded to be significantly minimum in the treatment

**Table 5: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on respiration rate of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Respiration rate (ml CO <sub>2</sub> /kg/h)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	101.13a	102.31a	101.72a	356.50a	324.91a	340.70a	248.99a	208.04b	228.51a
<b>T<sub>2</sub></b>	96.49b	94.92b	95.71b	270.73d	233.06e	251.90e	233.20b	193.71cd	213.45c
<b>T<sub>3</sub></b>	93.96c	92.72b	93.34c	329.87b	291.80b	310.83b	220.35c	221.62a	220.98b
<b>T<sub>4</sub></b>	87.23e	86.53d	86.88e	283.21c	241.57d	262.39d	208.30d	200.37c	204.34d
<b>T<sub>5</sub></b>	79.42f	78.00f	78.71g	254.29e	216.82f	235.56g	188.99e	185.35e	187.17e
<b>T<sub>6</sub></b>	89.81d	89.49c	89.65d	284.37c	283.99c	284.18c	212.00d	193.49d	202.74d
<b>T<sub>7</sub></b>	80.60f	81.28e	80.94f	254.81e	225.92e	240.37f	191.38e	180.92e	186.15e
<b>T<sub>8</sub></b>	75.55g	75.26g	75.40h	210.19f	182.71g	196.45h	181.87f	165.63f	173.75f
<b>S.Em±</b>	0.70	0.81	0.46	2.90	2.39	1.51	2.34	2.23	1.58
<b>C.D @ 5 %</b>	2.14	2.47	1.40	8.80	7.25	4.59	7.11	6.76	4.78

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

T<sub>8</sub> (5.97% and 6.01% respectively) at ripe stage and (10.06% and 10.12%) at beginning of senescence stage. Maximum PLW during 2014, 2015 and for pooled analysis was found associated with T<sub>1</sub> (Control) at ripe stage (12.78%, 11.69% and 12.24% respectively) and at beginning of senescence stage (18.77%, 18.19% and 18.48%) and it was found significantly differing with all other treatments.

#### **4.1.4.3 Shelf life (days)**

In general, shelf life of banana fruits differed significantly during both the seasons and even after pooling the two years' data (Table 6). The treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l + bagging of bunch) recorded significantly maximum shelf life in 2014, 2015 as well as in pooled analysis (12.33 days, 13.33 days and 12.83 days respectively) when compared to all other treatments. The least shelf life noticed in the control (T<sub>1</sub>) fruits (5.33 days, 6.33 days and 5.83 days respectively) differed significantly over all other treatments.

#### **4.1.4.4 Instrumental Colour measurements ( $L^*$ , $a^*$ , $b^*$ C and $h^o$ values)**

##### **4.1.4.4.1 $L^*$ value**

The changes in instrumental  $L^*$  values of banana fruits (var Grand Naine) as influenced by various pre harvest treatments showed significant differences among the treatments when the fruits were ripened under ambient condition (Table 7).

The minimum  $L^*$  value at ripe stage was observed in the treatment T<sub>1</sub> (control) (55.86, 56.41 and 56.14) during 2014, 2015 and for pooled analysis. It differed significantly with all other treatments. On the other hand, significantly maximum  $L^*$  value was found in the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) 66.96 (2014), 66.93 (2015) and 66.95 (pooled analysis).

##### **4.1.4.4.2 $a^*$ value**

The data concerning to  $a^*$  value that represent the colour change with respect to redness (positive value) or greenness (negative value) of banana fruits as affected by different pre harvest treatments showed remarkable variations (Table 7).

**Table 6: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on physiological loss in weight and shelf life of banana fruits var. ‘Grand Naine’ (AAA)**

Treatments	Physiological loss in weight (%)						Shelf life (Days)		
	Ripe stage			Senescence stage			2014	2015	Pooled
	2014	2015	Pooled	2014	2015	Pooled			
<b>T<sub>1</sub></b>	12.78a	11.69a	12.24a	18.77a	18.19a	18.48a	5.33f	6.33e	5.83f
<b>T<sub>2</sub></b>	11.00b	10.77b	10.88b	17.24b	16.76b	17.00b	7.33e	7.67d	7.50e
<b>T<sub>3</sub></b>	11.07b	9.87c	10.47c	16.28c	16.83b	16.56c	7.67e	8.33d	8.00e
<b>T<sub>4</sub></b>	10.82b	9.78c	10.30c	16.25c	16.53c	16.39d	8.67d	9.67c	9.17d
<b>T<sub>5</sub></b>	9.82c	7.67d	8.74d	15.95d	16.29d	16.12e	10.33b	11.67b	11.00b
<b>T<sub>6</sub></b>	9.81c	8.36e	9.09d	15.28e	15.51e	15.40f	9.33c	11.00b	10.17c
<b>T<sub>7</sub></b>	7.79d	7.07f	7.43e	12.55f	13.06f	12.81g	10.67b	11.67b	11.17b
<b>T<sub>8</sub></b>	6.05e	5.97g	6.01f	10.17g	10.06g	10.12h	12.33a	13.33a	12.83a
<b>S.Em±</b>	0.24	0.17	0.13	0.05	0.04	0.03	0.17	0.36	0.21
<b>C.D @ 5 %</b>	0.73	0.51	0.38	0.16	0.12	0.10	0.52	1.11	0.63

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

Significant differences were observed with respect to ' $a^*$ ' (redness) values at ripe stage during the two seasons in bananas under experimentation. During 2014, 2015 and pooled analysis, the maximum  $a^*$  value was obtained in the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (6.68, 6.72 and 6.70) followed significantly by T<sub>7</sub> (5.60, 6.52 and 6.06). Contrastingly, the minimum significant value for  $a^*$  was observed with T<sub>1</sub> (control) during 2014 (1.72), 2015 (1.71) and for pooled analysed values (1.71).

#### **4.1.4.4.3 $b^*$ value**

The data on colour change with respect to  $b^*$  value of banana fruit as influenced by different treatments revealed significant differences among the treatments (Table 7). The  $b^*$  value represents change in fruit colour with respect to blueness or yellowness.

The pooled analysis of 2 years data indicated maximum  $b^*$  value at ripe stage in treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (42.07) followed by T<sub>7</sub> (40.62). The minimum  $b^*$  value during this period of observation was found in the treatment T<sub>1</sub> (34.01).

#### **4.1.4.4.4 $C^*$ value**

The data pertaining to  $C^*$  value as influenced by different pre harvest treatments on banana fruits at ripe stage revealed significant differences among the treatments (Table 7).

Chroma ( $C^*$ ) values of banana differed significantly in both the seasons at ripe stage of storage. Significantly maximum  $C^*$  values were noted in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014, 2015 and in pooled analysis (38.55, 37.74 and 38.15). Minimum  $C^*$  values for similar observation periods were registered in T<sub>1</sub> (control) (31.69, 31.02 and 31.36).

#### **4.1.4.4.5 $h^o$ value**

Instrumental  $h^o$  value of banana fruit revealed significant differences among the treatments (Table 7).

**Table 7: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on instrumental colour values ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $C^*$ ,  $h^0$ ) of banana fruits var. ‘Grand Naine’ at ripe stage (AAA)**

Treatments	$L^*$ (Lightness)			$a^*$ (Redness)			$b^*$ (Yellowness)			$C^*$ (Chroma )			$h^0$ (Hue angle)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	55.86e	56.41d	56.14e	1.72f	1.71f	1.71g	34.21g	33.81e	34.01h	31.69g	31.02f	31.36h	101.46a	100.07a	100.77a
<b>T<sub>2</sub></b>	62.83c	62.17c	62.50c	4.69c	5.28c	4.99d	40.80c	39.94b	40.37c	36.78c	36.35b	36.57c	91.57d	86.58ef	89.08e
<b>T<sub>3</sub></b>	58.8e	60.85c	59.84d	2.26e	2.79e	2.53f	38.28f	37.91d	38.10g	34.00f	34.09e	34.05g	98.68b	96.97b	97.83b
<b>T<sub>4</sub></b>	60.26d	61.26c	60.76d	2.85d	4.40d	3.63e	39.64e	38.04d	38.84f	34.66e	34.43d	34.55f	98.32b	95.55c	96.94c
<b>T<sub>5</sub></b>	62.69c	61.81c	62.25c	4.69c	5.39c	5.04d	39.90d	39.01c	39.45e	35.36d	35.43d	35.40e	93.30c	91.58d	92.44d
<b>T<sub>6</sub></b>	63.99bc	64.35b	64.17b	5.48b	6.13b	5.80c	40.82c	39.26c	40.04d	36.5c	35.56c	36.03d	89.50e	86.94e	88.22f
<b>T<sub>7</sub></b>	64.78b	64.88b	64.83b	5.60b	6.52a	6.06b	40.95b	40.28b	40.62b	37.86b	36.49b	37.18b	88.27f	85.64fg	86.96g
<b>T<sub>8</sub></b>	66.96a	66.93a	66.95a	6.68a	6.72a	6.70a	42.10a	42.04a	42.07a	38.55a	37.74a	38.15a	86.57g	84.70g	85.64h
<b>S.Em±</b>	0.64	0.63	0.36	0.13	0.09	0.08	0.04	0.04	0.02	0.11	0.11	0.10	0.27	0.37	0.26
<b>C.D @ 5 %</b>	1.94	1.91	1.10	0.40	0.26	0.24	0.11	0.12	0.06	0.33	0.34	0.29	0.83	1.12	0.79

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

**T<sub>1</sub>**- Control

**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

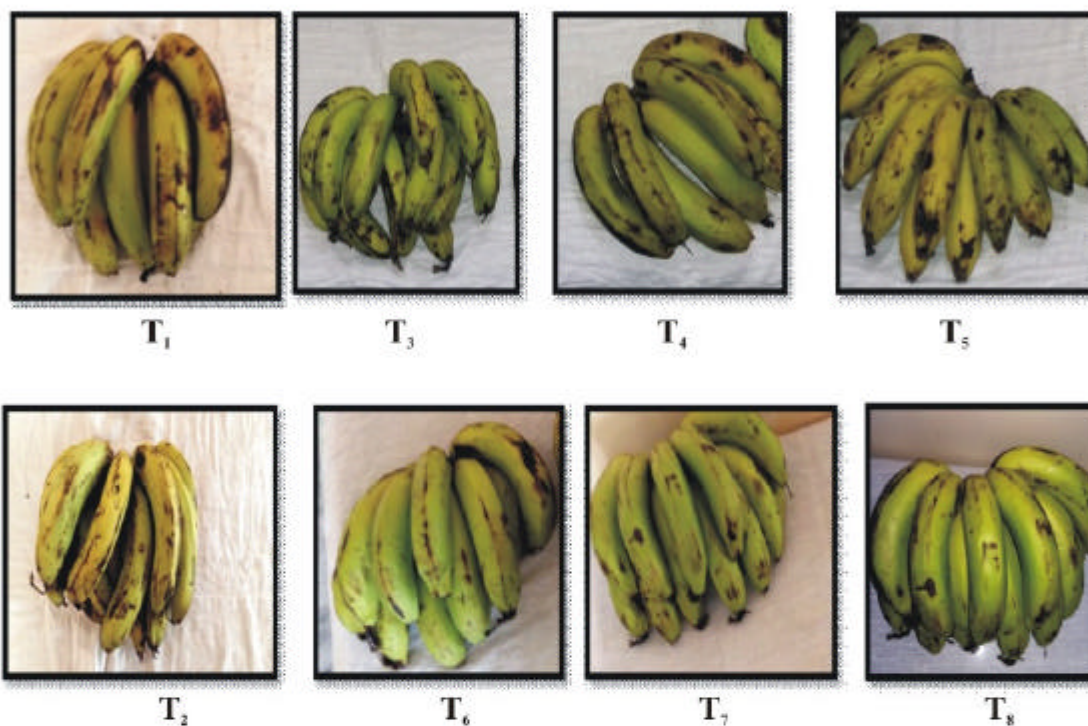
**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches



T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/plant at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/plant at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval+ polyethylene bagging of bunches

**Plate 6: Images showing fruits (Grand Naine) of different treatments after 12 days after harvesting**

The pooled data revealed significantly maximum  $h^o$  value of 100.77 and 97.83 in the treatments T<sub>1</sub> and T<sub>3</sub> respectively. Both these treatments differed significantly between themselves and with other treatments. The minimum  $h^o$  value found in T<sub>8</sub> (85.64) at ripe stage was at parity with T<sub>7</sub> (86.96).

#### 4.1.5 Quality parameters

##### 4.1.5.1 Total soluble solids (<sup>o</sup>B)

The mean TSS of banana fruits at mature green stage was recorded to be 4.45<sup>o</sup> B with pooled data ranging from 4.00<sup>o</sup> B to 4.72<sup>o</sup> B (Table 8). The total soluble solids (TSS) of banana fruits registered a sharp rise at ripe stage with a slight further increase at senescence stage.

Fruits treated with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) were found to have higher total soluble solids (TSS) (22.72 <sup>o</sup>B, 23.73 <sup>o</sup>B and 23.23 <sup>o</sup>B) when compared to all other treatments at optimum ripe stage during 2014, 2015 and even in pooled data (Table 8). The treatment continued to show higher level of TSS even in later stages of ripening in comparison to other treatments. Thus, maximum total soluble solids content at the beginning of senescence stage were recorded in T<sub>8</sub> (24.77 <sup>o</sup>B - 2014, 25.27 <sup>o</sup>B - 2015 and 25.02 - pooled analysis). However, T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) (24.37 <sup>o</sup>B, 24.83 <sup>o</sup>B, 24.60 <sup>o</sup>B) was at significance with T<sub>8</sub> at similar time of observation.

The lower TSS content during 2014, 2015 and in pooled data was noticed in T<sub>3</sub> at ripe stage (18.47 <sup>o</sup>B, 19.23 <sup>o</sup>B and 18.55 <sup>o</sup>B, respectively) and at the beginning of senescence stage (21.67 <sup>o</sup>B, 21.83 <sup>o</sup>B and 21.75 <sup>o</sup>B).

##### 4.1.5.2 Titratable acidity (%)

Titrate acidity of banana fruits under ambient storage exhibited significant differences among the treatments. Initial value of titrate acidity ranged from 0.21 per cent to 0.26 per cent and mean value was recorded to be 0.24 per cent (Table 9). The parameter exhibited an increasing trend at ripe stage followed by a decreasing trend at senescence stage.

**Table 8: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on total soluble solids of banana fruits var. 'Grand Naine' (AAA)**

Treatments	TSS ( <sup>0</sup> B)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	4.07d	3.93e	4.00f	19.34e	19.53de	19.44f	22.03g	22.47f	22.25e
<b>T<sub>2</sub></b>	4.13d	4.23d	4.18e	19.53e	20.03d	19.78f	22.47e	23.17d	22.82d
<b>T<sub>3</sub></b>	4.30bc	4.27d	4.28de	18.47f	19.23e	18.85g	21.67f	21.83e	21.75f
<b>T<sub>4</sub></b>	4.30bc	4.33cd	4.32d	20.62d	21.13c	20.88d	22.47e	22.7de	22.58c
<b>T<sub>5</sub></b>	4.40b	4.50bc	4.45bc	21.05c	22.27b	21.66c	23.63d	24.57bc	24.10c
<b>T<sub>6</sub></b>	4.20cd	4.47bc	4.33cd	20.88cd	20.07d	20.47e	24.03c	24.33c	24.18bc
<b>T<sub>7</sub></b>	4.37b	4.63ab	4.50b	22.11b	23.57a	22.84b	24.37b	24.83ab	24.60ab
<b>T<sub>8</sub></b>	4.67a	4.77a	4.72a	22.72a	23.73a	23.23a	24.77a	25.27a	25.02a
<b>S.Em±</b>	0.05	0.06	0.04	0.088	0.21	0.12	0.044	0.155	0.075
<b>C.D @ 5 %</b>	0.15	0.18	0.13	0.268	0.65	0.364	0.134	0.469	0.227

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

**T<sub>1</sub>**- Control  
**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

At optimum ripe stage, banana fruits of treatment T<sub>1</sub> (control) retained significantly maximum acidity (0.417%, 0.430% and 0.423% respectively) during the years 2014, 2015 and for pooled analysis in comparison to rest of the treatments. However, minimum titratable acidity was recorded in treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014, 2015 and for pooled analysis (0.337%, 0.327% and 0.332% respectively) was followed by T<sub>2</sub> (0.347) in 2014, and T<sub>4</sub> (0.340 and 0.353) in 2015 and for pooled analysis.

Conversely, the minimum titratable acidity was noted in T<sub>1</sub> (control) at beginning of senescence stage in 2014 (0.210%), 2015 (0.217%) and for pooled analysis (0.213%). This treatment was found to be significant over all the other treatments. However, the higher values were noticed in T<sub>8</sub> for both 2014 and 2015 and also for pooled analysis (0.273%, 0.277% and 0.275% respectively).

#### **4.1.5.3 Total sugars (%)**

The effect of pre-harvest bunch treatments of banana fruits on total sugars during ambient storage revealed the same trend as total soluble solids. Significant variations were observed among the treatments all through the storage duration. The initial total sugar observed in the fruits at mature green stage ranged from 1.35 per cent to 1.41 per cent and mean was found to be 1.38 per cent. The results of pooled data of total sugars during the storage period are as follows (Table 10).

The treatment T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/) recorded significantly minimum total sugar content at ripe stage (14.12%). This treatment was followed by T<sub>1</sub> (control) (14.31%) during the same period of examination. On the other hand, the maximum total sugars were associated with T<sub>8</sub> (18.98) (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) which was significantly followed by T<sub>7</sub> (18.50) (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch).

At senescence stage of banana fruits, the highest significant total sugars was noted in T<sub>8</sub> (24.07%). The treatment T<sub>1</sub> showed minimum total sugar content (19.99%) and it was found to be stastically significant with all other treatments.

**Table 9: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on acidity of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Acidity (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	0.253	0.237	0.245	0.417a	0.430a	0.423a	0.210e	0.217d	0.213d
<b>T<sub>2</sub></b>	0.240	0.247	0.243	0.347de	0.360bc	0.353cd	0.237d	0.233cd	0.235c
<b>T<sub>3</sub></b>	0.230	0.237	0.233	0.413a	0.433a	0.423a	0.227d	0.237bcd	0.232c
<b>T<sub>4</sub></b>	0.250	0.257	0.253	0.367cd	0.340c	0.353cd	0.230d	0.230cd	0.230c
<b>T<sub>5</sub></b>	0.250	0.257	0.253	0.360cde	0.363bc	0.362cd	0.250c	0.257abc	0.253b
<b>T<sub>6</sub></b>	0.213	0.213	0.213	0.403ab	0.413a	0.408ab	0.253bc	0.250abc	0.252b
<b>T<sub>7</sub></b>	0.213	0.227	0.220	0.383bc	0.390ab	0.387bc	0.262b	0.262ab	0.262b
<b>T<sub>8</sub></b>	0.233	0.223	0.228	0.337e	0.327c	0.332d	0.273a	0.277a	0.275a
<b>S.Em±</b>	0.014	0.012	0.007	0.008	0.016	0.011	0.006	0.009	0.004
<b>C.D @ 5 %</b>	NS	NS	NS	0.025	0.049	0.032	0.018	0.026	0.013

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

**T<sub>1</sub>**- Control  
**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**Table 10: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on total sugars of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Total Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	1.37	1.35	1.36	14.56g	14.06g	14.31g	20.02h	19.96g	19.99h
T <sub>2</sub>	1.36	1.37	1.37	15.28f	15.51f	15.40f	21.12f	21.29f	21.20g
T <sub>3</sub>	1.36	1.37	1.37	14.17h	14.06g	14.12	20.14g	20.03g	20.09f
T <sub>4</sub>	1.38	1.35	1.36	15.95e	16.29e	16.12e	21.61e	22.14e	21.88e
T <sub>5</sub>	1.38	1.39	1.39	16.25d	16.53d	16.39d	22.23d	22.74d	22.48d
T <sub>6</sub>	1.37	1.40	1.39	17.28c	17.83c	17.56c	23.36c	23.34c	23.35c
T <sub>7</sub>	1.38	1.40	1.39	18.24b	18.76b	18.50b	23.67b	23.92b	23.80b
T <sub>8</sub>	1.40	1.41	1.41	18.77a	19.19a	18.98a	23.98a	24.15a	24.07a
<b>S.Em±</b>	0.01	0.02	0.01	0.05	0.04	0.04	0.03	0.04	0.03
<b>C.D @ 5 %</b>	NS	NS	NS	0.16	0.12	0.11	0.10	0.11	0.08

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

#### 4.1.5.4 Reducing sugars (%)

The reducing sugars of banana fruits influenced by various pre harvest bunch treatments and stored at ambient conditions revealed significant differences. The initial reducing sugars in the fruits at mature green stage had a range from 0.91 per cent to 1.00 per cent while mean value recorded was 0.95 per cent (Table 11).

At ripe stage, banana fruits had significant level of reducing sugars in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (14.27%) 2014, (14.89%) 2015 and (14.58%) pooled analysis. While, control (T<sub>1</sub>) fruits were observed to have minimum reducing sugar in 2015 and pooled analysis (9.14% and 9.21%) where as T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/l) had minimum reducing sugars in 2014 (8.98).

The treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) was found to have maximum reducing sugar in both years as well as in pooled analysis (19.15%, 19.43% and 19.29%) at the beginning of senescence stage, and it was significantly different from other treatments. However, minimum amount of reducing sugars were found in T<sub>3</sub> (12.44%, 12.12% and 12.28%) and the treatment was closely followed by T<sub>1</sub>.

#### 4.1.5.5 Non-reducing sugars (%)

Non-reducing sugars of banana fruits disclosed significant differences among the treatments. The initial non-reducing sugar content at mature green stage had a range from 0.38 to 0.43 per cent and mean value of non-reducing sugar found in banana fruits was 0.40 per cent (Table 12). The results of pooled data of non reducing sugars at ripe and subsequent stage are as follows.

Significantly minimum non-reducing sugars at ripe stage were associated with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (4.18%) which was followed by T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) (4.47). However, the treatment T<sub>7</sub> was at parity with T<sub>6</sub> (4.61%). On the other hand, T<sub>4</sub> (Bunch spraying of potassium silicate at 4 ml/l) was associated with the maximum non-reducing sugars (5.99%) followed by T<sub>2</sub> (control+ bagging) (5.65) and (T<sub>1</sub>) (4.85%).

**Table 11: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on reducing sugars of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.93	0.93	0.93	9.28g	9.14f	9.21g	12.84g	12.57g	12.7g
T <sub>2</sub>	0.94	0.95	0.95	9.58f	9.31f	9.45f	13.34h	13.07f	13.21f
T <sub>3</sub>	0.95	0.92	0.94	8.98h	9.82e	9.40f	12.44f	12.12h	12.28h
T <sub>4</sub>	0.95	0.95	0.95	9.76e	9.87e	9.82e	15.37e	15.9e	15.63e
T <sub>5</sub>	0.96	0.95	0.96	11.12d	11.84d	11.48d	16.19d	16.55d	16.37d
T <sub>6</sub>	0.94	0.95	0.94	12.32c	13.10c	12.71c	17.57c	17.37c	17.47c
T <sub>7</sub>	0.95	0.98	0.97	13.54b	14.05b	13.79b	18.12b	18.38b	18.25b
T <sub>8</sub>	1.00	0.97	0.99	14.27a	14.89a	14.58a	19.15a	19.43a	19.29a
<b>S.Em±</b>	0.019	0.025	0.015	0.05	0.09	0.05	0.04	0.08	0.05
<b>C.D @ 5 %</b>	NS	NS	NS	0.15	0.27	0.15	0.11	0.24	0.14

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**Table 12: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on non-reducing sugars of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Non-Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.41	0.43	0.42	5.02c	4.67b	4.85c	6.82b	7.03c	6.92c
T <sub>2</sub>	0.38	0.41	0.40	5.41b	5.89a	5.65b	7.39a	7.81a	7.60a
T <sub>3</sub>	0.39	0.42	0.41	4.93cd	4.03c	4.48e	7.32a	7.52b	7.42b
T <sub>4</sub>	0.41	0.40	0.40	5.88a	5.81a	5.84a	6.03c	5.98d	6.01d
T <sub>5</sub>	0.40	0.42	0.41	4.87d	4.46b	4.66d	5.74d	5.88d	5.81e
T <sub>6</sub>	0.41	0.41	0.41	4.71e	4.50b	4.61de	5.50e	5.67e	5.58f
T <sub>7</sub>	0.40	0.41	0.41	4.47f	4.48b	4.47e	5.28f	5.26e	5.27f
T <sub>8</sub>	0.38	0.43	0.40	4.27g	4.09c	4.18f	4.59g	4.49f	4.54g
<b>S.Em±</b>	0.021	0.036	0.028	0.03	0.09	0.04	0.04	0.08	0.05
<b>C.D @ 5 %</b>	NS	NS	NS	0.11	0.26	0.13	0.11	0.25	0.14

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

Maximum non-reducing sugars at the beginning of senescence stage of banana fruits were associated with the treatment T<sub>2</sub> (7.60%), followed by T<sub>3</sub> (7.42%) and T<sub>1</sub> (6.92%). In contrast, minimum non-reducing sugar documented in T<sub>8</sub> (4.54%) was found significant over all other treatments.

#### **4.1.5.6 Sugar acid ratio (%)**

The influence of different pre-harvest bunch treatments on sugar acid ratio of banana fruits showed significant differences among the treatments. The pooled values at mature green stage ranged between 5.62 to 6.68 (Table 13).

At ripe stage of banana fruits, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded maximum sugar acid ratio of 55.82 (2014), 58.99 (2015) and 57.41 (pooled analysis) and it was significantly followed by T<sub>7</sub> (47.60, 48.12 and 47.86). However, significantly minimum sugar acid ratio was observed in T<sub>1</sub> (control) and in both consecutive years (34.41, 32.50) and for pooled analysis (33.46).

Conversely maximum sugar acid ratio during 2014, 2015 and in pooled analysis was observed in T<sub>1</sub> (92.43, 97.48 and 94.95, respectively) at beginning of senescence stage. Significantly minimum sugar acid ratio was associated with treatment T<sub>3</sub> (84.25, 82.46 and 88.53) in all stages of analysis.

#### **4.1.5.7 Starch (%)**

The data concerning starch content of banana fruits revealed a gradual decreasing tendency throughout the storage period. The initial mean starch content of banana at mature green stage was recorded to be 22.69 per cent ranging from 22.66 per cent to 22.74 per cent between the treatments (Table 14).

Starch content of banana fruits varied significantly among the imposed treatments at ripe stage. During 2014, 2015 and in pooled analysis of data, fruits under the treatment T<sub>1</sub> (control) (3.67%, 3.55% and 3.61%), T<sub>3</sub> (3.84%, 3.97% and 3.91%) and T<sub>2</sub> (4.01%, 4.28% and 4.15%) which were on par with each other showed

**Table 13: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on sugar acid ratio of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Sugar acid ratio								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	5.41	5.83	5.62	34.41d	32.50c	33.46d	92.43ab	97.48a	94.95a
T <sub>2</sub>	5.63	5.60	5.61	44.08c	43.11b	43.60e	89.28ab	89.84abc	89.56c
T <sub>3</sub>	5.91	5.79	5.85	34.97d	32.71c	33.84d	84.25c	82.46c	83.35e
T <sub>4</sub>	5.52	5.34	5.43	43.53c	48.27b	45.90bc	93.97a	95.58ab	94.78ab
T <sub>5</sub>	5.52	5.42	5.47	45.15bc	45.52b	45.33bc	91.39ab	89.20bc	90.30bcd
T <sub>6</sub>	6.66	6.71	6.68	42.88c	43.66b	43.27c	92.23ab	94.63ab	93.43abc
T <sub>7</sub>	6.51	6.39	6.45	47.60b	48.12b	47.86b	91.65ab	90.60ab	91.12abcd
T <sub>8</sub>	6.10	6.44	6.27	55.82a	58.99a	57.41a	88.94bc	88.12bc	88.53d
<b>S.Em±</b>	0.42	0.43	0.23	0.85	2.01	1.31	1.65	2.68	1.50
<b>C.D @ 5 %</b>	NS	NS	NS	2.59	6.10	3.96	4.99	8.12	4.56

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

significantly lower starch content over other treatments. However, T<sub>1</sub> had numerically low starch content. Significantly maximum starch content during both the years and for pooled data was observed in T<sub>8</sub> (5.83%, 5.98% and 5.91%) followed by T<sub>7</sub> (5.13, 5.22 and 5.28).

Similarly at senescence stage maximum starch content was found in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) 2.73% (2014), 3.07% (2015) and 2.90% (for pooled analysis) which was closely followed by treatment T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (2.61%, 2.80% and 2.71%). The minimum content of starch was noted in T<sub>1</sub> (1.53%, 1.63% and 1.58%) for both years and pooled analysis.

#### **4.1.6 Organoleptic evaluation**

##### **4.1.6.1 Peel colour and appearance**

With respect to peel colour and appearance, significant differences were observed both during 2014, 2015 and pooled analysis (Table 15). Fruits that received Bunch spraying of potassium silicate at 6 ml/l and then bagged with skirting materials (T<sub>8</sub>) obtained higher score (8.23, 8.54 and 8.39 respectively) when compared to all others treatments during 2014, 2015 and when analysed by pooling 2 years data. This treatment was non-significantly followed by T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (8.01, 8.21 and 8.11). The treatment T<sub>1</sub> (control) received significantly minimum score for peel colour and appearance (5.10, 5.40 and 5.25 respectively) in 2014, 2015 and in analysed pooled data.

##### **4.1.6.2 Pulp colour and appearance**

Pulp colour and appearance of banana showed significant differences among the treatments (Table 15). In 2014, 2015 and in pooled analysis the maximum score for pulp colour and appearance was noted in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (8.12, 8.33 and 8.23 respectively) and it was followed significantly by T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (7.94, 8.14 and 8.04 respectively).

**Table 14: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on starch of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Starch (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	22.68bc	22.68bc	22.68c	3.67d	3.55e	3.61d	1.53e	1.63g	1.58f
<b>T<sub>2</sub></b>	22.67c	22.68bc	22.68cd	4.01cd	4.28cde	4.15cd	2.01c	2.29e	2.15d
<b>T<sub>3</sub></b>	22.66c	22.67bc	22.67cd	3.84cd	3.97de	3.91cd	1.84d	1.90f	1.87e
<b>T<sub>4</sub></b>	22.68bc	22.60d	22.64e	5.05b	4.93bc	4.99b	2.05c	2.36de	2.21d
<b>T<sub>5</sub></b>	22.71a	22.70ab	22.70b	5.12ab	5.06b	5.09b	2.61a	2.80b	2.71b
<b>T<sub>6</sub></b>	22.67c	22.64cd	22.66de	4.59bc	4.67bcd	4.63bc	2.00c	2.42cd	2.21d
<b>T<sub>7</sub></b>	22.70ab	22.72ab	22.71ab	5.13ab	5.22b	5.18ab	2.20b	2.48c	2.34c
<b>T<sub>8</sub></b>	22.72a	22.74a	22.73a	5.83a	5.98a	5.91a	2.73a	3.07a	2.90a
<b>S.Em±</b>	0.01	0.02	0.01	0.25	0.25	0.25	0.04	0.04	0.02
<b>C.D @ 5 %</b>	0.03	0.05	0.02	0.76	0.75	0.76	0.13	0.11	0.07

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

**T<sub>1</sub>**- Control

**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

Minimum score for pulp colour and appearance was received by T<sub>1</sub> (control) with 5.04 in 2014, 5.33 in 2015 and 5.18 in pooled analysis. It was followed by the treatments T<sub>2</sub> (control +bagging) (6.05, 6.22 and 6.13) and T<sub>6</sub> (Bunch spraying of potassium silicate at 2 ml/l+ bagging of bunch) (6.27, 6.33 and 6.30) for similar periods of observation.

#### **4.1.6.3 Texture**

Significant differences were observed with respect to texture of banana fruit among different treatments (Table 15). Bananas under the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (7.96, 8.10 and 8.03) showed maximum score for texture during 2014, 2015 and pooled analysis. Control (T<sub>1</sub>) fruits received the least score of 4.97, 5.24 and 5.11, respectively during 2014, 2015 and when analysed by pooling 2 years' data and it differed significantly with all other treatments.

#### **4.1.6.4 Taste and flavour**

Significant differences were observed with respect to taste and flavour both during 2014, 2015 and when the 2 years' data was analysed after pooling (Table 15). Significantly higher score for taste and flavour was obtained in the treatment T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) during 2014 (8.19), 2015 (8.65) as well as in pooled analysis (8.42) and it showed non-significant difference with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (8.06, 8.12 and 8.09 respectively). The least scoring control (T<sub>1</sub>) (5.17, 5.34 and 5.26) during 2014, 2015 and when analysed by pooling 2 years data was statistically significant with all other treatments.

#### **4.1.6.5 Overall acceptability**

Overall acceptability data revealed significant differences during 2014, 2015 and even in pooled analysis (Table 15). In 2014 and 2015, higher overall acceptability scores were obtained by the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l + bagging of bunch) (8.12 and 8.24) and it was found on par with T<sub>5</sub> (Bunch

**Table 15: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on sensory attributes of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Peel colour and appearance			Pulp colour and appearance			Pulp texture			Pulp taste and flavour			Overall acceptability		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	5.10e	5.40d	5.25e	5.03g	5.33e	5.18e	4.97f	5.24e	5.11f	5.17f	5.34f	5.26e	5.13d	5.30d	5.21e
T <sub>2</sub>	6.13d	6.29c	6.21d	6.05f	6.22d	6.13d	5.63e	6.20d	5.92e	5.82e	6.10e	5.96d	5.71d	6.01c	5.86d
T <sub>3</sub>	7.11c	6.61c	6.86c	7.02d	6.79c	6.90c	6.90c	6.55c	6.73c	6.87cd	6.72d	6.80c	6.51c	6.49c	6.50c
T <sub>4</sub>	7.71b	7.52b	7.61b	7.30c	7.32b	7.31b	7.36b	7.35b	7.35b	7.36b	7.19c	7.28b	7.24b	7.21b	7.23b
T <sub>5</sub>	8.01a	8.21a	8.11a	7.94b	8.14a	8.04a	7.72a	7.88a	7.80a	8.19a	8.65a	8.42a	7.99a	8.18a	8.08a
T <sub>6</sub>	6.37d	6.35c	6.36d	6.27e	6.33cd	6.30d	6.33d	6.35cd	6.34d	6.51d	6.35dc	6.43c	6.51c	6.47c	6.49c
T <sub>7</sub>	7.45b	7.69b	7.57b	7.32c	7.46b	7.39b	7.18b	7.47b	7.32b	7.18bc	7.47c	7.32b	7.18bc	7.47b	7.32b
T <sub>8</sub>	8.23a	8.54a	8.39a	8.12a	8.33a	8.23a	7.96a	8.10a	8.03a	8.06a	8.12b	8.09a	8.12b	8.24a	8.18a
<b>S.Em±</b>	0.090	0.170	0.096	0.055	0.18	0.089	0.091	0.11	0.083	0.161	0.127	0.126	0.221	0.161	0.180
<b>C.D @ 5 %</b>	0.273	0.516	0.292	0.166	0.53	0.271	0.276	0.335	0.252	0.488	0.386	0.384	0.670	0.488	0.546

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$ .

T<sub>1</sub>- Control  
T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval  
T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches  
T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches  
T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

spraying of potassium silicate at 6 ml/l) (7.99 and 8.18). Pooled analysis of data revealed similar trend as in the individual years, with fruits of T<sub>8</sub> (8.18) receiving maximum score for overall acceptability and the treatment T<sub>8</sub> differing non-significantly with T<sub>5</sub> (8.08). The performance was acknowledged to be low with the treatment T<sub>1</sub> (5.13, 5.30 and 5.21) throughout the experimentation.

## **4.2 Experiment-2: Effect of bunch treatment (potassium silicate) and bagging on yield, post harvest quality and shelf life of banana fruits cv. ‘Ney Poovan’ (AB)**

### **4.2.1 Bunch characters**

#### **4.2.1.1 Bunch weight (kg)**

Pre-harvest treatments resulted in significant differences with respect to bunch weight of the banana plants of cv. Ney Poovan (Table 16). During 2014, 2015 and in pooled analysis, the bunch weight showed significant increase in all the treatments over T<sub>1</sub> (Control) (8.30 kg/plant, 8.57 kg/plant and 8.44 kg/plant). However, the treatment T<sub>2</sub> and T<sub>3</sub> were on par with T<sub>1</sub>. Maximum bunch weight (12.62 kg/plant) was observed in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014 and it was followed by T<sub>5</sub> (11.14 kg/plant) with significant difference. During 2015 also, the treatment T<sub>8</sub> significantly enhanced bunch weight (13.12 kg/plant) and it showed parity with T<sub>5</sub> (12.04 kg/plant). Interestingly, in the pooled data, the treatment T<sub>8</sub> (12.87 kg/plant) was on par with T<sub>5</sub> (11.59) and showed significant difference over all the treatments.

#### **4.2.1.2 Number of hands per bunch**

Spraying of banana bunches and bagging resulted in non-significant differences with respect to number of hands per bunch in cv. Ney Poovan during both the seasons and even in the pooled data when accounted at harvest (Table 16). During 2014, 2015 and in pooled analysis, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (12.33, 12.67 and 12.50) recorded maximum number of hands per bunch while minimum number of hands was recorded in untreated control (11.00, 11.33 and 11.17).

#### **4.2.1.3 Number of fingers in third hand**

The data pertaining to number of fingers in third hand showed non-significant differences among the treatments (Table 16). The least number of fruits were observed in T<sub>1</sub> (control) during 2014 (12.10), 2015 (12.07) and in pooled data (12.08). The maximum number of fingers observed in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014, 2015 and in pooled analysis (13.50, 13.67 and 13.59, respectively).

#### **4.2.1.4 Total no. of fingers per bunch**

Pre-harvest bunch treatment in banana fruits recorded significantly maximum number of fruits under the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) in 2014 (150.33), 2015 (153.67) and in pooled analysis (152.00) followed significantly by T<sub>7</sub> and T<sub>5</sub> in both the years. The treatment T<sub>1</sub> (control) recorded least number of fruits per bunch during both the years (2014-123.00 and 2015-124.67). However, it exhibited statistical significance with the treatment T<sub>2</sub> when subjected for pooled analysis (Table 16).

### **4.2.2 Fruit characters**

#### **4.2.2.1 Fruit characters at mature stage**

##### **4.2.2.1.1 Fruit weight (g)**

Influence of pre-harvest treatments resulted in significant differences with respect to fruit weight at harvest during two seasons and after pooling the two season's data (Table 17). During 2014, 2015 and in pooled analysis, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) resulted in maximum fruit weight (78.55 g, 88.13g and 83.87 g) and it was found to differ significantly with the next best treatment T<sub>5</sub> (75.98 g, 84.61 g and 80.94 g).

Minimum fruit weight during 2014, 2015 and in pooled data was associated with T<sub>1</sub> (Control) (65.53 g, 68.82 g and 67.83 g) and it was followed by T<sub>2</sub> (69.14 g, 71.30 g and 70.81g) with significant difference.

**Table 16: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on bunch weight and bunch characters of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Bunch weight (kg)			No. of hands /bunch			Fingers in third hand			Total no. of fruits		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	8.30d	8.57e	8.44e	11.00	11.33	11.17	12.10	12.07	12.08c	123.00h	124.67h	123.83h
T <sub>2</sub>	9.11cd	9.04de	9.07de	11.17	11.00	11.08	12.58	12.41	12.49bc	130.33g	132.67g	131.50g
T <sub>3</sub>	9.40cd	9.64cde	9.52de	11.00	11.67	11.33	12.92	12.67	12.79b	134.33f	135.67f	135.00f
T <sub>4</sub>	10.04bc	10.28cd	10.16bcd	11.33	11.67	11.50	13.06	12.95	13.01ab	140.33d	142.33b	141.33d
T <sub>5</sub>	11.14b	12.04ab	11.59ab	12.00	12.33	12.17	12.73	13.71	13.22ab	144.67b	147.33b	146.00b
T <sub>6</sub>	9.98bc	9.81cde	9.90cde	11.00	11.67	11.33	13.05	13.33	13.19ab	137.67e	139.67e	138.67e
T <sub>7</sub>	10.90b	11.09bc	11.00bc	11.33	12.33	11.83	13.07	13.37	13.22ab	141.67c	144.67c	143.17c
T <sub>8</sub>	12.62a	13.12a	12.87a	12.33	12.67	12.50	13.50	13.67	13.59a	150.33a	153.67a	152.00a
<b>S.Em±</b>	0.48	0.50	0.49	0.47	0.51	0.40	0.50	0.39	0.25	0.27	0.72	0.46
<b>C.D @ 5 %</b>	1.46	1.51	1.48	NS	NS	NS	NS	NS	0.76	0.82	2.18	1.39

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

#### **4.2.2.1.2 Fruit length (cm)**

In both the years, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded maximum fruit length (2014 – 13.93 cm and 2015 – 14.07 cm) (Table 17). This treatment was significantly followed by T<sub>5</sub> (2014 – 13.47 cm; 2015 – 13.90 cm). Conversely, the minimum fruit length was associated with T<sub>1</sub> (Control) both during 2014 (10.73 cm) and 2015 (10.93 cm). Pooled analysis of two years data showed significant increase in fruit length (14.00 cm) in T<sub>8</sub> over all other treatments. On the other hand, control treatment (T<sub>1</sub>) continued to record least fruit length (10.83 cm) and it exhibited significant difference over rest of the treatments.

#### **4.2.2.1.3 Fruit diameter (cm)**

The effect of pre-harvest treatments on fruit diameter of banana fruits followed similar trend as fruit length (Table 17). In the year 2014, T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded significantly maximum fruit diameter (2.78 cm) over all the treatments. The least fruit diameter (2.30cm) observed in T<sub>2</sub> (Control + bagging) was found to be at parity with T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/l) (2.32). In 2015, the maximum fruit diameter was associated with T<sub>8</sub> (2.82 cm). The treatment T<sub>1</sub> showed minimum fruit diameter (2.34 cm) and it did differ statistically with all other treatments except T<sub>2</sub>. Analysis of pooled data followed a similar trend as in 2014. Significantly higher overall fruit diameter was recorded in the treatment T<sub>8</sub> (2.80 cm), while it was lower in control + bagging of fruits (T<sub>2</sub>) (2.33 cm) which exhibited parity with untreated control (T<sub>1</sub>) (Table 17).

### **4.2.2.2 Fruit characters at ripe stage**

#### **4.2.2.2.1 Ripe fruit weight (g)**

Banana fruits exhibited significant differences for ripe fruit weight during both the years of experimentation (2014 and 2015) (Table 17). In 2014, significantly maximum fruit weight after ripening was noticed in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (72.52 g) in comparison to all the treatments. On the other hand, minimum fruit weight at ripe stage was observed in T<sub>1</sub> (control) (59.76 g). During 2015, fruits of the treatment T<sub>8</sub> (81.71 g) had higher ripe weight and

**Table 17: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on fruit characters of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Mature fruit weight (g)			Ripe fruit weight (g)			Fruit length (cm)			Fruit diameter (cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	65.53f	68.82g	67.83g	59.76f	61.63g	60.69g	10.73h	10.93f	10.83h	2.35d	2.34e	2.35f
<b>T<sub>2</sub></b>	69.14e	71.30f	70.81f	63.45e	65.29f	64.37f	11.27g	11.50e	11.38g	2.30e	2.35e	2.33e
<b>T<sub>3</sub></b>	71.48d	74.14e	73.34e	66.04	67.52e	66.78e	11.43f	11.83d	11.63f	2.32de	2.45d	2.38e
<b>T<sub>4</sub></b>	73.45c	75.79d	75.09d	68.28d	68.81d	68.54cd	12.30d	12.53c	12.42d	2.44c	2.47d	2.46d
<b>T<sub>5</sub></b>	75.98b	84.61b	80.94b	70.09b	77.93b	74.01b	13.47b	13.90a	13.68b	2.67b	2.73b	2.70b
<b>T<sub>6</sub></b>	73.18c	76.02d	75.22d	66.80d	68.85d	67.83d	11.73e	12.03d	11.88e	2.48c	2.55c	2.52c
<b>T<sub>7</sub></b>	74.13c	77.54c	76.37c	68.61c	70.32c	69.46c	12.87c	13.47b	13.17c	2.70b	2.73b	2.72b
<b>T<sub>8</sub></b>	78.55a	88.13a	83.87a	72.52a	81.71a	77.12a	13.93a	14.07a	14.00a	2.78a	2.82a	2.80a
<b>S.Em±</b>	0.43	0.44	0.29	0.44	0.36	0.31	0.05	0.07	0.05	0.01	0.02	0.01
<b>C.D @ 5 %</b>	1.31	1.35	0.88	1.35	1.08	0.95	0.14	0.21	0.15	0.04	0.07	0.04

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

**T<sub>1</sub>**- Control

**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

it was significantly followed by T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (77.93 g). Minimum ripe fruit weight (61.63 g) was found associated with T<sub>1</sub> (control) and it showed statistical significance over all other treatments. The combined data of two years was also significantly higher for ripe fruit weight in T<sub>8</sub> (77.12 g). While, minimum ripe weight of fruit (60.69 g) observed in T<sub>1</sub> (control) was significantly followed by T<sub>2</sub> (64.37 g).

#### **4.2.2.2.2 Pulp weight (g)**

Significantly higher pulp (64.28 g) weight was recorded in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014 when compared to all other treatments (Table 18). The pulp weight was significantly lower in T<sub>1</sub> (control) (52.75 g) followed by T<sub>2</sub> (Control + bagging) (55.41 g) and T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/l) (58.30 g) respectively. During 2015, fruits showed higher pulp weight (73.42 g) in the treatment T<sub>8</sub> which was closely and significantly followed by T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (69.84 g). On the other hand, control treatment (T<sub>1</sub>) with minimum pulp weight (54.64 g) was significantly different from rest of the treatments. However, it was followed by T<sub>2</sub> (57.24 g). Two years pooled data showed significantly higher pulp weight in T<sub>8</sub> (68.85 g) over rest of the treatments. Fruits in control recorded minimum pulp weight (53.70 g) followed by T<sub>2</sub> (56.32 g). Nevertheless, both the treatments differed significantly between each other.

#### **4.2.2.2.3 Peel weight (g)**

During 2014, peel weight was maximum (8.24 g) in the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l +bagging of bunch) followed by T<sub>2</sub> (control +bagging) (8.05), where the treatments remained significant with each other (Table 18). The maximum peel weight (8.32 g) during 2015 was linked with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) and it was significant with T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) (8.15 g). In pooled data, maximum peel weight (8.28 g) was recorded in T<sub>8</sub> which exhibited statistical significance with T<sub>7</sub> (8.09 g). Minimum peel weight during 2014, 2015 and in pooled data was observed in T<sub>1</sub> (control) (7.00 g, 6.99 and 7.00 respectively).

**Table 18: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on pulp weight, peel weight and pulp percentage of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Parameters								
	Pulp weight (g)			Peel weight (g)			Pulp percentage (%)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	52.75g	54.64f	53.70f	7.00e	6.99g	7.00g	88.28d	88.65c	88.46c
T <sub>2</sub>	55.41f	57.24e	56.32e	8.05b	8.05c	8.05b	87.32e	87.67e	87.49d
T <sub>3</sub>	58.30e	59.64d	58.97d	7.75c	7.89d	7.82d	88.27d	88.32d	88.29c
T <sub>4</sub>	61.18bc	61.54c	61.36c	7.10c	7.26e	7.18e	89.60a	89.44b	89.52a
T <sub>5</sub>	62.38b	69.84b	66.11b	7.71e	8.09c	7.90c	89.00b	89.62ab	89.31b
T <sub>6</sub>	59.79d	61.72c	60.75c	7.03e	7.13f	7.08f	89.50a	89.64ab	89.57a
T <sub>7</sub>	60.59cd	62.16c	61.38c	8.02b	8.15b	8.09b	88.31d	88.40d	88.36c
T <sub>8</sub>	64.28a	73.42a	68.85a	8.24a	8.32a	8.28a	88.63c	89.85a	89.24b
<b>S.Em±</b>	0.44	0.37	0.32	0.02	0.02	0.02	0.08	0.08	0.06
<b>C.D @ 5 %</b>	1.34	1.11	0.96	0.06	0.05	0.05	0.23	0.23	0.19

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

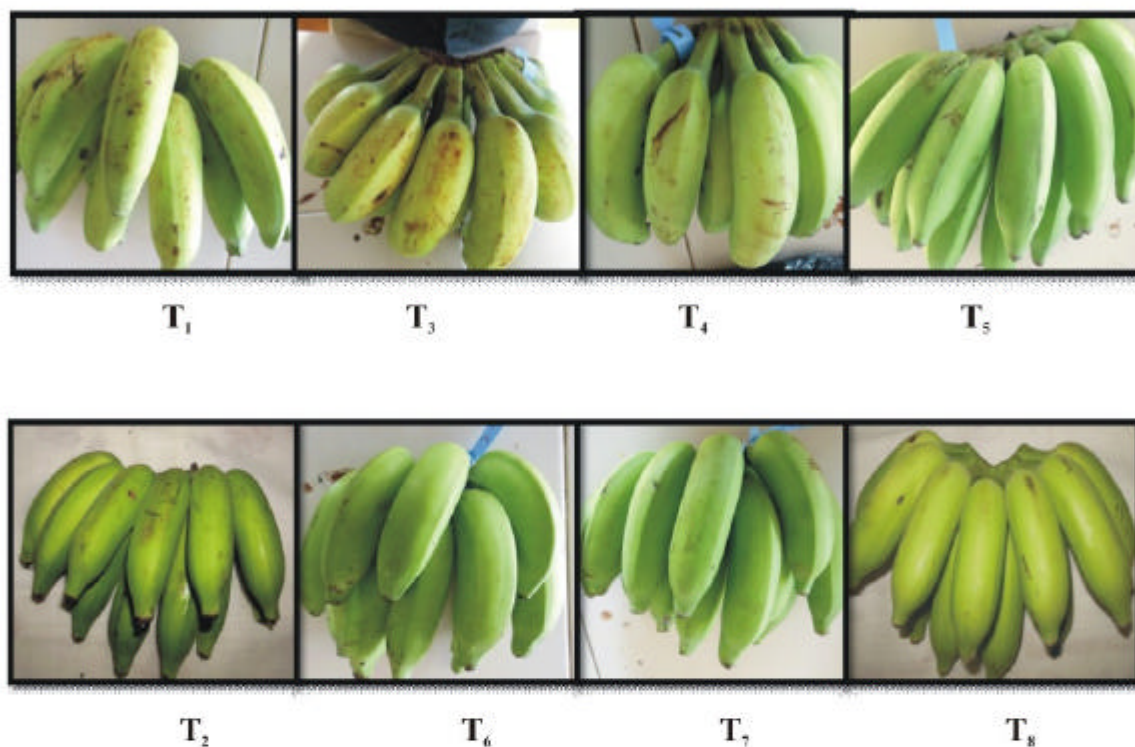
T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches



T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/plant at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/plant at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval+ polyethylene bagging of bunches

**Plate 7: Images showing fruits (Neypoovan) of different treatments at green stage**

#### **4.2.2.2.4 Pulp percentage (%)**

During the years 2014 and 2015, significant differences were observed with respect to pulp recovery (Table 18). During maximum pulp recovery (89.50%) 2014 was associated with the treatment T<sub>4</sub> (Bunch spraying of potassium silicate at 4 ml/l). It was closely and significantly followed by T<sub>6</sub> (Bunch spraying of potassium silicate at 2 ml/l+ bagging of bunch) (89.50%). During 2015, T<sub>8</sub> and T<sub>5</sub> recorded maximum pulp recovery of 89.85 per cent and 89.64 per cent respectively. Both these treatments were on par with each other, but differed significantly over all other treatments. Pooled data analysis revealed maximum pulp recovery in T<sub>6</sub> (89.57%) followed non-significantly by T<sub>4</sub> (89.52%) and T<sub>7</sub> (89.31%).

### **4.2.3 Pest incidence**

#### **4.2.3.1 Incidence of thrips at harvest (numbers)**

There was no incidence of thrips in all the bagged treatments *viz.*, T<sub>2</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub> when the banana bunches were observed at the time of harvest during 2014 and 2015 (Table 19). However, maximum number of thrips was noticed in control (T<sub>1</sub>) treatment during 2014, 2015 and for data analysed after pooling (19.67, 13.67 and 16.67 respectively). Which was significantly followed by T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/l) during 2014 and for pooled analysis (13.67 and 10.17) while in 2015 it was followed T<sub>4</sub> (Bunch spraying of potassium silicate at 4 ml/l) (10.33).

### **4.2.4 Post harvest behaviour of fruit**

#### **4.2.4.1 Respiration rate (ml CO<sub>2</sub>/kg/h)**

Banana fruits cv. Ney Poovan at mature green stage recorded a low rate of respiration. It increased further with the advancement in ripening and reached peak at ripe stage, declining slightly thereafter as it approached senescence. The respiration rate showed significant differences among the treatments at all the observed fruit stages.

**Table 19: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches thrips incidence of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Thrips incidence (numbers)		
	2014	2015	Pooled
<b>T<sub>1</sub></b>	19.67 (26.31)a	13.67 (21.59)a	16.67 (24.07)a
<b>T<sub>2</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>T<sub>3</sub></b>	13.67 (21.58b)	6.67 (14.89)b	10.17 (18.53)b
<b>T<sub>4</sub></b>	7.67 (16.02)c	10.33 (18.16)ab	9.00 (17.32)b
<b>T<sub>5</sub></b>	6.67 (14.84)c	5.67 (13.25)b	6.17 (14.19)c
<b>T<sub>6</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>T<sub>7</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>T<sub>8</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>S.Em±</b>	1.11	1.30	0.96
<b>C.D @ 5 %</b>	3.37	3.93	2.92

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

Figures in parentheses are arc sin transformed values

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

The mean values of pooled data at green stage showed a range from 91.23 (ml CO<sub>2</sub>/kg/h) (T<sub>8</sub>) (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) to 112.86 ml CO<sub>2</sub>/kg/h (T<sub>1</sub>) (Control) that were significantly minimum and maximum respectively over all other treatments (Table 20).

At ripe stage, fruits under the treatment T<sub>1</sub> (control) had significantly higher respiratory peak in both the seasons (2014 - 380.60 ml CO<sub>2</sub>/kg/h; 2015 - 369.08 ml CO<sub>2</sub>/kg/h) and in pooled analysis (374.83 ml CO<sub>2</sub>/kg/h). Minimum values of respiratory peak during 2014, 2015 and in pooled data were noted in T<sub>8</sub> (313.50 ml CO<sub>2</sub>/kg/h, 278.22 ml CO<sub>2</sub>/kg/h, 298.55 ml CO<sub>2</sub>/kg/h respectively) which were found to be significant with all the other treatments.

At senescence stage, the highest respiration rate was signified in the treatment T<sub>1</sub> during 2014 (271.37 ml CO<sub>2</sub>/kg/h), 2015 (254.68 ml CO<sub>2</sub>/kg/h) and in pooled analysis (263.02 ml CO<sub>2</sub>/kg/h) over rest of the treatments. The least respiration rate during 2014, 2015 and in pooled analysis was noticed in T<sub>8</sub> (212.40 ml CO<sub>2</sub>/kg/h, 189.83 ml CO<sub>2</sub>/kg/h and 201.12 ml CO<sub>2</sub>/kg/h respectively). This treatment was significantly followed by the treatment T<sub>5</sub> (227.45 ml g CO<sub>2</sub>/kg/h, 24.10 ml CO<sub>2</sub>/kg/h and 215.77 ml CO<sub>2</sub>/kg/h respectively).

#### **4.2.4.2 Physiological loss in weight (PLW) (%)**

During 2014, T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded minimum PLW both at ripe (4.39) and at beginning of senescence stage (9.16%) followed significantly by T<sub>7</sub> (5.49%) (10.91%) at both stage *viz.*, ripe and beginning of senescence (Table 21). Similar trend was followed in 2015. Pooled data analysis for PLW revealed significantly minimum in the treatment T<sub>8</sub> (4.09% and 4.24% respectively) at ripe stage and (9.40% and 9.28%) at beginning of senescence stage. Maximum PLW during 2014, 2015 and for pooled analysis was found associated with T<sub>1</sub> (Control) at ripe stage (10.97%, 9.74% and 10.35% respectively) and at beginning of senescence stage (14.80%, 13.53% and 14.16%). This treatment differed significantly over all other treatments.

**Table 20: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on respiration rate of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Respiration rate (ml CO <sub>2</sub> /kg/h)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	115.61a	110.11a	112.86a	380.59a	369.08a	374.83a	271.37a	254.68a	263.02a
<b>T<sub>2</sub></b>	109.60b	106.27b	107.93b	358.19b	348.15b	353.17b	253.13b	243.62b	248.37b
<b>T<sub>3</sub></b>	106.00c	102.21c	104.11c	344.18c	336.62c	340.40c	247.33c	236.36c	241.84c
<b>T<sub>4</sub></b>	103.19d	99.95d	101.57d	332.93de	330.35d	331.64de	237.90d	230.90d	234.40d
<b>T<sub>5</sub></b>	99.74e	89.56f	94.65f	324.26f	291.70f	307.98f	227.45e	204.10f	215.77f
<b>T<sub>6</sub></b>	103.55d	99.65d	101.60d	340.33cd	330.11d	335.22cd	239.64d	230.13d	234.89d
<b>T<sub>7</sub></b>	102.20d	97.71e	99.96e	331.38cf	323.24e	327.31e	229.44e	219.98e	224.71e
<b>T<sub>8</sub></b>	96.47f	85.99g	91.23g	313.47g	278.22g	295.84g	212.40f	189.83g	201.12g
<b>S.Em±</b>	0.59	0.52	0.39	2.45	2.02	1.95	1.37	1.19	0.91
<b>C.D @ 5 %</b>	1.80	1.58	1.19	7.43	6.12	5.90	4.15	3.60	2.76

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

#### 4.2.4.3 Shelf life (days)

In general, shelf life of banana fruits differed significantly during both the seasons and even after pooling the two years' data (Table 21). The treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded significantly maximum shelf life in 2014, 2015 as well as in pooled analysis with values of 7.33 days, 7.67 days and 7.50 days respectively when compared to all other treatments. The least shelf life noted in the control (T<sub>1</sub>) fruits (4.33 days, 4.67 days and 4.50 days) was found to differ significantly with rest of the treatments.

#### 4.2.4.4 Instrumental Colour measurements ( $L^*$ , $a^*$ , $b^*$ $C^*$ and $h^o$ values)

##### 4.2.4.4.1 $L^*$ value

The changes in instrumental  $L^*$  values of banana fruits (cv. Ney Poovan) as influenced by various pre harvest treatments showed significant differences among the treatments when the fruits were ripened under ambient condition (Table 22).

The minimum  $L^*$  value at ripe stage was observed in the treatment T<sub>1</sub> (control) (57.02, 57.62 and 57.35) during 2014, 2015 and for pooled analysis. It differed significantly with all other treatments. On the other hand, significantly maximum  $L^*$  value of 68.02 (2014), 67.99 (2015) and 68.01 (pooled analysis) was found in the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) at optimum ripe stage.

##### 4.2.4.4.2 $a^*$ value

The data concerning to  $a^*$  value that represent the colour change with respect to redness (positive value) or greenness (negative value) of banana fruits. Significant differences were observed with respect to ' $a^*$ ' values at ripe stage during the two seasons in bananas under experimentation indicating remarkable influence of pre-harvest treatments in this investigation (Table 22).

During 2014, 2015 and pooled analysis, maximum  $a^*$  value was obtained in the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch)

**Table 21: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on physiological loss in weight and shelf life of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Physiological loss in weight (%)						Shelf life (Days)		
	Ripe stage			Senescence stage					
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	10.97a	9.74a	10.35a	14.80a	13.53a	14.16a	4.33e	4.67d	4.50e
<b>T<sub>2</sub></b>	9.33b	8.54c	8.94c	13.40b	12.76b	13.08c	5.33cd	5.00cd	5.17de
<b>T<sub>3</sub></b>	9.74b	9.44b	9.59b	14.28a	13.52a	13.90a	4.67de	5.67bcd	5.17de
<b>T<sub>4</sub></b>	8.44c	8.36c	8.40d	13.25b	13.42a	13.34bc	6.00bc	6.00bc	6.00bc
<b>T<sub>5</sub></b>	8.48c	7.73d	8.11d	12.29c	12.24b	12.27d	6.33b	6.67ab	6.50b
<b>T<sub>6</sub></b>	8.15c	7.86d	8.00d	13.58b	13.40a	13.49b	5.00de	5.33cd	5.17dc
<b>T<sub>7</sub></b>	5.49d	4.70e	5.10e	10.91d	11.16c	11.04e	5.33cd	6.00bc	5.67cd
<b>T<sub>8</sub></b>	4.39e	4.09f	4.24f	9.16e	9.40d	9.28f	7.33a	7.67a	7.50a
<b>S.Em±</b>	0.22	0.09	0.13	0.18	0.19	0.12	0.31	0.38	0.27
<b>C.D @ 5 %</b>	0.66	0.28	0.41	0.55	0.58	0.38	0.93	1.15	0.82

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

**T<sub>1</sub>**- Control

**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

(6.73, 7.77 and 7.25) followed significantly by T<sub>7</sub> (6.62, 7.29 and 6.96). Contrastingly, significantly minimum value for  $a^*$  was observed with T<sub>1</sub> (control) during 2014 (2.93), 2015 (3.11) and for pooled analysed values (3.02).

#### **4.2.4.4.3 $b^*$ value**

The data on colour change with respect to  $b^*$  value of banana fruit as influenced by different treatments revealed significant differences among the treatments (Table 22). The  $b^*$  value represents change in fruit colour with respect to blueness or yellowness.

The pooled analysis of 2 years data indicated maximum  $b^*$  value at ripe stage in treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (44.12) followed by T<sub>7</sub> (43.25). The minimum  $b^*$  value during this period of observation was found in the treatment T<sub>1</sub> (36.27).

#### **4.2.4.4.4 $C^*$ value**

The data pertaining to  $C^*$  value as influenced by different pre harvest treatments on banana fruits at ripe stage revealed significant differences among the treatments (Table 22).

Chroma ( $C^*$ ) values of banana differed significantly in both the seasons at ripe stage of fruits. Significantly maximum  $C^*$  values were noted in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014, 2015 and in pooled analysis (40.76, 39.95 and 40.36). Minimum  $C^*$  values for similar observation periods were registered in T<sub>1</sub> (control) (33.94, 33.26 and 33.60).

#### **4.2.4.4.5 $h^o$ value**

Instrumental  $h^o$  value of banana fruit revealed significant differences among the treatments (Table 22).

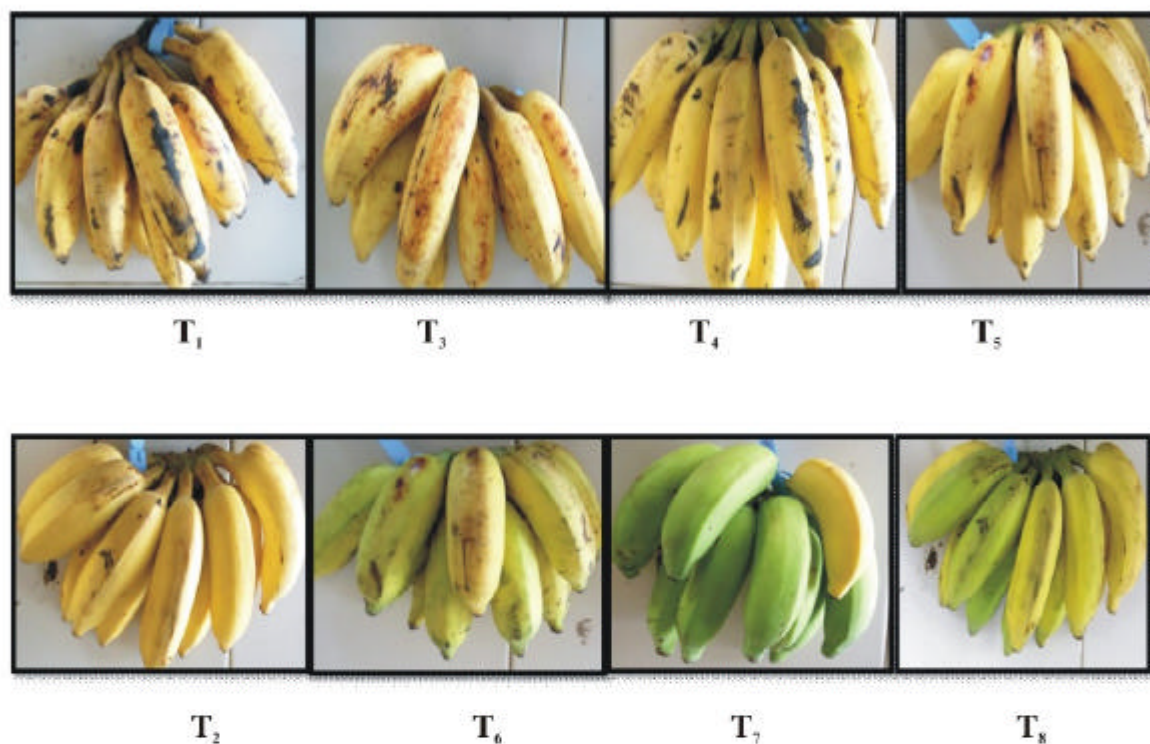
Two season's pooled data revealed significantly maximum  $h^o$  value of 97.87 and 96.27 in the treatments T<sub>1</sub> and T<sub>2</sub> respectively. Both these treatments differed significantly between themselves and also with other treatments. The minimum  $h^o$  value found in T<sub>8</sub> (85.21) at ripe stage was at parity with T<sub>7</sub> (85.14).

**Table 22: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on instrumental colour values ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $C^*$ ,  $h^0$ ) of banana fruits cv. 'Neypoovan' at ripe stage (AB)**

Treatments	$L^*$ (Lightness)			$a^*$ (Redness)			$b^*$ (Yellowness)			$C^*$ (Chroma)			$h^0$ (Hue angle)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	57.07f	57.62e	57.35e	2.93d	3.11h	3.02g	36.44g	36.09e	36.27g	33.94g	33.26f	33.60g	97.90a	97.84a	97.87a
<b>T<sub>2</sub></b>	63.02de	63.52cd	63.27d	5.39b	5.27f	5.33d	42.32d	41.47c	41.90cd	37.65d	37.55c	37.60d	96.77b	95.77b	96.27b
<b>T<sub>3</sub></b>	61.29e	62.36d	61.83c	3.34d	3.82g	3.58f	40.34f	39.98d	40.16f	36.03f	36.12e	36.08f	96.60b	95.24b	95.92bc
<b>T<sub>4</sub></b>	63.78cd	62.89d	63.34c	3.93c	5.46e	4.69e	41.71e	40.10a	40.91e	36.87e	36.64d	36.76e	96.21b	93.78c	95.00c
<b>T<sub>5</sub></b>	63.93cd	63.69cd	63.81c	5.41b	5.67d	5.54d	42.02de	41.13c	41.57d	37.55d	37.58c	37.57d	91.19c	89.81d	90.50d
<b>T<sub>6</sub></b>	65.13bc	65.48bc	65.31b	5.80b	6.50c	6.15c	42.91c	41.42c	42.17c	38.74c	37.84c	38.29c	88.65d	88.09e	88.37e
<b>T<sub>7</sub></b>	65.91b	66.02ab	65.97b	6.62a	7.29b	6.96b	44.10b	42.39b	43.25b	40.04b	38.67b	39.36b	86.02e	84.25f	85.14f
<b>T<sub>8</sub></b>	68.02a	67.99a	68.01a	6.73a	7.77a	7.25a	45.13	43.10a	44.12a	40.76a	39.95a	40.36a	85.59e	84.83f	85.21f
<b>S.Em±</b>	0.64	0.65	0.41	0.18	0.06	0.09	0.12	0.13	0.12	0.17	0.13	0.13	0.32	0.39	0.32
<b>C.D @ 5 %</b>	1.93	1.97	1.24	0.54	0.17	0.28	0.36	0.38	0.36	0.52	0.38	0.41	0.98	1.17	0.97

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |



T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/plant at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/plant at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval+ polyethylene bagging of bunches

**Plate 8: Images showing fruits (Neypoovan) of different treatments after 8 days after harvesting**

## 4.2.5 Quality parameters

### 4.2.5.1 Total soluble solids (<sup>0</sup>B)

The mean TSS of banana fruits at mature green stage was recorded to be 5.35<sup>0</sup> B with values ranging from 4.97<sup>0</sup> B to 5.70<sup>0</sup> B between the treatments of both the years. The total soluble solids (TSS) of banana fruits registered a sharp rise at ripe stage with a slight further increase as they approached senescence stage (Table 23).

Fruits treated with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (26.28<sup>0</sup>B, 27.10<sup>0</sup>B and 26.95<sup>0</sup>B) were found to have higher total soluble solids (TSS) when compared to all other treatments at optimum ripe stage during 2014, 2015 and even in pooled data (Table 23). The treatment continued to show higher level of TSS even in later stages of ripening in comparison to other treatments. Thus, maximum total soluble solids content at the beginning of senescence stage were recorded in T<sub>8</sub> (28.85<sup>0</sup> B - 2014, 29.73<sup>0</sup> B - 2015 and 29.29 - pooled analysis). However, T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) (27.50<sup>0</sup> B, 27.87<sup>0</sup> B, 27.68<sup>0</sup> B) was at significance with T<sub>8</sub> at similar time of observation.

The lower TSS content during 2014, 2015 and in pooled data was noticed in T<sub>1</sub> at ripe stage (22.57<sup>0</sup> B, 23.40<sup>0</sup> B and 22.98<sup>0</sup> B respectively) and also at the beginning of senescence stage (25.19<sup>0</sup> B, 26.40<sup>0</sup> B and 25.80<sup>0</sup> B).

### 4.2.5.2 Titratable acidity (%)

Titrateable acidity of banana fruits under ambient storage exhibited significant differences among the treatments. Initial pooled mean value of titrateable acidity was recorded to be 0.19 per cent and pooled value had a range from 0.17 per cent to 0.22 per cent (Table 24). The parameter exhibited an increasing trend at ripe stage followed by a decreasing trend at senescence stage.

Pooled analysis at optimum ripe stage of banana fruits during ambient storage revealed significantly maximum acidity in T<sub>1</sub> (control) (0.387%) than the rest of the treatments. However, the minimum titrateable acidity recorded in the treatment T<sub>8</sub>

**Table 23: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on total soluble solids of banana fruits cv. 'Neypoovan' (AB)**

Treatments	TSS ( <sup>0</sup> B)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	5.03d	4.97e	5.00f	22.57f	23.40f	22.98g	25.19d	26.40d	25.80g
<b>T<sub>2</sub></b>	5.17cd	5.23d	5.20e	23.47e	24.73d	24.10e	26.16c	27.90c	27.03d
<b>T<sub>3</sub></b>	5.27bc	5.27d	5.27de	23.03e	23.93e	23.48f	26.40c	26.57d	26.48ef
<b>T<sub>4</sub></b>	5.30bc	5.33cd	5.32de	24.47d	24.87d	24.67d	26.43c	26.40d	26.41f
<b>T<sub>5</sub></b>	5.40b	5.50bc	5.45bc	25.47c	25.57c	25.52c	28.05b	29.00c	28.52b
<b>T<sub>6</sub></b>	5.20cd	5.47bc	5.33cd	24.90d	24.80d	24.85d	26.10c	27.63c	26.87dc
<b>T<sub>7</sub></b>	5.33bc	5.63ab	5.48b	26.20b	26.47b	26.33b	27.50b	27.87b	27.68c
<b>T<sub>8</sub></b>	5.70a	5.77a	5.73a	26.80a	27.10a	26.95a	28.85a	29.73a	29.29a
<b>S.Em±</b>	0.06	0.06	0.04	0.15	0.13	0.08	0.18	0.16	0.13
<b>C.D @ 5 %</b>	0.20	0.19	0.13	0.45	0.41	0.26	0.55	0.49	0.41

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

**T<sub>1</sub>**- Control

**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

(Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (0.297%) was followed by T<sub>7</sub> (0.315%).

Conversely, the minimum titratable acidity was noted in T<sub>1</sub> (control) at the beginning of senescence stage for pooled analysis (0.213%). This treatment was found to be significant with all the other treatments. However, the higher values were noticed in T<sub>7</sub> (0.261%).

#### **4.2.5.3 Total sugars (%)**

The effect of pre-harvest bunch treatments on total sugars of banana fruits during ambient storage revealed the same trend as total soluble solids. Significant variations were observed among the treatments all through the storage duration. The initial mean total sugar observed in the fruits at mature green stage was 1.51 per cent with values ranging from 1.49 per cent to 1.55 per cent among the treatments. The results of pooled data of total sugars during the storage period are as follows (Table 25).

The treatment T<sub>1</sub> (control) recorded minimum total sugar content at ripe stage (18.06%). It was significantly followed by T<sub>3</sub> (Bunch spraying of potassium silicate at 2 ml/l) (18.50%) during the same period of examination. On the other hand, the maximum total sugars (23.72%) associated with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) was significantly (23.13) followed by T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch).

At senescence stage of banana fruits, the highest level of total sugars was noted in T<sub>8</sub> (27.68%). The treatment T<sub>1</sub> with minimum total sugar (24.00%) was found to be significantly different with all other treatments employed in this investigation.

#### **4.2.5.4 Reducing sugars (%)**

The reducing sugars of banana fruits revealed significant differences under the influence of various pre harvest treatments. The initial mean reducing sugars in the fruits at mature green stage was found to be 1.08 per cent while the values had a range from 1.05 per cent to 1.13 per cent among the treatments (Table 26).

**Table 24: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on acidity of banana fruits cv. 'Neyyipoovan' (AB)**

Treatments	Acidity (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	0.217	0.223	0.220	0.390a	0.383a	0.387a	0.217e	0.208f	0.213f
<b>T<sub>2</sub></b>	0.210	0.217	0.213	0.353b	0.323de	0.338c	0.227de	0.220ef	0.224cf
<b>T<sub>3</sub></b>	0.203	0.210	0.207	0.377a	0.363b	0.370b	0.235cde	0.229de	0.232dc
<b>T<sub>4</sub></b>	0.217	0.223	0.220	0.337bc	0.350bc	0.343c	0.239bcd	0.235cde	0.237d
<b>T<sub>5</sub></b>	0.193	0.207	0.200	0.323cd	0.337cd	0.330c	0.253ab	0.251ab	0.252ab
<b>T<sub>6</sub></b>	0.200	0.200	0.200	0.337bc	0.327de	0.332c	0.243bcd	0.239bcd	0.241cd
<b>T<sub>7</sub></b>	0.177	0.183	0.180	0.313de	0.317e	0.315d	0.250abc	0.247abc	0.249bc
<b>T<sub>8</sub></b>	0.177	0.170	0.173	0.303e	0.290f	0.297e	0.263a	0.258a	0.261a
<b>S.Em±</b>	0.011	0.010	0.011	0.006	0.005	0.004	0.006	0.006	0.003
<b>C.D @ 5 %</b>	NS	NS	NS	0.017	0.016	0.014	0.020	0.019	0.009

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

**T<sub>1</sub>**- Control

**T<sub>2</sub>**- Only bagging (No silicon application)

**T<sub>3</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>4</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>5</sub>**- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

**T<sub>6</sub>**- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**T<sub>7</sub>**- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

**T<sub>8</sub>**- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**Table 25: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on total sugars of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Total Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	1.49	1.51	1.50	18.18h	17.94h	18.06h	24.03h	23.96f	24.00h
<b>T<sub>2</sub></b>	1.49	1.51	1.50	19.10f	19.39f	19.24f	25.34e	25.55e	25.45e
<b>T<sub>3</sub></b>	1.49	1.50	1.50	18.47g	18.53g	18.50g	24.17g	24.04f	24.11g
<b>T<sub>4</sub></b>	1.51	1.50	1.50	19.94e	20.37e	20.15e	24.85f	25.46e	25.16f
<b>T<sub>5</sub></b>	1.51	1.52	1.52	20.31d	20.67d	20.49d	26.68b	27.27b	26.97b
<b>T<sub>6</sub></b>	1.50	1.51	1.51	21.60c	22.29c	21.95c	25.69d	25.67d	25.68d
<b>T<sub>7</sub></b>	1.52	1.54	1.53	22.80b	23.45b	23.13b	26.52c	26.79c	26.65c
<b>T<sub>8</sub></b>	1.53	1.55	1.54	23.46a	23.99a	23.72a	27.59a	27.77a	27.68a
<b>S.Em±</b>	0.019	0.020	0.010	0.10	0.08	0.08	0.03	0.04	0.03
<b>C.D @ 5 %</b>	NS	NS	NS	0.31	0.25	0.24	0.10	0.13	0.09

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

At ripe stage, banana fruits had significant level of reducing sugars in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) 17.84% (2014), 18.61% (2015) and 18.23% (pooled analysis). While, control (T<sub>1</sub>) fruits recorded minimum reducing sugar during both years and also for pooled analysis (11.32%, 11.43% and 9.21%).

As the senescence began, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) showed significantly maximum reducing sugar in both years as well as in pooled analysis (21.39%, 21.53% and 21.46%) in comparison to all other treatments. However minimum amount of reducing sugars were associated with T<sub>1</sub> (15.40%, 15.08% and 15.24%).

#### **4.2.5.5 Non-reducing sugars (%)**

Non-reducing sugars of banana fruits disclosed significant differences among the treatments. The initial mean non-reducing sugar content in banana fruits at mature green stage ranged from 0.38 per cent to 0.43 per cent and mean was found to be 0.41 per cent (Table 27). The results of pooled data of non reducing sugars at ripe and senescence stages are as follows.

Minimum non-reducing sugars at ripe stage were noted in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (5.22%) and it was closely but significantly (5.59) followed by T<sub>7</sub> (Bunch spraying of potassium silicate at 4 ml/l+ bagging of bunch) and T<sub>6</sub> (5.76%). On the other hand, T<sub>4</sub> (Bunch spraying of potassium silicate at 4 ml/l) was associated with maximum reducing sugars (7.49%) followed by T<sub>2</sub> (control+ bagging) (7.06) and (T<sub>1</sub>) (6.31%).

At the beginning of senescence stage, banana fruits had maximum non-reducing sugars in the treatment T<sub>2</sub> (9.12%). In contrast, T<sub>8</sub> documented minimum non-reducing sugars level (5.91%) which was significant with all the treatments.

#### **4.2.5.6 Sugar acid ratio (%)**

The influence of different pre-harvest bunch treatments on sugar acid ratio of banana fruits showed significant differences among the treatments of both the years with values ranging from 6.90 to 8.52 at mature green stage (Table 28).

**Table 26: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on reducing sugars of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	1.06	1.06	1.06	11.32h	11.43f	11.37g	15.40g	15.08g	15.24g
T <sub>2</sub>	1.07	1.08	1.08	11.98f	11.64f	11.81f	16.01f	15.68f	15.85f
T <sub>3</sub>	1.08	1.05	1.07	11.49g	12.28e	11.89f	14.93h	14.54h	14.74h
T <sub>4</sub>	1.08	1.08	1.08	12.20e	12.33e	12.27e	16.19e	16.39e	16.29e
T <sub>5</sub>	1.09	1.08	1.09	13.90d	14.80d	14.35d	18.40d	17.92d	18.16d
T <sub>6</sub>	1.07	1.08	1.07	15.40c	16.37c	15.89c	19.32c	18.74c	19.03c
T <sub>7</sub>	1.08	1.11	1.10	16.93b	17.56b	17.24b	19.97b	19.75b	19.86b
T <sub>8</sub>	1.13	1.10	1.12	17.84a	18.61a	18.23a	21.39a	21.53a	21.46a
<b>S.Em±</b>	0.019	0.02	0.01	0.07	0.11	0.06	0.04	0.08	0.04
<b>C.D @ 5 %</b>	NS	NS	NS	0.22	0.33	0.19	0.12	0.24	0.13

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No silicon application)

T<sub>3</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>4</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>5</sub>- Bunch spray of Potassium silicate @ 6 ml L<sup>-1</sup>/bunch at 30 days interval

T<sub>6</sub>- Bunch spray of Potassium silicate @ 2 ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

T<sub>7</sub>- Bunch spray of Potassium silicate @ 4 ml L<sup>-1</sup>/bunch at 30 days interval + polyethylene bagging of bunches

T<sub>8</sub>- Bunch spray of Potassium silicate @ 6ml L<sup>-1</sup>/bunch at 30 days interval+ polyethylene bagging of bunches

**Table 27: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on non-reducing sugars of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Non-Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.41	0.43	0.42	6.51b	6.10b	6.31c	8.20b	8.43c	8.32c
T <sub>2</sub>	0.39	0.41	0.40	6.76b	7.36a	7.06b	8.87a	9.37a	9.12a
T <sub>3</sub>	0.40	0.42	0.41	6.63b	6.17b	6.40c	8.78a	9.02b	8.90b
T <sub>4</sub>	0.40	0.40	0.40	7.35a	7.63a	7.49a	8.23b	8.61c	8.42c
T <sub>5</sub>	0.40	0.42	0.41	6.09c	5.57c	5.83d	7.87c	8.88b	8.37c
T <sub>6</sub>	0.41	0.41	0.41	5.89c	5.62c	5.76d	6.05e	6.59d	6.32e
T <sub>7</sub>	0.41	0.41	0.41	5.59d	5.60c	5.59d	6.22d	6.69d	6.45d
T <sub>8</sub>	0.38	0.43	0.40	5.34d	5.11d	5.22e	5.89f	5.93e	5.91f
<b>S.Em±</b>	0.03	0.02	0.02	0.09	0.15	0.10	0.05	0.06	0.04
<b>C.D @ 5 %</b>	NS	NS	NS	0.26	0.46	0.31	0.15	0.20	0.11

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| T <sub>2</sub> - | Only bagging (No silicon application)   | T <sub>6</sub> - | Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| T <sub>3</sub> - | Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | T <sub>7</sub> - | Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | T <sub>8</sub> - | Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

At ripe stage, the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) recorded significantly maximum sugar acid ratio of 77.59 (2014), 82.93 (2015) and 80.26 (pooled analysis) and it was non-significantly followed by T<sub>7</sub> (72.80, 74.08 and 73.44). However, significantly minimum sugar acid ratio was observed in T<sub>1</sub> (control) (46.64, 46.84 and 46.74) in the two consecutive years and for pooled analysis.

As the senescence approached, maximum sugar acid ratio during 2014, 2015 and for analysis was observed in T<sub>2</sub> (111.66, 116.05 and 113.86, respectively), where as minimum sugar acid ratio were associated with treatment T<sub>8</sub> (104.92 and 106.35) during 2014 and in pooled analysis where as in 2015 T<sub>5</sub> (107.62) recorded minimum sugar acid ratio.

#### **4.2.5.7 Starch (%)**

The data concerning to starch content of banana fruits revealed a gradual decreasing tendency throughout the post harvest study period. The initial mean starch content of banana fruits was recorded to be 21.45 per cent and range between the treatments was found to be from 21.37 per cent to 21.50 per cent at mature green stage (Table 29).

Starch content of banana fruits varied significantly among the imposed treatments at ripe stage. Pooled analysis data of both the years revealed that fruits under the treatment T<sub>1</sub> (control) had lower starch content (2.77%) and it had significant difference with T<sub>3</sub> (3.07%). The remaining treatments, found to have significantly maximum starch content but maximum starch content was observed in T<sub>8</sub> (5.07%).

Similarly at senescence stage maximum starch content (2.27%) was found in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch). It was significantly (2.11%) followed by treatment T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l), while minimum content of starch was observed to be present in untreated T<sub>1</sub> (1.17%).

**Table 28: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on sugar acid ratio of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Sugar acid ratio								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	7.28f	6.90f	7.09f	46.64f	46.80f	46.74f	110.98	115.11	113.04a
T <sub>2</sub>	7.62d	7.26e	7.44d	54.06e	60.00d	57.02e	111.66	116.05	113.86ab
T <sub>3</sub>	8.07c	7.61c	7.84c	49.06f	51.00e	50.03f	103.04	104.92	103.98b
T <sub>4</sub>	7.35f	6.85g	7.10f	59.27d	58.20d	58.73de	104.22	108.47	106.34b
T <sub>5</sub>	7.57de	7.32d	7.44d	62.83cd	61.40d	62.11d	106.01	109.18	107.60b
T <sub>6</sub>	7.52e	6.90f	7.21e	64.27c	68.30c	66.28c	105.62	107.62	106.62b
T <sub>7</sub>	8.20b	7.85b	8.03b	72.80b	74.08b	73.44b	106.04	108.63	107.33b
T <sub>8</sub>	8.52a	7.91a	8.21a	77.59a	82.90a	80.26a	104.92	107.79	106.35b
<b>S.Em±</b>	0.03	0.01	0.02	1.38	1.25	1.21	2.79	2.80	1.30
<b>C.D @ 5 %</b>	0.10	0.03	0.05	4.18	3.78	3.67	NS	NS	3.95

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| T <sub>2</sub> - | Only bagging (No silicon application)   | T <sub>6</sub> - | Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| T <sub>3</sub> - | Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | T <sub>7</sub> - | Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | T <sub>8</sub> - | Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

**Table 29: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on starch of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Starch (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	21.45bc	21.43cd	21.44c	2.83e	2.71f	2.77e	1.12e	1.21g	1.17f
<b>T<sub>2</sub></b>	21.44c	21.43cd	21.44c	3.17d	3.44d	3.31d	1.53c	1.76e	1.65d
<b>T<sub>3</sub></b>	21.43c	21.44bcd	21.44c	3.00de	3.13e	3.07d	1.39d	1.44f	1.41e
<b>T<sub>4</sub></b>	21.45bc	21.37e	21.41d	4.21b	4.09bc	4.15b	1.56c	1.83de	1.69d
<b>T<sub>5</sub></b>	21.48a	21.47abc	21.47b	4.28b	4.22b	4.25b	2.04a	2.19b	2.11b
<b>T<sub>6</sub></b>	21.44c	21.41dc	21.43cd	3.75c	3.83c	3.79c	1.52c	1.88cd	1.70d
<b>T<sub>7</sub></b>	21.47a	21.49ab	21.48ab	4.29b	4.38b	4.34b	1.69b	1.92c	1.80c
<b>T<sub>8</sub></b>	21.49a	21.51a	21.50a	4.99a	5.15a	5.07a	2.13a	2.42a	2.27a
<b>S.Em±</b>	0.01	0.02	0.01	0.09	0.10	0.09	0.04	0.03	0.02
<b>C.D @ 5 %</b>	0.03	0.05	0.03	0.28	0.30	0.29	0.11	0.09	0.06

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

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|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

## **4.2.6 Organoleptic evaluation**

### **4.2.6.1 Peel colour and appearance**

With respect to peel colour and appearance, significant differences were observed both during 2014, 2015 and pooled analysis (Table 30). Fruits that received Bunch spraying of potassium silicate at 6 ml/l and then bagged with skirting materials (T<sub>8</sub>) obtained higher score (8.50, 8.54 and 8.52 respectively) when compared to all others treatments during 2014, 2015 and when analysed by pooling 2 years data. This treatment was closely followed by T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (8.34, 8.55 and 8.45). The treatment T<sub>1</sub> (control) scored minimum for peel colour and appearance (5.35, 5.40 and 5.38 respectively) in 2014, 2015 and in analysed pooled data.

### **4.2.6.2 Pulp colour and appearance**

Pulp colour and appearance of banana showed significant differences both during 2014, 2015 and pooled analysis (Table 30). In 2014, maximum score for pulp colour and appearance (8.16) was noted in T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l), while in 2015 and in pooled analysis the maximum score for pulp colour and appearance was noted (8.26 and 8.19 respectively) in T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) and these results were non-significantly followed by T<sub>8</sub> (8.12) in 2014 and T<sub>5</sub> (8.14) in 2015 and (8.15) pooled analysis.

Minimum score for pulp colour and appearance was received by T<sub>1</sub> (control) with 5.11 in 2014, 5.24 in 2015 and 5.17 in pooled analysis. It was significantly followed by the treatment T<sub>2</sub> (control +bagging) (6.10, 6.22 and 6.15) for similar periods of observation.

### **4.2.6.3 Texture**

Significant differences were observed with respect to texture of banana fruit among different treatments (Table 30). Fruits treated with T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) (8.44, 8.58 and 8.51) showed maximum score for texture during 2014, 2015 and pooled analysis. Control (T<sub>1</sub>) received the least score of 5.26, 5.55 and 5.41 respectively during 2014, 2015 and

**Table 30: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bagging of banana bunches on sensory attributes of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Peel colour and appearance			Pulp colour and appearance			Pulp texture			Pulp taste and flavour			Overall acceptability		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	5.35f	5.40d	5.38d	5.11f	5.24f	5.17g	5.26g	5.55f	5.41g	5.45f	5.60e	5.53e	5.53c	5.61e	5.57e
<b>T<sub>2</sub></b>	6.41e	6.29c	6.35c	6.10e	6.20e	6.15f	5.96f	6.57e	6.26f	5.95f	6.22d	6.09d	7.27b	7.29bc	7.28bc
<b>T<sub>3</sub></b>	6.36e	6.61c	6.48c	7.05c	7.05d	7.05d	7.31d	6.94d	7.12d	7.02de	6.87c	6.95c	5.93c	6.83cd	6.38d
<b>T<sub>4</sub></b>	8.06c	7.96b	8.01b	7.32b	7.32c	7.32c	7.80c	7.78c	7.79c	7.58bc	7.41b	7.49b	7.56b	7.50b	7.53b
<b>T<sub>5</sub></b>	8.34b	8.25ab	8.29a	8.16a	8.14ab	8.15a	8.19ab	8.35ab	8.27ab	8.08ab	8.20a	8.14a	8.37a	8.48a	8.43a
<b>T<sub>6</sub></b>	6.63d	6.48c	6.56c	6.27d	6.31e	6.29e	6.70e	6.73de	6.72e	6.78e	6.61cd	6.70c	7.17b	6.76d	6.97c
<b>T<sub>7</sub></b>	8.34b	8.55a	8.45a	7.33b	8.10b	7.72b	8.11b	8.22b	8.16b	7.39cd	7.69b	7.54b	8.34a	8.25a	8.29a
<b>T<sub>8</sub></b>	8.50a	8.54a	8.52a	8.12a	8.26a	8.19a	8.44a	8.58a	8.51a	8.14a	8.39a	8.27a	8.42a	8.58a	8.50a
<b>S.Em±</b>	0.05	0.16	0.08	0.04	0.05	0.03	0.10	0.12	0.09	0.16	0.13	0.13	0.14	0.15	0.12
<b>C.D @ 5 %</b>	0.16	0.48	0.24	0.14	0.15	0.09	0.29	0.35	0.27	0.51	0.41	0.40	0.41	0.45	0.38

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Bunch spray of Potassium silicate @ 6 ml L <sup>-1</sup> /bunch at 30 days interval                                   |
| <b>T<sub>2</sub></b> - Only bagging (No silicon application)   | <b>T<sub>6</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches  |
| <b>T<sub>3</sub></b> - Bunch spray of Potassium silicate @ 2 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>7</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch spray of Potassium silicate @ 4 ml L <sup>-1</sup> /bunch at 30 days interval | <b>T<sub>8</sub></b> - Bunch spray of Potassium silicate @ 6ml L <sup>-1</sup> /bunch at 30 days interval+ polyethylene bagging of bunches   |

when analysed by pooling 2 years' data. The treatment was found significant difference over all the other treatments during the investigation.

#### **4.2.6.4 Taste and flavour**

Significant differences were observed with respect to taste and flavour both during 2014, 2015 and when the 2 years' data was analysed after pooling (Table 30). Significantly higher score for taste and flavour was obtained in the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) during 2014 (8.14), 2015 (8.39) as well as in pooled analysis (8.27) which however was statistically at par with T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (8.08, 8.20 and 8.14 respectively). The least scoring control (T<sub>1</sub>) (5.26, 5.55 and 5.41) during 2014, 2015 and in pooled data differed statistically over all other treatments.

#### **4.2.6.5 Overall acceptability**

Overall acceptability data revealed significant differences for both the seasons (Table 30). In 2014 (8.42) and 2015 (8.58), higher overall acceptability scores were obtained by the treatment T<sub>8</sub> (Bunch spraying of potassium silicate at 6 ml/l+ bagging of bunch) and it was found on par with T<sub>5</sub> (Bunch spraying of potassium silicate at 6 ml/l) (8.37, 8.48). Pooled analysis of data revealed similar trend as in the individual years, with fruits of T<sub>8</sub> (8.50) receiving maximum score for overall acceptability and the treatment T<sub>8</sub> differing non-significantly with T<sub>5</sub> (8.43). The performance was acknowledged to be low with the treatment T<sub>1</sub> (5.53, 5.61 and 5.57) throughout the experimentation.

### **4.3 Experiment-3: Effect of bunch treatment (urea, ammonium sulphate, SOP and 2, 4-D) and bagging on yield, post harvest quality and shelf life of banana fruits var. 'Grand Naine' (AAA).**

#### **4.3.1 Bunch characters**

##### **4.3.1.1 Bunch weight (kg)**

Significant differences were observed with respect to bunch weight of the banana plants imposed with different pre-harvest bunch treatments (Table 31). During

2014, 2015 and in pooled analysis, the bunch weight showed significant increase in all the treatments over T<sub>1</sub> (Control) (24.10 kg/plant, 24.61 kg/plant and 24.36 kg/plant). Maximum bunch weight (30.85 kg/plant) was observed in T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) during 2014 and it was on par with T<sub>6</sub> (30.74 kg/plant) (Application of slurry mixture with 7.5g urea+7.5g SOP in 100ml water + bagging of bunch) and T<sub>5</sub> (30.61 kg/plant) (Application of 2,4-D 20ppm + bagging of bunch). During 2015 also, the treatment T<sub>8</sub> resulted in significantly enhanced bunch weight (31.36 kg/plant) followed by T<sub>5</sub> (31.13 kg/plant). In the pooled data, the treatment T<sub>8</sub> differed significantly for bunch weight (31.11 kg/plant) over the treatments except T<sub>5</sub> (30.87 kg/plant) T<sub>6</sub> (30.79 kg/plant) and T<sub>7</sub> (30.49 kg/plant) T<sub>4</sub>(29.47 kg/plant).

#### **4.3.1.2 Number of Hands per bunch**

Different pre-harvest bunch treatments *viz.*, bunch spraying, feeding of bunches and bunch bagging resulted in non-significant differences on number of hands per bunch (Table 31). There were non significant differences among the treatments with number of hands per bunch, as the hands were completely opened and uniform bunches were selected during the imposition of treatments.

#### **4.3.1.3 Number of fingers in third hand**

The data pertaining to number of fingers per hand are furnished in Table 31. Treatments did not differ significantly for number of fingers per hand. However, number of fingers per hand in pooled data varied from 15.67 to 16.90 among the different treatments.

#### **4.3.1.4 Total no. of fingers per bunch**

Treatments did not have any effect in varying the number of fingers per bunch. The data pertaining to the number of fingers per bunch are presented in Table 31. Even though, more number of fingers (167.53, 170.67 and 169.10) was found in T<sub>8</sub> (Foliar Application of 2, 4-D 20ppm + bagging of bunch) and less number of fingers (161.13 and 160.63) in 2014 and in pooled analysis in T<sub>2</sub> (control+ bagging) and (159.33) in 2015 in untreated control.

**Table 31: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on bunch weight and bunch characters of banana fruits var. ‘Grand Naine’ (AAA)**

Treatments	Bunch weight (kg)			No. of hands /bunch			Fingers in third hand			Total no. of fruits/bunch		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	24.10c	24.61b	24.36d	11.07	11.15	11.11	16.56	16.46	16.51	162.13	159.33	160.73
T <sub>2</sub>	25.87bc	25.82b	25.84cd	11.18	11.33	11.26	15.89	15.45	15.67	161.13	160.13	160.63
T <sub>3</sub>	28.92b	30.02a	29.47ab	11.17	11.11	11.14	16.56	15.78	16.17	165.47	166.47	165.97
T <sub>4</sub>	27.22abc	27.98ab	27.60bc	11.15	11.33	11.24	16.78	16.45	16.61	165.67	169.40	167.53
T <sub>5</sub>	30.61a	31.13a	30.87a	11.17	11.05	11.11	16.33	16.00	16.17	167.42	170.50	168.96
T <sub>6</sub>	30.74a	30.85a	30.79a	11.26	11.17	11.21	15.78	16.23	16.01	165.13	170.67	167.90
T <sub>7</sub>	29.79a	31.19a	30.49ab	11.22	11.22	11.22	16.67	17.14	16.90	162.67	168.67	165.67
T <sub>8</sub>	30.85a	31.36a	31.11a	11.08	11.05	11.07	16.11	17.21	16.66	167.53	170.67	169.10
<b>S.Em±</b>	1.20	1.14	0.98	0.21	0.10	0.14	0.25	0.54	0.36	2.08	3.01	2.39
<b>C.D @ 5 %</b>	3.64	3.47	2.97	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |  |                  |  |
|------------------|--|------------------|--|
| T <sub>1</sub> - | Control  | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D  |
| T <sub>2</sub> - | Only bagging (No bunch treatment)  | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

#### 4.3.2

### 4.3.3 Fruit characters

#### 4.3.2.1 Fruit characters at mature stage

##### 4.3.3.1.1 Fruit weight (g)

Pre-harvest bunch treatments resulted in significant differences with respect to fruit weight (Table 32). During 2014, 2015 and in pooled analysis, the treatment T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) (151.62 g, 149.57 g and 150.60g, respectively) resulted in maximum fruit weight and it was found to be significant with T<sub>5</sub> (143.97 g, 145.94 g and 144.95 g). Both the treatments differed significantly over all other treatments.

Significantly minimum fruit weight during 2014, 2015 and in pooled data was associated with T<sub>1</sub> (Control) (123.12 g, 122.84 g and 122.98 g) followed non-significantly by T<sub>2</sub> (127.93 g, 126.51 g and 127.22 g).

##### 4.3.3.1.2 Fruit length (cm)

In both the years, the treatment T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) recorded maximum fruit length (2014 - 20.63 cm and 2015 - 20.64 cm) (Table 32). This treatment had statistical similarity with T<sub>5</sub> (2014 - 19.05 cm; 2015 - 20.02 cm). Conversely, the minimum fruit length was associated with T<sub>1</sub> (Control) during years 2014 (13.78 cm) and 2015 (14.06 cm). Pooled analysis of two years data showed significant increase in fruit length (20.64 cm) in T<sub>8</sub> over all other treatments. On the other hand, control treatment (T<sub>1</sub>) recorded least fruit length (13.92 cm) and it exhibited significant difference over rest of the treatments.

##### 4.3.3.1.3 Fruit diameter (cm)

The effect of pre-harvest bunch treatments on fruit diameter of banana fruits followed similar trend as fruit length (Table 32). In the year 2014, T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) recorded significantly maximum fruit diameter (3.79 cm) over all other treatments except T<sub>5</sub> (3.67) (Application of 2, 4-D 20ppm). The least fruit diameter (3.23cm) observed in T<sub>1</sub> (Control) was found to be at parity with T<sub>2</sub> (control +bagging) (3.32 cm) and T<sub>3</sub> (3.36 cm). In 2015, the maximum fruit diameter (3.82 cm) was associated with T<sub>8</sub>. The treatment T<sub>1</sub> showed minimum fruit

**Table 32: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on Fruit characters of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Mature fruit weight (g)			Ripe fruit weight (g)			Fruit length (cm)			Fruit diameter (cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	123.12e	122.84d	122.98g	116.91f	116.63f	116.77g	13.78e	14.06d	13.92e	3.23e	3.33d	3.28e
T <sub>2</sub>	127.93e	126.51d	127.22f	122.53e	124.53e	123.53f	14.09e	14.50d	14.30e	3.32de	3.37cd	3.35de
T <sub>3</sub>	133.68d	131.40c	132.54e	126.11d	125.85de	125.98ef	15.25d	15.75c	15.50d	3.36de	3.46bc	3.41d
T <sub>4</sub>	135.98cd	132.99c	134.49de	128.17cd	127.66d	127.92e	15.74d	16.14c	15.94d	3.40cd	3.39cd	3.39d
T <sub>5</sub>	143.97b	145.94a	144.95b	136.75b	138.82b	137.78b	19.05b	20.02a	19.53b	3.67ab	3.73a	3.70b
T <sub>6</sub>	139.57bc	137.03b	138.30c	135.07b	134.50c	134.79c	16.79c	18.22b	17.51c	3.55bc	3.74a	3.65bc
T <sub>7</sub>	136.62cd	137.77b	137.20cd	130.10c	131.58c	130.84d	17.26c	17.70b	17.48c	3.63b	3.55a	3.59c
T <sub>8</sub>	151.62a	149.57a	150.60a	145.08a	143.57a	144.32a	20.63a	20.64a	20.64a	3.79a	3.8b2a	3.81a
<b>S.Em±</b>	1.60	1.29	1.15	1.12	1.03	0.81	0.28	0.30	0.28	0.05	0.03	0.04
<b>C.D @ 5 %</b>	4.86	3.92	3.50	3.39	3.12	2.47	0.85	0.93	0.84	0.16	0.10	0.13

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |  |                  |  |
|------------------|--|------------------|--|
| T <sub>1</sub> - | Control  | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D  |
| T <sub>2</sub> - | Only bagging (No bunch treatment)  | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

diameter (3.32 cm) and it differed statistically with all other treatments except T<sub>2</sub>. Analysis of pooled data followed a similar trend as in 2014, significantly higher overall fruit diameter was recorded in the treatment T<sub>8</sub> (3.80 cm), while it was lower in control (T<sub>1</sub>) (3.27 cm) which was on par with T<sub>2</sub> (3.34 cm).

#### **4.3.3.2 Fruit characters at ripe stage**

##### **4.3.3.2.1 Ripe fruit weight (g)**

Banana fruits exhibited significant differences for ripe fruit weight during both the years of experimentation (2014 and 2015) (Table 33). In 2014, significantly maximum fruit weight (145.08 g) after ripening was noticed in T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) in comparison to all other treatments. On the other hand, minimum fruit weight (116.91 g) at ripe stage observed in T<sub>1</sub> (control) was significant with T<sub>2</sub> (122.53 g). During 2015, fruits of the treatment T<sub>8</sub> had higher ripe weight (143.57 g) and it was significantly followed by T<sub>5</sub> (Application of 2, 4-D 20ppm) (138.82 g). Minimum ripe fruit weight (106.77 g) was found associated with T<sub>1</sub> (control) and it was closely and significantly followed by with T<sub>2</sub> (123.53 g). The pooled data of two years was also significantly higher for ripe fruit weight in T<sub>8</sub> (144.32 g). While, minimum ripe fruit weight (116.77 g) observed in T<sub>1</sub> (control) was significantly followed by T<sub>2</sub> (123.53 g).

##### **4.3.3.2.2 Pulp weight (g)**

Significantly higher pulp weight (112.86 g) was recorded in T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) during 2014 when compared to all other treatments (Table 33). The pulp weight was significantly lower in T<sub>1</sub> (control) (85.46 g) followed by T<sub>2</sub> (Control + bagging) (91.19 g). During 2015, fruits showed higher pulp weight in the treatment T<sub>8</sub> (113.79 g) which was closely and significantly followed by T<sub>5</sub> (Application of 2, 4-D 20ppm) (108.85 g). On the other hand, control treatment (T<sub>1</sub>) (84.42 g) with minimum pulp weight was significantly different from rest of the treatments. Two years pooled data showed significantly higher pulp weight in T<sub>8</sub> (113.79 g) over rest of the treatments. Fruits in control (84.94 g) recorded minimum pulp weight which was significantly followed by T<sub>2</sub> (91.53 g).

**Table 33: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on pulp weight, peel weight and pulp percentage of banana fruits var. ‘Grand Naine’ (AAA)**

Treatments	Pulp weight (g)			Peel weight (g)			Pulp Percentage (%)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	85.46g	84.42f	84.94g	32.25d	30.54d	31.40f	73.10b	72.41c	72.75c
<b>T<sub>2</sub></b>	91.19f	91.87e	91.53f	33.62bc	32.02cd	32.82e	74.42b	73.77bc	74.10bc
<b>T<sub>3</sub></b>	93.50e	94.83d	94.17e	35.26a	34.86a	35.06a	74.14b	75.35b	74.75b
<b>T<sub>4</sub></b>	95.26e	95.12d	95.19e	33.55bc	33.81ab	33.68cd	74.32b	74.51b	74.41bc
<b>T<sub>5</sub></b>	108.10b	108.85b	108.48b	33.25cd	32.92bc	33.09de	79.07a	78.41a	78.74a
<b>T<sub>6</sub></b>	103.89c	105.18c	104.53c	34.40ab	34.79a	34.60ab	76.91a	78.19a	77.55a
<b>T<sub>7</sub></b>	101.49d	103.60c	102.54d	33.89bc	34.08ab	33.99bc	78.07a	78.74a	78.41a
<b>T<sub>8</sub></b>	112.86a	113.79a	113.33a	34.54ab	35.03a	34.79a	77.80a	79.26a	78.53a
<b>S.Em±</b>	0.70	0.81	0.54	0.34	0.40	0.24	0.81	0.52	0.57
<b>C.D @ 5 %</b>	2.11	2.45	1.65	1.02	1.20	0.72	2.45	1.59	1.73

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

#### 4.3.3.2.3 Peel weight (g)

During 2014 peel weight (35.26 g) was maximum in the treatment T<sub>3</sub> (Application of slurry mixture with 7.5g urea+7.5g SOP in 100ml water) followed non-significantly by T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) (34.54) (Table 33). The maximum peel weight (35.03 g) during 2015 was linked with T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) and it was on par with T<sub>3</sub> (Application of slurry mixture with 7.5g urea+7.5g SOP in 100ml water) (34.79 g) and T<sub>7</sub> (Application of slurry mixture with 7.5g urea+7.5g SOP in 100ml water+ bagging of bunch) (34.79). In pooled data, maximum peel weight was recorded in T<sub>3</sub> (35.06g) which exhibited parity with T<sub>4</sub> (34.79 g). Minimum peel weight during 2014, 2015 and for pooled analysis was observed in T<sub>1</sub> (32.25 g, 30.54 g and 31.40 respectively).

#### 4.3.3.2.4 Pulp percentage (%)

Both during 2014 and 2015, significant differences were observed with respect to pulp recovery (Table 33). Maximum pulp recovery (79.07%) during 2014 was associated with the treatment T<sub>5</sub> (Application of 2, 4-D 20ppm). It was closely and non-significantly followed by T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) (78.07%). During 2015, T<sub>8</sub> and T<sub>7</sub> recorded maximum pulp recovery of 79.26 per cent and 78.74 per cent respectively. Both these treatments were on par with each other and also with T<sub>5</sub> and T<sub>6</sub>. Pooled data analysis revealed maximum pulp recovery in T<sub>5</sub> (78.74%) followed by T<sub>8</sub> (78.53%) and T<sub>7</sub> (78.41%), where the treatments were on par with each other but differed significantly over others.

### 4.3.4 Pest incidence

#### 4.3.3.1 Incidence of thrips at harvest (numbers)

There was no incidence of thrips in all the bagged treatments *viz.*, T<sub>2</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub> when the banana bunches were observed at the time of harvest during 2014, 2015 and for pooled analysis (Table 34). However, maximum number of thrips was noticed in control (T<sub>1</sub>) treatment during 2014, 2015 and for data analysed after pooling (14.67, 12.49 and 13.58 respectively).

**Table 34: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on thrips incidence of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Thrips incidence (numbers)		
	2014	2015	Pooled
<b>T<sub>1</sub></b>	14.67 (22.37)a	12.49 (20.61)a	13.58 (21.55)a
<b>T<sub>2</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>T<sub>3</sub></b>	5.75 (13.65)c	6.17 (13.91)b	5.96 (13.81)c
<b>T<sub>4</sub></b>	7.84 (16.20)bc	9.67 (17.62)ab	8.75 (17.11)bc
<b>T<sub>5</sub></b>	11.63 (19.23)ab	9.75 (17.39)ab	10.69 (18.35)ab
<b>T<sub>6</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>T<sub>7</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>T<sub>8</sub></b>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>S.Em±</b>	1.58	1.64	1.36
<b>C.D @ 5 %</b>	4.81	4.99	4.12

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

**T<sub>1</sub>****T<sub>3</sub>****T<sub>4</sub>****T<sub>5</sub>****T<sub>2</sub>****T<sub>6</sub>****T<sub>7</sub>****T<sub>8</sub>****T<sub>1</sub>**-Control**T<sub>2</sub>**- Only bagging (No bunch treatment)**T<sub>3</sub>**- Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture**T<sub>4</sub>**- Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture**T<sub>5</sub>**- Application of 20 ppm of 2, 4-D**T<sub>6</sub>**- Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches.**T<sub>7</sub>**- Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches**T<sub>8</sub>**- Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches

**Plate 9: Images showing fruits (Grand Naine) of different treatments at green stages**

### 4.3.5 Post harvest behaviour of fruit

#### 4.3.5.1 Respiration rate (ml CO<sub>2</sub>/kg/h)

Respiration rate of banana fruits (var. Grand Naine) at mature green stage, ripe stage and senescence stage showed significant differences among the treatments. Respiration increased from green stage reaching peak at ripe stage and exhibited a decline towards senescent stage. The mean values of pooled data at green stage showed a range from 82.21 (ml CO<sub>2</sub>/kg/h) (T<sub>6</sub>) (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) to 117.36 ml CO<sub>2</sub>/kg/h (T<sub>1</sub>) (Control) (Table 35).

At ripe stage, fruits under the treatment of T<sub>1</sub> (control) had significantly higher respiratory peak in both the seasons (2014, 2015) and it is also reflected in pooled analysis (344.74 ml CO<sub>2</sub>/kg/h, 342.24 ml CO<sub>2</sub>/kg/h and 343.49 ml CO<sub>2</sub>/kg/h respectively). Minimum values of respiratory peak during 2014, 2015 and in pooled data were noted in T<sub>6</sub> (259.44 ml CO<sub>2</sub>/kg/h, 264.41 ml CO<sub>2</sub>/kg/h, 261.92 ml CO<sub>2</sub>/kg/h respectively) which were found to be significant over all other treatments.

At senescence stage, the highest respiration rate was signified in the treatment T<sub>1</sub> during 2014 (250.21 ml CO<sub>2</sub>/kg/h), 2015 (246.24 ml CO<sub>2</sub>/kg/h) and in pooled analysis (248.74 ml CO<sub>2</sub>/kg/h) over rest of the treatments. The least respiration rate during 2014, 2015 and pooled analysis was noticed in T<sub>6</sub> (181.44 ml CO<sub>2</sub>/kg/h, 183.73 ml CO<sub>2</sub>/kg/h and 182.59 ml CO<sub>2</sub>/kg/h respectively). This treatment was significantly followed by T<sub>7</sub> (190.34 ml g CO<sub>2</sub>/kg/h and 187.17 ml CO<sub>2</sub>/kg/h) during 2014 and for pooled analysis, but however non-significantly (185.35 ml CO<sub>2</sub>/kg/h) during 2015.

#### 4.3.4.2 Physiological loss in weight (PLW) (%)

During 2014, the treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) with minimum PLW both at ripe (5.85) and senescence stages (10.25%) was closely and significantly followed by T<sub>7</sub> at both stages (7.79% - ripe stage; 12.56% - senescence stage) (Table 36). Similar trend was noticed in 2015. But for pooled data analysis, PLW was recorded to be significantly minimum in the treatment T<sub>6</sub> at ripe stage (5.84% and 5.84% respectively)

**Table 35: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on respiration rate of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Respiration rate (ml CO <sub>2</sub> /kg/h)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	117.20a	117.53a	117.36a	344.74a	342.24a	343.49a	250.21a	246.74a	248.47a
<b>T<sub>2</sub></b>	96.49d	94.92c	95.71d	323.79b	319.11b	321.45b	233.20b	228.06b	230.63b
<b>T<sub>3</sub></b>	83.56f	86.48d	85.02f	275.91e	286.24e	281.07e	197.15e	203.44d	200.29e
<b>T<sub>4</sub></b>	87.02e	89.73d	88.37e	291.24d	298.37d	294.80d	207.80d	215.00c	211.40d
<b>T<sub>5</sub></b>	105.53b	104.00b	104.77b	325.00b	312.05bc	318.53b	221.62c	218.26c	219.94c
<b>T<sub>6</sub></b>	81.42f	82.99e	82.21g	259.44f	264.41f	261.92f	181.44g	183.73e	182.59g
<b>T<sub>7</sub></b>	83.22f	82.50e	82.86fg	270.75e	266.32f	268.53f	190.34f	185.41e	187.87f
<b>T<sub>8</sub></b>	100.73c	101.75b	101.24c	306.64c	302.36cd	304.50c	209.05d	205.03d	207.04d
<b>S.Em±</b>	0.94	1.09	0.78	3.03	3.41	2.48	2.13	2.33	1.71
<b>C.D @ 5 %</b>	2.84	3.30	2.38	9.18	10.34	7.53	6.45	7.06	5.19

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

and at beginning of senescence stage (9.66% and 9.96%). Maximum PLW during 2014, 2015 and for pooled analysis was found associated with T<sub>1</sub> (Control) at ripe stage (12.58%, 11.69% and 12.14% respectively) and at the beginning of senescence stage (19.70%, 18.34% and 19.02%) and it was found significantly different from all other treatments.

#### **4.3.5.2 Shelf life (days)**

In general, shelf life of banana fruits differed significantly during both the seasons and even after pooling the two years' data (Table 36). The treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) recorded significantly maximum shelf life in 2014, 2015 as well as in pooled analysis (11.57 days, 12.42 days and 11.99 days) when compared to all other treatments. The least shelf life noticed in the control (T<sub>1</sub>) fruits (5.33 days, 6.33 days and 5.83 days) differed significantly from rest of the treatments.

#### **4.3.5.3 Instrumental colour measurements ( $L^*$ , $a^*$ , $b^*$ $C^*$ and $h^o$ values)**

##### **4.3.4.3.1 $L^*$ value**

The changes in instrumental  $L^*$  values of banana fruits (var Grand Naine) as influenced by various pre-harvest treatments showed significant differences among the treatments when the fruits were ripened under ambient condition (Table 37).

The minimum  $L^*$  value at ripe stage was observed in the treatment T<sub>1</sub> (control) (53.01, 54.31 and 53.66) during 2014, 2015 and for pooled analysis. It differed significantly with all other treatments. On the other hand, significantly maximum  $L^*$  value was found in the treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (62.79) 2014, (64.88) 2015 and (63.84) pooled analysis.

##### **4.3.4.3.2 $a^*$ value**

The data concerning to  $a^*$  value showed remarkable variations indicating the influence of different pre harvest treatments on colour of banana fruits (Table 37).

**Table 36: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on physiological loss in weight and shelf life of banana fruits var. ‘Grand Naine’ (AAA)**

Treatments	Physiological loss in weight (%)						Shelf life (Days)		
	Ripe stage			Senescence stage					
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	12.58a	11.69a	12.14a	19.70a	18.34a	19.02a	5.33d	6.33f	5.83e
T <sub>2</sub>	10.60b	10.77ab	10.68b	17.24b	16.76b	17.00b	7.33c	7.67e	7.50d
T <sub>3</sub>	9.15c	9.36cd	9.25dbc	15.24f	14.98c	15.11f	10.57a	11.92a	11.24a
T <sub>4</sub>	10.36b	9.78bc	10.07cd	16.25d	16.53b	16.39d	8.83b	9.67c	9.25bc
T <sub>5</sub>	10.70b	8.35de	9.53cd	16.67c	16.61b	16.64c	8.33bc	8.67d	8.50c
T <sub>6</sub>	5.85e	5.84f	5.84f	10.25h	9.66e	9.96h	11.57a	12.42a	11.99a
T <sub>7</sub>	7.79d	7.07ef	7.43e	12.56g	13.06d	12.81g	10.67a	12.00a	11.33a
T <sub>8</sub>	9.66c	8.46d	9.06d	15.68e	15.05c	15.37e	8.90b	10.83b	9.87b
<b>S.Em±</b>	0.22	0.44	0.24	0.10	0.11	0.08	0.33	0.31	0.27
<b>C.D @ 5 %</b>	0.68	1.34	0.73	0.31	0.32	0.24	1.01	0.95	0.83

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| T <sub>1</sub> - Control  | T <sub>5</sub> - Application of 20 ppm of 2, 4-D  |
| T <sub>2</sub> - Only bagging (No bunch treatment)  | T <sub>6</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | T <sub>7</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | T <sub>8</sub> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

Significant differences were observed with respect to ' $a^*$ ' (redness) values at ripe stage during both the seasons in bananas under experimentation. During 2014, 2015 and pooled analysis, the maximum  $a^*$  value was obtained in the treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (8.60, 8.56 and 8.58) followed non-significantly by T<sub>7</sub> (8.48, 8.52 and 8.50). Contrastingly, the minimum significant value for  $a^*$  was observed with T<sub>1</sub> (control) during 2014 (5.22), 2015 (4.69) and for pooled analysed values (4.95).

#### **4.3.4.3.3 $b^*$ value**

The data on colour change with respect to  $b^*$  value of banana fruit as influenced by different treatments revealed significant differences among the treatments (Table 37). The  $b^*$  value represents change in fruit colour with respect to blueness or yellowness.

The pooled analysis of 2 years data indicated maximum  $b^*$  value at ripe stage in treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (40.04) followed by T<sub>7</sub> (38.52). The minimum  $b^*$  value during this period of observation was found in the treatment T<sub>1</sub> (31.93).

#### **4.3.4.3.4 $C^*$ value**

The data pertaining to  $C^*$  value of banana fruits at ripe stage as influenced by different pre-harvest treatments exhibited significant differences among the treatments (Table 37).

Chroma ( $C^*$ ) values of banana differed significantly in both the seasons at ripe stage. Significantly maximum  $C^*$  values were noted in T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) during 2014, 2015 and in pooled analysis (39.94, 38.26 and 39.10). Minimum  $C^*$  values were registered in T<sub>1</sub> (control) (32.19, 31.11 and 31.65).

#### **4.3.4.3.5 $h^o$ value**

Instrumental  $h^o$  value of banana fruit revealed significant differences among the treatments (Table 37).

**Table 37: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on instrumental colour values ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $C^*$ ,  $h^\theta$ ) of banana fruits var. 'Grand Naine' at ripe stage (AAA)**

Treatments	$L^*$ (Lightness)			$a^*$ (Redness)			$b^*$ (Yellowness)			$C^*$ (Chroma )			$h^\theta$ (Hue angle)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T1	53.01e	54.31e	53.66e	5.22d	4.69e	4.95d	32.13e	31.73g	31.93f	32.19g	31.11f	31.65h	103.77a	102.38a	103.08a
T2	61.06b	61.55bc	61.31b	7.81b	8.00bc	7.91b	38.66c	37.80c	38.23b	36.00d	34.73c	35.36d	92.85d	87.86e	90.36d
T3	58.05c	61.18bc	59.62c	5.47cd	5.17e	5.32d	37.61c	37.25d	37.43c	34.48e	34.64c	34.56e	93.30cd	91.59c	92.45c
T4	58.64c	60.18c	59.41c	5.85c	6.40d	6.13c	37.50c	35.90e	36.70d	34.12e	33.84d	33.98f	93.73c	90.96c	92.35c
T5	56.24d	57.44d	56.84d	5.37d	5.15e	5.26d	36.40d	35.29f	35.84e	33.39f	32.60e	33.00g	94.58b	92.86b	93.72b
T6	62.79a	64.88a	63.84a	8.60a	8.56a	8.58a	40.82a	39.26a	40.04a	39.94a	38.26a	39.10a	89.40f	86.51e	87.95e
T7	62.12ab	62.62b	62.37b	8.48b	8.52ab	8.50a	38.81b	38.23b	38.52b	39.22b	36.70b	37.96b	89.66f	87.29e	88.48e
T8	58.84c	59.78c	59.31c	7.68b	7.72c	7.70d	38.80b	38.17b	38.49b	38.57c	36.18b	37.38c	91.16e	89.29d	90.23d
Se. M $\pm$	0.52	0.58	0.45	0.16	0.17	0.14	0.15	0.10	0.10	0.19	0.18	0.11	0.270	0.338	0.240
CD @ 5%	1.58	1.77	1.36	0.47	0.53	0.43	0.45	0.30	0.30	0.59	0.55	0.33	0.820	1.025	0.727

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |



T<sub>1</sub>-Control

T<sub>2</sub>-Only bagging (No bunch treatment)

T<sub>3</sub>-Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture

T<sub>4</sub>-Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture

T<sub>5</sub>-Application of 20 ppm of 2, 4-D

T<sub>6</sub>- Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches.

T<sub>7</sub>- Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches

T<sub>8</sub>- Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches

**Plate 10: Images showing fruits (Grand Naine) of different treatments after 10 days after harvesting**

The pooled data revealed significantly maximum  $h^o$  value of 103.08 and 93.72 in the treatments T<sub>1</sub> and T<sub>5</sub> respectively. Both these treatments differed significantly between themselves and with other treatments. The minimum  $h^o$  value found in T<sub>6</sub> (87.95) at ripe stage was at parity with T<sub>7</sub> (88.48).

#### 4.3.6 Quality parameters

##### 4.3.6.1 Total soluble solids (<sup>o</sup>B)

Pooled values of total soluble solids at green stage were found to range from 3.93<sup>o</sup>B to 4.69<sup>o</sup>B and the initial mean TSS of banana fruits at mature green stage was recorded to be 4.49<sup>o</sup>B. The total soluble solids (TSS) of banana fruits registered a sharp rise at ripe stage with a slight further increase at senescence stage (Table 38).

Fruits treated with T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (25.50<sup>o</sup>B, 26.00<sup>o</sup>B and 25.74<sup>o</sup>B) were found to have higher total soluble solids (TSS) when compared to all other treatments at optimum ripe stage during 2014, 2015 and even in pooled data (Table 38). However, this treatment was at parity with T<sub>3</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water). The treatment T<sub>6</sub> continued to show higher level of TSS even in later stages of ripening in comparison to other treatments. Thus, maximum total soluble solids content at the beginning of senescence stage were recorded in T<sub>6</sub> (26.92<sup>o</sup>B - 2014, 26.81<sup>o</sup>B - 2015 and 26.87 - pooled analysis). Nevertheless, T<sub>3</sub> (26.15<sup>o</sup>B, 26.31<sup>o</sup>B, 26.23<sup>o</sup>B) was at significance with T<sub>6</sub> at similar time of observation.

The lower TSS content during 2014, 2015 and in pooled data was noticed in T<sub>1</sub> at ripe stage (20.44<sup>o</sup>B, 21.32<sup>o</sup>B and 20.88<sup>o</sup>B respectively) and at the beginning of senescence stage (22.14<sup>o</sup>B, 22.58<sup>o</sup>B and 22.36<sup>o</sup>B).

##### 4.3.6.2 Titratable acidity (%)

Titrateable acidity of banana fruits under ambient storage exhibited significant differences among the treatments. Mean initial value of titrateable acidity at mature green stage was recorded to be 0.24 per cent with range varying from 0.23 per cent to 0.25 per cent (Table 39). Irrespective of the treatments, this parameter exhibited an increasing trend at ripe stage followed by a decreasing trend at senescence stage.

**Table 38: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on total soluble solids of banana fruits var. 'Grand Naine' (AAA)**

Treatments	TSS ( <sup>o</sup> B)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	3.99e	3.87e	3.93f	20.44d	21.32e	20.88f	22.14h	22.58e	22.36f
<b>T<sub>2</sub></b>	4.25d	4.30d	4.28e	20.73d	21.87e	21.30e	22.62g	23.32d	22.97e
<b>T<sub>3</sub></b>	4.71a	4.54abcd	4.62bc	25.36a	25.71a	25.54a	26.15b	26.31ab	26.23b
<b>T<sub>4</sub></b>	4.51bc	4.48cd	4.49cd	22.72c	23.77d	23.25d	24.81f	25.04c	24.92d
<b>T<sub>5</sub></b>	4.40c	4.53bcdd	4.47d	22.85c	24.38cd	23.62c	25.39e	26.33ab	25.86c
<b>T<sub>6</sub></b>	4.73a	4.81a	4.77a	25.50a	25.97a	25.74a	26.92a	26.81a	26.87a
<b>T<sub>7</sub></b>	4.59ab	4.77ab	4.68ab	24.23b	25.55ab	24.89b	26.01c	26.47ab	26.24b
<b>T<sub>8</sub></b>	4.67a	4.71abc	4.69ab	24.13b	24.99bc	24.56b	25.82d	26.08b	25.95c
<b>S.Em±</b>	0.05	0.09	0.05	0.10	0.23	0.11	0.04	0.17	0.08
<b>C.D @ 5 %</b>	0.16	0.27	0.15	0.30	0.70	0.35	0.13	0.50	0.25

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

Pooled analysis at optimum ripe stage of banana fruits revealed significantly maximum acidity in T<sub>1</sub> (control) (0.41%) than the rest of the treatments. However, the minimum titratable acidity recorded in the treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water+ bagging of bunches) (0.33%) was significantly followed all other treatments.

Conversely, the minimum titratable acidity was noted in T<sub>1</sub> (control) at beginning of senescence stage for pooled data (0.22%). This treatment was found to be significant with all the other treatments. However, the maximum value was noticed in T<sub>6</sub> (0.26% respectively).

#### **4.3.6.3 Total sugars (%)**

The effect of pre-harvest treatments on total sugars of banana fruits revealed the same trend as total soluble solids. Significant variations were observed among the treatments all through the storage duration. The initial mean total sugar content observed in the fruits was 1.88 per cent and range of pooled values at mature green stage varying from 1.85 per cent to 1.91 per cent among the treatments. The results of pooled data of total sugars during the storage period are as follows (Table 40).

The treatment T<sub>1</sub> (control) recorded minimum total sugar content at ripe stage (16.08%). This treatment was significantly followed by T<sub>2</sub> (control + bagging) (17.00%) during the same period of examination. On the other hand, the maximum total sugars (20.84%) were associated with T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunches) which was non-significantly (20.64) followed by T<sub>3</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water).

At senescence stage of banana fruits, the highest significant total sugars was noted in T<sub>8</sub> (24.92%). The treatment T<sub>1</sub> showed minimum total sugar (20.81%) and it differed significantly with all other pre-harvest bunch treatments.

#### **4.3.6.4 Reducing sugars (%)**

The reducing sugars of banana fruits revealed significant differences signifying the influence of various pre harvest treatments and stored at ambient conditions. The initial mean reducing sugars in the fruits at mature green stage were

**Table 39: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on acidity of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Acidity (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.247	0.230	0.238	0.410a	0.403a	0.407a	0.210c	0.227b	0.218g
T <sub>2</sub>	0.230	0.230	0.230	0.390b	0.387b	0.383b	0.237ab	0.247ab	0.242e
T <sub>3</sub>	0.220	0.220	0.220	0.360cd	0.350e	0.355d	0.250ab	0.260a	0.255c
T <sub>4</sub>	0.240	0.240	0.240	0.370c	0.367de	0.363cd	0.237ab	0.247ab	0.242e
T <sub>5</sub>	0.250	0.230	0.240	0.383b	0.370bc	0.377bc	0.233b	0.243abb	0.238f
T <sub>6</sub>	0.250	0.250	0.250	0.347e	0.323f	0.330e	0.257a	0.267a	0.262a
T <sub>7</sub>	0.230	0.250	0.240	0.367d	0.367bc	0.362d	0.253ab	0.263a	0.258b
T <sub>8</sub>	0.227	0.227	0.227	0.350d	0.360cd	0.355d	0.240ab	0.253ab	0.247d
<b>S.Em±</b>	0.034	0.014	0.022	0.004	0.005	0.004	0.009	0.007	0.003
<b>C.D @ 5 %</b>	NS	NS	NS	0.013	0.016	0.013	0.026	0.022	0.009

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| T <sub>1</sub> - Control  | T <sub>5</sub> - Application of 20 ppm of 2, 4-D  |
| T <sub>2</sub> - Only bagging (No bunch treatment)  | T <sub>6</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | T <sub>7</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | T <sub>8</sub> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

**Table 40: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on total sugars of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Total Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	1.84	1.86	1.85	15.64e	16.52e	16.08f	20.64f	20.98f	20.81e
T <sub>2</sub>	1.84	1.88	1.86	16.43d	17.57d	17.00e	21.02e	21.72e	21.37d
T <sub>3</sub>	1.84	1.89	1.87	20.46a	20.81a	20.64a	24.25b	24.41abc	24.33b
T <sub>4</sub>	1.86	1.89	1.88	18.12c	19.17c	18.65d	23.01d	23.24d	23.12c
T <sub>5</sub>	1.86	1.91	1.89	18.35c	19.88b	19.12c	23.69c	24.63ab	24.16b
T <sub>6</sub>	1.85	1.91	1.88	20.6a	21.07a	20.84a	24.97a	24.86a	24.92
T <sub>7</sub>	1.86	1.94	1.90	19.13b	20.45ab	19.79b	24.16b	24.03c	24.10b
T <sub>8</sub>	1.88	1.95	1.91	18.93b	19.79bc	19.36c	24.14b	24.33bc	24.23b
<b>S.Em±</b>	0.02	0.03	0.018	0.10	0.23	0.11	0.05	0.16	0.08
<b>C.D @ 5 %</b>	NS	NS	NS	0.30	0.70	0.35	0.15	0.50	0.25

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |  |                  |  |
|------------------|--|------------------|--|
| T <sub>1</sub> - | Control  | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D  |
| T <sub>2</sub> - | Only bagging (No bunch treatment)  | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

1.13 per cent with range consisting of 0.98 per cent to 1.32 per cent among the treatments of both the years (Table 41).

At ripe stage, banana fruits had maximum level of reducing sugars in T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water+ bagging of bunches) in 2014 (16.04%), 2015 (16.48%) and pooled analysis (16.26%) but it was found to be at parity with T<sub>3</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water) (15.88%, 16.21% and 16.04% respectively). While, control (T<sub>1</sub>) fruits were observed to have minimum reducing sugar during 2014, 2015 and in pooled data (10.17%, 11.02% and 10.60%).

The treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water+ bagging of bunches) had maximum reducing sugar in both the years as well as in pooled analysis at the beginning of senescence stage (19.73%, 19.74% and 19.74% respectively), and it was significantly different from all other treatments. However, minimum amount of reducing sugars were found in T<sub>1</sub> (13.17%, 14.02% and 13.60%) and the treatment was closely and significantly followed by T<sub>2</sub> (11.13%, 12.22% and 11.67%).

#### **4.3.6.5 Non-reducing sugars (%)**

Non-reducing sugars of banana fruits disclosed significant differences among the treatments. The initial mean non-reducing sugar content found in banana fruits was 0.72 per cent (Table 41). The results of pooled data of non reducing sugars ranged from 0.58 per cent to 0.82 per cent at mature green stage and results of subsequent stages are as follows.

Significantly minimum non-reducing sugars at ripe stage were associated with T<sub>6</sub> (Application of slurry mixture with 7.5g urea+7.5g SOP in 100ml water+ bagging of bunches) (4.33%) which was non-significantly followed by T<sub>3</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water) (4.36). On the other hand, T<sub>1</sub> (control) was associated with maximum non-reducing sugars (5.21%) followed by T<sub>2</sub> (control+ bagging) (5.06).

Maximum non-reducing sugars at senescence stage of banana fruits were found in the treatment T<sub>1</sub> (6.85%) followed non-significantly by T<sub>5</sub> (6.27%) and T<sub>8</sub>

**Table 41: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on reducing sugars of banana fruits var. ‘Grand Naine’ (AAA)**

Treatments	Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.98e	1.01g	0.99f	10.17f	11.02e	10.60f	13.17g	14.02e	13.60f
T <sub>2</sub>	1.05d	1.09f	1.07e	11.13e	12.22d	11.67e	14.33f	15.42d	14.87e
T <sub>3</sub>	1.19a	1.18b	1.19b	15.88a	16.21ab	16.04a	19.37b	19.11ab	19.24b
T <sub>4</sub>	1.09cd	1.10ef	1.10e	13.32d	14.45c	13.89d	17.64d	17.97c	17.80d
T <sub>5</sub>	1.08d	1.13de	1.11de	13.35d	14.97c	14.16cd	16.80e	18.33bc	17.57d
T <sub>6</sub>	1.21a	1.32a	1.27a	16.04a	16.48a	16.26a	19.73a	19.74a	19.74a
T <sub>7</sub>	1.14b	1.16bc	1.15bc	14.33b	15.67b	15.00b	18.14c	19.31a	18.73c
T <sub>8</sub>	1.13bc	1.14cd	1.14cd	13.94c	14.82c	14.38c	17.43d	17.85c	17.64d
<b>S.Em±</b>	0.02	0.01	0.01	0.10	0.23	0.11	0.11	0.27	0.15
<b>C.D @ 5 %</b>	0.05	0.03	0.03	0.32	0.68	0.34	0.34	0.83	0.46

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| T <sub>1</sub> - Control  | T <sub>5</sub> - Application of 20 ppm of 2, 4-D  |
| T <sub>2</sub> - Only bagging (No bunch treatment)  | T <sub>6</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | T <sub>7</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | T <sub>8</sub> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

**Table 42: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on non-reducing sugars of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Non-Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.82a	0.81a	0.82a	5.19a	5.23a	5.21a	7.10a	6.61a	6.85a
T <sub>2</sub>	0.74b	0.75b	0.75b	5.04b	5.08b	5.06b	6.35b	5.99a	6.17b
T <sub>3</sub>	0.62d	0.67c	0.65d	4.35e	4.37ef	4.36e	4.64e	5.04b	4.84c
T <sub>4</sub>	0.73bc	0.75b	0.74dc	4.56d	4.48de	4.52d	5.10d	5.01b	5.05c
T <sub>5</sub>	0.74bc	0.75ab	0.74bc	4.75c	4.66c	4.70e	6.55b	5.99a	6.27b
T <sub>6</sub>	0.61b	0.56d	0.58e	4.33e	4.35f	4.34e	4.98d	4.87b	4.92c
T <sub>7</sub>	0.68c	0.74b	0.71c	4.56d	4.54d	4.55d	5.71c	4.49b	5.10c
T <sub>8</sub>	0.71bc	0.76ab	0.74bc	4.74c	4.72c	4.73c	6.37b	6.15a	6.26b
<b>S.Em±</b>	0.017	0.015	0.011	0.015	0.038	0.023	0.107	0.261	0.135
<b>C.D @ 5 %</b>	0.053	0.047	0.033	0.047	0.116	0.069	0.326	0.79	0.411

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| T <sub>1</sub> - Control  | T <sub>5</sub> - Application of 20 ppm of 2, 4-D  |
| T <sub>2</sub> - Only bagging (No bunch treatment)  | T <sub>6</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | T <sub>7</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | T <sub>8</sub> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

(6.26%). In contrast, minimum non-reducing sugar documented in T<sub>6</sub> (4.92%) was found significant over all other treatments of the experiment.

#### **4.3.6.6 Sugar acid ratio (%)**

The influence of different pre-harvest bunch treatments on sugar acid ratio of banana fruits showed significant differences among the treatments with range consisting of pooled values of both the years from 7.53 to 8.49 at mature green stage of fruits (Table 43).

At ripe stage of banana fruits, the treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) recorded maximum sugar acid ratio of 61.20 (2014), 65.19 (2015) and 63.19 (pooled analysis) and it was significantly followed by T<sub>3</sub> (56.83, 59.5 and 58.17). However, significantly minimum sugar acid ratio was observed in T<sub>1</sub> (control) during two consecutive years (38.16, 41.00) and for pooled analysis (39.56) of this study.

Conversely, maximum sugar acid ratio during 2014, 2015 and in pooled analysis was observed in T<sub>1</sub> (105.44, 105.46 and 105.45 respectively) at senescence stage. Significantly minimum sugar acid ratio was associated with treatments T<sub>6</sub> (88.83, 88.07 and 88.45).

#### **4.3.6.7 Starch (%)**

The data observed on starch content of banana fruits revealed a gradual decreasing tendency throughout the storage period. The initial mean starch content of banana fruits varied from 22.67 per cent to 24.34 per cent mean was recorded to be 23.06 per cent among the treatments at mature green stage of fruit (Table 44).

Starch content of banana fruits varied significantly among the imposed treatments at ripe stage. During 2014, 2015 and in pooled analysis of data, fruits under the treatment T<sub>1</sub> (control) (4.17%, 4.05% and 4.61%) and T<sub>5</sub> (4.19%, 4.13% and 4.16%) were on par with each other. However, both of them contained significantly lower starch content than all other treatments. Significantly maximum starch content during both the years and for pooled data was observed in T<sub>6</sub> (5.89%, 5.97% and 5.93%) significantly followed by T<sub>3</sub> (5.16, 5.20 and 5.18).

**Table 43: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on sugar acid ratio of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Sugar acid ratio								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	8.38a	8.10c	8.24b	38.16f	40.96e	39.56f	105.44a	105.46a	105.45a
<b>T<sub>2</sub></b>	7.99c	8.17c	8.08c	42.13e	46.66d	44.39e	97.34bc	93.27c	95.30bc
<b>T<sub>3</sub></b>	8.38a	8.61a	8.49a	56.83b	59.50b	58.17b	96.99bc	93.90bc	95.44bc
<b>T<sub>4</sub></b>	7.74e	7.89d	7.81f	48.98d	53.76c	51.37d	95.86c	94.27bc	95.07bc
<b>T<sub>5</sub></b>	7.45f	8.32b	7.89e	47.90d	53.78c	50.84d	103.01ab	102.61a	102.81a
<b>T<sub>6</sub></b>	7.41f	7.64e	7.53g	61.20a	65.19a	63.19a	88.83d	88.09c	88.46d
<b>T<sub>7</sub></b>	8.10b	7.75e	7.92de	53.65c	55.78c	54.72c	95.38c	91.29c	93.33cd
<b>T<sub>8</sub></b>	7.82d	8.11c	7.97d	54.11c	55.02c	54.57c	99.23bc	101.50ab	100.36ab
<b>S.Em±</b>	0.02	0.04	0.02	0.52	1.15	0.77	2.00	2.51	2.09
<b>C.D @ 5 %</b>	0.07	0.12	0.06	1.57	3.48	2.35	6.07	7.62	6.33

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

At senescence stage, maximum starch content was found in T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) 2014 (3.78%), (2015) (3.96%) and for pooled analysis (3.87%) which was closely and non-significantly followed by treatment T<sub>3</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP) (3.72%, 3.84% and 3.78%). The minimum content of starch was noted in T<sub>1</sub> (1.62%, 1.72% and 1.67%) for both the years and their pooled analysis.

### **4.3.7 Organoleptic evaluation**

#### **4.3.7.1 Peel colour and appearance**

With respect to peel colour and appearance, significant differences were observed both during 2014, 2015 and pooled analysis (Table 45). Fruits from the bunches applied with 20 ppm 2,4-D + bagging of bunch (T<sub>8</sub>) obtained higher scores (8.25), when compared to all others treatments during 2014. While in 2015 and when analysed by pooling 2 years' data, the treatment T<sub>6</sub> fed with slurry mixture, urea and SOP, then bagged with skirting materials received maximum sensory scores (8.54 and 8.39). The treatment T<sub>1</sub> (control) received minimum score for peel colour and appearance (5.00, 5.18 and 5.09 respectively) in 2014, 2015 and in analysed pooled data indicating less attractive skin.

#### **4.3.7.2 Pulp colour and appearance**

Colour and appearance of banana pulp showed significant differences (Table 45). In 2014, 2015 and for pooled analysis, maximum score for pulp colour and appearance was noted in T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water+ bagging of bunch) (8.21, 7.86 and 8.03 respectively). The treatment T<sub>6</sub> was non-significantly followed by T<sub>3</sub> (8.03) in 2014 and T<sub>5</sub> (7.64) in 2015 and significantly by T<sub>5</sub> (7.71) and T<sub>3</sub> (7.16) in pooled analysis.

Minimum score for pulp colour and appearance was received by T<sub>1</sub> (control) with score of 4.87 in 2014, 4.83 in 2015 and 4.85 in pooled analysis. It was significantly followed by the treatment T<sub>2</sub> (control +bagging) (5.88, 5.72 and 5.80) when similarly observed.

**Table 44: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on starch content of banana fruits var. ‘Grand Naine’ (AAA)**

Treatments	Starch (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	22.67c	22.71g	22.69f	4.17c	4.05d	4.11d	1.62d	1.72e	1.67e
<b>T<sub>2</sub></b>	22.69c	22.76g	22.72f	4.63bc	4.90bc	4.77bc	2.16c	2.44c	2.30c
<b>T<sub>3</sub></b>	22.84b	23.27d	23.06c	5.16b	5.20b	5.18b	3.72a	3.84a	3.78a
<b>T<sub>4</sub></b>	22.68c	22.90f	22.79e	4.86b	5.18b	5.02bc	2.83b	2.94b	2.89b
<b>T<sub>5</sub></b>	23.02a	24.20b	23.61b	4.19c	4.13d	4.16d	1.72d	2.15d	1.94d
<b>T<sub>6</sub></b>	22.69c	23.34c	23.02c	5.89a	5.97a	5.93a	3.78a	3.96a	3.87a
<b>T<sub>7</sub></b>	22.71c	23.02e	22.87d	4.53bc	4.62c	4.58cd	2.55b	3.02b	2.79b
<b>T<sub>8</sub></b>	23.06a	24.34a	23.70a	4.57bc	4.72c	4.64c	1.84d	2.07d	1.96d
<b>S.Em±</b>	0.03	0.02	0.02	0.22	0.13	0.16	0.09	0.09	0.08
<b>C.D @ 5 %</b>	0.08	0.05	0.05	0.66	0.38	0.47	0.28	0.28	0.24

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

#### **4.3.7.3 Texture**

Significant differences were observed with respect to texture of banana fruit among different treatments (Table 45). Fruits treated with T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (7.09, 8.38 and 7.74) obtained maximum score for texture during 2014, 2015 and pooled analysis. Control (T<sub>1</sub>) received the least score of 4.02, 4.61 and 4.32 respectively during 2014, 2015 and when analysed by pooling 2 years' data.

#### **4.3.7.4 Taste and flavour**

Significant differences were observed with respect to taste and flavour (Table 45). Significantly higher score for taste and flavour was obtained in the treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea + 7.5g SOP in 100ml water + bagging of bunch) during 2014 (8.48), 2015 (8.65) as well as in pooled analysis (8.56) which differed significantly with T<sub>5</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water) (8.14) in 2014, but was on par during 2015 and in pooled analysis (8.59 and 8.36 respectively). The least scoring control (T<sub>1</sub>) (5.17, 5.34 and 5.26) during 2014, 2015 and in 2 years' data was statistically significant over all other treatments.

#### **4.3.7.5 Overall acceptability**

Overall acceptability data revealed significant differences during 2014, 2015 and in pooled analysis (Table 45). In 2014 and 2015, higher overall acceptability scores were obtained by the treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (8.45, 8.62). Pooled analysis of data revealed similar trend as in the individual years, with fruits of T<sub>6</sub> (8.54) receiving maximum score for overall acceptability. The performance was acknowledged to be low with the treatment T<sub>1</sub> (4.44, 4.61 and 4.52) throughout the experimentation.

**Table 45: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on sensory attributes of banana fruits var. 'Grand Naine' (AAA)**

Treatments	Peel colour and appearance			Pulp colour and appearance			Pulp texture			Taste and flavour			Overall acceptability		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	5.00f	5.18e	5.09f	4.87e	4.83e	4.85f	4.02e	4.61g	4.32e	5.17g	5.34f	5.26e	4.44e	4.61f	4.52f
<b>T<sub>2</sub></b>	6.02e	6.29d	6.15e	5.88d	5.72d	5.80e	4.68d	5.57f	5.12d	5.82f	6.10e	5.96d	5.02d	5.46e	5.24e
<b>T<sub>3</sub></b>	8.15ab	8.22b	8.18bc	8.03ab	6.29c	7.16c	7.05a	7.03b	7.04b	8.14b	8.59ab	8.36a	8.11a	8.25b	8.18b
<b>T<sub>4</sub></b>	7.71c	7.52c	7.61dd	7.14c	6.82b	6.98cd	6.41b	6.36c	6.38c	7.69c	7.19d	7.44c	6.55c	6.52d	6.54d
<b>T<sub>5</sub></b>	8.01b	7.98b	8.00c	7.78b	7.64a	7.71b	5.85c	7.25e	6.55c	7.21e	7.71cd	7.46c	7.30b	7.49c	7.39c
<b>T<sub>6</sub></b>	8.23a	8.54a	8.39a	8.21a	7.86a	8.03a	7.09a	8.38a	7.74a	8.48a	8.65a	8.56a	8.45a	8.62a	8.54a
<b>T<sub>7</sub></b>	7.45d	7.69c	7.57d	7.16c	6.96b	7.06cd	6.23b	6.83c	6.53c	7.33cde	7.47cd	7.40c	6.49c	6.78d	6.63d
<b>T<sub>8</sub></b>	8.25a	8.21b	8.23ab	7.96ab	5.89cd	6.92d	7.01a	7.46b	7.24b	7.57cd	8.03bc	7.80b	7.43b	7.55c	7.49c
<b>S.Em±</b>	0.066	0.088	0.062	0.088	0.174	0.066	0.120	0.179	0.111	0.090	0.202	0.095	0.137	0.108	0.111
<b>C.D @ 5 %</b>	0.20	0.26	0.18	0.26	0.52	0.20	0.36	0.54	0.33	0.27	0.61	0.28	0.41	0.32	0.33

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |   |   |
|---|---|
| <b>T<sub>1</sub></b> - Control  | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D  |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)  | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches  |

#### **4.4 Experiment-4: Effect of bunch treatment (urea, ammonium sulphate, SOP and 2, 4-D) and bagging on yield, post harvest quality and shelf life of banana fruits cv. 'Ney Poovan' (AB)**

##### **4.4.1 Bunch characters**

###### **4.4.1.1 Bunch weight (kg)**

Pre-harvest bunch treatments resulted in significant differences with respect to bunch weight of the banana plants of cv. Ney Poovan (Table 46). During 2014, 2015 and in pooled analysis, the bunch weight showed significant increase in all the treatments over T<sub>1</sub> (Control) (8.17 kg/plant, 8.57 kg/plant and 8.37 kg/plant respectively). However, the treatment T<sub>2</sub> (control + bagging) remained on par with T<sub>1</sub>. Maximum bunch weight (11.97 kg/plant) observed in T<sub>8</sub> (Application of 2, 4-D at 20ppm + bagging of bunch) during 2014 was on par with T<sub>5</sub> (11.43 kg/plant) (Application of 2, 4-D at 20ppm) and T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water+ bagging of bunches). During 2015 also, the treatment T<sub>8</sub> significantly resulted in enhancement of bunch weight (12.69 kg/plant) followed by T<sub>5</sub> (12.07 kg/plant). In the pooled data, the treatment T<sub>8</sub> showed significant difference for bunch weight (12.33 kg/plant) over all the treatments except T<sub>5</sub> (11.75 kg/plant) and T<sub>7</sub> (11.50 kg/plant).

###### **4.4.1.2 Number of hands per bunch**

Bunch feeding with nutrients and Bunch spraying (2,4-D at 20 ppm) of banana bunches and bunch bagging resulted in non- significant differences as the hands were completely opened and uniform bunches were selected during the imposition of treatments. However, number of hands in pooled data varied from 10.07 to 10.26 among the different treatments (Table 46).

###### **4.4.1.3 Number of fingers in third hand**

Different pre-harvest bunch treatments *viz.*, Bunch spraying, feeding of bunches and bunch bagging resulted in non-significant differences with respect to number of fingers in third hand (Table 46). Maximum number of fruits in pooled data

was found in T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water+ bagging of bunches) (13.68) and lowest was in T<sub>2</sub> (control+bagging) (12.16).

#### **4.4.1.4 Total no. of fingers per bunch**

Treatments did not have any effect in varying the number of fingers per bunch. The data pertaining to the number of fingers per bunch are presented in Table 46. Even though, more number of fingers (127.53) in T<sub>8</sub>, (130.67) in T<sub>6</sub> and (128.96) in T<sub>5</sub> was found during 2014, 2015 and in pooled data respectively. While less number of fingers (121.13, 120.13 and 120.63) were found in T<sub>2</sub> in both the years and in pooled data.

### **4.4.2 Fruit characters**

#### **4.4.2.1 Fruit characters at mature stage**

##### **4.4.2.1.1 Fruit weight (g)**

Pre-harvest bunch treatments resulted in significant differences with respect to fruit weight at harvest during two seasons and after pooling the two season's data (Table 47). During 2014, 2015 and in pooled analysis, the treatment T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) (79.60 g, 82.78 g and 81.19 g respectively) recorded maximum fruit weight. The treatment T<sub>8</sub> was found to be significant with T<sub>5</sub> (77.27 g and 79.71) in 2014 and in pooled analysis but had non-significant difference with T<sub>5</sub> (82.15 g) in 2015.

Significantly minimum fruit weight during 2014, 2015 and in pooled data was associated with T<sub>1</sub> (Control) (66.49 g, 68.82 g and 67.66 g) followed by T<sub>2</sub> (69.96 g, 71.30 g and 67.66g).

##### **4.4.2.1.2 Fruit length (cm)**

In both the years, the treatment T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) recorded maximum fruit length (2014 – 14.03 cm and 2015 – 14.18 cm) (Table 47). This treatment was found to differ significantly with T<sub>5</sub> (2014 – 13.50 cm;

**Table 46: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on bunch weight and bunch characters of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Bunch weight (kg)			No. of hands /bunch			Fingers in third hand			Total no. of fruits/bunch		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	8.17c	8.57d	8.37d	10.07	10.15	10.11	12.17	12.30	12.24	122.13	120.67	121.40
T <sub>2</sub>	9.06c	9.04d	9.05d	10.18	10.33	10.26	12.03	12.30	12.16	121.13	120.13	120.63
T <sub>3</sub>	10.39b	10.98c	10.69c	10.17	10.11	10.14	12.70	13.08	12.89	125.47	126.47	125.97
T <sub>4</sub>	10.78b	10.84c	10.81c	10.15	10.33	10.24	12.70	13.88	13.29	125.67	129.40	127.53
T <sub>5</sub>	11.43ab	12.07ab	11.75ab	10.17	10.05	10.11	12.35	12.92	12.63	127.42	130.50	128.96
T <sub>6</sub>	11.07ab	11.28ab	11.18bc	10.26	10.17	10.21	13.25	13.55	13.40	125.13	130.67	127.90
T <sub>7</sub>	11.27ab	11.72abc	11.50abc	10.22	10.22	10.22	13.59	13.76	13.68	122.67	128.67	125.67
T <sub>8</sub>	11.97a	12.69a	12.33a	10.08	10.05	10.07	13.06	13.68	13.37	127.53	129.33	128.43
<b>S.Em±</b>	0.37	0.34	0.29	0.21	0.10	0.14	0.51	0.57	0.40	2.08	2.95	2.30
<b>C.D @ 5 %</b>	1.11	1.04	0.87	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

2015 – 14.03 cm). Conversely, the minimum fruit length was associated with T<sub>1</sub> (Control) both during 2014 (10.85 cm) and 2015 (10.96 cm). Pooled analysis of two years data showed significant increase in fruit length (14.11 cm) in T<sub>8</sub> over all other treatments. On the other hand, least fruit length (10.90 cm) recorded in control treatment (T<sub>1</sub>) exhibited significant difference over rest of the treatments.

#### **4.4.2.1.3 Fruit diameter (cm)**

The effect of pre-harvest bunch treatments on fruit diameter of banana fruits followed similar trend as fruit length (Table 47). In the year 2014, T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) (2.79 cm) recorded significantly maximum fruit diameter over all the treatments except T<sub>5</sub> (2.67) (Application of 2, 4-D 20ppm). The least fruit diameter observed in T<sub>1</sub> (Control) (2.30 cm) was found to be at parity with T<sub>2</sub> (control +bagging) (2.31 cm). In 2015, the maximum fruit diameter was associated with T<sub>8</sub> (2.82 cm). The treatment T<sub>1</sub> showed minimum fruit diameter (2.31 cm) and it differed statistically with all other treatments except T<sub>2</sub>. Analysis of pooled data followed a similar trend as in 2014. Significantly higher overall fruit diameter was recorded in treatment T<sub>8</sub> (2.80 cm), while it was lower in control (T<sub>1</sub>) (2.30 cm) which was on par with T<sub>2</sub> (2.32 cm).

#### **4.4.2.2 Fruit characters at ripe stage**

##### **4.4.2.2.1 Ripe fruit weight (g)**

Banana fruits exhibited significant differences for ripe fruit weight during both the years of experimentation (2014 and 2015) (Table 47). In 2014, significantly maximum fruit weight after ripening was noticed in T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) (71.36 g) in comparison to all other treatments. On the other hand, minimum fruit weight at ripe stage observed in T<sub>1</sub> (control) (59.24 g) significantly differed with T<sub>2</sub> (62.54 g). During 2015, fruits of the treatment T<sub>8</sub> (74.84g) had higher ripe weight followed non-significantly by T<sub>5</sub> (Application of 2, 4-D 20ppm) (74.52 g). Minimum ripe fruit weight was found associated with T<sub>1</sub> (control) (61.57 g) and it differed significantly with T<sub>2</sub> (64.15 g). The combined data of two years for ripe fruit weight was significantly higher in T<sub>8</sub> (73.10 g). While,

**Table 47: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on Fruit characters of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Mature fruit weight (g)			Ripe fruit weight (g)			Fruit length (cm)			Fruit diameter (cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	66.49f	68.82f	67.66g	59.24f	61.57f	60.41e	10.85f	10.96f	10.90h	2.30f	2.31f	2.31g
T <sub>2</sub>	69.69e	71.30e	70.50f	62.54e	64.15e	63.35d	11.32e	11.19f	11.25g	2.32f	2.33f	2.32g
T <sub>3</sub>	72.54d	74.14d	73.34e	65.50d	67.10d	66.30c	11.43e	11.86e	11.65f	2.40e	2.46e	2.43f
T <sub>4</sub>	75.17c	75.79cd	75.48cd	68.32b	68.94bc	68.63b	12.49cd	12.54c	12.52d	2.48d	2.48e	2.48e
T <sub>5</sub>	77.27b	82.15a	79.71b	71.03a	74.52a	72.78a	13.50b	14.01a	13.75b	2.67c	2.73c	2.70c
T <sub>6</sub>	74.41c	76.02c	75.22d	66.45cd	68.06cd	67.26c	12.31d	12.14d	12.22e	2.49d	2.55d	2.52d
T <sub>7</sub>	75.58c	78.10b	76.84c	67.58bc	70.10b	68.84b	12.87c	13.49b	13.18c	2.73b	2.78b	2.75b
T <sub>8</sub>	79.60a	82.78a	81.19a	71.36a	74.84a	73.10a	14.03a	14.18a	14.11a	2.79a	2.82a	2.81a
<b>S.Em±</b>	0.55	0.59	0.47	0.55	0.45	0.43	0.14	0.08	0.08	0.01	0.01	0.01
<b>C.D @ 5 %</b>	1.66	1.80	1.41	1.66	1.36	1.30	0.43	0.24	0.25	0.03	0.04	0.02

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

minimum ripe fruit weight observed in T<sub>1</sub> (control) (60.41 g) was significantly followed by T<sub>2</sub> (63.35 g).

#### 4.4.2.2.2 Pulp weight (g)

Significantly higher pulp weight was recorded in T<sub>5</sub> (Application of 2, 4-D 20ppm) (63.45 g) during 2014 when compared to all other treatments except T<sub>8</sub> (63.37 g) (Table 48). The pulp weight was significantly lower in T<sub>1</sub> (control) (52.77 g) followed by T<sub>2</sub> (Control + bagging) (56.07 g). During 2015, fruits showed higher pulp weight in the treatment T<sub>5</sub> (68.34 g) which was closely and significantly followed by T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunches) (66.55 g). On the other hand, control treatment (T<sub>1</sub>) (55.10 g) with minimum pulp weight was significantly different from rest of the treatments. Two years' pooled data showed significantly higher pulp weight in T<sub>5</sub> (65.89 g) over rest of the treatments except T<sub>8</sub> (64.96 g). Untreated (T<sub>1</sub>) (53.93 g) recorded minimum pulp weight which was significantly followed by T<sub>2</sub> (56.87 g).

#### 4.4.2.2.3 Peel weight (g)

During 2014 peel weight was maximum in the treatment T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunches) (8.25 g) followed by T<sub>5</sub> (Application of 2, 4-D 20ppm) (8.23), where the treatments remained non-significant with each other (Table 48). The maximum peel weight during 2015 was associated with T<sub>8</sub> (Application of 2, 4-D 20ppm + bagging of bunch) (8.37 g) and it differed significantly with T<sub>4</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water). In pooled data, maximum peel weight recorded in T<sub>8</sub> (8.31 g) was to be found significant with T<sub>4</sub> (8.21 g). Minimum peel weight during 2014, 2015 and for pooled analysis was observed in T<sub>1</sub> (7.04 g, 7.07 g and 7.06 g respectively).

#### 4.4.2.2.4 Pulp percentage (%)

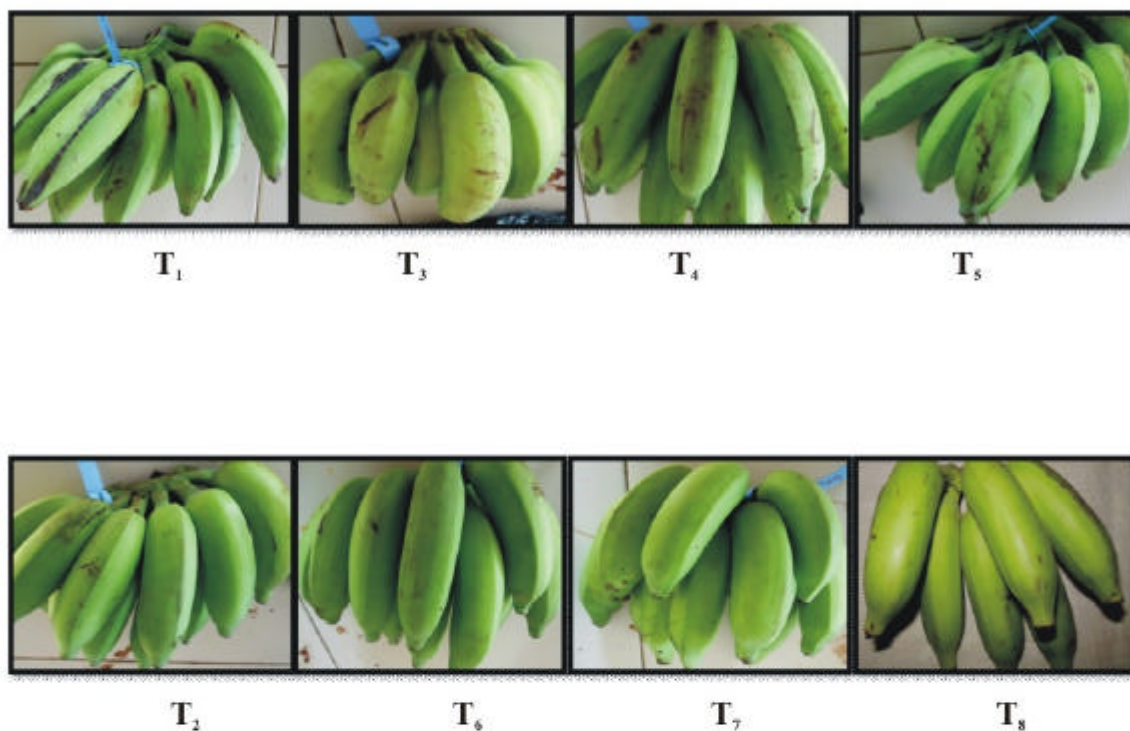
The data pertaining to pulp recovery showed varied differences among the treatments (Table 48). Pooled analysis of two years' data recorded minimum pulp percentage in T<sub>1</sub> (control) (88.35%). Whereas, the maximum pulp percentage observed in T<sub>8</sub> (Application of 2, 4-d at 20 ppm + bagging) (89.92%) remained

**Table 48: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on pulp weight, peel weight and pulp percentage of banana fruits cv. 'Neypooan' (AB)**

Treatments	Pulp weight (g)			Peel weight (g)			Pulp percentage (%)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	52.77e	55.10f	53.93e	7.04e	7.07e	7.06f	88.53	88.17	88.35d
T <sub>2</sub>	56.07d	57.68e	56.87d	8.06c	8.05cd	8.06d	88.88	88.98	88.93bcd
T <sub>3</sub>	59.21c	60.81cd	60.01bc	7.89d	7.95d	7.92e	88.82	88.64	88.73cd
T <sub>4</sub>	60.88b	61.50cd	61.19b	8.11bc	8.21b	8.16bc	88.47	88.67	88.57cd
T <sub>5</sub>	63.45a	68.34a	65.89a	8.23ab	8.20b	8.21b	89.33	89.86	89.60ab
T <sub>6</sub>	58.50c	60.11d	59.31c	8.01cd	8.13bc	8.07cd	89.72	89.70	89.71a
T <sub>7</sub>	59.35bc	61.87c	60.61bc	8.08c	8.15bc	8.12cd	89.17	89.21	89.19abc
T <sub>8</sub>	63.37a	66.55b	64.96a	8.25a	8.37a	8.31a	89.86	89.99	89.92a
S.Em±	0.51	0.58	0.43	0.04	0.04	0.03	0.44	0.46	0.25
C.D @ 5 %	1.56	1.74	1.32	0.13	0.12	0.09	NS	NS	0.76

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |



T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No bunch treatment)

T<sub>3</sub>- Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture

T<sub>4</sub>- Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture

T<sub>5</sub>- Application of 20 ppm of 2, 4-D

T<sub>6</sub>- Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches.

T<sub>7</sub>- Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches

T<sub>8</sub>- Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches

**Plate 11: Images showing fruits (Neypoovan) of different treatments at green**

statistically on par with T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunches) (89.71%) and T<sub>5</sub> (89.60%) followed by T<sub>7</sub>.

### 4.4.3 Pest incidence

#### 4.4.3.1 Incidence of thrips at harvest (numbers)

At the time of harvest, banana bunches had no incidence of thrips in all the bagged treatments *viz.*, T<sub>2</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub> during 2014, 2015 and for pooled analysis (Table 49). However, maximum number of thrips was noticed in control (T<sub>1</sub>) treatment during 2014, 2015 and for data analysed after pooling (21.74, 19.50 and 20.62 respectively).

### 4.4.4 Post harvest behaviour of fruit

#### 4.4.4.1 Respiration rate (ml CO<sub>2</sub>/kg/h)

Respiration rate of banana fruits (cv. Ney Poovan) at mature green stage, ripe stage and senescence stage showed significant differences among the treatments. Respiration increased from green stage reaching peak at ripe stage and exhibited a decline towards senescent stage. The mean values of pooled data at green stage showed a range from 98.62 (ml CO<sub>2</sub>/kg/h) (T<sub>7</sub>) (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) to 112.07 ml CO<sub>2</sub>/kg/h (T<sub>1</sub>) (Control) (Table 50).

At ripe stage, fruits under the treatment of T<sub>1</sub> (control) had significantly higher respiratory peak in both the seasons (2014, 2015) and in pooled analysed data (384.40 ml CO<sub>2</sub>/kg/h, 369.26 ml CO<sub>2</sub>/kg/h and 376.85 ml CO<sub>2</sub>/kg/h respectively). Minimum values of respiratory peak during 2014, 2015 and in pooled data were noted in T<sub>7</sub> (336.3 ml CO<sub>2</sub>/kg/h, 324.20 CO<sub>2</sub>/kg/h, 330.26 ml CO<sub>2</sub>/kg/h respectively) which were found to be significant over all other treatments.

At senescence stage, the highest respiration rate was recorded to be present in the treatment T<sub>1</sub> during 2014 (284.75 ml CO<sub>2</sub>/kg/h), 2015 (269.04 ml CO<sub>2</sub>/kg/h) and in pooled analysis (276.90 ml CO<sub>2</sub>/kg/h) over rest of the treatments. The least respiration rate during 2014, 2015 and pooled analysis was noticed in T<sub>7</sub> (215.26 ml CO<sub>2</sub>/kg/h, 208.00 ml CO<sub>2</sub>/kg/h and 211.63 ml CO<sub>2</sub>/kg/h respectively). This treatment

**Table 49: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on pest incidence of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Pest incidence (numbers)		
	2014	2015	Pooled
T <sub>1</sub>	21.74 (27.77)a	19.50 (26.11)a	20.62 (26.96)a
T <sub>2</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58d)
T <sub>3</sub>	14.51 (22.35)b	12.40 (18.40)b	13.46 (21.50)b
T <sub>4</sub>	11.70 (20.00)c	10.51(17.20)b	11.11 (19.35)bc
T <sub>5</sub>	10.25 (18.62)c	8.79 (17.20)b	9.52 (17.94)c
T <sub>6</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
T <sub>7</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
T <sub>8</sub>	0.00 (0.58)d	0.00 (0.58)c	0.00 (0.58)d
<b>S.Em±</b>	0.75	1.62	1.04
<b>C.D @ 5 %</b>	2.28	4.92	3.14

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

Figures in parentheses are the arc sin transformed values

- |  |  |
|--|--|
| T <sub>1</sub> - Control   | T <sub>5</sub> - Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - Only bagging (No bunch treatment)   | T <sub>6</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

**Table 50: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on respiration rate of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Respiration rate (ml CO <sub>2</sub> /kg/h)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	114.04a	110.11a	112.07a	384.45a	369.26a	376.85a	284.75a	269.04a	276.90a
T <sub>2</sub>	108.74b	106.27b	107.50b	363.52c	354.34b	358.93c	251.02d	244.09c	247.55d
T <sub>3</sub>	104.45c	102.21c	103.33c	347.02d	338.81c	342.91d	240.81e	235.04d	237.92e
T <sub>4</sub>	100.78d	99.95cd	100.37d	343.74dc	340.65c	342.19d	234.82f	232.73d	233.78f
T <sub>5</sub>	112.76a	106.08b	109.42b	378.69ab	360.90b	369.80ab	278.99b	266.11a	272.55b
T <sub>6</sub>	101.82cd	99.65d	100.73d	336.35e	328.35d	332.35e	224.52g	217.42e	220.97g
T <sub>7</sub>	100.24d	97.00e	98.62d	336.32e	324.20d	330.26e	215.26h	208.00f	211.63h
T <sub>8</sub>	109.46b	105.25b	107.36b	371.61bc	354.30b	362.95bc	270.85c	260.54b	265.70c
<b>S.Em±</b>	0.90	0.84	0.74	3.50	2.44	2.65	1.68	1.26	1.07
<b>C.D @ 5 %</b>	2.74	2.54	2.23	10.63	7.41	8.03	5.09	3.84	3.25

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

was significantly followed by T<sub>6</sub> (224.52 ml g CO<sub>2</sub>/kg/h and 217.42 ml CO<sub>2</sub>/kg/h and 220.97 ml g CO<sub>2</sub>/kg/h) during 2014, 2015 and in pooled data.

#### 4.4.4.2 Physiological loss in weight (PLW) (%)

During 2014, T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) recorded minimum PLW both at ripe (4.42%) and at beginning of senescence stage (9.19%) followed significantly by T<sub>6</sub> (5.49%) (11.57%) at both stages *viz.*, ripe and beginning of senescence (Table 51). Similar trend was followed in 2015. Pooled data analysis for PLW revealed significantly minimum in the treatment T<sub>7</sub> (4.70% and 4.56% respectively) at ripe stage and (9.07% and 9.13%) at beginning of senescence stage. Maximum PLW during 2014, 2015 and for pooled analysis was found associated with T<sub>1</sub> (Control) at ripe stage (11.40%, 10.34% and 10.87% respectively) and at the beginning of senescence stage (15.11%, 14.17% and 14.64%). This treatment differed significantly over all other treatments.

#### 4.4.4.3 Shelf life (days)

In general, shelf life of banana fruits differed significantly under the influence of pre-harvest treatments (Table 51). The treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) recorded significantly maximum shelf life in 2014, 2015 as well as in pooled analysis (7.08 days, 7.58 days and 7.33 days) when compared to all other treatments. The least shelf life noticed in the control (T<sub>1</sub>) fruits (4.50 days, 4.67 days and 4.58 days) differed significantly over all other treatments.

#### 4.4.4.4 Instrumental Colour measurements ( $L^*$ , $a^*$ , $b^*$ $C^*$ and $h^o$ values)

##### 4.4.4.4.1 $L^*$ value

Significant differences among the treatments were observed for instrumental  $L^*$  values of banana fruits (var Ney Poovan) (Table 52).

Minimum  $L^*$  value at ripe stage was observed in the treatment T<sub>1</sub> (control) (54.22, 53.31 and 53.77) during 2014, 2015 and for pooled analysis. It differed significantly with all other treatments. On the other hand, significantly maximum  $L^*$

**Table 51: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on physiological loss in weight and shelf life of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Physiological loss in weight (%)						Shelf life (Days)		
	Ripe stage			Senescence stage					
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	11.40a	10.34a	10.87a	15.11a	14.17a	14.64a	4.50e	4.67f	4.58e
T <sub>2</sub>	9.50b	8.81b	9.16b	13.36cb	12.93ab	13.15b	5.58bcde	5.17ef	5.38de
T <sub>3</sub>	8.45c	8.36c	8.40d	13.25c	13.10ab	13.18b	6.67abc	6.42bcd	6.54ab
T <sub>4</sub>	8.36c	7.78d	8.07e	12.02d	11.96b	11.99c	6.25abcd	6.58bc	6.42bc
T <sub>5</sub>	8.75c	8.73b	8.74c	13.88b	12.74b	13.31b	5.25de	5.58def	5.42d
T <sub>6</sub>	5.49e	4.09g	4.79h	11.57e	10.63c	11.10d	7.08a	7.58a	7.33a
T <sub>7</sub>	4.42f	4.70f	4.56g	9.19f	9.07d	9.13e	6.75ab	7.08ab	6.92ab
T <sub>8</sub>	6.89d	6.77e	6.83f	13.24c	12.52b	12.88b	5.50cde	5.75cde	5.63cd
<b>S.Em±</b>	0.15	0.08	0.07	0.06	0.43	0.22	0.41	0.32	0.27
<b>C.D @ 5 %</b>	0.44	0.24	0.21	0.19	1.30	0.67	1.24	0.96	0.81

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

value was found in the treatment T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) 64.67 (2014), 63.78 (2015) and 64.23 (pooled analysis) which was found on par with T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (64.38, 63.17 and 63.78).

#### **4.4.4.4.2 *a*\* value**

The data concerning to *a*\* value of banana fruits as affected by different pre-harvest bunch treatments showed remarkable variations (Table 52).

Significant differences were observed with respect to '*a*\*' (redness) values at ripe stage of banana during two seasons of investigation. During 2014, 2015 and in pooled analysis, the maximum *a*\* value was obtained in the treatment T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) (9.73, 9.77 and 9.75) followed significantly by T<sub>8</sub> (8.80, 8.50 and 8.65). Contrastingly, the minimum significant value for *a*\* was observed with T<sub>1</sub> (control) during 2014 (5.05), 2015 (4.72) and for pooled analysed values (4.89).

#### **4.4.4.4.3 *b*\* value**

The *b*\* value represents change in fruit colour with respect to blueness or yellowness. The data on colour change with respect to *b*\* value of banana fruit as influenced by different treatments revealed significant differences among the treatments (Table 52).

The pooled analysis of 2 years data indicated maximum *b*\* value at ripe stage in treatment T<sub>7</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunch) (42.17) significantly followed by T<sub>6</sub> (41.10). The significantly minimum *b*\* value during this period of observation was found in the treatment T<sub>1</sub> (34.19).

#### **4.4.4.4.4 *C*\* value**

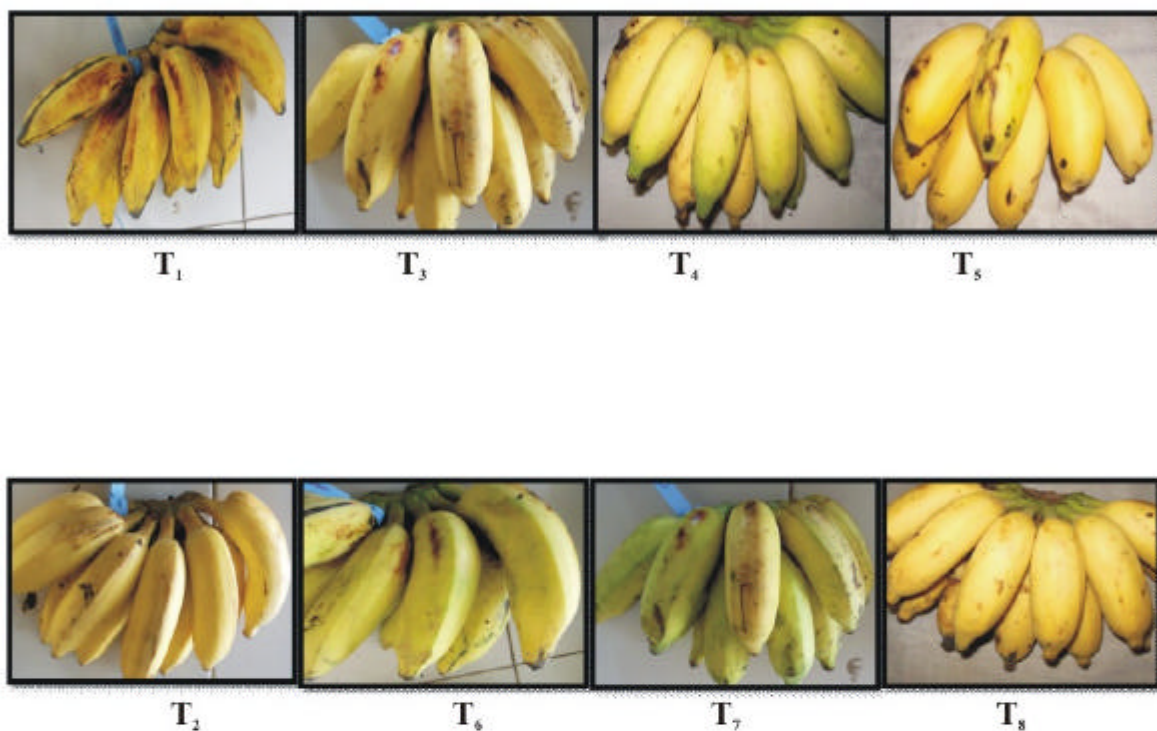
The data pertaining to *C*\* value as influenced by different pre harvest treatments on banana fruits at ripe stage revealed significant differences among the treatments (Table 52).

**Table 52: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on instrumental colour values ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $C^*$ ,  $H^\theta$ ) of banana fruits cv. 'Neypoovan' at ripe stage (AB)**

Treatments	$L^*$ (Lightness)			$a^*$ (Redness)			$b^*$ (Yellowness)			$C^*$ (Chroma)			$h^\theta$ (Hue angle)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	54.22d	53.31d	53.77d	5.05d	4.72e	4.89e	34.36f	34.01e	34.19f	31.47f	30.20e	30.84f	101.22a	101.15a	101.19a
<b>T<sub>2</sub></b>	61.12b	60.71b	60.92b	8.51b	7.99bc	8.25bc	40.18c	39.33bc	39.76c	35.77c	33.71c	34.74c	98.05c	97.05d	97.55d
<b>T<sub>3</sub></b>	60.89b	61.38b	61.14b	6.55c	6.20d	6.38d	39.54d	38.07d	38.80de	34.63de	32.56d	33.60d	99.62b	99.53bc	99.58bc
<b>T<sub>4</sub></b>	60.49bc	60.64b	60.57b	6.93c	7.46c	7.19c	39.67cd	39.19bc	39.43cd	34.68d	32.88d	33.78d	99.22b	99.37c	99.30c
<b>T<sub>5</sub></b>	58.89c	58.26c	58.57c	5.16d	4.79e	4.97e	38.52e	38.30cd	38.41e	33.99e	32.51e	33.25e	100.13b	100.42ab	100.28b
<b>T<sub>6</sub></b>	64.38a	63.17a	63.78a	8.80b	8.50b	8.65b	41.96b	40.24b	41.10b	38.78a	37.00a	37.89a	88.65e	88.09f	88.37f
<b>T<sub>7</sub></b>	64.67a	63.78a	64.23a	9.73a	9.77a	9.75a	42.91a	41.42a	42.17a	39.27a	36.70a	37.98a	87.31f	85.54g	86.43g
<b>T<sub>8</sub></b>	59.82bc	58.25c	59.04c	8.44b	8.29b	8.37b	41.83b	39.81b	40.82b	38.09b	35.20b	36.65b	90.18d	89.42e	89.80e
<b>SE. M±</b>	0.53	0.44	0.39	0.20	0.19	0.16	0.20	0.35	0.25	0.21	0.16	0.11	0.31	0.31	0.27
<b>CD @ 5%</b>	1.60	1.33	1.18	0.62	0.58	0.50	0.59	1.06	0.76	0.65	0.49	0.34	0.94	0.93	0.81

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D   |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)   | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |



T<sub>1</sub>- Control

T<sub>2</sub>- Only bagging (No bunch treatment)

T<sub>3</sub>- Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture

T<sub>4</sub>- Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture

T<sub>5</sub>- Application of 20 ppm of 2, 4-D

T<sub>6</sub>- Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches.

T<sub>7</sub>- Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml cowdung slurry mixture + polyethylene bagging of bunches

T<sub>8</sub>- Application of 20 ppm of 2, 4-D + polyethylene bagging of bunches

**Plate 12: Images showing fruits (Neypoovan) of different treatments after 8 days after harvesting**

Chroma ( $C^*$ ) values of banana differed significantly in both the seasons at ripe stage of storage. Significantly maximum  $C^*$  values were noted in  $T_7$  (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) during 2014 and in pooled analysis (39.27, 37.98). Whereas in 2015,  $T_6$  (37.00) recorded the highest chroma value which was on par with  $T_7$  (36.70). Minimum  $C^*$  values for similar observation periods were noticed in  $T_1$  (control) (31.47, 30.20 and 30.84).

#### 4.4.4.4.5 $h^o$ value

Instrumental  $h^o$  value of ripe banana fruits revealed significant differences among the treatments (Table 52).

The pooled data revealed significantly maximum  $h^o$  value of 101.99 and 100.28 in the treatments  $T_1$  and  $T_5$  respectively. Both these treatments differed significantly between themselves and with other treatments. The minimum  $h^o$  value found in  $T_7$  (86.43) at ripe stage was closely and significantly followed by  $T_6$  (88.37).

### 4.4.5 Quality parameters

#### 4.4.5.1 Total soluble solids ( $^oB$ )

The mean TSS of banana fruits at mature green stage was recorded to be 5.49  $^oB$ , while the values ranged from 5.17  $^oB$  to 6.04  $^oB$  among the treatments of both the years data. The total soluble solids (TSS) of banana fruits registered a sharp rise at ripe stage with a slight further increase at senescence stage (Table 53).

Fruits treated with  $T_7$  (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) (26.55  $^oB$ , 26.80  $^oB$  and 26.67  $^oB$ ) were found to have higher total soluble solids (TSS) when compared to all other treatments at optimum ripe stage during 2014, 2015 and even in pooled data (Table 53) except the treatment  $T_6$  (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water+ bagging of bunches) (26.21  $^oB$ , 26.30  $^oB$  and 26.35  $^oB$ ) and  $T_4$  (26.11  $^oB$ , 26.50  $^oB$  and 26.31  $^oB$ ). The treatment continued to show higher level of TSS even in later stages of ripening in comparison to other treatments. Thus, maximum total soluble solids content at the beginning of senescence stage were

**Table 53: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on total soluble solids of banana fruits cv. 'Neypoovan' (AB)**

Treatments	TSS ( <sup>o</sup> B)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	5.23cd	5.17e	5.20d	22.78d	23.61e	23.19e	27.90c	29.33c	28.61e
<b>T<sub>2</sub></b>	5.27cd	5.34cde	5.31d	23.81c	25.07d	24.44d	29.11bc	31.03b	30.07bc
<b>T<sub>3</sub></b>	5.47b	5.49c	5.48c	25.05b	25.95bc	25.50b	29.61ab	29.82c	29.72cd
<b>T<sub>4</sub></b>	5.70a	5.76b	5.73b	25.90a	26.51ab	26.20a	30.09ab	31.39ab	30.74ab
<b>T<sub>5</sub></b>	5.20d	5.30de	5.25d	24.53bc	24.63d	24.58cd	28.85bc	29.45c	29.15de
<b>T<sub>6</sub></b>	5.50b	5.77b	5.64b	26.21a	26.27ab	26.24a	29.33bc	31.38ab	30.36bc
<b>T<sub>7</sub></b>	5.73a	6.04a	5.89a	26.55a	26.79a	26.67a	30.86a	31.85a	31.36a
<b>T<sub>8</sub></b>	5.40bc	5.48cd	5.44c	25.06b	25.36cd	25.21bc	29.35bc	29.21c	29.28d
<b>S.Em±</b>	0.06	0.06	0.04	0.24	0.25	0.22	0.50	0.24	0.22
<b>C.D @ 5 %</b>	0.20	0.18	0.12	0.74	0.77	0.68	1.51	0.72	0.66

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D   |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)   | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

recorded in T<sub>6</sub> (30.86 °B - 2014, 31.85 °B - 2015 and 31.36 °B - pooled analysis). However, T<sub>4</sub> (30.09 °B, 31.39 °B, 31.36 °B) was at parity with T<sub>6</sub>.

The lower TSS content during 2014, 2015 and in pooled data was noticed in T<sub>1</sub> at ripe stage (22.78 °B, 23.60 °B and 23.19 °B respectively) and at the beginning of senescence stage (27.90 °B, 29.33 °B and 28.61 °B).

#### **4.4.5.2 Titratable acidity (%)**

Titratable acidity of banana fruits under ambient storage exhibited significant differences among the treatments. Mean initial value of titratable acidity was recorded to be 0.19 per cent with range varying from 0.17 per cent to 0.21 per cent at mature green stage (Table 54). The parameter exhibited an increasing trend at ripe stage followed by a decreasing trend at senescence stage.

Pooled analysis at optimum ripe stage of banana fruits revealed significantly maximum acidity in T<sub>1</sub> (control) (0.40%) than rest of the treatments except T<sub>2</sub> (0.39%). However, the minimum titratable acidity was recorded in the treatment T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water+ bagging of bunches) (0.33%) was non-significantly followed by T<sub>6</sub> (0.34%).

Conversely, the minimum titratable acidity was noted in T<sub>1</sub> (control) at beginning of senescence stage for pooled analysis (0.25%). This treatment was found to be significant with all the other treatments except T<sub>5</sub> (0.26) and T<sub>3</sub> (0.26). However, the higher values were noticed in T<sub>7</sub> (0.29%) and it was found significant over all other treatments.

#### **4.4.5.3 Total sugars (%)**

The effect of pre-harvest bunch treatments on total sugars of banana fruits during ambient storage revealed the same trend as total soluble solids. Significant variations were observed among the treatments all through the storage duration. The initial mean total sugar observed in the fruits at mature green stage was 1.52 per cent with range varying from 1.49 per cent to 1.55 per cent at green stage. The results of pooled data of total sugars during the storage period are as follows (Table 55).

**Table 54: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on acidity of banana fruits cv. 'Neyypoovan' (AB)**

Treatments	Acidity (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.200	0.210	0.205	0.407a	0.410a	0.409a	0.259c	0.252e	0.255d
T <sub>2</sub>	0.190	0.200	0.195	0.381b	0.405a	0.393a	0.273bc	0.275cd	0.274bcd
T <sub>3</sub>	0.180	0.190	0.185	0.353c	0.376bc	0.365a	0.263c	0.268d	0.265cd
T <sub>4</sub>	0.173	0.183	0.178	0.345c	0.358cd	0.352bc	0.279b	0.277bc	0.278bc
T <sub>5</sub>	0.203	0.210	0.207	0.375b	0.387ab	0.381cd	0.262c	0.265d	0.264cd
T <sub>6</sub>	0.187	0.200	0.193	0.331d	0.340d	0.335ab	0.285ab	0.288ab	0.287ab
T <sub>7</sub>	0.180	0.193	0.187	0.328d	0.338d	0.333d	0.296a	0.303a	0.299a
T <sub>8</sub>	0.203	0.177	0.190	0.353c	0.358cd	0.356bcd	0.274bc	0.279bc	0.277bc
<b>S.Em±</b>	0.007	0.006	0.005	0.006	0.009	0.007	0.005	0.004	0.004
<b>C.D @ 5 %</b>	NS	NS	NS	0.017	0.028	0.020	0.015	0.012	0.011

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

The treatment T<sub>1</sub> (control) recorded minimum total sugar content at ripe stage (19.11%). This treatment was significantly followed by T<sub>2</sub> (control +bagging) (20.22%). On the other hand, maximum total sugars (25.00%) were associated with T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water+ bagging of bunches) which was significantly (24.16%) followed by T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water + bagging of bunches).

At senescence stage of banana fruits, the highest significant total sugars was noted in T<sub>7</sub> (29.19%). The treatment T<sub>1</sub> showed minimum total sugar (27.14%) and it was found to be significantly different over all other pre-harvest bunch treatments.

#### **4.4.5.4 Reducing sugars (%)**

The reducing sugars of banana fruits influenced by various pre-harvest treatments and stored at ambient conditions revealed significant differences. The initial mean reducing sugars in the fruits (mature green stage) were 1.09 per cent and range varied from 1.06 per cent to 1.14 per cent among the treatments (Table 56).

At ripe stage, significantly maximum reducing sugars were recorded in T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water+ bagging of bunches) (21.05%) 2014, (21.68%) 2015 and (21.36%). While, control (T<sub>1</sub>) fruits were observed to have minimum reducing sugar content during 2014, 2015 and pooled analysis (14.62%, 14.73% and 14.67%).

The treatment T<sub>7</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water+ bagging of bunches) was found to have maximum reducing sugar in both years as well as in pooled analysis (25.16%, 25.24% and 25.20%) at the beginning of senescence stage, and it was significantly different from other treatments. However, minimum amount of reducing sugars were found in T<sub>1</sub> (20.46%, 20.57% and 20.51%) and this treatment was significantly followed by T<sub>2</sub>.

#### **4.4.5.5 Non-reducing sugars (%)**

Non-reducing sugars of banana fruits disclosed significant differences among the treatments. The initial mean non-reducing sugar content found in banana fruits

**Table 55: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on total sugars of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Total Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	1.49	1.51	1.50	19.42f	18.80e	19.11g	26.53g	27.74de	27.14f
T <sub>2</sub>	1.51	1.51	1.51	20.08e	20.37d	20.22f	27.86f	28.30cd	28.08de
T <sub>3</sub>	1.53	1.52	1.52	20.85d	20.72d	20.78e	28.02e	27.66e	27.84e
T <sub>4</sub>	1.54	1.53	1.53	22.26c	22.69c	22.47d	29.68a	29.97a	29.83a
T <sub>5</sub>	1.51	1.52	1.51	20.31de	20.67d	20.49ef	27.93ef	27.82de	27.88e
T <sub>6</sub>	1.53	1.52	1.52	23.81b	24.50b	24.16b	28.63d	28.61c	28.62c
T <sub>7</sub>	1.55	1.55	1.55	24.67a	25.32a	25.00a	29.06b	29.33b	29.19b
T <sub>8</sub>	1.52	1.54	1.53	23.46b	23.99b	23.72c	28.87c	27.49e	28.18d
<b>S.Em±</b>	0.023	0.025	0.019	0.20	0.21	0.14	0.04	0.21	0.10
<b>C.D @ 5 %</b>	NS	NS	NS	0.61	0.65	0.42	0.11	0.62	0.30

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

**Table 56: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on reducing sugars of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	1.06	1.07	1.06	14.62g	14.73h	14.67h	20.46g	20.57g	20.51f
T <sub>2</sub>	1.07	1.07	1.07	15.21f	15.45g	15.33g	22.33f	22.7e	22.52e
T <sub>3</sub>	1.08	1.08	1.08	15.11f	16.17f	15.64f	22.85e	23.53c	23.19d
T <sub>4</sub>	1.11	1.10	1.11	17.32d	17.97d	17.65e	23.73d	24.38b	24.06b
T <sub>5</sub>	1.08	1.08	1.08	16.69e	17.62e	17.16d	23.01e	21.96f	22.49e
T <sub>6</sub>	1.07	1.08	1.07	20.30b	21.04b	20.67b	24.55b	23.74c	24.15b
T <sub>7</sub>	1.13	1.14	1.14	21.05a	21.68a	21.36a	25.16a	25.24a	25.2a
T <sub>8</sub>	1.08	1.07	1.07	19.74c	20.46c	20.10c	24.10c	23.13d	23.62c
<b>S.Em±</b>	0.017	0.037	0.020	0.07	0.05	0.03	0.07	0.08	0.06
<b>C.D @ 5 %</b>	NS	NS	NS	0.20	0.15	0.08	0.23	0.24	0.18

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

was 0.41 per cent (Table 57). The results of pooled data of non-reducing sugars at mature green stage varied from 0.39 per cent to 0.42 per cent and results at subsequent stage of study are as follows.

Significantly minimum non-reducing sugars at ripe stage were associated with T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water+ bagging of bunches) (3.32%) which was significantly followed by T<sub>5</sub> (Application of 2,4 –D at 20 ppm) (3.44). On the other hand, T<sub>3</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water) was associated with the maximum non-reducing sugars (4.78%) followed by T<sub>2</sub> (control+ bagging) (4.65%).

Maximum non-reducing sugars at the beginning of senescence stage of banana fruits were associated with the treatment T<sub>1</sub> (6.29%), followed significantly by T<sub>4</sub> (5.48%) and T<sub>3</sub> (5.42%). In contrast, minimum non-reducing sugar documented in T<sub>7</sub> (3.79%) was found significant over all other treatments.

#### **4.4.5.6 Sugar acid ratio**

The influence of different pre-harvest bunch treatments on sugar acid ratio of banana fruits showed significant differences among the treatments ranging from 7.17 to 8.60 during initial mature green stage (Table 58).

At ripe stage, the treatment T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) recorded maximum sugar acid ratio of 75.35 (2014), 74.86 (2015) and 75.10 (pooled analysis) and it was non-significantly followed by T<sub>6</sub> (72.07, 72.59 and 72.33). However, significantly minimum sugar acid ratio was observed in T<sub>1</sub> (control) in both consecutive years (47.67, 45.82) and for pooled analysis (46.75).

Conversely maximum sugar acid ratio during 2014, 2015 and in pooled analysis was observed in T<sub>3</sub> (107.08), T<sub>1</sub> (110.21) and T<sub>4</sub> (107.40) respectively at beginning of senescence stage. Significantly minimum sugar acid ratio was associated with treatments T<sub>7</sub> (98.28, 96.25 and 97.62) and T<sub>6</sub> (100.37, 99.35 and 99.86) and were found on par with each other.

**Table 57: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on non-reducing sugars of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Non-Reducing Sugars (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	0.41	0.42	0.41	4.56b	3.86c	4.21a	5.77a	6.81a	6.29a
T <sub>2</sub>	0.41	0.42	0.41	4.63b	4.67a	4.65b	5.25b	5.31b	5.28b
T <sub>3</sub>	0.42	0.41	0.42	5.23a	4.32b	4.78a	5.91c	4.92d	5.42c
T <sub>4</sub>	0.41	0.40	0.41	4.69b	4.48f	4.58b	5.66a	5.31b	5.48b
T <sub>5</sub>	0.41	0.41	0.41	3.44c	2.89e	3.16f	4.67e	5.57b	5.12b
T <sub>6</sub>	0.43	0.42	0.43	3.34c	3.29d	3.32e	3.88d	4.63c	4.25c
T <sub>7</sub>	0.39	0.38	0.39	3.45c	3.46d	3.45d	3.70e	3.88d	3.79c
T <sub>8</sub>	0.42	0.45	0.44	3.53c	3.35d	3.44d	4.52d	4.14cd	4.33c
<b>S.Em±</b>	0.026	0.050	0.032	0.06	0.059	0.04	0.07	0.21	0.130
<b>C.D @ 5 %</b>	NS	NS	NS	0.20	0.18	0.12	0.23	0.63	0.40

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

#### 4.4.5.7

#### 4.4.5.8 Starch (%)

The starch content of banana fruits revealed a gradual decreasing tendency throughout their post harvest period. The initial mean starch content of banana fruits was recorded to be 21.45 per cent from the range of 21.41 per cent to 21.51 per cent between the treatments during mature green stage of fruits (Table 59).

Starch content of banana fruits varied significantly among the treatments at ripe stage. During 2014, 2015 and in pooled analysis of data, fruits under the treatment T<sub>1</sub> (control) (3.33%, 3.21% and 3.27%) and T<sub>5</sub> (3.38%, 3.50% and 3.44%) were on par with each other and showed significantly lower starch content over other treatments. Significantly maximum starch content during both the years and for pooled data was observed in T<sub>7</sub> (5.04%, 5.15% and 5.09%) followed by T<sub>4</sub> (4.46, 4.34 and 4.40%).

Similarly, at senescence stage, maximum starch content was found in T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) 1.53 per cent (2014), 1.76 per cent (2015) and 1.64 per cent (for pooled analysis) which was closely and non-significantly followed by treatment T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100 ml water + bagging of bunch) (1.39%) during 2014 and significantly (1.58% and 1.49%) during 2015 and in pooled analysis respectively. The minimum content of starch was noted in T<sub>1</sub> (1.03%, 1.12% and 1.08%) for both the years and pooled analysis.

### 4.4.6 Organoleptic evaluation

#### 4.4.6.1 Peel colour and appearance

Peel colour and appearance exhibited significant differences among the treatments (Table 60). Fruits of banana bunches applied with slurry mixture, ammonium sulphate and SOP, then bagged with skirting materials (T<sub>7</sub>) obtained higher score (8.32, 8.19 and 8.25 respectively) than all other treatments during 2014, 2015 and when analysed by pooling 2 years data. Treatment T<sub>8</sub> (Application of 20 ppm 2,4-D + bagging of bunch) was on par with T<sub>7</sub> with next best scores (8.23, 8.03

**Table 58: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on sugar acid ratio of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Sugar acid ratio								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	7.45e	7.17e	7.31e	47.67e	45.82d	46.75e	102.46abc	110.21a	106.34ab
T <sub>2</sub>	7.93d	7.55cd	7.74d	52.74d	50.26cd	51.50d	102.07abc	103.04cd	102.56bc
T <sub>3</sub>	8.48b	8.00b	8.24bc	59.15c	55.49c	57.32c	107.08a	103.33bcd	105.20ab
T <sub>4</sub>	8.87a	8.33b	8.60a	64.46b	63.45b	63.96b	106.45a	108.34ab	107.40a
T <sub>5</sub>	7.43e	7.22de	7.33e	54.16d	53.42c	53.79cd	106.48a	105.14abc	105.81ab
T <sub>6</sub>	8.18c	7.60c	7.89d	72.07a	72.59a	72.33a	100.37bc	99.35de	99.86cd
T <sub>7</sub>	8.59b	8.01b	8.30b	75.35a	74.86a	75.10a	98.28c	96.95de	97.62d
T <sub>8</sub>	7.48e	8.74a	8.11c	66.52b	66.97b	66.75b	105.23ab	98.80e	102.02bcd
<b>S.Em±</b>	0.08	0.11	0.06	1.08	1.73	1.23	1.92	1.68	1.54
<b>C.D @ 5 %</b>	0.24	0.33	0.19	3.27	5.25	3.72	5.82	5.11	4.66

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |                  |   |                  |   |
|------------------|---|------------------|---|
| T <sub>1</sub> - | Control   | T <sub>5</sub> - | Application of 20 ppm of 2, 4-D   |
| T <sub>2</sub> - | Only bagging (No bunch treatment)   | T <sub>6</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| T <sub>3</sub> - | Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | T <sub>7</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| T <sub>4</sub> - | Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | T <sub>8</sub> - | Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

**Table 59: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on starch content of banana fruits cv. 'Neypoovan' (AB)**

Treatments	Starch (%)								
	Mature green stage			Ripe stage			Senescence stage		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	21.41e	21.43d	21.42d	3.33d	3.21d	3.27d	1.03c	1.12d	1.08d
<b>T<sub>2</sub></b>	21.43cd	21.43d	21.43d	3.79c	4.06bc	3.93c	1.17bc	1.35c	1.26c
<b>T<sub>3</sub></b>	21.45c	21.46bcd	21.45c	4.23b	4.36b	4.30b	1.08c	1.14d	1.11d
<b>T<sub>4</sub></b>	21.45bc	21.47abc	21.46bc	4.46b	4.34b	4.40b	1.15bc	1.21d	1.18cd
<b>T<sub>5</sub></b>	21.42de	21.45bcd	21.43d	3.38d	3.50d	3.44d	1.10c	1.16d	1.13cd
<b>T<sub>6</sub></b>	21.47ab	21.48ab	21.48b	3.78c	3.91c	3.85c	1.39ab	1.58b	1.49b
<b>T<sub>7</sub></b>	21.48a	21.51a	21.50a	5.04a	5.15a	5.09a	1.53a	1.76a	1.64a
<b>T<sub>8</sub></b>	21.42de	21.45cd	21.44a	3.73c	3.86c	3.79c	1.36ab	1.51b	1.44b
<b>S.Em±</b>	0.01	0.01	0.01	0.08	0.10	0.07	0.08	0.05	0.05
<b>C.D @ 5 %</b>	0.03	0.04	0.02	0.25	0.31	0.22	0.24	0.14	0.14

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D   |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)   | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

and 8.13). The treatment T<sub>1</sub> (control) received minimum score for peel colour and appearance (4.91, 5.06 and 4.98 respectively) in 2014, 2015 and in analysed pooled data.

#### **4.4.6.2 Pulp colour and appearance**

Pulp colour and appearance also showed significant differences during 2014, 2015 and in pooled analysis (Table 60). In 2014, 2015 and for pooled analysis maximum score for pulp colour and appearance was noted in T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) (8.28, 7.95 and 8.12 respectively).

Minimum score for pulp colour and appearance was received by T<sub>1</sub> (control) with 4.79 in 2014, 4.98 in 2015 and 4.89 in pooled analysis. It was significantly followed by the treatments T<sub>2</sub> (control +bagging) (5.88, 5.72 and 5.80) for similar periods of observation.

#### **4.4.6.3 Pulp texture**

Organoleptic scores for texture of banana fruit differed significantly among different treatments (Table 60). Fruits treated with T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate+7.5g SOP in 100ml water + bagging of bunch) (7.17) showed maximum score for texture during 2014, whereas in 2015 and in pooled analysis T<sub>6</sub> (8.38 and 7.24) scored maximum, while pooled score for texture (7.24) was similar in T<sub>8</sub> and T<sub>6</sub>.

The least score of 4.02 (2014), 4.61 (2015) and 4.32 (pooled data analysis) was observed in T<sub>1</sub> (control) and was found significant over all the other treatments of the investigation.

#### **4.4.6.4 Taste and flavour**

Significant differences were observed with respect to taste and flavour both during 2014, 2015 and when the 2 years' data was analysed after pooling (Table 60). Significantly higher score for taste and flavour was obtained in the treatment T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate+7.5g SOP in 100 ml

**Table 60: Influence of pre-harvest bunch treatments (bunch feeding of nutrients) and bagging of banana bunches on sensory attributes of banana fruits var. 'Neypoovan' (AB)**

Treatments	Peel colour and appearance			Pulp colour and appearance			Pulp texture			Taste and flavour			Overall acceptability		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>T<sub>1</sub></b>	4.91g	5.06e	4.98f	4.79e	4.98f	4.89g	4.13e	4.61f	4.37d	5.28f	5.34e	5.31e	4.44f	4.85f	4.65f
<b>T<sub>2</sub></b>	6.02f	6.29d	6.15e	5.88d	5.72e	5.80f	4.68d	5.57e	5.12e	5.82e	6.10d	5.96d	5.02e	5.46e	5.24e
<b>T<sub>3</sub></b>	7.16e	7.23c	7.19d	7.14c	6.82c	6.98d	6.42b	6.36d	6.39b	8.04b	8.59a	8.32a	7.05d	7.05d	7.05d
<b>T<sub>4</sub></b>	7.71c	7.52b	7.61c	7.47bc	7.83a	7.65b	7.05a	7.03bc	7.04a	8.16b	7.19c	7.68c	7.91b	8.12a	8.02b
<b>T<sub>5</sub></b>	8.01b	7.98a	8.00b	7.78b	7.64b	7.71b	5.85c	7.25bc	6.55b	7.21d	7.71bc	7.46c	7.30cd	7.49c	7.39c
<b>T<sub>6</sub></b>	7.45d	7.69b	7.57c	7.05c	7.69b	7.37c	6.10bc	8.38a	7.24a	8.11b	8.16ab	8.14ab	7.47c	7.62b	7.55c
<b>T<sub>7</sub></b>	8.32a	8.19a	8.25a	8.28a	7.95a	8.12a	7.17a	6.83cd	7.00a	8.43a	8.56a	8.50a	8.42a	8.24a	8.33a
<b>T<sub>8</sub></b>	8.23ab	8.03a	8.13ab	6.30d	5.89d	6.10e	7.01a	7.46b	7.24a	7.57c	8.03bc	7.80bc	7.43c	7.55bc	7.49c
<b>S.Em±</b>	0.07	0.09	0.06	0.14	0.05	0.07	0.12	0.18	0.13	0.06	0.24	0.12	0.10	0.05	0.05
<b>C.D @ 5 %</b>	0.21	0.27	0.19	0.44	0.14	0.21	0.37	0.55	0.39	0.17	0.72	0.37	0.29	0.14	0.15

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at  $P = 0.05$

- |  |  |
|--|--|
| <b>T<sub>1</sub></b> - Control   | <b>T<sub>5</sub></b> - Application of 20 ppm of 2, 4-D   |
| <b>T<sub>2</sub></b> - Only bagging (No bunch treatment)   | <b>T<sub>6</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches.             |
| <b>T<sub>3</sub></b> - Bunch feeding with 7.5g of urea + 7.5g of SOP in 500 ml of cow dung slurry mixture              | <b>T<sub>7</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture + polyethylene bagging of bunches |
| <b>T<sub>4</sub></b> - Bunch feeding with 7.5g of ammonium sulphate + 7.5g of SOP in 500 ml of cow dung slurry mixture | <b>T<sub>8</sub></b> - Application of 20 ppm of 2, 4-D+ polyethylene bagging of bunches  |

water + bagging of bunch) during 2014 (8.43), 2015 (8.56) as well as in pooled analysis (8.50). The treatment T<sub>7</sub> was significantly followed by T<sub>6</sub> (Application of slurry mixture with 7.5g urea +7.5g SOP in 100ml water +bagging of bunch) (8.11, 8.16 and 8.14) in 2014, 2015 and in pooled analysis. The least scoring control (T<sub>1</sub>) (5.28, 5.34 and 5.31) during 2014, 2015 and when analysed by pooling 2 years data was statistically significant over all other treatments.

#### **4.4.6.5 Overall acceptability**

Overall acceptability data revealed significant differences during 2014, 2015 and in pooled analysis (Table 60). In 2014 and 2015, higher overall acceptability scores were obtained by the treatment T<sub>7</sub> (Application of slurry mixture with 7.5g ammonium sulphate +7.5g SOP in 100ml water + bagging of bunch) (8.42, 8.24). Pooled analysis of data revealed similar trend as in the individual years, with fruits of T<sub>7</sub> (8.33) receiving maximum score for overall acceptability. The treatment T<sub>1</sub> received significantly minimum score (4.44, 4.85 and 4.65) in comparison to all other treatments.

## 5. DISCUSSION

One of the major problems in the banana production is the lower yield, small finger size, poor quality and shelf life associated with poor management practices, improper and imbalanced supply of nutrients during growth and productive stages. The whole complex of crop production with the resultant yield on a profitable basis is based mainly on balanced nutrition under congenial agro-ecological conditions. Banana is a heavy feeder of nutrients and thus needs balanced nutrition for better growth, development, potential yield and quality of fruits.

In the present investigation banana fruits Grand Naine and Ney Poovan were selected. Grand Naine is a popular variety and Ney Poovan is a commercial cultivar of banana grown in many parts of Karnataka. Both are relished for their characteristic sweet aroma with good sugar acid blend by different groups.

Keeping this in view, the present study was undertaken with an objective to improve the quality and yield of banana fruits by different methods *viz.*, bunch spraying of nutrients, use of growth regulator and feeding of distal end of bunch stalk with nutrients. In addition to these bunch treatments, skirting (bagging) material was used to assess the bunch development, yield and quality, and also to check incidence on pest and diseases.

The results obtained in these experiments with regard to yield, quality, enhancement of shelf life and the effect of treatments on physico-chemical quality of banana fruits var. 'Grand Naine' and cv. 'Ney Poovan' are discussed here under.

### **5.1 Effect of bunch sprays of potassium silicate and bagging on Banana var. Grand Naine and cv. Ney Poovan**

#### **5.1.1 Bunch weight and finger characters**

In the present investigation, bunch weight was maximum in bunches applied silicon treatments in both banana var. Grand Naine and cv. Ney Poovan in comparison to untreated control. Prophylactic role of silicon against several stresses is observed in a variety of plant species (Epstein and Bloom, 2005). According to Ma and Takahashi (2002) silicon can benefit through increased plant growth and crop

quality, stimulate photosynthesis, reduced transpiration rate and increased plant resistance to abiotic and biotic stresses. Silicon contributes to greater stalk strength and resistance to lodging by contributing to the structure of cell wall. Silicon impregnates the walls of epidermal and vascular tissues where it appears to strengthen the tissues, retards fungal infection and reduces water loss. It increases photosynthesis because of better light interception (Tisdale *et al.*, 1993). The yield increase in wheat was attributed to increase in plant water status, chlorophyll content, coupled with reduced values of water potential, increase in dry matter accumulation, dry matter production rate, leaf area and decrease in transpiration rate coupled with decrease in stomatal conductance (Pandey and Yadav, 1999). Though most of the research conducted on Si has been confined to field crops, unarguably it can even benefit in horticultural crops such as banana as the mechanism of its physiological action in the plant system has been proved.

In addition, banana bunches covered with skirting material (PE sleeves) registered an increase in yield in the present study. Fruits undergo several physical and chemical changes and are susceptible to insect pest infestations, bird attack, various pathogens, and mechanical damage during their growth and development. All these can reduce their commercial value and thereby cause significant yield and economic losses. To prevent the losses caused by biotic and abiotic factors, several good agricultural practices (GAP) are becoming popular throughout the World (Sharma, 2009). More emphasis is being placed on reducing the use of pesticides to ensure worker safety, consumer health, and environmental protection (Sharma *et al.*, 2009). Among several such alternatives, pre-harvest fruit bagging has emerged as an effective approach in different parts of the World. In this technique, individual fruit or fruit bunches are bagged on the tree for a specific period.

Bagging is a physical protection technique, commonly applied to many fruit, which not only improves their visual quality by promoting peel colouration and reducing the incidence of fruit cracking and russeting, but it can also change the microenvironment for fruit development (Fan and Mattheis, 1998). Thus, an improvement noticed with regard to bunch and bunch characters both in Grand Naine and Ney Poovan in covered bunches could be attributed to the reduced temperature inside the sleeves as compared to outside temperature. Further, the bunch covering

also helps to slight increase in the humidity inside the cover which might have resulted in better developments of fruits in these treatments and also the bunch covered with sleeves had no blemishes and injuries as they were free from pest attack and disease incidence. Reddy (1989) reported a slightly increase in the diameter and weight of finger in polythene covered bunches. Findings of Haladankar *et al.*, (2015) in mango and Weerasinghe and Ruwaphathirana, (2002) in banana also reported an increase in the fruit size at harvest in fruits or bunches sealed with polythene bag.

The beneficial effects of bunch covers in increasing the yield of banana have been reported by many workers (Anon 2011a and 2011b; Anon 2013) in banana. A study reported an increase in bunch weight by 2.8 kg in Grand Naine, 2.1 kg in Ney Poovan and 1.6 kg in Rasthali banana over control (Anon, 2013). Similar results were also observed by Kassem *et al.* (2011) in Zaghoul date palm, Mohamed *et al.* (2012) in Barhee date palm and Abbsai *et al.* (2014) in guava. The findings of above workers are in accordance with the results obtained in the present investigation.

The maximum pooled (2014 and 2015) bunch weight (32.69 kg/plant and 12.87 kg/ plant) was recorded in the treatment (T<sub>8</sub>) with bunch spraying of potassium silicate at 6ml/l + bagging of bunches at 30 days interval and lowest was recorded in the control T<sub>1</sub> (Table 1 and 16) in both var. Grand Naine and cv. Ney Poovan. The increase in bunch weight could be the result of an increase in bunch size and finger size and numbers. The increase in finger size can be a major factor contributing to the bunch weight. The similar observation was recorded by Bhavya (2010) in Bangalore Blue grapes.

The maximum total number of fingers per bunch in pooled data was recorded in the plants bunch sprayed with potassium silicate + bagging of bunches as compared to control. Maximum number of fingers per bunch (203.83 and 152.00) was recorded in the plants with (T<sub>8</sub>) bunch spraying of potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval + bagging of bunches and the lowest number of fingers per bunch (159.67 and 123.83) was recorded in the control (Table 1 and 16) in both types of fruits. Silicon helps in cell division; Si improves the structural stability of cell walls during cell elongation and division and thereby maintains cell shape, which may be important for the function and survival of cells (Sivanesan and Park 2014), Silicon in plants can stimulate nutrient uptake and plant photosynthesis (Smith, 2011).As silicon

helps in cell division, may result in production of more number of fruits. Similar observations were made by Gorecki and Danielskibusch (2009) in green house cucumber where results revealed that, increased yield was attributed on the number of fruits. Nesreen *et al.* (2011) noticed application of silicon increased the number of pods per plant in beans. Stamatakis *et al.* (2003) reported that, silicon application increased fruit retention and increased number of fruits per plant and similar results were observed by Bhavya (2010) in Bangalore Blue grapes.

Results indicated profound influence of foliar application of silicon and bagging treatments on finger characters *viz.*, finger weight, finger length and finger diameter. These parameters recorded significantly maximum values in silicon and bagging treatments than in untreated control. The increase in finger size might be due to higher photosynthetic activity and biomass production in the plant which might have resulted in more metabolites in the fruits (Young *et al.*, 1996). As the growth and development of the fingers advances, large amount of water and other metabolites moves in to the fingers resulting in higher fruit weight, length and diameter.

The maximum pooled finger weight (150.71g and 83.87g at mature stage, and 144.60 g and 77.12g at ripe stage) during both the years of study was recorded in the treatment T<sub>8</sub> (foliar application of potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval+ bagging of bunches) and the lowest (121.72g and 67.83g at mature, and 115.6g and 60.69g at ripe stage) was recorded in T<sub>1</sub> (control) (Table 2 and 17) in both Grand Naine and Ney Poovan. Silicon in plants can stimulate nutrient uptake and plant photosynthesis (Smith, 2011). The increase in finger weight was mainly due to cell division in the initial stages and later due to cell expansion associated with movement of water and other metabolites into the cell causing increase in overall weight of the finger. Similar findings have been reported by Young *et al.* (1996). Nesreen *et al.* (2011) recorded an increase in pod weight in beans plant, Mustaffa *et al.* (2004) and Bhavya (2010) in Bangalore Blue grapes.

The maximum pooled finger length (20.33 and 14.00 cm) was found in the treatment T<sub>8</sub> (foliar application of potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval + bagging of bunches) in both types of fruits (Table 2 and 17). The plants receiving foliar treatment also resulted in higher finger diameter. The maximum pooled (2014 and 2015) finger diameter (3.79 cm and 2.80 cm) was recorded in the

treatment T<sub>8</sub> (bunch spraying of potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval + bagging of bunches). Similar findings were observed in grapes by Shukla *et al.* (2011) and Bhavya (2010) reported that, this might be due to beneficial effect of nutrients which led to cell expansion.

The increase length, diameter and weight of finger could also be due to the effect of skirting materials. The growth and development of a plant organ follows a rhythm and log phase contributes maximum to increase in size. Covering fruits with a bag at a particular developmental stage may influence their growth and size. According to Xu *et al.*, (2008) bagging with plastic bags increased fruit weight in carambola when applied 10 days after full bloom.

The significant increase in finger characters in the present study due to skirting of banana bunches could be attributed to enhanced heat units in comparison to uncovered control. These results are in agreement with those obtained by Awad (2007) in date palm. Johns and Scott (1989) reported that the length, girth and weight of covered banana bunches was increased by 11, 13 and 37 per cent respectively. However, reports on the effects of fruit bagging on fruit size and weight have been contradictory, and may be due to differences in the type of bag used, fruit age at bagging, fruit and cultivar responses, prevailing climatic conditions *etc.* (Tyas *et al.*, 1998; Zhen *et al.*, 2000; Wang *et al.*, 2002; He *et al.*, 2003; Huang *et al.*, 2007; Chen *et al.*, 2012; Zhou *et al.*, 2012). Fruit bagging can increase, reduce, or have no effect on fruit weight and size. Nevertheless, positive response of bagging was observed by Justus *et al.* (2006) in peach, Harhash and Al-Obeed (2010) in date palm, Kassem *et al.* (2011) in Zaghloul date palm, Abbasi *et al.* (2014) in guava, and in banana (Annon, 2013) which supports the present findings.

On the other hand significant variations in finger quality *viz.*, pulp weight and peel weight were observed in both Grand Naine and Ney Poovan (Table 3 and 18). The maximum pooled values for pulp weight (111.80 g) in T<sub>8</sub>, peel weight (34.45g) in T<sub>4</sub> were recorded in banana var. Grand Naine. But in Ney Poovan maximum pooled values for pulp weight (68.85 g) and peel weight (8.28 g) were recorded in T<sub>8</sub>. The favourable effects of fruit bagging on quality improvement in banana have also been reported (Anon, 2003). The increase in pulp weight and pulp percentage in this study could also be due to beneficial role of silicon (Roshdy *et al.*, 2014), leading to

production of higher quantities of photosynthates and their translocation to the growing fingers. These results are also in accordance with findings of Kaluwa *et al.* (2010) in Avocado and in banana (Anon, 2013). The minimum pooled pulp weight (82.67g and 53.70g) and weight of peel (31.40g and 7.00g) per fruit were recorded in control (T<sub>1</sub>) in both the fruits. Thus, significant increase in bunch weight, bunch and finger characters under the influence of bunch spraying of potassium silicate @ 6 ml L<sup>-1</sup>/plant at 30 days interval + bagging of bunches (T<sub>8</sub>) in these experiments could be attributed to the synergistic effect of Si and bagging more than their individual effect.

### 5.1.2 Pest incidence

The incidence of thrips showed significant variations due to effect of potassium silicate and skirting materials. There was no incidence of thrips on fruits produced by employing treatments of potassium silicate and skirting materials. It is obvious that the covering of bunches with skirting materials might have prevented the reach of thrips to the fruits inside the skirting bags. Silicon can benefit though increased plant resistance to abiotic and biotic stresses (Ma and Takahashi, 2002). Silicon impregnates the walls of epidermal and vascular tissues where it appears to strengthen the tissues, retards pest and fungal infection (Tisdale *et al.*, 1993).

The maximum incidence of thrips (number of thrips per bunch - 15.00 and 16.67) was recorded in control treatment at harvest in both the fruits *viz.*, Grand Naine and Ney Poovan (Table 4 and 19). Several studies in different fruit crops in different parts of the world have indicated that bagging reduced the incidence of fruit fly in guava (Pereira, 1990; Morera-Montoya *et al.*, 2010), in mango (Buganic *et al.*, 1997; Hofman *et al.*, 1997; Sarker *et al.*, 2009), codling moth in apple (Walter and Mario, 1992), fruit borer in litchi (Debnath and Mitra, 2008), San Jose scale in apple (Sharma *et al.* 2013). Similar results were also obtained by Ani *et al.* (2011) in banana which supports the present findings. Fruit bagging can also prevent pathogens from reaching the developing fruit by secondary infection caused by pests which protects them from several diseases that can cause major losses. Bagging can protect some fruit from several pathogens, (Kitagawa *et al.*, 1992; Amarante *et al.*, 2002; Senghor *et al.*, 2007). Fruit bagging has been reported to reduce the incidence of anthracnose and stem-end rot in mango (Buganic *et al.*, 1997; Hofman *et al.*, 1997; Senghor *et al.*,

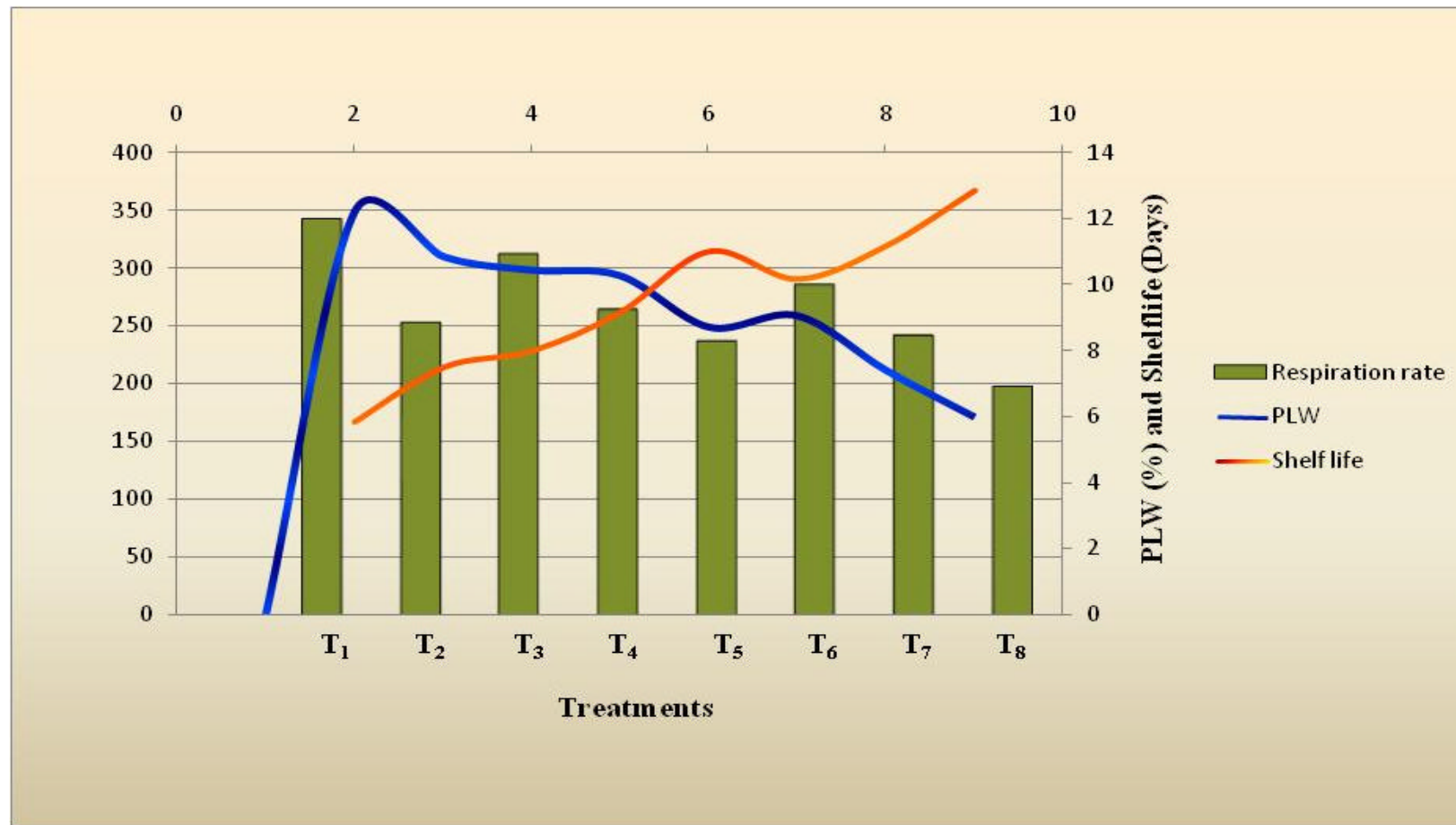
2007), sooty blotch and fly speck in apple (Sharma *et al.* 2013), and anthracnose and fruit rot in guava and loquat, respectively (Martins *et al.*, 2007; Ko *et al.*, 2010). Thus, pre-harvest fruit bagging is a good technique to maintain a physical separation between the environment and the produce. Several studies reported above support the findings of the present investigation.

### **5.1.3 Physiological behaviour of fruits**

#### **5.1.3.1 Respiration**

Banana is a climacteric fruit and it exhibits a respiratory peak during which declines as the ripening advances (Salunkhe and Kadaam, 1995). Among the three stages (mature green, ripe and senescence) studied in this investigation, maximum rate of respiration was seen in ripe stage of fruits of all the treatments indicating the vigorous process of ripening (Table 5 and 20) and it declined subsequently as the senescence approached in both the experiments. Similar trend of respiratory pattern was reported in banana cv. Gros Michel (Gane, 1936); in cv.Latundan and Klui Khai (Abdullah *et al.*, 1990).

The fruits treated with potassium silicate followed by bagging showed minimum respiration rate (196.45 CO<sub>2</sub>/kg/h and 295.84 CO<sub>2</sub>/kg/h) in treatment T<sub>8</sub> (Table 5 and 20) as compared to control (340.70 CO<sub>2</sub>/ kg/h and 374.83 CO<sub>2</sub>/ kg/h) in both var. Grand Naine (Fig. 1) and cv. Ney Poovan at ripe stage. The minimum respiration rate in potassium silicate treated fruits is mainly due to its antisenescence properties, inhibition of ethylene biosynthesis (Babak and Majid, 2011), or reduced rate of metabolism. Signes *et al.* (2007) reported that pre-harvest bagging delayed ripening in 'Perla', a black table-grape. Physical barrier of bagging also provides protection of fruits against atmospheric events (hailstones) and attack of insects or birds. The possible damage on fruits by insects, birds or atmospheric events might have led to secondary infection in control fruits which is expected to trigger respiration rate. Thus, bagging might have accounted for reducing the rate of respiration in addition to silicon in both types of banana fruits. The results are in conformity with report of Barbang *et al.*, (2002) in banana; Kaluwa *et al.* (2010) and Stamatakis *et al.*, (2003) in avocado, Babak and Majid (2011) in cut carnations.



**Fig. 1: Respiration rate, PLW and shelf life of banana fruits var. 'Grand Naine' as influenced by pre harvest bunch spraying and bunch bagging**

### 5.1.3.2 Physiological loss in weight and shelf life

The weight loss is an important index of post harvest storage life in the fresh produce. It is mainly attributed to loss of water during metabolic process like respiration and transpiration. Transpiration that occurs in banana fruits through stomata present on the skin leads to direct loss of moisture resulting in loss of weight. The transpiration rate is accelerated by cellular breakdown (Woods, 1990). Respiration which is a catabolic process, results in utilization of reserved foods. It causes weight reduction because a carbon atom is lost from the fruit each time a carbon dioxide molecule is produced from an absorbed oxygen molecule and evolved into the atmosphere. Thus physiological loss in weight progressively increased during the storage of banana fruit at ambient condition.

Pre-harvest treatment with potassium silicate and subsequent bagging in polyethylene sleeves showed the minimum pooled physiological loss in weight (7.43% and 4.24% at ripe stage, and 10.12% and 9.28% at senescence stage) in treatment T<sub>8</sub> (Table 6 and 21) as compared to control (12.24% and 10.35 at ripe stage, and 18.48% and 14.16% at senescence stage) in both var Grand Naine (Fig. 1) and cv. Ney Poovan. Reduced PLW in T<sub>8</sub> could be corroborated by reduced respiration rate. Minimum respiration rate in potassium silicate treated fruits is thought to be due to its antisenesescence properties, inhibition of ethylene biosynthesis or reduced rate of metabolism (Stamatakis *et al.*, 2003). Bagging in the present experiment provided protection to the fruits against possible mechanical damage on fruits by insects, birds or atmospheric events (Sharma *et al.*, 2014) which would have otherwise led to rapid loss of moisture. The results are in conformity with reports of Barbang *et al.*, (2002) in banana; Kaluwa *et al.* (2010) and Stamatakis *et al.*, (2003) in avocado, Babak and Majid (2011) in cut carnations, Mathooko *et al.*, (2011) in mango.

The rate of weight loss in control fruits could be reasoned to acceleration of senescence, which is significantly suppressed by exogenous treatment of potassium silicate in treated fruits. Reduced weight loss in treated fruits could also be attributed to stabilization and consolidation of both cell integrity and the permeability of the tissues as it forms linkage with cell membranes and preserves waxes of cuticle layer there by delay the removal of epicuticular waxes which play a very important role in water exchange through the skin (Abraham *et al.*, 2008 and Mathaba *et al.*, 2009). A

report on apricot fruits revealed reduced weight loss during storage of fruits treated with sodium silicate ( $10\text{mmol L}^{-1}$ ) (Shi *et al.*, 2012).

Due to antisenesescence properties, inhibition of ethylene biosynthesis or reduced metabolic rate, banana fruits treated with potassium silicate had higher shelf life compared to control fruits. Maximum shelf life was observed in treatment T<sub>8</sub> both in Grand Naine (12.83 days) (Fig.1) and Ney Poovan (7.50 days) fruits (Table 5 and 20). The results are in conformity with report of Barbang *et al.*, (2002) in banana; Kaluwa *et al.* (2010) and Stamatakis *et al.*, (2003) in avocado, Babak and Majid (2011) in cut carnations.

#### 5.1.4 Instrumental colour analysis of banana fruit ( $L^*$ , $a^*$ , $b^*$ , $C^*$ , $h^{\circ}$ )

Colour and appearance is one of the important attributes that determine the edibility of a fruit. Colour change in a ripening banana fruit results from various physico-chemical changes that a fruit undergoes during ripening leading to characteristic appealing yellow skin colour.

In the present investigation, fruits at ripe stage were analyzed objectively in terms of  $L^*$ ,  $a^*$  and  $b^*$  using the instrument. The colour was measured based on rectangular coordinates of an early opponent colour system (Hunter) that labeled three dimensions of a colour as  $L^*$ ,  $a^*$ ,  $b^*$ . The  $L^*$  coordinate represents lightness, the  $a^*$  coordinate represents redness ( $+a^*$ ) or greenness ( $-a^*$ ), and the  $b^*$  coordinate represents yellowness ( $+b^*$ ) or blueness ( $-b^*$ ). Using this system, an object measured for colour would be assigned an  $L$ ,  $a$ ,  $b$  value to describe the colour and specify its location in the three-dimensional colour space. The distance between two colours, each having its own location in the colour space, relates to a measurable colour difference. Chroma or saturation ( $C^*$ ) is the relation of a colour to a neutral gray of the same lightness (Kevin, 2002). It is the index or purity of hue and it shows brightness of fruits (Shafiee *et al.*, 2010). Hue ( $h^{\circ}$ ) angle is expressed in degrees, with  $0^{\circ}$  corresponding to  $+a^*$  axis (red), then continuing to  $90^{\circ}$  for the  $+b^*$  axis (yellow),  $180^{\circ}$  for  $-a^*$  (green) and finally  $270^{\circ}$  for  $-b^*$  (blue) (Kevin, 2002).

The peel colour of banana fruits changes from green (chloroplasts) to yellow colour (chromoplasts) during ripening (Seymour, *et al.*, 1993; Stover and Simmonds, 1987).  $L^*$  (brightness) values of peel colour were significantly higher in the fruits

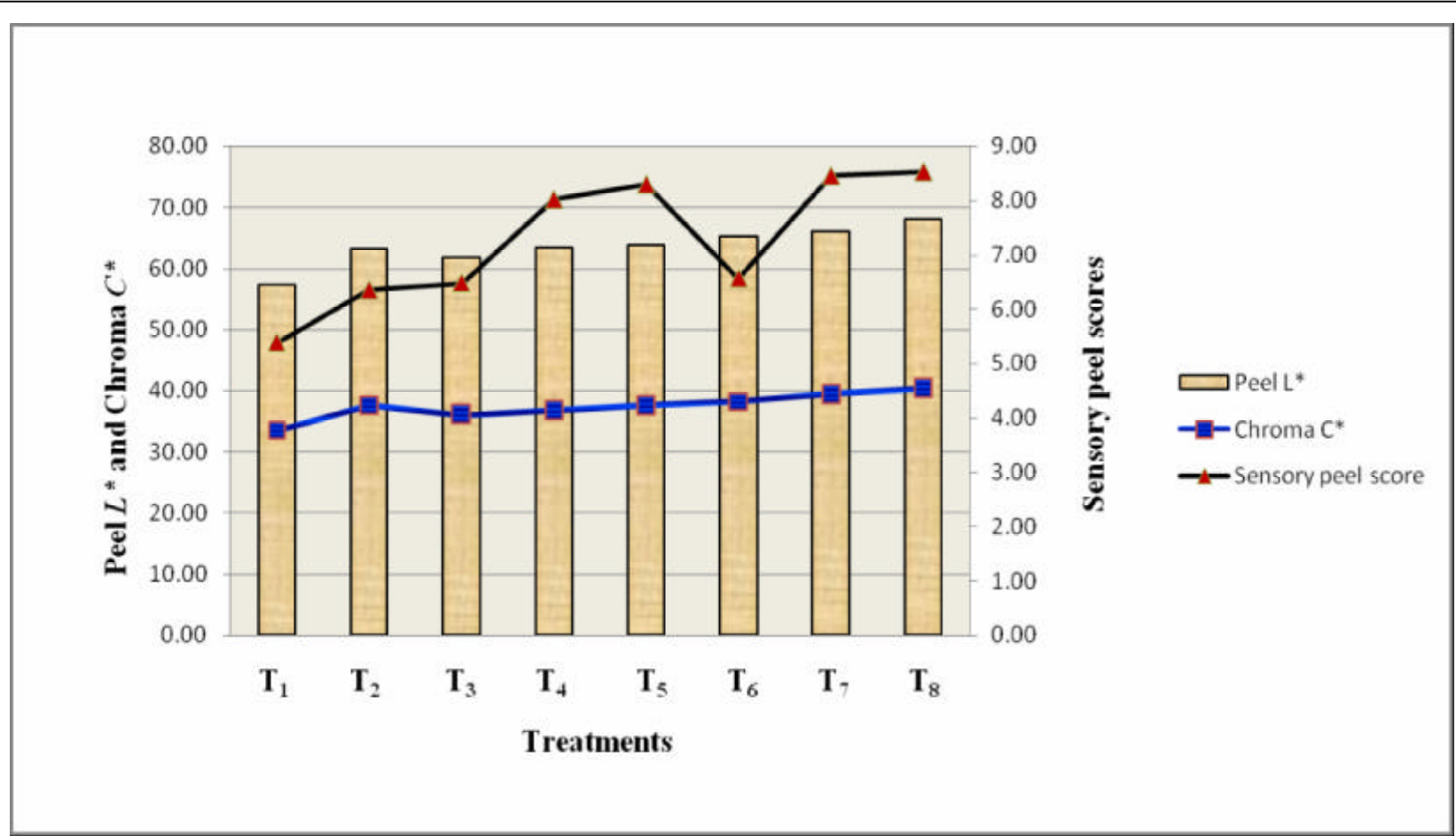


Fig. 2: Lightness, chroma and sensory peel score of banana fruits cv. 'Neypoovan' as influenced by pre harvest bunch spraying and bunch bagging

sprayed with potassium silicates followed by bunch bagging ( $T_8$ -66.95 and 68.01,  $T_7$ -64.83 and 65.97, and  $T_6$ -64.17 and 65.31) in both Grand Naine and Ney Poovan (Fig. 2) respectively. The values for  $a^*$  (redness) and  $b^*$  (yellowness) were positive and maximum in fruits of the same treatments. As a result chroma ( $C^*$ ), the index or purity of the hue ( $h^\circ$ ) that correlates between  $a^*$  and  $b^*$  were also significantly higher in fruits under those treatments in comparison to unbagged treatments (Table 7 and 22). This indicates the role of potassium silicate and bagging in conversion of peel pigments leading to improved peel colour of banana fruits. Some reports revealed that the pre-harvest sprays of silicon and potassium influenced the colour of the crops *viz.*, rose (Saeed *et al.*, 2009) and banana (Kumar *et al.*, 2006) respectively. In this study all the colour coordinates were significantly influenced by the potassium silicate application and bagging of bunches. Saeed *et al.* (2009) observed the role of silicon sprays in improving colour and appearance of *Rosa hybrida* var. Hot lady and A-Shiaran *et al.* (2004) noticed increased chroma and lightness in grapes bagged with black paper.

Pooled data of potassium silicate at 6ml/l + bagging of fruits ( $T_8$ ) significantly differed with other treatments of potassium silicate + bagging as well as potassium silicate alone with respect to peel colour indicating higher values for  $b^*$  (42.10 and 44.12) and  $C^*$  (38.15 and 40.36). On the other hand,  $L^*$  (56.14 and 57.35),  $b^*$  (34.01 and 36.27),  $C^*$  (31.36 and 33.60) were lower for the peel colour of control fruits in both Grand Naine and Ney Poovan indicating dullness of skin colour.

### 5.1.5 Biochemical parameters

The quality parameters *viz.*, acidity, total soluble solids, total sugars, reducing sugar, non-reducing sugars, sugar acid ratio and starch of the fruit were significantly influenced by foliar application of silicon and covering of bunches. Higher photosynthetic activity and biomass production, reduced metabolic activities in the fruits treated with silicon (Young *et al.*, 1996), besides antisenescence effect (Stamatakis *et al.*, 2003) and increased fruit firmness due to silicon (Ma and Takahashi, 2002) might be the reasons for better quality attributes of bananas under those treatments. Similar observation were made by and Bhavya (2010) in Bangalore Blue grapes, Kaluwa *et al.*, (2010) in avocado, Dimitrios *et al.*, (2011) in zucunni

squash fruit and Lebedeva *et al.*,(2011) in potato and Abbasi (2014) in Guava with respect to the influence of silicon and effects of bagging.

The amount of TSS in fruits usually increases as they mature and ripen. The soluble solids content of the fruit can be a useful index of maturity or stage of ripeness. During the climacteric stage, the accumulated polysaccharide is rapidly degraded and most of it is converted into soluble sugars leading to high TSS in banana (Seymour *et al.*, 1993).

Significantly maximum total soluble solids were found in the treatment T<sub>8</sub> (bunch spraying of potassium silicate at 6 ml/l + bagging of bunches) both in banana var Grand Naine (23.23 °B) and cv. Ney Poovan (26.95° B). Whereas, the lowest total soluble solids (19.44 ° B and 22.98° B) content was recorded in control T<sub>1</sub> (Table 8 and 23). Silicon and potassium help in photosynthesis, increased translocation of solutes and more assimilation of synthates from source to sink thus increasing total soluble solids in fruits. The results of this study are in accordance with Stamatakis *et al.*, (2003) in 'Hass' avocado and Bhavya (2010) in Bangalore Blue grapes.

In general, acidity increases in banana during ripening and the predominant organic acid present in banana is malic acid. As ripening further advances beyond climacteric, acidity declines presumably due to the utilization as respiratory substrates (Seymour *et al.*, 1993). The increase in acidity level in banana fruits during ripening might result from an obstruction in protein transfer as the fruit ripen (Sen *et al.*, 1982). Titratable acidity increased during the ripening process in all the treatments and decreased towards the end of the storage period (Table 9 and 24). Desai and Deshpande (1975) also reported that titratable acidity in bananas increased during ripening at 20°C and then decreased.

The titratable acidity was less (0.33% and 0.29%) in bunch spraying of potassium silicate at 6 ml/l and bagging (Table 9 and 24) and maximum acidity was found in T<sub>1</sub>(control) (0.42% and 0.38%) at ripe stage of both the fruits. The decrease in acidity content in treated fruits might be due to increase in the total soluble solids and it was also because of potassium might have involved in fast conversion of metabolites into sugar and their derivatives (Tisdale and Nelson 1966). Similar, observations were made by Bhavya (2010) in Bangalore Blue grapes, increased total

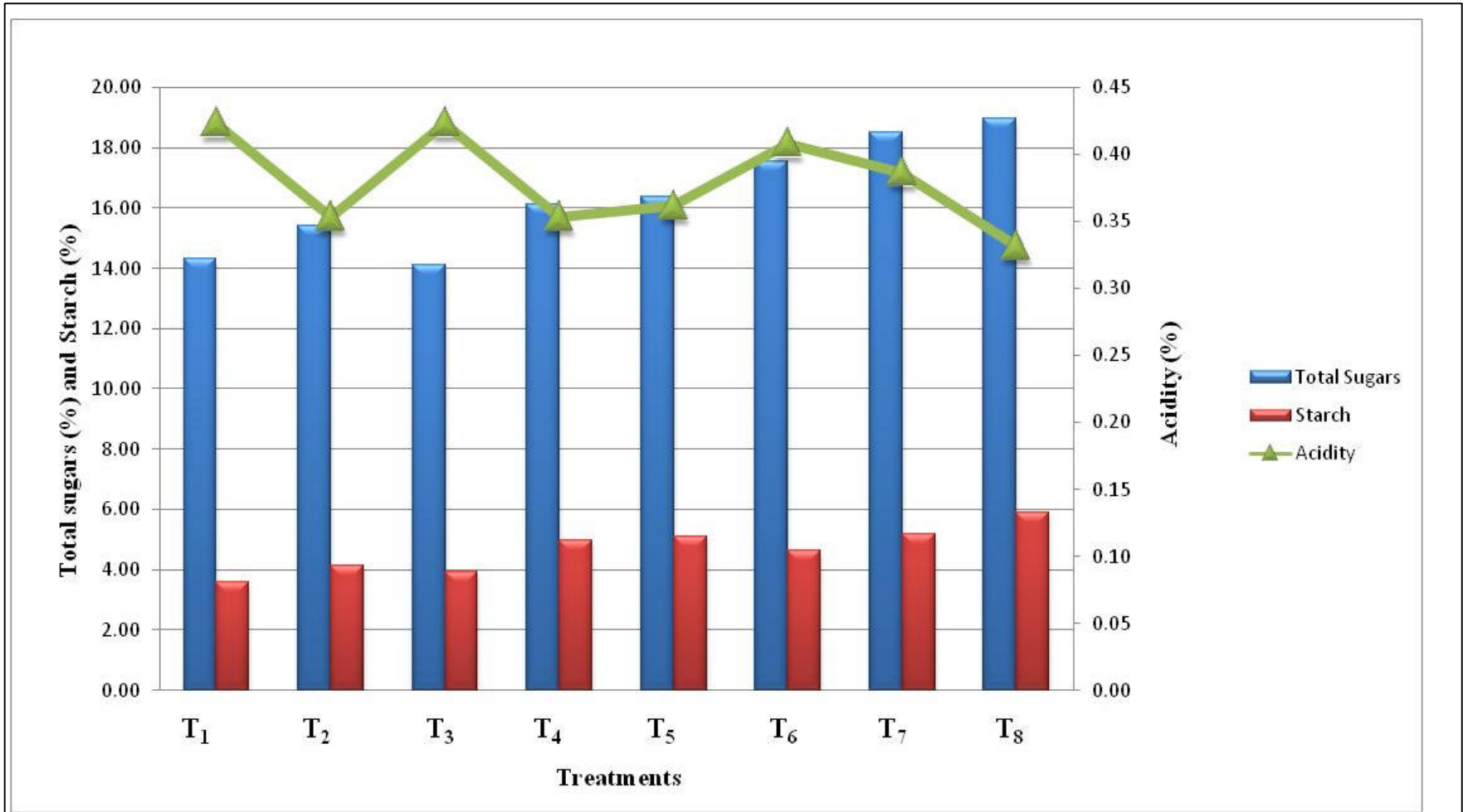
soluble solids contents in the berries led to decrease in acidity content. Similarly Justus *et al.* (2006) in peach, in banana (Annon, 2013) also noticed minimum acidity due to bagging of fruits during growth phase.

Hydrolysis of starch and accumulation of sugars are the most striking chemical changes that occur during the post-harvest ripening of banana fruits. About 20-25 per cent of the pulp of the fresh fruit is starch which hydrolysis and gets reduced to as low as one or two per cent during the progressive ripening process. After ripening there may be no detectable starch in Puerto Rican plantains (Turner, 2005). The green peel also contains starch, mostly in cells adjacent to pulp. The degradation of starch to sugars during the storage of ripe banana was accompanied by the increase in  $\beta$ -amylase activity (Hubbard *et al.*, 1990).

In the present study, the amount of starch content in banana var. Grand Naine and cv. Ney Poovan decreased significantly as the fruit ripened (Tapre and Jain 2012). The fruits treated with potassium silicate (Table 14 and 29) followed by bagging ( $T_8$ ) had maximum starch content (5.91% and 5.07% at ripe stage and, 2.90% and 2.27% at senescence stage) while lower starch was observed in control (3.61% and 2.77% at ripe stage and, 1.58% and 1.17% at senescence stage). The results indicated that the conversion of starch into sugars was rapid in untreated fruits than in treated fruits. This could be due to the rapid induction of pre-climacteric and climacteric phases and onset of climacteric peak in respiratory metabolic pathways in starch hydrolysis (Marriot, 1980).

The postulate of effect of potassium silicate on maximum per cent of starch content is due to slow hydrolysis of starch associated with delayed ripening and antisenesescence process of silicon due to low respiration as observed by Stamatakis *et al.*, (2003) in avocado. An increase in amylase and phosphorylase activities is strongly correlated with starch degradation during banana ripening (Hubbard *et al.*, 1990). Potassium silicate may affect the activities of such enzymes involved in starch metabolism. Effects of potassium silicate on the activities of amylase and phosphorylase are yet to be investigated.

The sugar content increases from harvest till ripening and as senescence approaches, the sugars undergo metabolic transformation, both qualitatively and



**Fig. 3: Total sugars, starch and titratable acidity content in banana fruits var. 'Grand Naine' as influenced by pre harvest bunch spraying and bunch bagging**

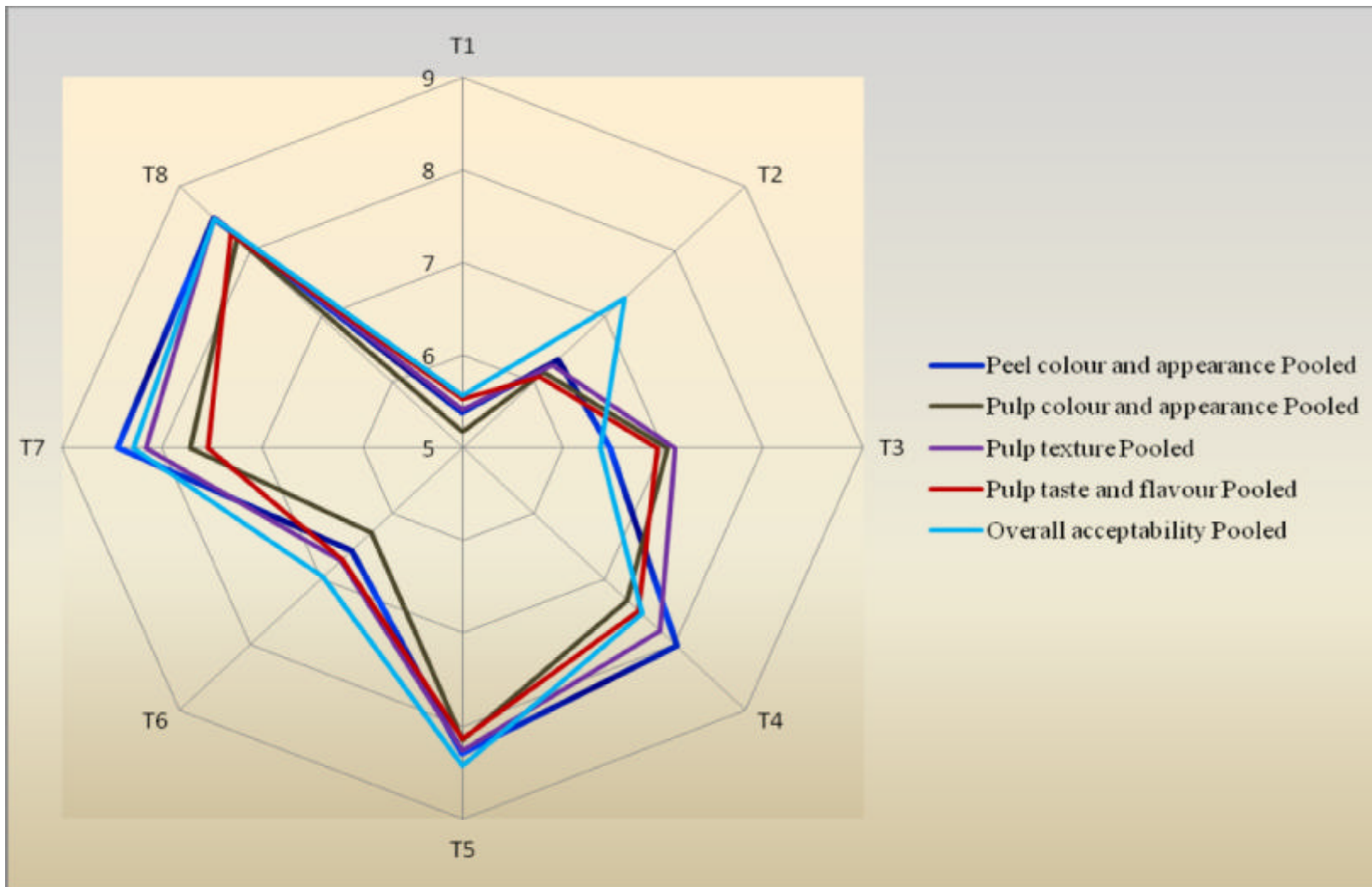
quantitatively The increase in initial low sugar content of banana fruits during normal ripening process that leads to senescence with the progress of storage time was due to the degradation of starch to glucose and fructose by the activities of amylase and maltase (Wills *et al.*, 1989).

However at optimum ripe stage, the total sugar content (18.98% and 23.72%) and reducing sugar content (14.58% and 18.23%) was more in fruits treated with bunch spraying of potassium silicate at 6 ml/l and bagging while minimum total sugar (14.31% and 18.06%) and reducing sugar (9.21% and 11.51%) were noticed in control (T<sub>1</sub>) in both Grand Naine and Ney Poovan (Fig. 3) fruits (Table 10 and 11, Table 25 and 26 respectively). This progressive increase could be related to increase in total soluble solids content of fruits. The similar results obtained by Bhavya (2010) in Bangalore Blue grapes, Su *et al.* (2011) in apple and Stamatakis *et al.* (2003) in tomato. The increase in sugar content could be attributed to enzymatic conversion of starch to reducing sugars.

Sugar acid blend is the characteristic feature of fruits owing to its edible quality, delicious taste and flavour. Significantly higher sugar to acid ratio observed in fruits that were given pre-harvest sprays of potassium silicate (57.41% and 80.26%) (Table 13 and 28). On the other hand, untreated fruits (T<sub>1</sub>) (33.46% and 46.74%) were associated with the lowest sugar to acid ratio in both the fruits Grand Naine and Neypovan (Fig. 3). In the present study, potassium silicate not only increased sugars but also maintained optimum acidity contributing to high sugar acid ratio.

### 5.1.6 Organoleptic evaluation

Both the fruits (Grand Naine and Ney Poovan) sprayed with potassium silicate and then bagged obtained maximum organoleptic score for peel and pulp colour that were significant compared to other treatments (Table 15 and 30, and Fig. 4). However, peel colour was slightly lower in potassium silicate spray alone (8.11 and 8.29) T<sub>5</sub> than bagged (T<sub>8</sub>) (8.39 and 8.52). The high scores for peel and pulp colour are due to pre-harvest sprays of potassium silicate and bagging effect which have already been reported by Saeed *et al.* (2009) in rose, A-Shiaran *et al.* (2004) in grapes and (Mathooko *et al.*, 2011) in mango respectively. The bagging effect on colour development was reported to be affected by increasing the brightness of fruit



**Fig. 4: Sensory attributes of banana fruits cv. 'Neypoovan' as influenced by pre harvest bunch spraying and bunch bagging**

(Bin *et al.* 2006). Hence, the treatment might have affected the peel colour conversion mechanism but not the pulp colour synthesis. But during the ripening of banana, the pulp colour changes from the typical “opaque white” of a product with high starch content to a “very soft yellow” as the skin intensifies (Salvador *et al.*, 2007).

Similarly, the same treatments had scored significantly higher for pulp texture (Table 15 and 30). Maximum firmness of fruits under potassium silicate treatment substantiates the significantly maximum score for texture (8.03 and 8.51) ( $T_8$ ). The low texture during ripening leads to lower quality and higher incidences of mechanical damage during handling and transportation (Dadzie and Orchard, 1977). The loss of texture is associated with two or three processes. The first is the breakdown of starch to form sugar. The second is the breakdown of the cell walls or reduction in the middle lamella cohesion due to solubilisation of pectic substances (Smith, 1989). Thus these high scores could be attributed to positive effects of potassium silicate.

Sugar acid blend in the potassium silicate treated fruits might have impressed the panel members resulting in higher sensory scores for pulp taste and flavour (8.09 and 8.27). This may be due to the changes in acidity and sugars content during ripening. During banana fruit ripening, the accumulated starch hydrolyses as a result of amylase activity leading to the formation of sugars and thus reducing the organic acid content giving a proper blend to taste of the fruit. As a result, of all the above parameters *viz.*, colour and appearance, pulp texture and, taste and flavor the fruits under the treatment of potassium silicate and bagging (8.18 and 8.50) showed greater overall acceptability than the other treatments (Table 15 and 30). Control fruits were organoleptically inferior (overall acceptability 5.21 and 5.57) with low scores in both Grand Naine and Ney Poovan (Fig. 4) fruits.

## **5.2 Effect of bunch feeding and bagging on Banana var. Grand Naine and cv. Ney Poovan on bunch characters**

### **5.2.1 Bunch weight and finger characters**

There was a noticeable increase in weight of bunches upon the influence of treatments over control (Table 31 and 46). Bunch feeding with nitrogen source +

Sulphate of potash and bunch spraying of 2,4-D at 20 ppm increased the bunch weight. Treatment T<sub>8</sub> (2,4-D at 20 ppm + bagging) showed highest pooled (2014 and 2015) bunch weight (31.11 kg/plant and 12.33 kg/plant) followed by T<sub>6</sub> and T<sub>7</sub>. Untreated control had the lowest bunch weight (24.37kg/plant and 8.37 kg/plant) in both Grand Naine and Ney Poovan.

Spraying of 2, 4-D to the bunch after the opening of last hand improves bunch weight and yield. This increase in weight in present study can be associated with the fact that auxins promote extensibility of cell wall. The wall pressure along the cell decreases and pressure caused by osmotic forces in the vascular sap make water enter the cell resulting in cell enlargement. Auxin may also function by activating the RNA that induces the synthesis of specific enzymes which could cause insertion of newer materials into the cells resulting in extension of fingers (Thiman 1969). Increase in bunch weight due to 2,4-D was observed by Athani and Hulmani (1999); Selvarajan and Doraipandian(1996); Barman and Baruah (2003) in banana.

Increase in bunch weight was also associated with bunch stalk feeding treatments. Bunch stalk feeding with urea and ammonium sulphate results in higher urease activity which coincides with better bunch and finger grade. This also reveals the possibility of conversion or hydrolysis of urea into ammonia (NH<sub>3</sub>) and carbon dioxide (CO<sub>2</sub>) and its better absorption and assimilation (urease pathway) in plants. The enzyme activity in turn, is related with the molecular absorption of urea (Ancy *et al.* 1998). Thus, released NH<sub>3</sub> would be incorporated into amino acids and then into protein *via* the glutamate synthase cycle (Kumar and Abrol, 1990). Presence of sulphur in nutrients is proved to be beneficial as it is essential for carbon dioxide absorption and utilization, synthesis of RNA and auxin. Sulphur can increase the absorption of potassium or it can react with nitrogen and potassium (Farrag *et al.*, 1990). Sulphur helps in energy transformation and activation of enzymes in carbohydrate metabolism and subsequently greater partitioning of photosynthates in yield attributes as it is a constituent of amino acid and protein production (Ahmed *et al.*, 1998). The influence of sulphur in enhancing fruit yield in bananas was stressed by Lahav and Turner (1983). Similarly this study was supported by Ancy and Kurien (2000) in banana cv. Nendran and Kotur and Murthy (2008) in banana cv Robusta. The results of present findings are in close conformity with Alagarsamy and Kumar

(2008) in cv. Robustsa, Ramesh and Kumar (2007 & 2010) in banana cv. Ney Poovan and Ramesh *et al.*, (2008) in cv. Robusta.

Similarly increase in yield in covered bunches after the treatment imposition in the present study could be attributed to the positive effects of bagging. The bunches covered with sleeves had no blemishes and injuries as they were free from pest attack and disease incidence. Fruits undergo several physical and chemical changes and are susceptible to insect pest infestations, bird attack, various pathogens, and mechanical damage during their growth and development. All these can reduce their commercial value and thereby cause significant yield and economic losses (Sharma *et al.*, 2009). The findings of present studies are on parallel line with study of Reddy (1989), who reported that the diameter and weight of finger were slightly increased by polythene bunch covers. The results obtained by Haladankar *et al.*, (2015) in mango and Weerasinghe and Ruwaphirana, (2002) in banana also reported an increase in the fruit size at harvest in fruits or bunches sealed with polythene bag.

The length, diameter and weight of the finger determine the market value and yield in banana. In the present investigation, the above characters were significantly influenced by application of different bunch feeding treatments. The maximum pooled finger weight (150.60g and 81.19g at mature stage, and 144.30 g and 73.10g at ripe stage) during both the years was recorded in the treatment T<sub>8</sub> (foliar application of 20 ppm 2, 4-D+ bagging of bunches) followed by the bunch feeding treatments (T<sub>6</sub> and T<sub>7</sub>) and minimum finger weight (122.98 g and 67.66g at mature, and 116.8 g and 60.41 g at ripe stage) was recorded in T<sub>1</sub> (control) (Table 32 and 47) in both Grand Naine and Ney Poovan. Similar results on fruit weight by spraying 2,4-D were reported by Pradhan *et al.*, (1988) in banana var Giant Governor; Selvarajan and Doraipandian (1996) in cv. Nendran. Application of urea as a spray in Dwarf Cavendish and Giant cavendish increased fruit weight over control by 14.80 per cent and 17.24 per cent respectively (Venkatarayappa *et al.*, 1976). Application of SOP as a spray in Ney Poovan increases yield (Ramesh and Kumar, 2007 and 2010), similiarly Nandan *et al.* (2011) in Nanjanagudu Rasabale found urea applied as spray to growing bunches increased fruit length.

Application of 2, 4 D is involved in increasing finger fruit weight and length by cell elongation which results in filling up of more starch materials in the elongated

cell (Thimann, 1969; Geetha and Nair, 2002). The results are in line with the research findings of Athani *et al.*, (2001). On the other hand, increase in finger weight by urea and ammonia can be supported with the findings by Calvin *et al.* (1952), Mothes (1961) and Harper (1984). They reported that in plants allantoin and allantoic acid seems to be more immediately concerned with the synthesis and use of nitrogen they contain, and these compounds may be derived from glyoxylic acid with urea as a possible donor. In a study on the morpho-physiological aspects of finger development it was observed that, in the final stage of development, cell enlargement took place thus reducing the available air space followed by starch filling in the cells. The late application of nitrogen based nutrients, coinciding with the stages of cell division, when the early nitrogen pool becomes exhausted, may be involved in fruit development as a nitrogen source (Kurien *et al.*, 1999). The results were in close conformity with Ancy and Kurien (2000) in cv. Nendran.

The length of finger was increased (20.64 cm and 14.11) in the treatment T<sub>8</sub> (bunches applied with 2,4-D at 20ppm + bagging) followed by T<sub>5</sub> (application of 20ppm 2,4-D only). These two treatments were significantly followed by the treatments T<sub>6</sub> and T<sub>7</sub> (bunch feeding with nitrogen and potassium sources + bagging). The least weight was observed in control (13.92 and 10.90) in pooled data of both the fruits. The increase in the length of fruit was in turn reflected on finger weight in all the treatments. The results were in close conformity with Pradhan *et al.*, (1988) in banana var Giant Governor and Selvarajan and Doraipandian (1996) in cv. Nendran, Ancy and Kurien (2000) in cv. Nendran; and Nandan *et al.* (2011) in cv. Nanjangudu Rasabale (AAB).

Bunches applied with 20 ppm 2, 4-D + bagging (T<sub>8</sub>) resulted in better finger diameter as observed in the pooled data of both the fruit types (3.80 cm and 2.80 cm) followed by bunch feeding with urea + SOP (T<sub>6</sub>) and ammonia + SOP (T<sub>7</sub>) respectively. The lowest diameter of fruits was found in control (3.27 cm and 2.30 cm) both in Grand Naine and Ney Poovan.

It can be inferred that, 2, 4-D may also function by activating the RNA that induces the synthesis of specific enzymes which could cause insertion of newer materials into the cells resulting in extension of fingers (Chellappan, 1983; Athani and Hulmani, 1999). While in the bunch fed treatments nutrient supplied in the form of

urea and ammonical form was utilized more for cell elongation of the fruits rather than for cell multiplication which resulted in more length than diameter. The urease activity also coincided with elongation of fruits as reported by Ancy *et al.* (1998).

The increase in diameter in turn reflected on final weight of the finger, which clearly indicated that potassium is involved in cell enlargement. The increase in finger weight might be due to the exogenous potassium supply which acted as an activator of several enzymes. Potassium also had a role in synthesizing the precursor of chlorophyll pigments. Presence of sulphur in sulphate of potash has a synergistic effect with other nutrients which are essential for carbon dioxide absorption and utilization, synthesis of RNA and auxins, which increase the size of fruit. Similar observations were made by Mustaffa *et al.* (2004) in cv. Nendran, Ramesh and Kumar (2007) in cv. Ney Poovan and Nandan *et al.* (2011) in cv. Nanjanagudu Rasabale.

On the other hand, significant variations in finger quality *viz.*, pulp weight and peel weight were observed in both the fruits var. Grand Naine and cv. Ney Poovan. The maximum pooled values for pulp weight (113.33 g) and peel weight (34.79 g) in treatment T<sub>8</sub> were recorded in Grand Naine variety fruits (Table 33). Whereas in Ney Poovan, maximum pooled values for pulp weight (65.89 g) and peel weight (8.31 g) were recorded in T<sub>5</sub> and T<sub>8</sub> respectively followed closely by bunch fed treatments (T<sub>6</sub> and T<sub>7</sub>) (Table 48). This could be due to beneficial role of 2, 4 - D (Thimann, 1969) and potassium (Kumar *et al.*, 2006) leading to production of higher qualities of photosynthates and their translocation towards the growth and development of fingers. Thus, it might have resulted in production of higher pulp and pulp percentage. Minimum pooled pulp weight (84.94 and 53.93 g) and peel weight (31.40 g and 7.06g) per fruit were recorded in control (T<sub>1</sub>) in both the banana fruit types. These results are in accordance with the findings of Mustaffa *et al.* (2004) in cv. Nendran, Ramesh and Kumar (2007) in cv. Ney Poovan; and Nandan *et al.* (2011) in cv. Nanjanagudu Rasabale. The increase length, diameter, weight of finger and pulp weight could also be due to the effect of skirting materials. Suitable micro environment created by bagging around the banana bunches might have enhanced the physiological and metabolic activities leading to improvement in finger characteristics (Johns and Scott, 1989).

## 5.2.2 Pest incidence

Results pertaining to incidence of thrips showed significant variations due to effect of potassium feeding and skirting materials. There was no incidence of thrips on fruits produced under skirting materials. The results confirmed the fact that, covering of bunches with skirting materials might have prevented entry of thrips inside the skirting bags. The maximum incidence of thrips (number of thrips per bunch - 13.58 and 20.62) was recorded in control treatment at harvest in both the fruits *viz.*, Grand Naine and Ney Poovan (Table 34 and 49). Several studies in different fruit crops in different parts of the world have indicated that bagging has reduced the incidence of fruit fly in guava (Pereira, 1990; Morera-Montoya *et al.*, 2010), in mango (Buganic *et al.*, 1997; Hofman *et al.*, 1997; Sarker *et al.*, 2009), codling moth in apple (Walter and Mario, 1992), fruit borer in litchi (Debnath and Mitra, 2008), San Jose scale in apple (Sharma *et al.* 2013). Similar results were obtained by Ani *et al.* (2011) in banana which supports the present findings. Fruit bagging avoids secondary infection caused by pests and thus prevents pathogens from reaching the developing fruit which protects them from several diseases that can cause major losses (Kitagawa *et al.*, 1992; Amarante *et al.*, 2002; Senghor *et al.*, 2007). Fruit bagging has been reported to reduce the incidence of anthracnose and stem-end rot in mango (Buganic *et al.*, 1997; Hofman *et al.*, 1997; Senghor *et al.*, 2007), sooty blotch and fly speck in apple (Sharma *et al.* 2013), anthracnose and fruit rot in guava and loquat (Martins *et al.*, 2007; Ko *et al.*, 2010 respectively).

## 5.2.3 Physiological behaviour

### 5.2.3.1 Respiration rate

In the present study, respiration rate of banana fruits increased gradually reaching a peak and declined later in all the treatments. Banana is a climacteric fruit that shows a climacteric pattern of respiration during ripening (Gane, 1936). Among the three stages (green, ripe, senescence), maximum rate of respiration was seen in ripe stage of fruits in all the treatments indicating the vigorous process of ripening (Table 35 and 50) and then declined as the fruits approached senescence in all the experiments. Similar trend of respiratory pattern was observed in cv. Gros Michel by Gane (1936); and in cv. Latudan and Klui Khai by Abdullah *et al.* (1990).

The fruits applied with nutrients in the form urea, ammonia and SOP exhibited lower respiration rate followed by the fruits treated with 2, 4 D. The minimum respiration rate at ripe stage was observed in T<sub>6</sub> in Grand Naine (268.53 CO<sub>2</sub>/kg/h) and in the treatment T<sub>7</sub> in Ney Poovan (324.30 CO<sub>2</sub>/kg/h) (Table 35 and 50). Maximum respiration rate was recorded in control (343.49 CO<sub>2</sub>/ kg/h and 376.89 CO<sub>2</sub>/ kg/h) in both Grand Naine and Ney Poovan (Fig 5). This reduction in respiration rate in nutrient treated fruits was due to lower metabolic activities and mechanism of regulation of metabolic activities by potassium (Kumar *et al.*, 2006) thus increasing green life of fruit (Ramesh and Kumar, 2010). Besides, bagging resulted in less mechanical damage to banana bunches leading to lower metabolic activities. The results of the present study are in agreement with those of Chunhui *et al.*, (2009) and in pears, Amarante *et al.*, (2002) in pear, and Hofman *et al.*, (1997) in mangoes. On the other hand, 2, 4 - D slightly triggers ethylene production due to increase in levels of ACC (Vendrell and Dominguez, 1989) causing an increase in respiration than the bunch fed treatments.

### 5.2.3.2 Physiological loss in weight and shelf life

The loss in weight of produce due to ongoing physiological processes is known as physiological loss in (PLW). Weight loss of fresh banana is primarily due to transpiration and respiration. Transpiration is a mechanism in which water is lost due to differences in vapour pressure of water in the atmosphere and the transpiring surface. In the present study, irrespective of the treatments, the PLW of the bananas increased as the time advanced (Table 36 and 51).

Fruits of banana bunches fed with nutrients followed by bagging (T<sub>6</sub> and T<sub>7</sub>) showed minimum pooled physiological loss in weight (5.84% and 4.56% at ripe stage, and 9.96% and 9.13% at senescence stage) in treatment in Grand Naine and Ney Poovan respectively (Table 36 and 51) (Fig 5). Control fruits in both var Grand Naine and cv. Ney Poovan (12.14% and 10.87% at ripe stage, and 19.02% and 14.64% at senescence stage) recorded maximum PLW. Lower metabolic rates associated with positive effects of potassium and/or least or no physical damage in bagged fruits might have resulted in low physiological loss in weight. The results obtained in these experiments are in conformity with reports of Sateesh and Bangarusamy (2006) in banana cv. Rasthali; and Ramesh and Kumar (2010) in

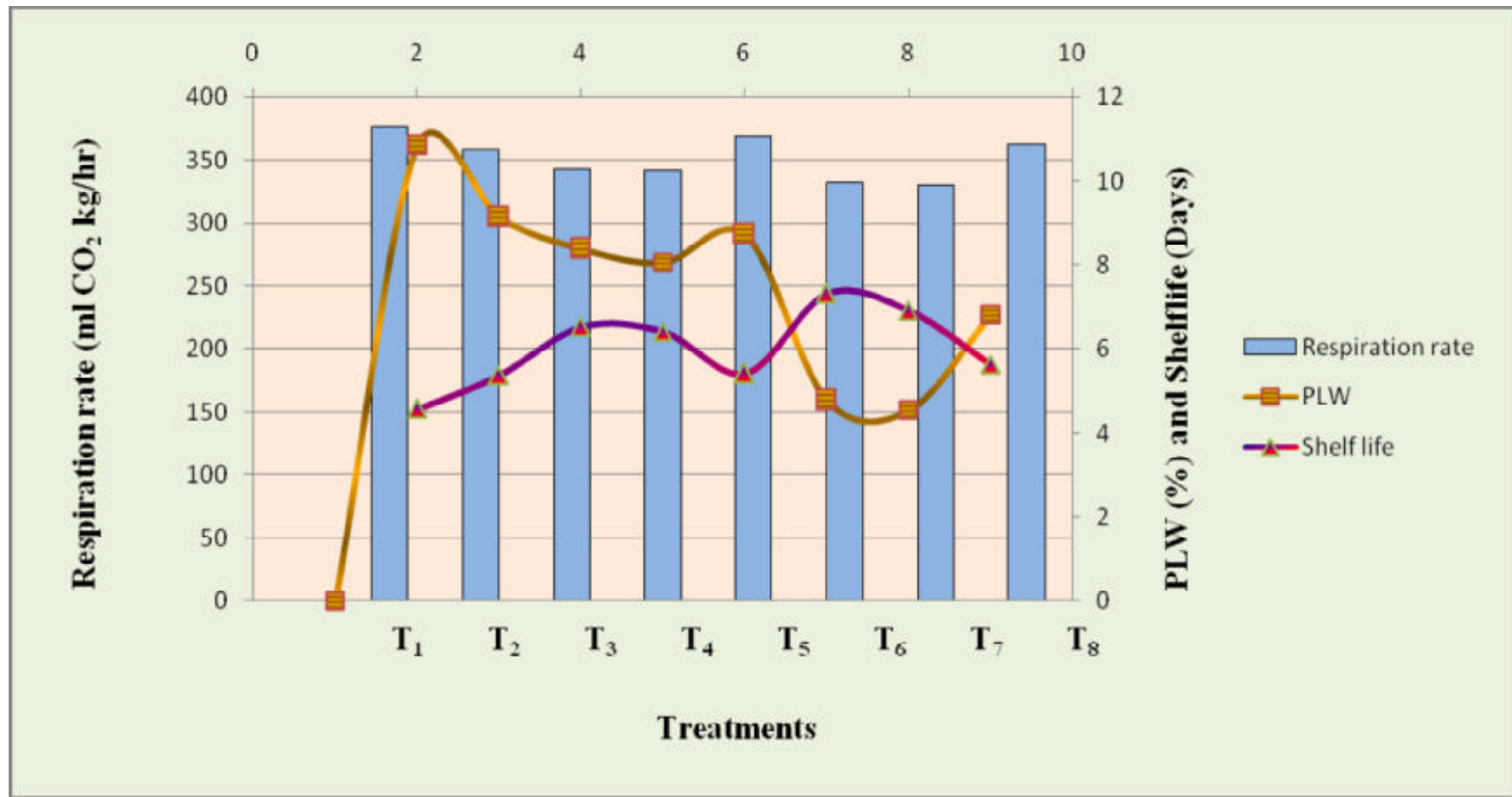


Fig. 5: Respiration rate, PLW and shelf life of banana fruits cv. 'Neypoovan' as influenced by pre harvest bunch treatments (feeding of nutrients) and bunch bagging

banana cv. Ney Poovan. Other beneficial effects of K include high pulp content, high vitamin C content, uniformity and resistance to bruising or physical breakdown during shipping and storage. Several research results suggest the role of K in enhancing the quality of fruits and their keeping and marketable quality (Usherwood, 1985; Kumar *et al.*, 2006; Lester *et al.*, 2007; Ganeshmurthy *et al.*, 2011).

Due to increased turgor pressure in the cells or reduced metabolic rate (Kumar *et al.*, 2006) of banana fruits treated with potassium nutrients in combination with nitrogen nutrients (T<sub>6</sub> and T<sub>7</sub>) had longer shelf life compared to control fruits. Maximum shelf life of 11.99 days was observed in T<sub>6</sub> in Grand Naine and 7.33 days in Ney Poovan fruits (Table 36 and 51) (Fig. 5). The results are in conformity with report of Barbang *et al.* (2002) in banana; Ramesh and Kumar (2010) in Ney Poovan banana; Ramesh *et al.* (2008) in Robusta, Nandan *et al.* (2011) in cv. Nanjanagudu Rasabale and Sateesh and Bangarusamy (2006) in cv. Rasthali.

#### **5.2.4 Instrumental colour analysis of banana fruit ( $L^*$ , $a^*$ , $b^*$ , $C^*$ , $h^0$ )**

$L^*$  (brightness) values of peel colour were significantly higher in the fruits fed with slurry mixture in combination with nitrogen and potassium nutrients + bagging (T<sub>6</sub>-63.84 and 62.37, and T<sub>7</sub>-63.78 and 64.23) in both Grand Naine and Ney Poovan. The values for  $a^*$  (redness) and  $b^*$  (yellowness) were positive and maximum in fruits of the same treatments. As a result chroma ( $C^*$ ), the index or purity of the hue ( $h^0$ ) that correlate between  $a^*$  and  $b^*$  were also higher with significance in fruits under those treatments (Table 37 and 52). This indicates the role of potassium sources (Ganeshmurthy *et al.*, 2011) and bagging (Amarante *et al.*, 2002) in conversion of peel pigments leading to improved peel colour of banana fruits. Saeed *et al.* (2009) observed the role of potassium silicate sprays in improving colour and appearance of *Rosa hybrida* var. Hot lady. Improvement in colour of banana fruits treated with potassium was observed by Kumar *et al.*, (2006). A-Shiaran *et al.* (2004) noticed increased chroma and lightness in grapes underwent bagging with black paper. Similar result was obtained by Mathooko *et al.*, (2011) due to fruit bagging in mango. In the present study, all the colour coordinates were significantly influenced by the potassium application and bagging of bunches.

Pooled data of from bunch fed treatments and then bagged significantly differed with other treatments with respect to peel colour indicating higher values for  $b^*$  ( $T_6$ -40.04 and 41.10, and  $T_7$ -38.57 and 42.17) and  $C^*$  ( $T_6$ -39.10 and 37.89, and  $T_7$ -37.96 and 37.98) and in both the type of fruits (Table 36 and 51). On the other hand, the peel colour of control fruits as indicated by  $L^*$  (53.66 and 53.77),  $b^*$  (31.93 and 34.19) and  $C^*$  (31.65 and 30.89) were lower in both Grand Naine and Ney Poovan.

### 5.2.5 Biochemical parameters

The quality parameters *viz.*, acidity, total soluble solids, total sugars, reducing sugar, non-reducing sugars, sugar acid ratio and starch of the fruit were significantly influenced by application of nitrogen, sulphur and potassium sources. Of all the nutrients, potassium appears to have profound influence on fruit quality through its influence on size, appearance, colour, soluble solids, acidity and vitamin contents. Fruits like banana, grapes, peach and passion fruit require high potassium. Although potassium does not form part of the structure of plant constituents, it regulates many vital functions like carbon assimilation, translocation of proteins and sugars, maintaining water balance in plants, maintaining turgor pressure in the cell, improving quality of the fruits by maintaining desirable sugar to acid ratio, ripening of fruit and many other processes. Thus, it is the most important nutrient regulating the quality of fruits. Potassium is involved in many aspects of plant physiology *viz.*, activation of more than 60 enzymes, aiding in photosynthesis, favouring high energy status, regulation of stomata opening *etc.*, (Kumar *et al.*, 2006).

Significant difference was noticed in the total soluble solids with application of nitrogen source and sulphate of potash in banana var Grand Naine and cv. Ney Poovan. The maximum total soluble solids (25.74<sup>0</sup>B and 26.67<sup>0</sup>B) were found in the treatment  $T_6$  (application of slurry mixture with 7.5 g urea + 7.5 g SOP in 100 ml water + bagging of bunches) in Grand Naine (Fig. 6) and  $T_7$  (application of slurry mixture with 7.5 g ammonium sulphate + 7.5 g SOP in 100 ml water + bagging of bunches) in Ney Poovan. Whereas, the lowest total soluble solids (20.88<sup>0</sup>B and 23.19<sup>0</sup>B) content was recorded in control ( $T_1$ ) (Table 40 and 55). Potassium helped in synthesis of more sugars in the fruit due to increased translocation of solutes and more

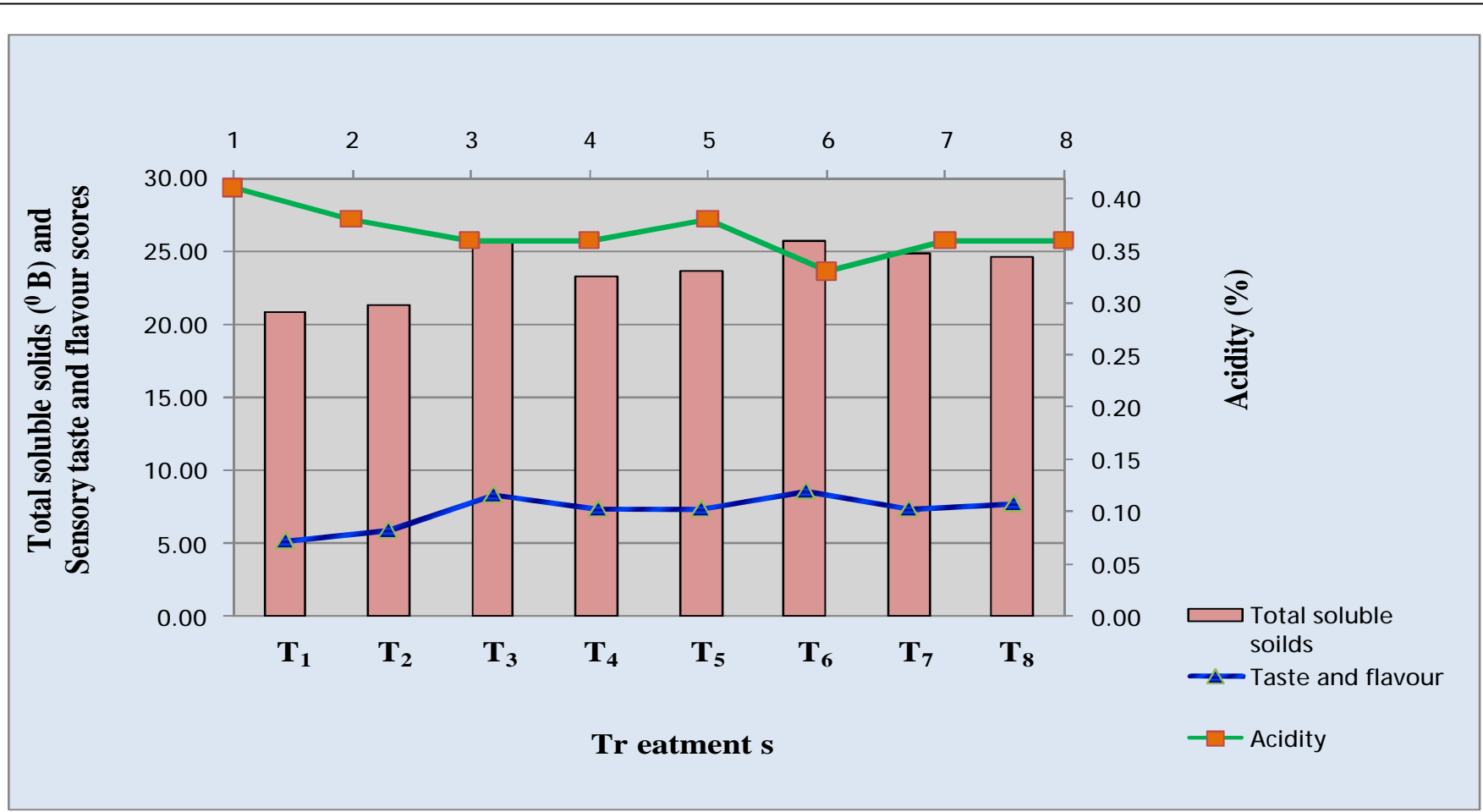
assimilation of synthates thus increasing total soluble solids in those treatments where potassium was involved.

Nandan *et al.* (2011) reported an increase in TSS in banana cv. Nanjangudu Rasabale due to spray of sulphate of potash (2%) to bunch. Exogenous application of SOP increases the flow of plant assimilates into the developing fruits especially when assimilate flow from other parts of plant becomes limited. The findings are in close conformity with Ramesh and Kumar (2007 and 2010) in cv. Ney Poovan and Ramesh *et al.* (2008) in cv. Robusta.

Banana pulp shows an increase in acidity during ripening and the main organic acid present are malic acid and as ripening advances, acidity declines presumably due to the utilization as respiratory substrates (Seymour *et al.*, 1993).

Titrateable acidity content was lower in treatment T<sub>6</sub> (application of slurry mixture with 7.5 g urea + 7.5 g SOP in 100 ml water + bagging) in Grand Naine (Fig. 6) and in T<sub>7</sub> (application of slurry mixture with 7.5 g ammonium sulphate + 7.5 g SOP in 100 ml water + bagging) in Ney Poovan (0.33% and 0.33%) and maximum in untreated (control) (0.41% and 0.40%) at ripe stage of both the fruits (Table 39 and 54). The decrease in acidity content in treated fruits might be due to increase in the total soluble, and may be due to potassium which might have either involved in fast conversion of metabolites into sugar and their derivatives (Tisdale and Nelson, 1966). During development of fingers under low potassium regime, phosphoenol pyruvate (PEP) was apparently shunted into alternate pathways resulting in a shortage of acetyl CO-A (Pattee and Teel 1967). Hence, oxalo acetate appeared to be preferentially formed from PEP in plants with low levels of potassium and thus organic acid derivative accumulated. With additional dose of potassium during development of fingers neutralizes organic acids due to a high potassium level in tissues which could have also resulted in the reduction in acidity (Tisdale and Nelson 1966). Similar results are noted by Nalina and Kumar (2007) in cv. Robusta; Ramesh and Kumar (2007 and 2010) in cv. Ney Poovan; Ramesh *et al.* (2008) in cv. Robusta; and Nandan *et al.* (2011) in cv. Nanjanagudu Rasabale.

In the present study, the amount of starch content in banana Grand Naine and Ney Poovan decreased significantly as the fruit ripened, while sugar content in the



**Fig. 6:** Total soluble solids content, sensory taste and flavour scores, and titratable acidity content in banana fruits var. ‘Grand Naine’ as influenced by pre harvest bunch treatments (feeding of nutrients) and bunch bagging

fruits increased significantly (Tapre and Jain 2012). The fruits obtained from bunches fed with nitrogen as urea and potassium sources (SOP) + bagging (T<sub>6</sub>) (5.93% at ripe stage and 3.87% at senescence stage) (pooled values) had maximum starch content in Grand Naine (Table 44). Whereas, nitrogen in ammonical form and potassium sources (SOP) + bagging (T<sub>7</sub>) also recorded maximum starch in Ney Poovan (5.09% at ripe stage and 1.64% at senescence stage) (Table 59). Lower starch content was observed in control (4.11% and 3.27% at ripe stage and, 1.67% and 1.08% at senescence stage) in both the fruits. The results indicated that the conversion of starch into sugars was rapid in untreated fruits than in treated fruits. This could be due to the rapid induction of climacteric phases, higher respiration and higher respiratory metabolic pathways leading to starch hydrolysis (Marriot, 1980).

At optimum ripe stage, the pooled total sugar content (20.84% in T<sub>6</sub> in Grand Naine; 24.16% in T<sub>7</sub> in Ney Poovan) and reducing sugar content (16.26% in T<sub>6</sub> in Grand Naine; 21.36% in T<sub>7</sub> in Ney Poovan) was more in fruits from bunches fed with slurry mixture of nitrogen and potassium source, while minimum total sugar (16.08% and 19.11%) (Fig. 7) and reducing sugar (10.60% and 14.67%) were noticed in control (T<sub>1</sub>) in both types of fruits (Table 40 and 55, and Table 41 and 56 respectively), further increasing trend of sugars were noticed in all treatments at senescence stage. This progressive increase could be related to increase in total soluble solids content and also due to enzymatic conversion of starch to reducing sugars. Potassium plays a vital role in carbon assimilation, translocation of proteins and sugars, maintaining water balance in plants, maintaining turgor pressure in the cell, improving quality of the fruits by maintaining desirable sugar to acid ratio (Kumar *et al.*, 2006).

Application of sulphate of potash was also found to be beneficial in increasing sugar content as potassium played a major role in carbohydrates synthesis, breakdown and translocation and synthesis of protein and neutralization of physiologically important organic acids (Tisdale and Nelson, 1966). Further, potassium when supplied in the form of sulphate of potash favoured conversion of starch into simple sugars during ripening by activating the sucrose synthase enzyme leading to higher sugar percentage (Marschner, 1995). Potassium is involved in phloem loading and unloading of sucrose and amino acids and storage in the form of starch in developing

fruits by activating the enzyme starch synthase (Mengel and Kirkby, 1987). In plants supplied with potassium, the osmotic potential of the phloem sap and the volume flow were higher than in bunches with low K supply and as a result, sucrose concentration in phloem sap was increased (Marschner, 1995). Results of the present investigation are supported by Ramesh and Kumar (2007 and 2010) in banana cv. Ney Poovan, Nandan *et al.*, (2011) in cv. Nanjanagudu Rasabale and Ramesh *et al.*, (2008) in cv. Robusta.

Higher sugar-acid ratio was observed in the treatment T<sub>6</sub> in Grand Naine (63.19) (Fig. 7) and in the treatment T<sub>7</sub> in Ney Poovan (75.10) at ripe stage of fruits (Table 43 and 58). The least sugar-acid ratio value (39.56% and 46.75%) was noted in untreated fruits (T<sub>1</sub>) of Grand Naine and Ney Poovan respectively. Significantly low sugars and high acids in control fruits reveal lack of optimal blend of sugar-acid that could have otherwise brought better taste to fruits. This fact has been confirmed by significantly low sensory scores obtained by the fruits of control treatment.

### 5.2.6 Organoleptic evaluation

Organoleptic evaluation of a product is an important tool for deciding the consumer acceptability. Sensory characteristics of quality include appearance (in terms of colour, absence of blemishes and spotting), texture, flavour and overall acceptability. Colour increases the attractiveness of fruits. Surface colour is important for choosing fruits in the market and internal colour is important to influence overall acceptability during consumption. Peel colour of banana fruits changes on ripening from dark green to yellow.

In this investigation, maximum score for skin colour (8.39 and 8.25) and pulp colour (8.03 and 8.12) was noted in fruits obtained from bunches fed with slurry mixture with nitrogen and potassium source + bagging in Grand Naine (T<sub>6</sub>) and Ney Poovan (T<sub>7</sub>) (Table 45 and 60). Role of potassium (Kumar *et al.*, 2006) and effectiveness of bagging (Sharma *et al.*, 2014) in improving colour and appearance of fruits has been reported. During the ripening of banana, the pulp colour changes from the typical “opaque white” of a product with high starch content to a “very soft yellow” as the skin colour intensifies (Salvador *et al.*, 2007).

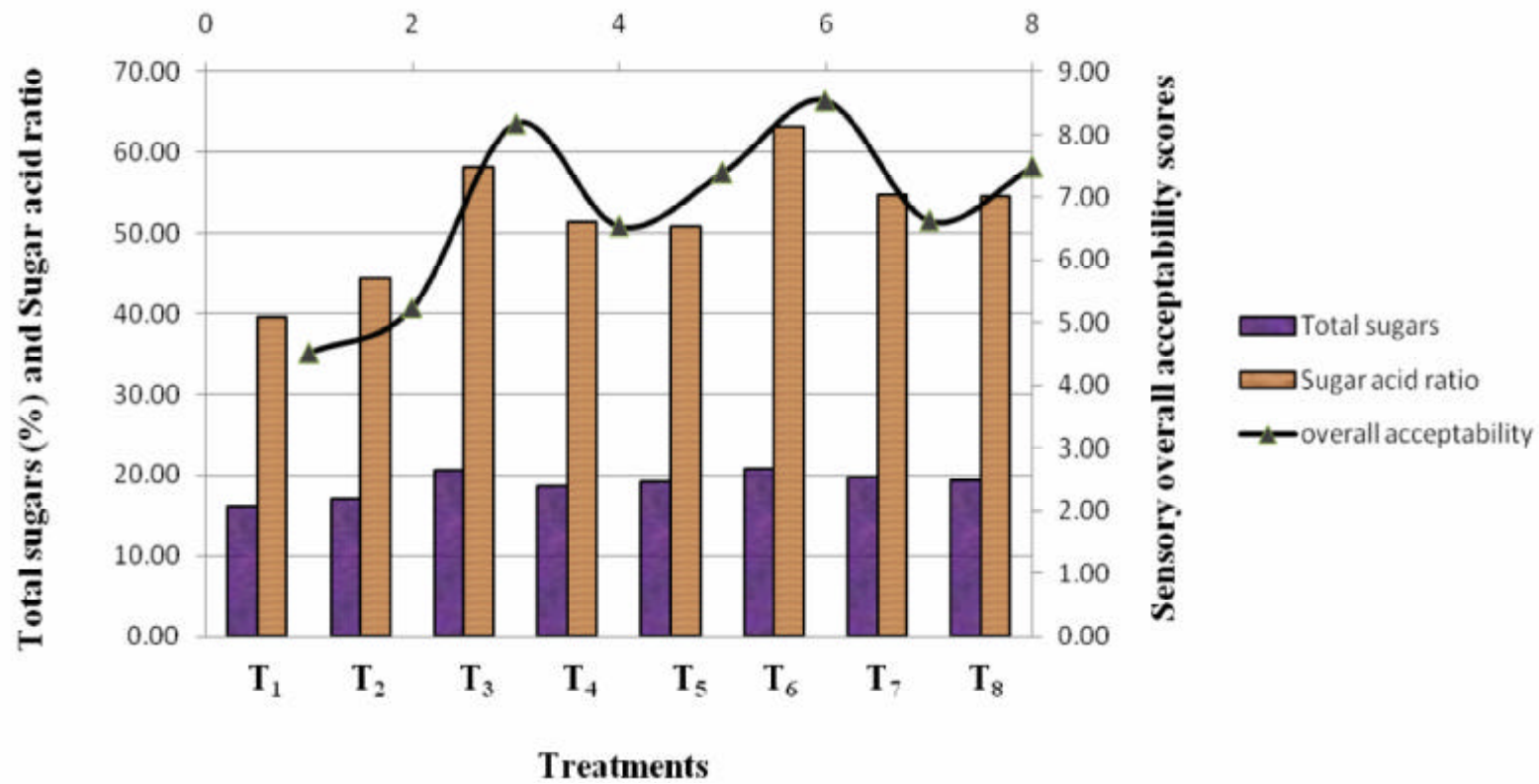


Fig. 7: Total sugars content, sugar acid ratio and overall acceptability scores of banana fruits var. 'Grand Naine' as influenced by pre harvest bunch treatments (feeding of nutrients) and bunch bagging

Similarly, the same treatments had scored significantly higher for pulp texture (Table 45 and 60). Seemingly greater firmness of fruits under potassium treatments substantiates the significantly maximum score observed for texture (7.74 and 7.24). Very soft texture acquired by the fruit during ripening leads to lower quality and higher incidences of mechanical damage during handling and transportation (Dadzie and Orchard, 1977). The loss of texture is associated with processes like breakdown of starch to form sugar and breakdown of the cell walls or reduction in the middle lamella cohesion due to solubilisation of pectic substances (Smith, 1989). Potassium plays to reduce the fungal infection by increasing turgor pressure of cells thus giving rigidity to cell wall (Kumar *et al.*, 2006). Pre-harvest fruit bagging is known to influence fruit size, maturity, skin colour, flesh mineral content and fruit quality (Hofman *et al.*, 1997; Fan and Mattheis, 1998).

The taste and flavour of any fruit is influenced by the proportion of sugars, acidity, volatiles and firmness factors influencing the mouth-feel. During banana fruit ripening, the accumulated starch hydrolyses as a result of amylase activity leading to the formation of sugars. Desirable flavours may be produced by loss of organic acids and increased volatiles compounds during ripening (Kishor *et al.*, 2006). The changes in acidity and sugars were at an incredibly desirable level in the bunch fed treatments (T<sub>6</sub> and T<sub>7</sub>). These changes in sugars and acid might have given rise to an exceptional blend that has greatly influenced the taste and flavour of fruits leading to high scores in treatment T<sub>6</sub> in Grand Naine (8.56) (Fig. 6) and in treatment T<sub>7</sub> in Ney Poovan (8.50) (Table 45 and 60).

Fruits fed with nutrient sources and bagging showed greater overall acceptability (8.54 and 8.33) in treatment T<sub>6</sub> in Grand Naine (Fig. 7) and in treatment T<sub>7</sub> in Ney Poovan respectively than the other treatments (Table 45 and 60). Control fruits were organoleptically inferior (overall acceptability 4.52 and 4.65). The high score for overall acceptability of fruits obtained in these treatments may be due to good appearance, better texture, skin colour and good taste.

### **5.3 Future line of work**

- 1) The present study indicated better performance of banana with respect to yield, quality and shelf life with the pre-harvest bunch treatment involving potassium silicate at the concentration of 6ml/l which is the maximum concentration used in the study. However, research may be furthered to know the efficacy of potassium silicate at the concentration more than 6ml/l on different varieties of banana under different agro-climatic conditions.
- 2) Another experiment in the present investigation revealed better performance of banana bunches fed with urea (7.5g) + SOP (7.5g) + bagging in variety Grand Naine and ammonium sulphate (7.5g) + SOP (7.5g) + bagging in Ney Poovan. Research may carried out to further assess the combined effect of bunch feeding and potassium silicate at the concentration 6ml/l. This helps to conclude whether these treatments are effective in isolation or in combination on yield and quality of banana.
- 3) Assess effect of different colours of bunch covers in influencing the yield and quality of banana fruits.

## 6. SUMMARY AND CONCLUSION

The present investigation on “Studies on effect of pre-harvest bunch treatment and bagging on yield and post harvest quality of banana” was planned as four different experiments for convenience. The important findings of these experiments are summarized here under.

### **6.1 Experiment-1: Effect of bunch treatment (potassium silicate) and bagging on yield, post harvest quality and shelf life of banana fruits var. ‘Grand Naine’**

#### **Experiment-2: Effect of bunch treatment (potassium silicate) and bagging on yield, post harvest quality and shelf life of banana fruits cv. ‘Ney Poovan’**

The study was carried out for two consecutive years (2014 and 2015) on both the type of fruits (Grand Naine and Ney Poovan). The treatments involved pre-harvest application of potassium silicate (at monthly intervals after the emergence of inflorescence) at different concentrations in combination with bagging to know their efficacy on yield, quality and shelf life. On the whole, potassium silicate at 6 ml/l in combination with bunch bagging (T<sub>8</sub>) performed better over other treatments in both the type of fruits.

Pooled data of both the fruits (Grand Naine and Ney Poovan) exhibited improved bunch weight (32.69kg/plant and 12.87 kg/plant), total number of fruits per bunch (203.83 and 152.00) and physical quality of banana fruits *viz.*, mature fruit weight (150.71g and 83.87g), fruit length (19.93cm and 14.00), fruit diameter (3.80 cm and 2.80 cm), ripe fruit weight (144.65g and 77.12g), pulp weight (111.82g and 68.85) and pulp percentage (77.31% and 89.24%) with potassium silicate sprays at 6ml/l + bagging of fruits (T<sub>8</sub>) indicated its positive role in manipulating growth characters and physiological developmental processes. The least bunch weight (24.71 and 8.44 kg), fruit parameters such as mature fruit weight (121.72g and 67.83g), length (13.98cm and 10.83cm), ripe fruit weight (115.59g and 60.69g), pulp weight (82.67g and 53.70g) and peel weight (31.40g and 7.00g) were observed in the untreated control (T<sub>1</sub>) in both the fruits.

Minimum physiological loss in weight (6.01% and 4.24% at ripe stage, and 10.06% and 9.28% at senescence stage), extended shelf life (12.83 days and 7.50 days) and lower respiration rates were recorded in fruits of bunches sprayed with potassium silicate at 6 ml/l + bagging of bunches in both types fruits (Grand Naine and Ney Poovan). The control fruits that were severely affected by accelerated respiration and transpiration were associated with higher PLW (12.24% and 10.35% at ripe stage, and 18.48% and 14.16% at senescence stage) and short shelf life (5.83 days and 4.50 days). Banana fruits treated with 6 ml/l of potassium silicate + bagging also resulted in better instrumental colour values ( $L^* a^* b^*$ ) indicating good colour development and appearance of fruits. Banana fruits under this treatment were also free from pest attack compared to control and other treatments.

At ripe stage of both the fruits recorded significantly high TSS (23.23<sup>0</sup>B and 26.95<sup>0</sup>B), high total sugar (18.98% and 23.72%), reducing sugar (14.58% and 18.23%) and the lowest titratable acidity (0.33% and 0.29%) were recorded with foliar application of potassium silicate at 6ml /l + bagging. Sugar-acid ratio and starch were also higher in these fruits (57.41 and 80.26, 5.91% and 5.07% respectively).

The fruits under potassium silicate sprays at 6 ml/l + bagging treatment exhibited high organoleptic acceptability (8.18 and 8.50) with better score for colour, texture, and taste and flavour. Untreated control fruits lacked both peel and pulp colour appearance. Untreated fruits were also associated with high acidity (0.42% and 0.38%), minimum TSS (19.44<sup>0</sup>B and 22.98<sup>0</sup>B), lower total sugars (14.31% and 18.06%), reducing sugars (9.21% and 11.37%) and sugar-acid ratio (33.46 and 46.74). Hence, the fruits were least acceptable organoleptically (5.21 and 5.57).

**6.2 Experiment-3: Effect of bunch treatment (urea, ammonium sulphate, SOP and 2, 4-D) and bagging on yield, post harvest quality and shelf life of banana fruits var. 'Grand Naine'**

**Experiment-4: Effect of bunch treatment (urea, ammonium sulphate, SOP and 2, 4-D) and bagging on yield, post harvest quality and shelf life of banana fruits var. 'Ney Poovan'**

The above experiments involved feeding of bunches with source of nitrogen and potassium at distal end of rachis, applying 2, 4-D in combination with bagging of

bunches on banana var. Grand Naine and cv. Ney Poovan. The treatments were imposed after the emergence of bunch. In general, pooled data of two consecutive years (2014 and 2015) revealed better performance of feeding treatments with nitrogen and potassium source, and 2, 4-D with respect to quality, shelf life, and yield both in var. Grand Naine and cv. Ney Poovan.

Maximum bunch weight (31.11 kg/plant and 12.33 kg/plant) was obtained from the bunches applied with 2,4 D at 20ppm + bagging (T<sub>8</sub>) and 2, 4 D alone (T<sub>5</sub>) followed by bunches fed with nutrient mixture of nitrogen source and SOP + bagging (T<sub>6</sub> and T<sub>7</sub>). The lowest bunch weight was recorded in control (24.36 kg/plant and 8.37 kg/plant) in both the fruits.

Bunches applied with 20 ppm 2, 4-D + bagging (T<sub>8</sub>) recorded the highest ripe finger weight (144.3g and 73.10g), finger length (20.64cm and 14.11 cm), finger diameter (3.81cm 2.79 cm) and pulp weight (113.33 and 64.96) which were followed by fruits applied with 2, 4-D alone(T<sub>5</sub>). Treatments involving nutrient sources + bagging were next best to 2, 4-D for bunch and finger characters. The least performance with respect to these parameters was recorded in control.

Minimum physiological loss in weight (5.84% at ripe stage and 9.96% at senescence stage) and extended shelf life (11.99 days) was noticed in bunches fed with urea + SOP + bagging (T<sub>6</sub>) in Grand Naine fruits, whereas, minimum PLW (4.56% at ripe stage and 9.13% at senescence stage) and extended shelf life (6.92 days) was recorded in bunches fed with ammonium sulphate + SOP + bagging (T<sub>7</sub>) in Ney Poovan. As untreated control fruits were associated with higher respiration rate, they recorded maximum PLW (12.18% and 10.87% at ripe stage and 19.02 and 14.64% at senescence stage) and minimum shelf life (5.83 days and 4.58days) in both Grand Naine and Ney Poovan fruits.

Fruits treated with nutrient mixture (nitrogen source and SOP) + bagging also fared well in obtaining better colour values ( $L^* a^* b^*$ ). Both the fruits (Grand Naine and Ney Poovan) had good peel colour and appearance, and had greater acceptability by panelists when subjected to sensory analysis.

Total soluble solids was found to be the highest (25.74 °B) in the bunches fed with urea + SOP + bagging (T<sub>6</sub>) in Grand Naine fruits at ripe stage of fruit.

Consequently, total sugar and reducing sugar content was also found to be higher (20.84% and 16.26 respectively) in this treatment. Fruits of the same treatment exhibited lower titratable acidity (0.36%) at optimum ripe stage.

Similarly in Ney Poovan fruits, higher TSS (26.67<sup>0</sup>B), total sugars (25.00%), reducing sugars (21.36%) were found in fruits treated with ammonium sulphate + SOP + bagging (T<sub>7</sub>) with lower amount of titratable acidity (0.35%).

Sugar-acid ratio (63.19 and 75.10) and starch content (5.93% and 5.09%) were higher in the fruits treated with urea + SOP+ bagging (T<sub>6</sub>) in Grand Naine and ammonium sulphate+ SOP+ bagging (T<sub>7</sub>) in case of Ney Poovan respectively.

As the peel colour, pulp colour, texture, taste and flavour were higher for fruits treated with urea + SOP+ bagging (T<sub>6</sub>) and ammonium sulphate + SOP + bagging (T<sub>7</sub>), the fruits of Grand Naine (8.54) and Ney Poovan (8.33) respectively recorded higher overall acceptability scores. Untreated control fruits were found to be least acceptable in view of low organoleptic scores (4.52 and 4.62) in both the fruits (Grand Naine and cv. Ney Poovan).

## Conclusions

- Pre-harvest sprays of potassium silicate (6 ml/l) + bagging augmented bunch weight, delayed ripening, extended shelf life, improved the quality and edibility of fruits in var. Grand Naine and cv. Ney Poovan
- Application of 2, 4 D at 20 ppm + bagging gave better results in terms of bunch weight and finger characters *viz.*, finger weight, finger length and diameter, and pulp weight in both fruits, closely followed by bunch fed treatments
- Bunch feeding with urea (7.5 g) + SOP (7.5 g) + bagging had better quality and sensory attributes in case of Grand Naine fruits
- Ney Poovan fruits fed with ammonium sulphate (7.5 g) + SOP (7.5 g) + bagging exhibited better quality, extended shelf life and high acceptability scores

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**Appendix I: Weather data recorded (Jan 2014 to Dec 2015) at Horticulture Research Station, Arsikere, Karnataka during the experimental period**

Months	Temperature (° C)		Relative Humidity (%)	
	Maximum	Minimum	Morning	Evening
<b>2014</b>				
January	28.90	12.17	55.30	27.40
February	29.80	15.55	53.20	29.45
March	32.45	18.80	52.60	34.25
April	33.75	20.50	66.65	33.10
May	33.45	20.16	60.58	40.38
June	29.87	21.42	62.44	46.72
July	27.05	21.11	64.78	54.21
August	26.71	21.35	66.75	51.84
September	28.15	20.40	62.64	43.21
October	27.67	20.12	69.52	52.25
November	26.64	14.71	67.22	43.48
December	26.77	14.33	61.75	38.72
<b>2015</b>				
January	27.55	12.10	54.05	26.77
February	30.26	11.38	51.02	22.60
March	33.55	14.06	74.65	30.33
April	32.92	18.20	70.45	41.10
May	32.31	19.62	78.64	39.40
June	29.28	19.92	80.25	61.75
July	29.22	19.05	75.50	58.52
August	29.92	18.97	78.25	57.55
September	28.70	18.50	80.54	61.71
October	30.95	17.02	81.55	55.28
November	26.53	17.25	81.50	71.10
December	28.03	15.46	77.80	65.28

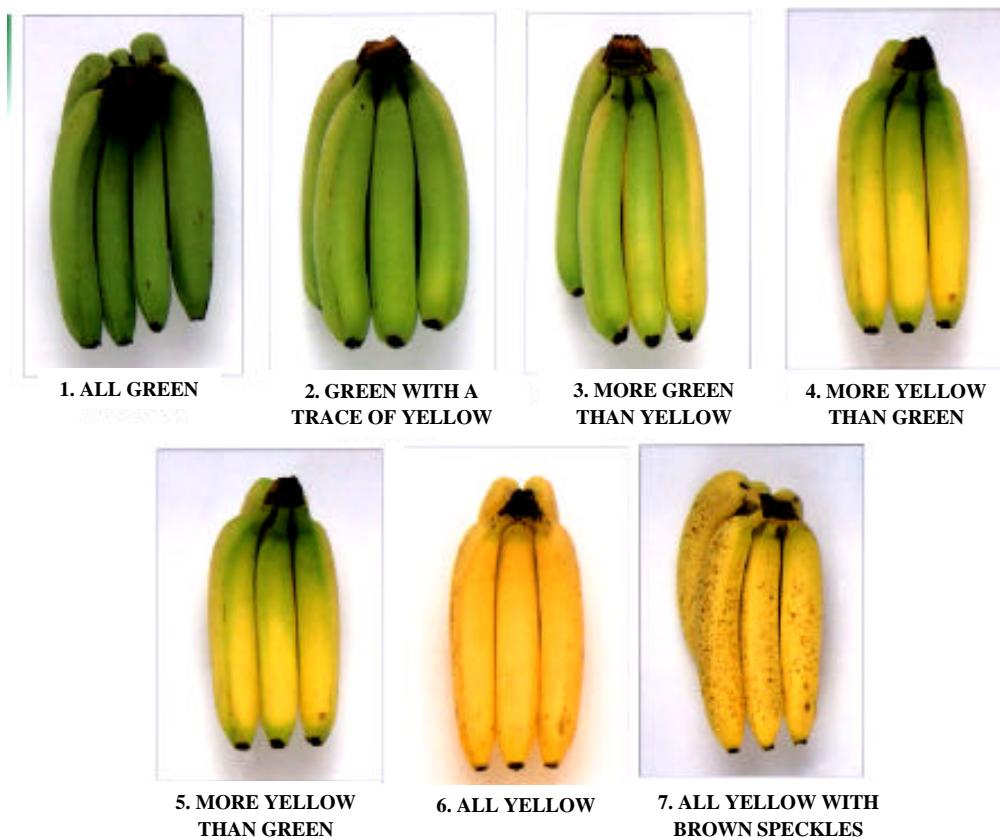
**Appendix II: Metrological data recorded during the experimental period from January 2014 to January 2016 at Agriculture Research Station, Arabhavi-591 218.**

Month	Temperature °C		RH%
	Maximum	Minimum	
<b>2014</b>			
January	28.80	9.30	95.00
February	31.20	16.00	89.70
March	34.60	17.30	88.50
April	38.25	20.10	82.20
May	36.30	26.40	89.70
June	33.70	22.30	86.40
July	30.60	21.60	87.80
August	28.70	22.20	93.10
September	29.00	20.40	87.90
October	31.60	19.60	88.90
November	29.80	16.70	92.90
December	28.40	17.80	91.10
<b>2015</b>			
January	28.45	14.40	88.50
February	31.90	18.10	87.50
March	34.10	18.05	85.00
April	38.00	20.20	82.10
May	38.00	22.70	85.50
June	31.40	21.20	85.50
July	31.10	20.70	84.50
August	30.90	19.90	88.30
September	31.90	18.90	89.40
October	34.60	18.30	89.90
November	30.90	14.30	87.00
December	28.00	19.00	90.00
<b>2016</b>			
January	31.50	10.40	88.90
February	35.90	14.50	91.70
March	37.36	16.30	84.30

**Appendix III: Initial soil parameters of the experimental site**

<b>Sl. No.</b>	<b>Parameters</b>	<b>Content</b>
<b>Physical parameters</b>		
1	Coarse Sand (%)	37.82
2	Fine sand (%)	30.20
3	Silt (%)	16.75
4	Clay (%)	15.38
<b>Chemical parameters</b>		
5	Ph	5.90
6	EC (dSm <sup>-1</sup> )	0.26
7	Organic carbon (%)	1.14
8	N (kg/ha)	110.71
9	P (kg/ha)	37.00
6	K (kg/ha)	208.92

**Appendix IV: Picture indicating stages\* of banana fruit considered for physiological and chemical analysis**



**\* Stages**

Mature green stage :Stage 2

Ripe stage :Stage6

Senescence stage :Stage7

**Appendix V: Benefit cost ratio of conducted experiments****Benefit cost ratio of Experiment No. 1**

<b>Treatments</b>	<b>Bunch weight (kg/plant)</b>	<b>Yield (t/ha)</b>	<b>Gross income (Rs)</b>	<b>Cost of cultivation (Rs)</b>	<b>Net returns (Rs)</b>	<b>B:C ratio</b>
T <sub>1</sub>	24.71	57.53	690,388	220,000	470,388	2.14
T <sub>2</sub>	25.88	60.26	723,077	256,000	467,077	1.82
T <sub>3</sub>	28.53	65.40	784,853	223,500	561,353	2.51
T <sub>4</sub>	29.14	66.80	801,634	225,000	576,634	2.56
T <sub>5</sub>	30.16	69.14	829,694	227,000	602,694	2.66
T <sub>6</sub>	29.58	67.81	813,739	258,000	555,739	2.15
T <sub>7</sub>	31.19	71.50	858,029	260,000	598,029	2.30
T <sub>8</sub>	32.69	74.94	899,294	262,000	637,294	2.43

**Benefit cost ratio of Experiment No. 2**

<b>Treatments</b>	<b>Bunch weight (kg/plant)</b>	<b>Yield (t/ha)</b>	<b>Gross income (Rs)</b>	<b>Cost of cultivation (Rs)</b>	<b>Net returns (Rs)</b>	<b>B:C ratio</b>
T <sub>1</sub>	8.44	19.65	353,715	132,000	221,715	1.68
T <sub>2</sub>	9.07	21.12	380,118	168,000	212,118	1.26
T <sub>3</sub>	9.52	21.82	392,839	135,500	257,339	1.90
T <sub>4</sub>	10.16	23.29	419,249	137,000	282,249	2.06
T <sub>5</sub>	11.59	26.57	478,257	139,000	339,257	2.44
T <sub>6</sub>	9.90	22.70	408,520	170,000	238,520	1.40
T <sub>7</sub>	11.00	25.22	453,911	172,000	281,911	1.64
T <sub>8</sub>	12.87	29.50	531,076	174000	357,076	2.05

**Benefit cost ratio of Experiment No. 3**

<b>Treatments</b>	<b>Bunch weight (kg/plant)</b>	<b>Yield (t/ha)</b>	<b>Gross income (Rs)</b>	<b>Cost of cultivation (Rs)</b>	<b>Net returns (Rs)</b>	<b>B:C ratio</b>
T <sub>1</sub>	24.36	56.72	680,609	220,000	460,609	2.09
T <sub>2</sub>	25.84	60.16	721,959	256,000	465,959	1.82
T <sub>3</sub>	29.47	67.56	810,713	222,500	588,213	2.64
T <sub>4</sub>	27.60	63.27	759,269	222,500	536,769	2.41
T <sub>5</sub>	30.87	70.77	849,226	222,000	627,226	2.83
T <sub>6</sub>	30.79	70.59	847,026	258,500	588,526	2.28
T <sub>7</sub>	30.49	69.90	838,773	258,500	580,273	2.24
T <sub>8</sub>	31.11	71.32	855,829	258000	597,829	2.32

**Benefit cost ratio of Experiment No. 4**

<b>Treatments</b>	<b>Bunch weight (kg/plant)</b>	<b>Yield (t/ha)</b>	<b>Gross income (Rs)</b>	<b>Cost of cultivation (Rs)</b>	<b>Net returns (Rs)</b>	<b>B:C ratio</b>
T <sub>1</sub>	8.37	19.49	350,782	132,000	218,782	1.66
T <sub>2</sub>	9.05	21.07	379,280	168,000	211,280	1.26
T <sub>3</sub>	10.69	24.51	441,119	134,500	306,619	2.28
T <sub>4</sub>	10.81	24.78	446,071	137,000	309,071	2.26
T <sub>5</sub>	11.75	26.94	484,860	139,500	345,360	2.48
T <sub>6</sub>	11.18	25.63	461,339	170,000	291,339	1.71
T <sub>7</sub>	11.50	26.36	474,543	172,000	302,543	1.76
T <sub>8</sub>	12.33	28.27	508,793	174,000	334,793	1.92

**STUDIES ON EFFECT OF PRE-HARVEST BUNCH TREATMENT AND BAGGING ON YIELD AND POST HARVEST QUALITY OF BANANA**

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**2016**

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**ABSTRACT**

The investigation entitled “Studies on effect of pre-harvest bunch treatment and bagging on yield and post harvest quality of banana” was undertaken in a farmer’s field (Kadur Tq.) and laboratory analyses were done at K.R.C. College of Horticulture, Arabhavi, Belgaum District of Karnataka during 2014-2016. The study was carried out for two consecutive years (2014 and 2015) on Grand Naine and Ney Poovan.

The treatments involved pre-harvest bunch spraying of potassium silicate (at monthly intervals after the emergence of inflorescence) at different concentrations (2ml/l, 4ml/l and 6ml/l) with or without bagging (Experiment 1 and 2) as well as application of 2, 4- D (20 ppm) and use of urea, ammonium sulphate and sulphate of potash for bunch feeding with or without bagging (Experiment 3 and 4) on banana var. Grand Naine and cv. Ney Poovan.

The bunches sprayed with potassium silicate sprays at 6 ml/l + bagging treatment significantly improved bunch weight, total number of fruits per bunch and physical quality (mature fruit weight, fruit length, fruit diameter, ripe fruit weight and pulp weight) over control. Treatment also recorded the significantly minimum cumulative PLW, respiration rate and maximum shelf life of 12.83 days in var. Grand Naine and 7.50 days in case of cv. Ney Poovan. The TSS, sugars, sugar-acid ratio and starch content were found maximum. Both Grand Naine and Ney Poovan fruits in this treatment had better colour values (maximum  $L^*, a^*, b^*, c^*$ ). The treated fruits were also found organoleptically superior.

Bunches sprayed with 20 ppm of 2, 4 D (Experiment 3 and 4) recorded better bunch weight, fruit weight, length, diameter and pulp weight in Grand Naine and Ney Poovan fruits. The TSS, sugars, sugar-acid ratio, starch and colour values ( $L^*, a^*, b^*, c^*$ ) were better in fruits fed with nitrogen source+potassium source dissolved in slurry mixture+bagging. Bunch feeding + bagging also recorded minimum respiration rate and maximum shelf life in both Grand Naine and Ney Poovan fruits.

