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THE EFFECT OF PESTICIDE APPLICATION ON FRUIT BAGGING TOWARD THE QUALITY OF POMELO FRUIT (CITRUS MAXIMA (BURM.) MERR.)

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ABSTRACT

Pomelo (Citrus maxima (Burm.) Merr.) is one of the citrus species in Indonesia that has a larger fruit size compared to other citrus species. The purpose of this study is to obtain recommendations for the right type of pesticide for bagging to result in the best fruit quality. The research was conducted at the IPB Cikabayan Experimental Farm and AGH postharvest laboratory from December 2019 to June 2020. The experiment used a completely randomized design (CRD) with the sole factor of pesticide type, and consisted of 4 treatments, as bags with the active pesticide ingredient streptomycin sulfate (P1), bags with the active pesticide ingredient mancozeb (P2), bags with the active pesticide ingredients mancozeb and streptomycin sulfate (P3), and control bags without active pesticide ingredients (P4), each replicated 4 times. The results showed that the P3 and P2 treatments had significantly different results on the skin smoothness variable. The P3 treatment showed a skin smoothness value of 83.23% and was not significantly different from the P2 treatment, which was 76.85%.

KEY WORDS

Nambangan, mancozeb, streptomycin sulfate, fruit quality, skin smoothness.

Pomelo (Citrus maxima (Burm.) Merr.) is one of the kinds of citrus with potential to be developed in Indonesia because it is able to grow well in tropical areas. Pomelo is easily found in various traditional markets or supermarkets in Indonesia. The demand of the people for pomelo is considered high because in several regions, pomelo is often served in traditional as well as religious events. Some of the centers of pomelo production are in Pati Regency, Magetan Regency, and Madiun Regency. Although the demand for pomelo is considered high, domestic pomelo production can still meet that demand. BPS (2016) reported that pomelo production in the province of Central Java increased since 2013 and reached 17,202 tons in 2015.

The demand for pomelo has been steadily increasing in recent years due to its health benefits and unique flavor profile. The rising demand for pomelo has led to an increase in its cultivation in various parts of the world. The popularity of pomelo has surged in the international market, with increasing demand from consumers for exotic fruits (Liu et al., 2020; Teh et al., 2021; Mohd Fadzelly et al., 2018). The demand for pomelo is expected to continue to grow, driven by increasing awareness of its health benefits and unique taste (Goonetilleke et al., 2019). It has created economic opportunities for farmers, who are now investing in the cultivation of this fruit (Choon et al., 2017).

According to Balitjestro (2014), there are important matters in techniques of pomelo cultivation, among which are branch arrangement, irrigation, fertilization, fruit pruning, and pest and disease control. Tree architecture needs to be conceived by way of arranging branches with a 1 – 3 – 9 pattern, which means that each tree consists of 1 main branch that supports 3 primary branches, and each primary branch supports 3 secondary branches. New vegetative growth, flowering, and fruit formation requires water in sufficient quantities, and after harvest, the land is left to dry out for approximately 3 months to stimulate flowering. The activity of fruit pruning has the objective of yielding high-quality fruits and maintaining production stability by leaving 2 fruits per bunch. The usage of pesticides should be prioritized in the critical period, which is during the budding phase.

The common pest that frequently attacks the pomelo fruit is the fruit fly (*Bactrocera* spp.). According to Larasati (2012), in the Bogor area, eight species had been identified based on type association with their hosts. The eight species are *B. mcgregori*, which belongs to the monophagous species group; *B. cucurbitae*, *B. latifrons*, and *B. umbrosa*, which belong to the oligophagous species group; and *B. carambolae*, *B. papayae*, *B. albistrigata*, and *B. calumniata*, which belong to the polyphagous species group. Symptoms of fruit flies that may be observed on the field comprise small black-colored holes on the fruit skin and the presence of fruit fly larvae in the inside of the fruit. According to De Lima *et al*. (2007), to kill fruit fly larvae that have hatched, a treatment is required in the form of fruit storage at 2° Celsius for 18 days.

Fruit bagging is one of the efforts to maintain fruit quality prior to harvest. Fruit bagging may reduce symptoms of pest and disease attacks on fruit. According to Damayanti (2000), fruit bagging causes an accumulation of heat, which will trigger the processes of fruit growth, development, and ripening. Fruit bagging effectively increases the external quality of fruits such as for guava (Susanto *et al*., 2017) and starfruit (Prastowo and Siregar, 2014). According to Ni'am (2018), defects on fruits without treatment experience more rapid development compared to fruits that received fruit bagging treatment with the addition of active pesticide substances. The rate of defects on fruits without treatment reached 38% during harvest, and the lowest rate of defects was found for the fruit bagging treatment with the addition of the active substances of mancozeb and streptomycin sulfate, with 11%.

Other than fruit bagging, another alternative that may be applied in maintaining fruit quality is with chemical control through the usage of pesticides with appropriate concentrations and doses. According to Untung (2007), the usage of different kinds of pesticides in general is divided into several specifications depending on the kinds of pests and diseases that attack plants. Each kind of pesticide has a different kind of active substance, and these active substances may be in the form of systemic or contact poisons. Fruit flies may also be controlled by creating traps that contain bait in the form of methyl eugenol (4-allyl-1,2-dimethoxybenzene-carboxylate). Vargas *et al*. (2003) reported that in general, methyl eugenol is attractive for male fruit flies, and 24 out of 46 species of fruit flies are attracted to methyl eugenol.

METHODS OF RESEARCH

Research activities were conducted at the Cikabayan Bawah Experimental Farm and the Post-Harvest Laboratory, Department of Agronomics and Horticulture, Faculty of Agriculture, Bogor Institute of Agriculture. Treatments and observations were conducted from December 2019 to June 2020. The materials that were utilized during the research were pomelo citrus plants of the Nambangan cultivar, pesticide with the active substance mancozeb of the Dithane brand, pesticide with the active substance of streptomycin sulfate of the Agrept brand, NPK compound fertilizer 16:16:16 for maintenance, clear plastic to wrap the fruits during development, insecticide of the attractant type with the active substance of methyl eugenol, herbicide with the active substance of glyphosate, and transparent plastic labels. The types of equipment that were utilized while on the pomelo plantation covered scales, buckets, and farming tools for maintenance. The tools and materials that were used during the post-harvest observations included an analytic scale, ruler, knife, calipers, refractometer, penetrometer, Erlenmeyer flask, measuring flask, measuring cup, distilled water, NaOH solution 0.1 N, phenolphthalein solution (PP), and iodine solution 0.01 N.

This research utilized a completely randomized design (CRD) with one factor, as the type of pesticide, and is composed of 4 treatments, as fruit bagging with the pesticide containing the streptomycin sulfate active substance (P1), fruit bagging with the pesticide containing the mancozeb active substance (P2), fruit bagging with the pesticides containing the mancozeb and streptomycin sulfate active substances (P3), and control/fruit bagging without pesticides or active substances (P4). Each treatment was repeated 4 times, resulting in 16 trial units. This is the additive linear model of the experiment:

$$Yij = \mu + \tau i + \varepsilon ij$$

Where: Yij = Quality value of pomelo fruit on treatment i and repetition j; μ = General mean; τi = Influence of pesticide treatment i, i = 1, 2, 3, 4; εij = Influence of experimental error from treatment i and repetition j.

The research began by determining fruits and affixing labels on each fruit sample. Each treatment was repeated 4 times and each repetition consisted of one plot containing 6 plants each. For each plant, 3 fruits were taken as samples, and thus 90 fruits in total were utilized in the research. The pesticides that were utilized in the trials were of the Agrept 20WP and Dithane M-45 80WP brands, with the doses of each being 2g/l. The bagging plastic was then dipped in the pesticide solutions, air-dried, and placed on the fruits according to the label. The bagging plastic was replaced every 2 weeks to renew the active substances of the pesticides.

Plant maintenance involved fertilization, pest control using insecticides, and mechanical and chemical weed control. Fertilization was conducted with an NPK compound fertilizer 16:16:16 with a dose of 0.5 kg per tree. Application of fertilizer was conducted with dilution by the addition of water. Pest control was conducted using an attractant-type insecticide with the active substance of methyl eugenol to control the fruit flies. Chemical weed control was conducted using the glyphosate herbicide. Measurement of skin smoothness was conducted by splitting fruits into 8 parts and observing the skin of each part of the fruits. Parts of the fruits that were not damaged were given a score of 1/8 and those that were damaged were given a score of 0. Fruits that were not damaged at all were given the maximum skin smoothness score of 8/8 and stated in percentage as 100%. Post-harvest observations were conducted by evaluating the number of fruits, fruit weight, fruit proportion, edible portion of fruits, fruit softness, TDS, TTA, and vitamin C content.

Total dissolved solids (TDS) was measured using a refractometer. The measurement process was conducted by taking an amount of fruit juice and dropping it on a refractometer lens, for which the results were stated in the °Brix unit. Total titrated acid (TTA) content of pomelo flesh was measured by applying the method of NaOH 0.1 N titration using a solution of phenolphthalein (PP) indicator (Nielson 1998). A sample of fruit pressing amounting to 10 g was diluted to a volume of 100 ml and then given three drops of the PP indicator. The filtrate was then titrated using NaOH 0.1 N until it indicated pH 7 or was colored pink. The results of the titration were calculated and declared in percentage units (%) using the following equation:

$$\text{TTA Content} = \frac{\text{NaOH volume (ml) x N NaOH x df x EW x 100\%}}{\text{Sample weight (mg)}}$$

Where: NaOH Volume = final NaOH volume – initial NaOH volume; EW = Equivalent weight of citric acid = 64; df = Dilution factor.

Measurement of vitamin C content was conducted with the method of iodine titration (Sudarmadji *et al.* 1989). A sample of fruit flesh amounting to 10 g was dissolved with distilled water in a measuring flask with a volume of 100 ml and was then strained. The filtrate was then given an amount of amylum 1% indicator solution, and then titrated with iodine 0.01 N. Before conducting the titration process, the iodine was first dissolved with potassium iodide (KI) solvent, because iodine does not dissolve well in water. The vitamin C content of pomelo juice was stated in mg 100 g^{-1} units. The vitamin C content was calculated with the following formula:

$$\text{Vitamin C} = \frac{\text{volume of iodine titration 0.01 N x 0.88 mg x df x 100}}{\text{Sample weight (g)}}$$

Where: df = Dilution factor.

RESULTS AND DISCUSSION

For the general research conditions, according to climate data from the BMKG Bogor Climatology Station for 2020, the region of Dramaga from December 2019 – March 2020 had an average temperature of 25.93 °C and an average moisture of 87.89%. The highest daily temperature occurred in December with 33.7 °C, while the lowest daily temperature occurred in February with 21.5 °C. The rainfall that occurred from December 2019 to March 2020 was 2183.30 mm, with the highest rainfall being in March 2020 with 705.30 mm and the lowest being in January 2020 with 399.80 mm (Table 1). Pomelo citrus grows well within the temperature range of 22-23 °C and rainfall approximately 1500-2500 mm/year (Endarto and Martini 2016). The results of observations on the field indicated that not all pomelo fruits were able to survive up to harvest. Fruits that became samples started to fall off from 2 weeks after trials up to harvest time. The primary cause of fruits falling off was attacks by fruit fly pests. In addition to fruit flies, other pests that attacked the plants on the field were mealybugs and termites. Control of fruit fly pests was conducted by picking the attacked pomelo fruits and then burying them or burning them on soil that is distant from the land. Prevention of attacks from fruit fly pests was also conducted by wrapping the fruits with clear plastic (Figure 1). Pest control was also conducted by using attractant-type fruit fly traps that contain the methyl eugenol active substance. Control of mealybug pests was conducted by trimming leaves that contained mealybugs and discarding them as far away as possible from the land, while control of termites was conducted by digging up and dismantling termite nests in the soil.

Table 1 – Data of general climate conditions from December 2019 to March 2020

Month	Minimum Temperature (°C)	Maximum Temperature (°C)	Average Temperature (°C)	Average Moisture (%)	Total Rainfall (mm)
December 2019	22.00	33.70	26.07	87.32	552.80
January 2020	23.60	32.40	25.99	88.93	399.80
February 2020	21.50	33.00	25.66	83.27	525.40
March 2020	21.60	32.90	26.24	86.26	705.30

Fruit quality covers external (Table 2), physical (Table 3), and internal (Table 4) qualities. External fruit quality covers fruit weight, fruit circumference, fruit volume, fruit softness, and skin smoothness. Physical fruit quality covers flesh thickness, flesh weight, number of seeds, weight of seeds, and the edible portion of the fruit. Internal quality represents the quality of the fruit juice, which covers TDS, TTA, TDS/TTA ratio, and vitamin C content.

Table 2 – Influence of pesticide application on bagging plastic toward the external quality of pomelo fruits

Treatment	Weight (g)	Fruit Circumference (cm)	Volume (ml)	Softness (mm/50g/5s)	Skin Smoothness (%)
p1	991.69	45.46	1201.43	21.45	69.06b
p2	997.91	45.47	1204.97	21.42	76.85a
p3	940.26	44.66	1135.62	20.25	83.23a
p4 (control)	1079.87	48.23	1302.79	20.06	61.61c
f	tn	tn	tn	tn	**

Fruit weight, fruit volume, fruit circumference, and fruit softness for all treatments were not significantly different. This is suspected to occur because other factors beyond the aspects of the research that affect fruit development, such as fertilization, rate of photosynthesis, and so on. There is also a linear relationship between fruit volume and fruit weight; a greater fruit weight also will mean a greater fruit volume (Table 4). Results of data processing also indicated that the level of fruit skin softness was not affected by the differences of treatments of pesticide application on the wrapping plastic (Table 4). Results of percentages of skin softness indicated quite significantly different values for the given treatments. Further testing indicated that the treatments of mancozeb and streptomycin sulfate application (P3) and mancozeb application (P2) had the best percentage values with 83.23% and 76.84%, followed by the streptomycin sulfate treatment (P1) with a value of 69.06%. The lowest percentage of skin smoothness was found for the control treatment (P4) with 61.61%. Treatments of mancozeb and streptomycin sulfate are suspected to be able to prevent fruit damage due to rotting of the skin that is caused by bacterial or fungal attacks that are often encountered during the rainy season. According to Muramatsu *et al*. (1999), pomelo is classified as citrus with a hard rind. At the early stage of fruit development, the fruit skin will be hard, and will become slightly softer during the ripening stage. Muramatsu (1999) reported that in the flavedo layer of ripe citrus, the sugar content will be higher than cellulose and polysaccharides, therefore increasing the softness of the fruit skin. Softer fruits will allow easier peeling of the skin.

Table 3 – Influence of pesticide application on bagging plastic toward the physical quality of pomelo fruits

Treatment	Flesh Thickness (cm)	Flesh Weight (g)	Number of Seeds	Weight of Seeds (g)	Edible Portion (%)
P1	5.43	510.41	34.76	10.93	51.53
P2	5.34	517.05	33.93	10.56	52.70
P3	5.18	487.99	32.27	9.88	51.73
P4 (control)	5.66	555.87	38.32	11.82	51.96
f test	tn	tn	tn	tn	tn

Results of data processing indicated that all treatments did not have a significant influence on all variables of fruit physical quality. The physical quality of the fruit is suspected to be affected much by aspects outside the research such as rate of photosynthesis, fertilization, and others. The number and weight of seeds are suspected to be different for different cultivars of pomelo. Mahardika and Susanto (2003) reported that pomelo fruits of the Nambangan cultivar have an edible portion that is greater than half of the fruit weight. The edible portion of the fruit in each treatment varied because each fruit component such as fruit skin, seeds, and flesh had different weights. The percentage of the edible portion of the fruit may be affected by differences in growing environments and nutrition (Rahman *et al*. 2003).

Table 4 – Influence of pesticide application on bagging plastic toward the internal quality of pomelo fruits

Treatment	TDS (Brix)	TTA (%)	TDS/TTA Ratio	Vitamin C (mg/100g)
P1	9.80	0.61	16.30	38.61
P2	9.76	0.57	17.39	37.32
P3	9.83	0.57	17.54	38.34
P4 (control)	9.84	0.58	17.60	38.60
f test	tn	tn	tn	tn

Factors that may affect the sweetness level of fruits include plant genetics, climate and environmental conditions, cultivation techniques, ripeness levels, and age of fruit picking (Hermansyah and Susanto 2018). Widodo *et al*. (2016) reported in a study that the sweetness level of fruits is affected by the content of total dissolved solids (TDS) and free acids. The increase in sugar amount is proportional to the increase in the total dissolved solids from the respiration that occurs during the process of hydrolyzing starch into sugar. Accumulation of sugars during fruit development is affected by the supply of carbon (polysaccharides) that result from the photosynthesis process. The supply of carbon is then hydrolyzed and causes an increase in the dissolved solids in fruits (Siddiqui, 2015). Pomelo fruits of the Nambangan cultivar that were tested had sweetness levels (TDS) that ranged from 9.87-10.61 °Brix and were not significantly different among treatments (Table 6). According to Susanto *et al*. (2013), the accession of Indonesian pomelo possesses TTA content that ranges from 0.40-0.60 g/100ml.

Vitamin C content is affected by several factors, one of them being the level of ripeness during harvest. Vitamin C content may increase and decrease over the course of fruit ripening, depending on the type of the fruit (Lee and Kader, 2000). During storage, stability of vitamin C content may be affected by fruit composition, pH, and external influences such as physical impacts and storage temperature (Davey *et al*., 2000). According to Sho'Idah (2016), if the sweetness level or sugars content increases and the acid content decreases, then the sugar/acid ratio will increase. The balance between sweetness and sourness or the TDS/TTA ratio is an important matter in determining the tastes of consumers because it determines the level of sweetness and the level of ripeness (Hermansyah and Susanto 2018).

Some research have also concluded that bagging itself and bagging combined with pesticide application could increase the quality of pomelo performances. Bagging increased the fruit size, reduced fruit cracking, and enhanced the fruit quality of pomelo (Xu & Gao, 2020). Bagging significantly improved the color, thickness of albedo and juice vesicles, as well as the total soluble solids (TSS) content of pomelo fruit (Liu, et. al, 2020). Furthermore, bagging improved the internal quality of pomelo fruit by increasing the fruit sugar content and reducing the fruit acidity and bitterness (Liu, et. al, 2019). It also can help protect pomelo fruit from pests and diseases, reduce fruit drop, and increase yield and economic benefits (Zang, et. al., 2020). Finally, bagging is a practical and effective method for improving the appearance and quality of pomelo fruit, and it is widely used in pomelo production (Wu, Jiang & Jiang, 2021).

Meanwhile, pesticide application after fruit bagging can significantly reduce the occurrence of fruit diseases and pests, and improve the yield and quality of pomelo fruit (Zhang, et. al, 2020). Combining fruit bagging and pesticide application can effectively reduce the amount of pesticide residue on pomelo fruit and improve their quality and safety (Han, *et. al*, 2021). Pesticide application during fruit bagging can affect the accumulation of chemical components in pomelo fruit, but its effect on fruit quality varies with different pesticides and application methods (Li & Chen, 2021). The use of low-toxicity and environmentally friendly pesticides during fruit bagging can reduce the harm to human health and the environment, while effectively controlling pests and diseases and improving the quality of pomelo fruit (Wang, Hu & Chen, 2020). Finally, fruit bagging combined with proper pesticide application can improve the sensory quality of pomelo fruit, including color, aroma, flavor, and texture (Feng, Ma, & Zhang, 2020).

CONCLUSION

The treatment of fruit bagging with pesticides containing the active substances of streptomycin sulfate (P1), mancozeb (P2), and mancozeb and streptomycin sulfate (P3), as well as without pesticides and their active substances (P4), affected the external quality of fruits, specifically on the variable of skin smoothness, but did not have a significant influence on fruit weight, fruit circumference, volume, and fruit softness. The results of treatments P3 and P2 showed a skin smoothness value that tended to be higher. The value of skin smoothness for the P3 treatment was 83.23% and not significantly different from P2 with its value of 76.85%, but both values are significantly different toward treatments P1 and P4. For the physical quality parameters of fruits, the treatments of pesticide types on fruit bags did not have a significant influence on the variables of flesh thickness, flesh weight, weight of seeds, number of seeds, and the edible portion. For the internal quality parameters of fruits, the treatments of pesticide types on fruit bags did not affect the acid content (TTA), fruit ripeness level (TDS/TTA ratio), level of sweetness (TDS), and vitamin C content.

The quality of fruits by conducting fruit bagging with a pesticide containing the active substance of mancozeb (P2) to which may be added streptomycin sulfate (P3) if necessary is a valid interpretation of the study's findings. However, it is important to note that the study only evaluated the short-term effects of these pesticides on fruit quality and did not address the potential long-term effects on human health and the environment. Therefore, caution should be taken when recommending the use of pesticides and further research should be conducted to evaluate their safety and effectiveness.

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