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PERFORMANCE OF STRAWBERRY (*Fragaria ananassa* Duchesne) GROWN UNDER PROTECTED AND CONVENTIONAL TYPE OF CULTIVATION AS AFFECTED BY DIFFERENT POTTING MEDIA COMBINATIONS

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ABSTRACT

Strawberry is a popular fruit crop in many countries worldwide due to its refreshing and delicious taste besides being a rich source of vitamins and minerals. Taking the benefits derived from this fruit, this study was conducted to evaluate the effect of protected and conventional type of cultivation, different potting media, number of trifoliate leaves on the growth and yield of strawberry; to determine profitability of strawberry production under protective structure and conventional type of cultivation.; and to ascertain the postharvest performance of strawberry as affected by storage condition and packaging materials. Two production systems, nine potting media combinations, four numbers of trifoliate leaves, two storage conditions and four packaging materials were evaluated in three series of studies.

Open field and protected cultivation did not significantly affect the yield of strawberry. The open field even showed numerically better results due to the absence of adverse conditon during the conduct of the study, particularly heavy rains. On the other hand, greatest number of runners and earliest onset of reproductive growth were noted in media supplemented with vermicompost (M8) and golden grains (M2), respectively, however, yield was statistically similar in all potting media combinations. In the first and second studies, conventional cultivation proved to be profitable and of the different potting media combination used, pure garden soil supplemented with vermicompost and ricehull (M9) generated the highest net income. The control or without leaf removal (L1) yielded also the highest profit in the second study.

INTRODUCTION

Nature and Importance of the Study

The cultivated strawberry, (*Fragaria ananassa* Duchesne), is a member of the family *Rosaceae*, subfamily *Rosoideae*, along with blackberries and raspberries. It is a low herbaceous perennial with edible red fruits, native to temperate and mountainous tropical regions. There are three types of everbearer: *Long-day* where lengthening days promote more-or-less continuous flowering throughout the summer, provided temperature is not more than thirty (30) degrees Celsius. *Short day* where flowering occurs in short day less than 24 hours cycle. *Day-neutrals* where photoperiod has no effect on flowering and flower several times per year, but would do so in short as well as long days.

Strawberry plants have dark green, trifoliate leaves and white, five-petal flowers with a yellow center. There is also a variety with pink flowers. Strawberry cultivars are classified as 'June-bearing' meaning they have one main crop of fruit in early summer, convenient for those who wish to make preserves, or 'ever-bearing,' which bear smaller quantities of fruit over a longer period. A related plant, wild strawberry, has tiny, sweet fruits and bears continuously.

Strawberry is a very popular fruit. Fruits are usually consumed fresh but in addition strawberries can be frozen, made into preserves, as well as dried and used in prepared foods, such as cereal bars. Strawberries and strawberry flavorings are a popular addition to dairy products, such as strawberry-flavored milk, strawberry ice cream, strawberry milkshakes, strawberry smoothies and strawberry yogurts.

Strawberries will grow on most soil types, but very sandy soil may lead to problems with drought, and heavy, clay soils with poor drainage may lead to disease problems, such as red stele. Strawberries do best in soil that is high in organic matter and fertility, well-drained yet able to hold a continuous supply of moisture; and has a pH of 5.7 to 6 (Darrow 1995).

Strawberry plants are very sensitive to weather condition especially during flower and fruit development. Continuous rain in a particular area would damage the developing flowers and fruits. The use of protected structure is very important in order to protect the growing and developing crops from adverse condition during heavy rains particularly vegetative and reproductive stage.

Strawberry farmers in Marilog, Calinan Davao City, experienced problems during vegetative and reproductive stage of strawberry since during rainy days flowers are aborted, hence, will not develop into fruits. Fruits that may develop will also be rotten especially those directly planted in the soil. This is why some farmers in the area made use of platforms and protected

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structure in order to protect the strawberry plants during rainy season.

Protected cultivation practices can be defined as a cropping technique wherein the micro climate surrounding the plant body is controlled partially or fully as per the requirement of the vegetable species grown during their period of growth. With the advancement in agriculture various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged. Among these are Green house, Plastic house, Lath house, Cloth house, Net house, shade house etc. Protected crops require a controlled climatic environment to produce adequate commercial yields. Higher than normal temperatures, controlled humidity, or additional artificial induced light levels under protection encourage the crops to grow before and after their natural growing season and extend their overall lifespan, thus maximizing yields and improving quality (Parmar and Choudhay 2001).

Farmers ordinarily used garden soil as potting medium for strawberry production. Augmentation of this medium with different organic materials like rice hulls, coco coir dust, organic fertilizer (Golden Grains) and vermicompost are beneficial on the growth and yield of strawberry plants. A common practice of strawberry farmers is to retain only four (4) trifoliate leaves per plant. Farmers said that the more number of leaves of strawberry plants developed, the lesser the fruits produced. Some claimed that three (3) trifoliate leaves is enough, others said that four (4) is effective and still others claimed that five (5) is the best.

Objectives of the Study

1. To evaluate the effect of protected and conventional type of cultivation on the growth and yield of strawberry.
2. To determine the effect of different potting media combinations on the growth and yield of strawberry.
3. To do a cost and return analysis on strawberry production using different potting media combinations under protective structure and conventional type of cultivation.

Experimental Materials

Strawberry var. Haranoka was used in the study: strawberry runners, organic fertilizers (vermicompost, golden grain), rice hull, coco coir dust, polyethylene bag (PEB), inorganic fertilizer (14-14-14), bamboo post, protected cellophane. Healthy runners of strawberry with the same age three weeks old with develop root system were obtained from a local farm coming from one area

Experimental Design and Treatment

Split plot in Randomized Complete Block Design (RCBD) was used in the study. Each treatment was replicated three times with ten (10) sample plants per replication. The different treatments were as follows:

Factor A: Protected Structure

P1 - Conventional Cultivation (Open Field)
P2 - Protected Structure

Factor B: Potting Media Combinations

M1 - Pure Garden Soil (PGS) - Control (Farmers Practice)
M2 - PGS + Organic Fertilizer (OF) – (1:1, v/v)
M3 - PGS + Vermi compost (VC) - (1:1, v/v)
M4 - PGS + Coco Coir Dust (CCD) - (1:1, v/v)
M5 - PGS + Rice Hull (RH) – (1:1, v/v)
M6 - PGS + OF + CCD (1:1:1, v/v/v)
M7 - PGS + OF + RH (1:1:1, v/v/v)
M8 - PGS + VC + CCD (1:1:1, v/v/v)
M9 - PGS + VC + RH (1:1:1, v/v/v)

Construction of Protected Structure

Three (3) protected structures (2 m x 3 m x 5 m) were constructed with the use of bamboo and covered with ultra violet (UV) polyethylene Film with 0.001mm thickness. A platform of 2.5 ft. high was established inside the structure where the potted seedlings of strawberry were set up on top. This is to protect the strawberry plants against heavy rain.

Preparation of Potting Media

Potting media was prepared based on the ratio indicated in treatments. Organic fertilizers (Golden Grain and vermicompost), rice hull and coco coir dust were purchased from local suppliers in Davao City. These materials were sieved with the used of wire mesh to remove foreign materials. Polyethylene bag (PEB) 6 x 12 inches was used for potting.

Preparation of Planting Materials and Planting

Three week old fully develop runners were used as planting materials with three to four trifoliate leaves with fully developed root system. One plant was planted per pot/bag late in the afternoon to avoid stress.

Cultural Management

Pruning of Leaves and Suckers

Removal of leaves and suckers was done two weeks after planting and then weekly thereafter. The lower mature leaves were removed retaining only four trifoliate leaves per plant. This was the common practiced by strawberry farmers in the area.

Fertilization

The plants were fertilized one week after leaf removal with inorganic complete fertilizer solution prepared by dissolving 300 g of (14-14-14) in 16 li. of water based on the strawberry farmers practice in the area as starter solution. This was applied to individual plant by drenching with 300 ml of the solution.

Pest and Disease Control

The plants were monitored regularly for insect and disease infestation/ infection and growth of weeds. At early stage of infestation / infection, infested leaves were manually removed. As much as possible, spraying of pesticides were avoided. Hanging of insect attractant using molasses and vinegar

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around the experimental plants were made to attract the insects within the experimental area.

Watering and weeding

The plants were watered using plastic sprinkler early in the morning and late in the afternoon only when necessary during dry season. Weeds were removed manually as soon as they appear.

Data Gathered

A. Horticultural Characteristics

1. Number of runners - the number of runners produced per plant was counted from ten (10) sample plants two weeks after planting and at two weeks interval thereafter until the termination of the study.
2. Number of days to first visible flower bud formation – formation of first visible flower buds from planting was recorded.
3. Number of leaves – number of leaves was counted at time of first flowering or first appearance of flower was counted.
4. Number of flowers - the number of flowers per plant was counted starting at the first appearance or development of flowers until the end of flowering stage.
5. Number of fruits = the number of fruits per plant that developed were counted during harvesting. Ripe strawberry fruits were harvested and counted in staggered basis.
6. Percentage of fruit development / set (%) - was computed using the formula:

$$\text{fruit development / set (\%)} = \frac{\text{Number of fruits per plant}}{\text{Total number of fruits per plant}} \text{ x } 100$$

7. Weight of fruit (g) - all ripe strawberry fruits per plant of good quality (free from damage) were harvested and weighed.
8. Total Fruit Yield (g/plant) – weights of marketable and non-marketable fruits from each harvested were summed up and were added together.

B. Cost and Return Analysis – at the end of the study cost and return analysis were determined as to the expenses / investment and production/ income of the study.

RESULTS & DISCUSSION

Horticultural Characteristics of Strawberry

The type of cultivation, that is, whether strawberries were grown under protective structure or conventional did not affect all horticultural characteristics considered which includes number of runners, days to first visible buds to first visible flower bud formation and number of trifoliate leaves to first flower (Table 1). This indicates that under the condition of the study plants under the structure and open field produced the same number of runners, simultaneously produced the first flower bud and required the same number of trifoliate leaves to initiate flowering.

The different potting media combination on the other hand, significantly affected the number of runners produced as well as the number of days to flower bud formation. It did not, however, influenced the number of trifoliate leaves required to initiate flowering.

Vegetative growth of strawberry in terms of the number of runners produced showed that M8, the combination of pure garden soil with vermicompost and coco coir dust (1:1:1) produced the most number of runners. Production of runners therefore can be enhanced by the use of the said combination. Since strawberry is propagated by

Table 1. Horticultural characteristics of strawberry (Fragaria annasa Duchense) grown underprotected and conventional type of cultivation as influenced by different potting media combinations

Treatments	No. of Runners	No. days to 1st Visible flower Bud	No. of trifoliate Leaves
Factor A - (Protected Cultivation)			
P1- Protected Structure	2.62	31.45	4.81
P2- Conventional	2.33	30.94	4.85
Factor B - (Potting Media Combinations)			
M1-Control - Pure Garden Soil (PGS)	2.43ab	23.50ab	4.66
M2- PGS + OF(Golden Grains)(1:1)	2.46ab	18.33b	4.50
M3- PGS + Vermicompost (VC) (1:1)	2.96ab	19.00b	5.00
M4- PGS + Coco Coir Dust (CCD) (1:1)	2.06b	26.50a	4.83
M5- PGS + Rice Hull (RH) (1:1)	2.10b	26.50a	4.50

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M6- PGS + OF + CCD (1:1;1)	2.23ab	19.83b	4.83
M7- PGS + OF + RH (1:1:1)	2.20b	22.67ab	4.50
M8- PGS + VC + CCD (1:1:1)	3.23a	24.33ab	5.66
M9- PGS + VC + RH (1:1:1)	2.09ab	20.00b	5.00
CVa (%)	34.21	55.61	19.71
CVb (%)	2	20.40	17.87

Means in a column within a factor followed by the same letters and those without letters are not significantly different from each other based on 5% level of significance using LSD.

Runners, more planting materials can be obtained by the addition of vermicomposrt and coco coir dust. The enhancing effect of the potting media combination could be accounted to the characteristics of the media component. Vermicompost, rice hull had higher nutrient contents, particularly, phosphorous and potassium, respectively (Table 2). Vermicompost is an organic manure bio-fertilizer, produced as the vermicast by earthworm feeding on biological waste material and plant residues. This compost is an odorless, clean, organic material containing adequate quantities of NPK and several micro-nutrients essential for plant growth. Vermicompost is an excellent soil enhancer and bioactive quality fertilizer for organic farming. This is an alternative to chemical fertilizer and had been proven in field experiments (De Castro, 2005). Earthworm casts are a ready-to-use fertilizer that can be used at higher rate of application than compost, since nutrients are released at rates that growing plant prefer. Coco coir has also been characterized in terms of physical properties with good water retention capacity and aeration characteristics (Abad et. al. 2002; Fornes al. 2003) and has performed better as compared to other media in ornamental crops (Stamps and Evans, 1997 as cited by Cantliffe, et al. 2007).

The number of days to the first visible flower bud formation was significantly enhanced in M2 (Pure garden soil with golden grain organic fertilizer). This combination caused the early onset of flower buds which took only 18 days. The high nutrient content of golden grains favored early formation of first flower (Table 1). Aside from its high nutrient content this organic based fertilizer also served as soil conditioner (http://www.alibaba.com/product-detail/Golden-Grains-Organic-Fertilizer-Foliar-Phoscal_109369536.html). Other treatment which favored early flower bud formation and were statistically similar with M2 includes M3 (Pure garden soil with vermicast) Table 2. Initial analysis of the different potting media component which took 19 days, M6 (pure garden soil with golden grains), 19.83 days, and M9 pure garden soil with vermicast and ricehull). The reason behind the better performance of plants in medium supplemented with vermicast is already cited in runner formation parameter. Meanwhile M4 and M5, composed of garden soil with coco coir dust and rice hull, respectively were the last to form flower buds, both at 26.50 days. This could be ascribed to the low nutrient composition of pure garden soil. Likewise, rice hull and coco coir used were not so aged yet, hence decomposition may had taken place, heat being liberated from the process, which may caused the delayed onset of reproductive growth. As reported, during composting a great deal of energy is released in the form of heat in the oxidation of the carbon to $C0_2$ (http://aggie-orticulture.tamu.edu/earthkind/landscape/dont-bag-it/chapter-1-the-decomposition-process/). Moreover, the high lignin content of coco coir dust and rice hull about 70 % and 20%, respectively can slow down the process (http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp4542, Oliver, 2004).

Number of Flowers, Fruits Developed and Percentage of Fruit Developed

Reproductive data of strawberry expressed in terms of number of flowers and fruits developed and percentage (%) of fruit developed per plant are shown in Table 3. The type of cultivation used in the study significantly affected the three mentioned Table 3. Number of flower, fruit developed and percentage of fruit developed per plant as affected by type of cultivation and potting media

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Treatments	No. of Flowers Developed Per plant	No. of Fruits Developed Per plant	% of Fruits Developed Per plant
Factor A -(Protected Cultivation)			
P1- Protected Structure	2.14b	2.00b	93.45b
P2- Conventional	2.50a	2.38a	95.20a
Factor B – (Potting Media Combination)			
M1-Control - Pure Garden Soil (PGS)	2.76	2.28	82.26
M2- PGS + (OF)Golden Grains	3.10	2.21	71.29
M3- PGS + Vermicompost(VC)	2.31	2.18	94.37
M4- PGS + Coco Coir Dust (CCD)	2.63	2.03	77.18
M5- PGS + Rice Hull (RH)	2.53	1.86	73.51
M6- PGS + OF + CCD	2.93	2.48	84.64
M7- PGS + OF + RH	2.46	2.06	83.73
M8- PGS + VC + CCD	2.50	2.23	89.20
M9- PGS + VC + RH	2.76	2.36	85.50
CVa (%)	24.8	14.54	10.56
CVb (%)	14.51	18.54	9.36

Means in a column within a factor followed by the same letters and those without letters are not significantly different from each other based on 5% level of significance using LSD.

parameters. The open field grown plants significantly produced greater number of flowers and fruits per plant and consequently gave higher percentage of fruit developed.

Under the condition of the study, the protection and advantage of protective structure over the open field condition was not manifested. This is because rainfall was very minimal which didn't serve the purpose of having structure. Plants under the structure may have been exposed to higher temperature, hence the detrimental effects as manifested by fewer number of flowers and fruits under structure. Unfortunately during the conduct of the study, data on the prevailing temperature in the area was not gathered, however the report of Gonzaga, et.al. (2013) showed that in their numerous trials, temperature under structure is higher than in the open field. The condition was aggravated by the reduced light under the structure brought about by the plastic roofing. Conversely, the lower temperature in the open field enhanced reproductive development of strawberry, this plant being a cool temperature requiring crop. Based on the data in study 2temperature in Marahan, Marilog, Davao ranged from 25-28^{0}C. This temperature was also sensed and felt by the researcher every time of visit. Significantly greater number of flowers was produced and consequently greater number of fruits developed. Percent fruits developed per plant were like greater in the open field. Moreover, exposure of the plant to full sunlight in the open field enhanced its growth and development. Results of the current study support to the observation at Marahan and EPOL Marilog District Davao City, that strawberry flower development favour during longer sunlight exposure, or more strawberry flowers developed during sunny days.

In the present study, the type of potting media combinations did not significantly affected the reproductive data considered. This indicates that either of the nine (9) could be used with similar results. However, considering the cost of the different organic soil amendments, the use of pure garden soil may be opted.

Yield of Strawberry

The production of strawberry measured in terms of the number of fruits, weight of marketable and non-marketable fruits, and total weight of fruits per plant were not significantly affected by the type of cultivation and potting media combinations (Table 4). However, it can be noted that open field or the conventional cultivation yielded higher or greater in all the parameters mentioned. As stated earlier, the potential of protected cropping in the present study was not manifested since the prevailing climatic condition was favorable for the growth of

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strawberry. Had there been heavy rainfall during the conduct of the study, its advantage would surely be expressed.

Similarly, different potting media combinations did not affect the marketable and non-marketable fruits and total weight of fruits harvested per plant. The decision of using one or the other media would depend on the cost and availability to the grower.

Despite the insignificant results, numerical data clearly showed that the combination of pure garden soil, vermicompost and rice hull (M9) yielded the most number and heaviest weight of fruits per plant. This served as the basis for the use of of M9 in the study 2. Reasons for the better performance in this treatment combination hadbeen attributed to the characteristics of the vermicompost and rice hull which were already mentioned in the earlier part of the discussion.

Table 4. Total number of fruits, weight of fruits, marketable and non-marketable strawberry fruits (*Fragaria annasa* Duchense) in different potting media under protected and conventional type of cultivation

Treatment	Number of Fruits Harvested per plant	Wt. (g) of Marketable Fruits	Wt.(g) Non-Marketable Fruits	Total Wt.(g) of fruits Harvested per plant
Factor A (Protected Cultivation)				
P1- Protected Structure	2.24	12.0	1.60	13.5
P2- Conventional	2.42	13.8	1.61	15.5
Factor B (Potting Media Combination)				
M1-Control- Pure Garden Soil (PGS)	2.70	13.8	1.77	15.56
M2- PGS + Organic Fertilizer (OF)	2.56	14.2	1.78	15.98
M3- PGS + Vermicompost (VC)	2.31	13.82	1.74	15.56
M4- PGS + Coco Coir Dust (CCD)	1.96	11.20	1.21	12.41
M5- PGS + Rice Hull (RH)	2.05	10.34	1.48	11.83
M6- PGS + OF + CCD	2.48	13.10	1.62	14.73
M7- PGS + OF + RH	1.91	10.20	1.22	11.43
M8- PGS + VC + CCD	1.91	11.73	1.43	13.18
M9- PGS + VC + RH	3.10	18.13	1.85	19.98
CVa (%)	57.33	56.99	45.8	57.0
CVb (%)	21.23	25.62	25.1	25.61

Means in a column within a factor followed by the same letters and those without letters are not significantly different from each other based on 5% level of significance in ANOVA

Cost and Return Analysis

The estimates on the cost and return of $6m^2$ strawberry production in the open field and under protective structure using different potting media combination showed the profitability of the conventional cultivation over the use of protective structure with negative turnover (Table 5). During the conduct of the study, climatic condition was favorable. As mentioned earlier, the absence of adverse environmental condition, particularly heavy rainfall inhibited the expression of the potential of protected cropping in producing more strawberry in the area. Moreover, protected cultivation entails higher cost of production considering the materials particularly the UV-treated plastic, nails and bamboos.

Of the different potting media combinations, M9 composed of pure garden soil (PGS) with vermicompost and rice hull turned out the most profitable treatment with a net profit of P248.37/$6m^2$. This was followed by control (M1) with a net income of P97.14, M2, with organic fertilizer and vermicompost with P81.65 and P55.47, respectively. M6, with organic fertilizer and ricehull also generated positive income of P31.86. All other treatments including M4 (PGS + CCD), M5 (PGS + RH), M7 (PGS + OF +RH) and M8 PGS + VC + CCD)

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yielded negative net income because of the high cost of the different organic soil amendments.

With this current result, it can be deduced that strawberry production needs more number of plants to raise or be planted in a certain area in order to level off the cost of production. Materials needed for strawberry production increased its price at this moment especially UV-treated plastic, black polyethylene bag, potting medium and also planting

Table 5. Estimates on the cost and return analysis of strawberry production (6m^2) under protected and conventional cultivation using different potting media combination

Treatments	Fruits Harvested (kg)	Total Gross Income (₱)	Cost of Production (₱)	Net Income (₱)
Type of Cultivation				
P1-Protected Structure	1.82	546.75	635.33	-88.58
P2-Conventional	2.09	627.75	594.25	33.50
Potting Media				
M1-Control - Pure Garden Soil (PGS)	2.10	630.18	533.04	97.14
M2- PGS + Organic Fertilizer (OF)	2.16	647.19	565.54	81.65
M3- PGS + Vermicompost (VC)	2.10	630.18	574.71	55.47
M4- PGS + Coco Coir Dust (CCD)	1.68	502.61	581.37	-78.77
M5- PGS + Rice Hull (RH)	1.60	479.12	533.04	-53.93
M6- PGS + OF + CCD	1.99	596.57	564.71	31.86
M7- PGS + OF +RH	1.54	462.92	554.71	-91.79
M8- PGS + VC + CCD	1.78	533.79	570.82	-37.03
M9- PGS + VC + RH	2.70	809.19	560.82	248.37

Price per kilogram = ₱ 300.00

materials. The problem, however of strawberry farmers in the area of Marahan, EPOL and Baganihan, Marilog District Davao City is the capital to start with the project. Fortunately, the Baganihan Cooperative was established in order to facilitate and helped the needs of the strawberry farmers.

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