Australian Journal of Crop Science AJCS

AJCS 16(05):620-627 (2022) ISSN:1835-2707
doi: 10.21475/ajcs.22.16.05.p3593

Effect of coconut water concentration and planting media on growth and post-harvest characters of large chili using multivariate and non-parametric analyses

Fachirah Ulfa[1*], Muhammad Fuad Anshori[1], Rusdayani Amin[1], Aisyah Amini Iqbal[2]

[1]Department of Agronomy, Faculty of Agriculture, Hasanuddin University, Perintis Kemerdekaan Street Km 10, Makassar, South Sulawesi, 90245, Indonesia
[2]Bachelor Student, Department of Agronomy, Hasanuddin University, Perintis Kemerdekaan Street Km 10, Makassar, South Sulawesi, 90245, Indonesia

***Corresponding author: fachirahulfa@unhas.ac.id**

Abstract

This study was conducted to determine the best practices for combination of planting media and coconut water concentration on large chilies growth characteristics using multivariate analysis. The second aim was to determine the best combination of temperature and cultivation combination for post-harvest characteristics of large chilies using non-parametric analyses. The study was conducted in Jeneponto Regency, Indonesia, at 100 meters above sea level with dusty clay soil and 21-34 °C temperatures. The study used two experimental set up. The first experiment was arranged in split-plot design with planting media (combination of soil, compost or husk charcoal) as main factor (3 level) and concentrations of coconut water as subplot (4 levels). The second experiment was the temperature conditions (the room and refrigeration temperature conditions) as the post-harvest experiment after the first experiment that arranged with a nested design. The observation parameters were consisted of 9 growth parameters in the first experiment analyzed by multivariate analyses and 2 post-harvest parameters in the second stage by non-parametric analyses. Based on the results of multivariate and non-parametric analyses, increase was observed in the cultivation technology effectiveness. The variance of growth and post-harvest characteristics of large chilies were more influenced by the coconut water than the planting media effect. Furthermore, the best concentration of coconut water in large chilli is expected to occur at 15%, with a blend of refrigeration temperature for post-harvest treatment. This value is recommended in the urban farming of large chillies, using organic applications.

Keywords: Capsicum annuum, Factor analysis, Organic fertilization, Spearman correlation, Urban farming.
Abbreviations: DFH_days to first harvest; FL_fruit length; FW_fruit weight; FWP_fruit weight per plant; LA_leaf area; NF_number of fruits; NPB_number of productive branches; PH_plant height; SD_stomata density; SOA_Stomata opening area.

Introduction

Chili (*Capsicum annuum* L.) is a major plant type that easily found in Southeast Asia, including Indonesia. The crop appears rich in capsaicin, flavonoids as well as in vitamins C, A and E (Hamed et al., 2019; Chilczuk et al., 2021). These contents have a high capacity to protect humans from various diseases by increasing the body's immune system (Hamed et al., 2019). As a consequence, the demand for chili continues to increase alongside the growing population (Saleh et al., 2018; Agustika, 2021). However, its production is not in line with this demand (Suryani et al., 2019). Therefore, the continuous increase in chili production through intensification appears necessary in fulfilling the steady demands. A major intensification technique involves the introduction of organic fertilization.

Organic fertilization is an approach closely related to the concept of sustainable agriculture (Lin et al., 2019; Beeby et al., 2020; Shah et al., 2021). Commonly applied chemical fertilizers exhibit several side effects on the soil, including the damage to its physical and biological properties (Beeby et al., 2020; Pahalvi et al., 2021). This negative outcome significantly instigates a long term impact on crop productivity. So, the development of sustainable agriculture using organic fertilization serves as an effective solution in overcoming these prevalent challeges (Lin et al., 2019; Shah et al., 2021). This concept also supports the expansion of small-scale urban farming systems (Markussen et al., 2014; Schröder et al., 2021), in line with the conversion of agricultural land resources into buildings (Avgoustaki and Xydis, 2020). Similarly, application of urban farming also help to maintain food security. Under this circumstance, the organic fertilizers play a significant role in strengthening urban farming concepts.

Organic fertilizer is obtained from the decomposition of organic materials, both in solid and liquid forms (Ji et al., 2017; Beeby et al., 2020; Shah et al., 2021). Various natural components in fertilizer production have also been widely reported, such as livestock manure, forage and microorganisms (Ji et al., 2017). One of the potential materials

in ogranic fertilizer is coconut water. The use of coconut water not only affects plant growth, but also provides ecological and economic benefits. In general, coconut water is a major plant product that triggers crop growth (Winarto and Da Silva, 2015). Previous study results showed its content in potassium, minerals such as calcium (Ca), sodium (Na), magnesium (Mg), iron (Fe), cuprum (Cu) and sulfur (S) as well as in sugar and protein. Apart from the mineral richness, coconut water also serves as a plant growth regulator (PGR) source, particularly cytokinins and gibberellins (Tiwery, 2014; Darmawan et al., 2020). The coconut water content is potentially applied as a natural source of nutrients and PGR that are environmentally friendly, cheap and easily obtained (Prando et al., 2014; Lazim et al., 2015; Mintah et al., 2018). These instances indicate that the use of coconut water, specifically in fermented form, appears very important in the support of plant growth and productivity (Darmawan et al., 2020).

The applications of organic fertilizers are more effective under fertilization conditions, based on specific interval and concentration as well as the interaction with the planting media. The planting media is an important element that supports plant growth, with soil as a typical example. This is because the soil contains the main factors for plant growth, such as nutrients, water and air (Bhattacharyya and Pal, 2015). However, its conditions are currently declining due to low available organic matter (Gomiero et al., 2016; Timmis and Ramos, 2021), which affects the physical, biological and chemical quality. As a consequence, farmers tend to combine the soil with other growing media, termed compost, husk charcoal and cocopeat (Gomiero et al., 2016; Khaitov et al., 2019). Several kinds of studies on planting media combination have been conducted, including Dalimunthe et al. (2017), where a blend of compost and husk charcoal potentially increased the vegetative and generative growth of red chili plants. Therefore, study on the effect of combining planting media and coconut water concentration on large chili pepper appears very interesting. This technology needs to be evaluated with precision to demonstrate a positive effect in enhancing crop productivity.

The evaluation of a cultivation technology is greatly dependent on the characters of the applied assessment. In general, yield is the commonly used character (Anshori et al., 2021), although with low effectiveness. This observation was based on the polygenic nature of productivity, where environmental influences appear predominant (Fellahi et al., 2018). So, the evaluation should not only focus on the yield but also the yield supporting characters through the multivariate analysis approach. This concept has been reported by Abduh et al. (2021) on maize, Farid et al. (2020) as well as on wheat and Anshori et al. (2021) on rice plants. As a consequence, the use of the productivity concept in examining the combination of planting media and coconut water concentration on the growth of large chillies appears valid. However, a more effective outcome is possible with the involvement of post-harvest characters. Horticultural crops' quality generally includes post-harvest conditions or fruit phase life, where a faster rate potentially influences the product price. This means the evaluation is not only based on the effectiveness of the growth assessment but also needs to consider the post-harvest aspect analyzed by a non-parametric approach (Anshori et al. 2020). Therefore, this study aimed at two goals. The first is to determine the best cultivation for the combination of planting media and coconut water concentration on large chilies growth characteristics using multivariate analysis. The second to is to determine the best combination of temperature and cultivation combination for large chilies post-harvest characteristics using non-parametric analyses.

Results

Evaluation of the morphological growth characters

Based on the analysis of variance results (Supplementary 1), the various coconut concentrations showed a significant effect on almost all growth characters, except for the age of first harvest, productive branches and fruit weight. Conversely, planting media only influenced the density of the stomata, productive branches and total dissolved solids (TDS), while the interaction between the growth media and concentration impacted extensively only on stomatal density.

Pearson correlation analysis results showed productivity as the main character with a significantly positive interaction with TDS (0.38), stomata aperture area (0.41), fruit length (0.51), plant height (0.54), and the fruit number (0.98). Conversely, the negatively correlated character was obtained as the age of the first harvest (-0.72), while the positive aspect formed the basis for a more in-depth study, including factor analysis (Fig. 1).

Fig. 2 represents the factor analysis results where 3 groups of treatment combinations were obtained. The first category comprised of M1C1, M3C1, M2C1and M2C4, while the second encompassed M1C4, M1C3, M1C2, M2C2 and M3C2. Finally, the third group contained M3C4, M2C3 and M3C3. Based on the loading factor value (Table 2), factor 2 dimensions were identified, where the diversity of factor 1 was strongly influenced by the fruit weight, as well as its quantity and length. Meanwhile, the TDS and the stomata opening width contributed to the significant influence in factor 2.

The LSD test results showed that C2 concentration treatment was the best coconut concentration treatment on fruit length, number and weight per plant, while k1 obtained the minimum treatment (Table 3). Based on the wide characters of the stomata opening and TDS, C3 was known to generate the optimal performance, followed by C2. Conversely, C1 also exhibited the lowest concentration in both characters.

Evaluation of the post-harvest fruit character

The Kruskal Walis analysis results showed that the combination of concentration and temperature treatment significantly affected the 20 days storage, in terms of color and texture (Table 4). Based on the color, the refrigerator treatment obtained a lower z value (-3.61), compared to the room temperature at C2 concentration. Conversely, room temperature with k1 concentration generated the combination treatment with the maximum z value (3.63). Based on the texture, the refrigerator treatment had a higher z value (3.86) at C3, compared to the room temperature treatment, while for room temperature at C1, the minimum z value (-3.82) was obtained.

Spearman correlation analysis was used to assess the relationship between growth and post-harvest characters in the refrigerator temperature treatment (Table 5). The results showed that the fruit color was more negatively correlated

with its number and weight per plant. Negative values in color correlation demonstrated an inverse interpretation of fruit quality, while the texture obtained a significantly positive correlation with the TDS character. Therefore, a more positive texture correlation value tends to generate superior fruit quality

Discussion

The results of this study indicated that the difference in the coconut water concentrations was very predominant in the growth of large chilies. Media treatments are generally known to affects plant growth, including chili. This conclusion was also reported by Gungor and Yildirim (2013), Mathowa et al. (2017), and Khaitov et al. (2019), where separate media compositions generated different responses to the chili growth and productivity. However, the variation is not considered very significant if the treatment is juxtaposed with the effect of coconut water concentration. This condition was further reinforced by the interaction effect, without any relative impact on the plant development. According to Saptaji et al. (2015), the combination of media and coconut water treatments reported a significant effect on stevia growth, due to the relatively large proportion of compost from the media treatment. In contrast, a more dominant soil composition was observed, in comparison to husk and compost. Yong et al. (2009) and Prades et al. (2012) also showed a rich content of hormones in the coconut water. As a consequence, the application of several concentrations of coconut water tends to affect the plant growth (Prando et al., 2014; Winarto and Da Silva, 2015; Darmawan et al., 2020), including chili (Mythili et al., 2017; Fassya et al., 2020). Based on this circumstance, further analysis in the present study was then dominated by the concentration of coconut water on chili growth.

Great Pearson correlations in terms of productivity were also obtained in TDS characters, plant height, fruit length and number. These results were equally reported by Bijalwan and Mishra (2016), Yenny et al. (2019) and Fitry et al. (2021), where a significant correlation between chili productivity as well as fruit length and number of fruits. The performances above showed that the five characters possibly serve as the basis for treatment evaluation in this study, specifically coconut water concentration. However, the use of correlation analysis is considered an estimation, due to its inability to describe the specific relationship between characters. Correlation analysis is also inseparable from the nature of multicollinearity, but forms the basis of further in-depth investigation. This concept has also been reported by Farid et al. (2020), Akbar et al. (2021) and Anshori et al. (2021). Based on this phenomenon, a deeper analytical approach highly dependent on the correlation technique, such as the factor analysis, appears very significant in the evaluation of this study. Factor analysis occurs among the major multivariate assessments in identifying specific internal covariates and reducing the weak covariates between dimension variables. This approach is used to evaluate the important character determinants of a large variable (Rocha et al., 2017). Further use of factor analysis in obtaining important growth characters has been reported by Rocha et al. (2017) and Farid et al. (2020). Therefore, its application in this study has the capacity to also evaluate the characters specifically correlated with productivity. Under this circumstance, two resulting methods were obtained, including the use of the biplot concept and identification of character diversity based on factor dimensions. Biplots are significant in the diversity visualization and the grouping basis between treatment objects on their variables, particularly when combined with principal component or factor analysis. Figure 2 shows that the grouping was very identical to the coconut concentration treatment, specifically at C2 and C1, while C3 and C4 were extended relatively in each group. This observation provides another evidence that coconut water concentration is a determinant of the growth diversities of large chilies. Table 2 outlines the factor dimensions, where fruit length and number, productivity, TDS, as well as the width of stomata opening served as the evaluation characters. This outcome was based on the factor loading value of these characters which exceeded 0.32 (Yong and Pearce, 2013), both on the dimensions of factors 1 and 2. This selection concept was also reported by Farid et al. (2020) on the determination of preferred characters in lowland wheat collections. Therefore, the characters of fruit length and number, productivity, TDS, as well as the stomata opening width were further analyzed by the LSD significant difference test.

The LSD test results also observed the significant effect of coconut water on the growth of large chilies. In addition, the best treatment for the chili production components was obtained in C2, although C3 demonstrated the ability improve the plant quality. This optimal performance of C2 was based on the relatively suitable TDS potential and the stomata opening width. The results of this study also matched the previous study of Fassya et al. (2020), where 25% coconut water was stipulated as the best dose in increasing chili growth, while a 50% increment showed a linearly decreasing effect. Therefore, C2 treatment is highly recommended as a major coconut water dose in the cultivation of large chilies.

Post-harvest testing is an important indicator in terms of the quality of large chilies, where refrigerator storage was generally superior, compared to the room temperature. These results have been reported by several studies, including Galani et al. (2017) and Contreras et al. (2021). Based on coconut water concentration, C2 treatment showed a more effective storage quality, specifically when combined with refrigerated spaces. In general, the observation of post-harvest characters such as color quality and texture, serves as the main character in assessing storage efficiency. The process of post-harvest cell degradation appears faster, depending on the fruit's physiological processes, including respiration, ripening and senescence (Edusei et al., 2012; Ziv and Fallik, 2021). These prompt techniques tend to induce rapid changes in fruit color and texture (Contreras et al., 2021; Ziv and Fallik, 2021). Chili plants are non-climacteric (Razo-Mendivil et al., 2021). However, the post-harvest fruit quality is highly dependent on the fruit water loss (Maalekuu et al., 2006; Edusei et al., 2012; Elibox et al., 2015). This causes the chili to experience a rapid ripening process, identified by color and texture similar to other climacteric fruits (Maskey et al., 2021; Berry et al., 2021). In this study, color depicts an inverse interpretation of the fruit quality, where the smaller color scores instigate extensive change in appearance. Meanwhile, the texture showed a

Table 1. Score value and its description on the postharvest characters.

Score	Fruit Color	Fruit texture
1	Red	not hard
2	brownish red	a bit hard
3	reddish brown	quite hard
4	brown	hard
5	very brown	very hard

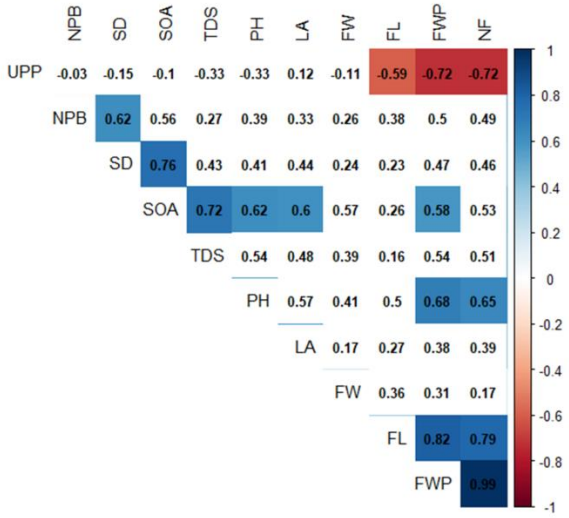

Fig 1. Pearson correlation analysis on chili growth characters (PH= Plant height, LA= Leaf area, SD = Stomata density, SOA= Stomata opening area, NPB= Number of productive branches, NF= Number of fruits, FL = Fruit Length, FW= Fruit Weight, FWP= Fruit weight per plant).

Table 2. Factor analysis of characters correlated with fruit weight per plant.

Variable	Height	TDS	FWP	NF	FL	SOA
Factor1	0.181	-0.13	0.332	0.346	0.413	-0.126
Factor2	-0.139	-0.506	-0.03	0.008	0.29	-0.515
Communality	0.531	0.778	0.673	0.86	0.898	0.737

Notes : SOA = stomata opening area, NF = number of fruits, FL = fruit length (cm), FWP = fruit weight per plant, TDS = total dissolved solids

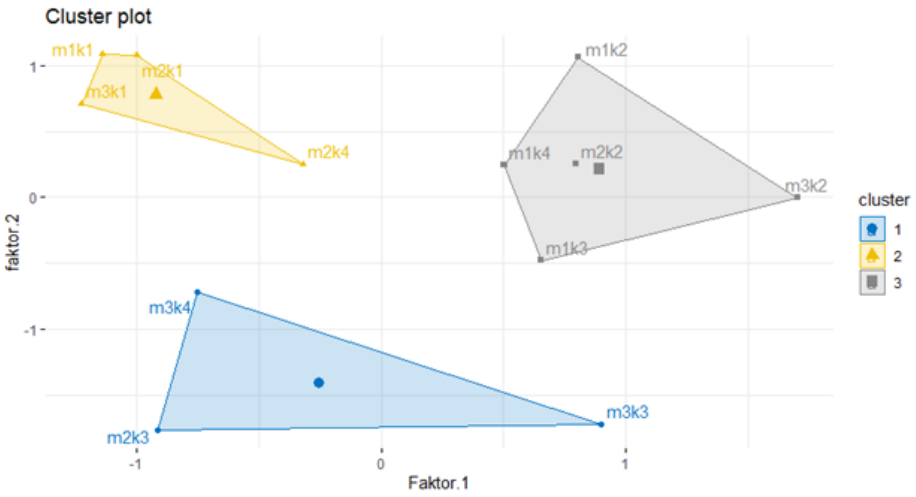

Fig 2. Grouping of combinations of planting media and the coconut water concentration based on factor analysis biplots.

Table 3. Post-hoc test of BNT 5% on coconut water concentration treatment.

Treatment	Stomata Opening Area		Fruit Length		Number of Fruits		Fruit Weight Per Plant		TDS	
	Mean	Notation	Mean	Notation	Mean	Notation	Mean	Notation	Mean	Notation
C1	0.0002	c	8.81	c	34.63	b	210.85	c	7.38	c
C2	0.0003	b	10.19	a	46.59	a	294.56	a	8.42	b
C3	0.0004	a	9.41	b	44.56	a	279.07	ab	10.1	a
C4	0.0003	b	9.44	b	41.15	a	255.78	b	8.94	b

Notes = the same letter in one column indicates a value that is not significantly different at 5 % level, C= coconut water concentration, TDS = total dissolved solids, ** significant at 1%, Multiple R-squared: 0.7519 dan Adjusted R-squared: 0.7478.

Table 4. Kruskal-Walis analysis on post-harvest characters of chili.

Treatment	Color 10 days		Color 20 days		Texture 10 days		Texture 20 days	
	Median	z-value	Median	z-value	Median	z-value	Median	z-value
Rf_C1	2.0	1.13	2	-2.10	3.0	-1.72	3	1.99
Rf_C2	1.5	0.07	2	-3.61	3.0	-0.9	3	2.38
Rf_C3	1.0	2.06	2	-3.34	3.0	0.40	3	3.86
Rf_C4	2.0	0.60	2	-3.07	3.0	0.08	3	3.47
R_C1	2.0	0.60	3	3.63	3.0	-0.73	1	-3.82
R_C2	1.0	-0.47	3	2.69	4.0	1.07	2	-2.63
R_C3	1.0	-1.00	3	2.69	3.5	0.90	2	-2.33
R_C4	2.0	1.13	3	3.11	3.5	0.90	2	-2.92
P value	0.178		0.000		0.331		0.000	

Note: Rf = refrigerator, R = room, C= coconut water concentration.

Table 5. Spearman correlation analysis on the important characters of growth on post-harvest characters of the fruit.

	Color	Texture	SOA	FL	NF	FWP
Texture	-0.40					
SOA	-0.63	0.95				
FL	-0.80	0.20	0.32			
NF	-1.00**	0.40	0.63	0.80		
FWP	-1.00**	0.40	0.63	0.80	1.00	
TDS	-0.40	1.00**	0.95	0.20	0.40	0.40

Notes: SOA= stomata opening area, TDS = total dissolved solids FL = fruit length (cm), NF = number of fruits, FWP = fruit weight per plant.

positive interpretation, where higher texture scores obtained superior fruit texture. Based on this phenomenon, C2 treatment also serves as a possible recommendation in enhancing the post-harvest chili quality.

Spearman correlations are generally performed on data with different properties (Anshori et al., 2020; Anshori et al., 2021). The growth characters in the present study were numerical or parametric, while post-harvest properties were categorical or non-parametric, resulting in an effective correlation. Based on Spearman correlation results, the growth and post-harvest characters showed a very close relationship, particularly in the treatment of the refrigerator storage. This observation indicates that the treatment on the growth character significantly impacted on the post-harvest components. Therefore, the fruit quality assessment possibly refers to the plant growth, particularly in terms of the fruit number, production per plant and the TDS.

Materials and Methods

This study was conducted between January-May 2020 in Balang Toa village, Jeneponto Regency, Indonesia, at an altitude of 100 meters above sea level. The soil type was dusty clay. The average monthly rainfall of more than 120 mm per month and the wettest month is January with a monthly rainfall of more than 250 mm per month. The air temperature in the Jeneponto Regency area is between 21-34 °C with a relative humidity level of about 76%. The study was consisted of two experiments. The first experiment focused on evaluating of the morphological growth characters and the second experiment evaluated the post-harvest fruit characters. The chili variety used in this study was the “Pilar” variety.

Evaluation of the morphological growth characters

Experimental design

The first experiment was arranged by a split-plot design experiment with randomized complete block design as environmental design. The main plot served as the planting media (M) comprising 3 levels, including M1 = soil: compost (2:1), M2 = soil: husk charcoal (2:1) and M3 = soil: compost: husk charcoal (2:1:1). Meanwhile, the sub-plot comprised of the coconut water concentrations (C) with 4 levels, termed C1 = 0% (1000 mL distilled water), C2 = 15% (150 mL coconut water + 850 mL distilled water), C3 = 30% (300 mL coconut water + 700 mL distilled water) and k4 = 45% coconut water concentration (450 mL coconut water + 550 mL distilled water). Based on the two treatment blends, 3 repetitions were

observed in the 12 combinations, resulting in a total of 36 units, with each comprising 4 samples.

Research procedure

Chili seeds were soaked in warm water for about 12 hours and the floating parts were discarded. The remnants were then induced for germination, using a moistened tissue in the absence of light. This was followed by the introduction of the germinated seeds into the combined soil and compost media at a ratio of 2:1, with polybags measuring 10 cm x 12 cm. The seedlings were preserved for 4 weeks and transferred to polybags, based on the growing media treatment without any use of basic organic or inorganic fertilizers. Meanwhile, the transplanting process was conducted simultaneously in the afternoon and the polybags were moistened until the attainment of field capacity. Young coconut water was obtained from similar tree that is yellow colored with characteristics of smooth fruit skin color, pests, and diseases free, as well as soft and thin endosperm. The coconut water was then mixed with distilled water at ratio 1:1, ready to apply to sugar which was fermented for 15 days as a growth regulator. Coconut water was applied twice a week until harvest with according to experiment concentrations. In the first, second, third, and fourth months, the volume of giving coconut water was approximately 10 ml, 45 ml, 75 ml, and 100 ml (per plant), respectively. The application is done by spraying onto the leaves of the plant. Spraying begins when the plants are 4 weeks old after sowing until the observation is complete (10 times). Furthermore, the maintenance of chili plants involved replanting, watering, pruning of the water shoots, weeding, as well as pest and disease control. The embroidery process was conducted for one week after its application on the growing resistant seedlings, using similar seeds according to initial cultivation. Watering was performed daily, in the morning and evening, although it was dependent on the plant condition. The pruning or cutting of the shoots in the leaf axils under the Y branch commenced at 7.00 pm. The weeds were subsequently removed, and the pest control process involved the installation of trap bottles containing methylate glue. Growth regulators with concentrations of 0, 15, 30 and 45%, were applied twice every week by the spray method. Spraying was introduced when the plants are 4 weeks after planting (WAP) until the observation was completed. This was followed by the harvesting process, based on certain criteria, such as the absolute red appearance of the chilies (90%). The present study reported a total harvest rate of 10 repetitions, with 2 occurrences every week.

Observation and data analysis

The observations parameters were plant height (cm), leaf area (cm^2), stomata density, stomata opening area (stomata/mm^2), number of productive branches (branches), number of fruits, fruit length (cm), fruit weight (gram) as well as the fruit weight per plant (gram). Meanwhile, the data evaluation process encompassed several stages, with the first involving the analysis of variance at 5% level. The significant characters were continued using the multivariate approach in the forms of Pearson correlation and factor assessments. Duncan's test was further used to sustain the important character of the multivariate analysis results at the 5% level.

Evaluation post-harvest fruit character

The second experiment was conducted following the first experiment. After fruit harvest, the fruits obtained from coconut water concentration on first experiment were stored in two temperature conditions (the room (R) and refrigeration temperature conditions) arranged in a randomized complete nesting design. These temperatures were specified at 28 and 4 C°, for the room and refrigeration conditions, respectively. The evaluation of the post-harvest properties were carried out based on the fruit color and texture. The fruit observations were performed for two weeks, although the texture and color were examined on a weekly basis. These views were achieved by scoring (Table 1) and subsequently analyzed using the non-parametric methods, such as the Kruskal-walis and Spearman correlation analyses

Conclusion

Based on this study, the use of multivariate and non-parametric analyses increased the effectiveness of the evaluation process of parametric and categorical data, respectively. The concentration of coconut water dominated the diversities of the growth and post-harvest characters of large chilies. Plant height, TDS, fruit weight, number and length, as well as the stomata opening width served as the important characters, particularly on the effect of coconut water concentration. The best coconut water concentration in large chili cultivation in polybags potentially occurs at 15%. Combining these concentrations with the refrigeration temperature generated a significant ability in enhancing the post-harvest fruit quality. Therefore, a coconut water concentration of 15% is possibly recommended in the urban farming of large chillies, using organic applications.

References

Abduh ADM, Padjung R, Farid M, Bahrun AH, Anshori MF, Nasaruddin, Ridwan I, Nur A, Taufik M (2021) Interaction of genetic and cultivation technology in maize prolific and productivity increase. Pak J Biol Sci. 24: 716–723

Agustika DK, Mercuriani IS, Ariyanti NA, Purnomo CW, Triyana K, Iliescu DD, Leeson MS (2021) Gas chromatography-mass spectrometry analysis of compounds emitted by pepper yellow leaf curl virus-infectedA chili plants: a preliminary study. Separations. 8:1–14

Akbar MR, Purwoko BS, Dewi IS, Suwarno WB, Sugiyanta, Anshori MF (2021) Agronomic and yield selection of doubled haploid lines of rainfed lowland rice in advanced yield trials. Biodiversitas J. 22: 3006–3012.

Anshori MF, Purwoko BS, Dewi IS, Ardie SW, Suwarno WB (2020). Cluster Heatmap for Detection of Good Tolerance Trait on Doubledhaploid Rice Lines under Hydroponic Salinity Screening. IOP Conf Ser Mater Sci Eng. 484: 012001.

Anshori MF, Purwoko BS, Dewi IS, Ardie SW, Suwarno WB (2021) A new approach to select doubled haploid rice lines under salinity stress using indirect selection index. Rice Sci. 28: 368–378.

Avgoustaki DD, Xydis G (2020) Indoor vertical farming in the urban nexus context: Business growth and resource savings. Sustainability. 12: 1965. doi:10.3390/su12051965

Beeby J, Moore S, Taylor L, Nderitu S (2020) Effects of a One-Time Organic Fertilizer Application on Long-Term Crop and Residue Yields, and Soil Quality Measurements Using Biointensive Agriculture. Front Sustain Food Syst. 4:67. doi: 10.3389/fsufs.2020.00067

Berry HM, Lai F, Kende A, Rickett DV, Baxter CJ, Enfissi EMA, Fraser PD (2021) Understanding colour retention in red chilli pepper fruit using a metabolite profiling approach. Food Chem: Mol Sci. 2: 1–10.

Bhattacharyya T, Pal DK (2015) The soil: A natural resource. In: Rattan RK, Katyal JC, Dwivedi BS, Sarkar AK, Bhattacharyya T, Tarafdar JC, Kukal SS (eds) Soil science: An introduction. ISSS, New Delhi. Chapter 2 (1–19).

Bijalwan P, Mishra AC (2016) Correlation and path coefficient analysis in chilli (*Capsicum annuum* L.) for yield and yield attributing traits. Int J Sci Res. 5: 1589–1592.

Chilczuk B, Marciniak B, Kontek R, Materska M (2021) Diversity of the chemical profile and biological activity of Capsicum annuum L. extracts in relation to their lipophilicity. Molecules. 26: 1–11.

Contreras C, Hermosilla A, Contreras E, Naranjo P, Zoffoli JP, Gambardella M (2021) Postharvest physiology and storage potential of new Chilean raspberry cultivars. Chil J Agric Res. 81(2): 161–171.

Dalimunthe MB, Ellen L, Azwana (2017) Growth and production of chili plants (*Capsicum annuum* L.) against provision of organic fertilizer in various media plant. J Agrotekma. 2(1): 16–28. (In Indonesian).

Darmawan R, Dewi VGP, Rizaldi MA, Juliastuti SR, Gunawan S, Aparamarta HW, Wiguno A (2020) Production of liquid bio-fertilizer from old coconut water and molasses using consortium microbes. IOP Conf Ser Mater Sci Eng. 845: 1–7.

Edusei VO, Ofuso-Anim J, Johnson P-NT, Cornelius EW (2012) Extending postharvest life of green chilli pepper fruits with modified atmorsphere packaging. Ghana J Hortic. 10: 131–140.

Elibox W, Meynard CP, Umaharan P (2015) Morphological changes associated with postharvest fruit deterioration and physical parameters for early determination of shelf life in *Capsicum chinense* Jacq. Hort Science. 50: 1537–1541.

Farid M, Nasaruddin, Musa Y, Anshori MF, Ridwan I, Hendra J, *et al* (2020) Genetic parameters and multivariate analysis to determine secondary traits in selecting wheat mutant adaptive on tropical lowlands. Plant Breed Biotech. 8: 368–377.

Fassya HM, Handayani TT, Wahyuningsih S, Mahfut (2020) The application effect of coconut water (*Cocos nucifera* L.) and atonic on the growth of large red chili plant (*Capsicum annuum* L.). Techno. 9: 315–324. (In Indonesian).

Fellahi ZEA, Hannachi A, Bouzerzour H (2018) Analysis of direct and indirect selection & indices in bread wheat (*Triticum aestivum* L.) segregating progeny. Intl J Agron. 8312857: 1–11

Fitry R, Rostini N, Hersanti, Anas (2021) Biplot and correlation analysis of 189 superior f2 genotypes chili-Unpad in Indonesia. J adv res biol sci. 9: 10–14.

Galani JHY, Patel JS, Patel NJ, Talati JG (2017) Storage of fruits and vegetables in refrigerator increases their phenolic acids but decreases the total phenolics, anthocyanins and vitamin C with subsequent loss of their antioxidant capacity. Antioxidants. 6: 1–19.

Gomiero T (2016) Soil degradation, land scarcity and food security: Reviewing a complex challenge. Sustainability. 8: 281. doi:10.3390/su8030281

Gungor F, Yildirim E (2013) Effect of different growing media on quality, growth and yield of pepper (*Capsicum annuum* L.) under greenhouse conditions. Pak J Bot. 45: 1605–1608.

Hamed M, Kalita D, Bartolo ME, Jayanty SS (2019) Capsaicinoids, polyphenols and antioxidant activities of *Capsicum annuum*: comparative study of the effect of ripening stage and cooking methods. Antioxidants. 8: 1–19.

Ji R, Dong G, Shi W, Min J (2017) Effects of liquid organic fertilizers on plant growth and rhizosphere soil characteristics of chrysanthemum. Sustainability. 9: 841. doi:10.3390/su9050841

Khaitov B, Yun HJ, Lee Y, Ruziev F, Le TH, Umurzokov M, Bo AB, Cho KW, Park KW (2019) Impact of organic manure on growth, nutrient content and yield of chilli pepper under various temperature environments. Int J Environ Res Public Health. 16: 1–14.

Lazim MIM, Badruzaman NA, Peng KS, Long K (2015) Quantification of cytokinins in coconut water from Different Maturation Stages of Malaysia's Coconut (*Cocos nucifera* L.) Varieties. J Food Process Technol. 6(11): 515. http://dx.doi.org/10.4172/2157-7110.1000515

Lin W, Lin M, Zhou H, Wu H, Li Z, Lin W (2019) The effects of chemical and organic fertilizer usage on rhizosphere soil in tea orchards. Plos One 14(5): e0217018. Doi: 10.1371/journal.pone.0217018

Maalekuu K, Elkind Y, Frenkel AL, Lurie S, Fallik E (2006) The relationship between water loss, lipid content, membrane integrity and LOX activity in ripe pepper fruit after storage. Postharvest Biol Technol 42: 248–255

Markussen MV, Kulak M, Smith LG, Nemecek T, Østergård H (2014) Evaluating the sustainability of a small-scale low-input organic vegetable supply system in the United Kingdom. Sustainability. 6: 1913–1945.

Maskey B, Bhattarai R, Bhattarai G, Shrestha NK (2021) Post-harvest quality of fresh akabare chili (*Capsicum chinese*) as affected by hydrocooling, package modification and storage temperature. Int J Food Prop. 24: 163–173.

Mathowa T, Tshipinare K, Mojeremane W, Legwaila GM, Oagile O (2017) Effect of growing media on growth and development of sweet paper (*Capsicum annuum* L.) seedlings. J Appl Hortic. 19: 200–204.

Mintah LO, Arhin L, Ofosu-Anim J, Nkansah GO (2018) Effect of coconut (*Cocos nucifera* L.) water of different fruit maturity stages on axillary bud initiation, growth and development of plantain (*Musa AAB*.). J Appl Hortic. 20 (1): 42–47

Mythili JB, Rajeev PR, Vinay G, Nayeem A (2017) Synergistic effect of silver nitrate and coconut water on shoot differentiation and plant regeneration from cultured cotyledons of *Capsicum annuum* L. Indian. J Exp Biol. 55: 184–190.

Pahalvi HN, Rafiya L, Rashid S, Nisar B, Kamili AN (2021) Chemical fertilizers and their impact on soil health. In: Dar GH, Bhat RA, Mehmood MA, Hakeem KR (eds) Microbiota and Biofertilizers, Vol 2. Springer, Cham. 1-20. https://doi.org/10.1007/978-3-030-61010-4_1

Prades A, Dornier M, Diop N, Pain JP (2012) Coconut water uses, composition and properties: a review. Fruits. 67: 87–107.

Prando MAS, Chiavazza P, Faggio A, Contessa C (2014) Effect of coconut water and growth regulator supplements on in vitro propagation of *Corylus avellana* L. Sci Hortic. 171: 91–94.

Rocha JRDADC, Machado JC, Carneiro FCS (2018) Multitraits index based on factor analysis and ideotype-design: proposal and application on elephant grass breeding for bioenergy. Bioenergy. 10 (1): 52–60.

Razo-Mendivil FG, Hernandez-Godı´nez F, Hayano-Kanashiro C, Martı´nez O (2021) Transcriptomic analysis of a wild and a cultivated varieties of Capsicum annuum over fruit development and ripening. Plos One 16(8): e0256319. https://doi.org/10.1371/journal. pone.0256319

Saleh BK, Omer A, Teweldemedhin B (2018) Medicinal uses and health benefits of chili pepper (*Capsicum spp*.): A review. MOJ Food Process Technol. 6 (4): 325–328.

Saptaji, Setyono, Rochman N (2015) The effect of coconut water and media of planting on the growth of stevia cuttings (*Stevia rebaudiana* Bertoni). Jurnal Agronida. 1: 83–91. (In Indonesian).

Schröder C, Häfner F, Larsen OC, Krause A (2021) Urban organic waste for urban farming: growing lettuce using vermicompost and thermophilic compost. Agronomy. 11(6): 1175. https://doi.org/10.3390/agronomy11061175

Shah KK, Modi B, Pandey HP, Subedi A, Aryal G, Pandey M, Shrestha J (2021) Diversified crop rotation: An approach for sustainable agriculture production. Adv Agri. 2021: Article ID 8924087 (9 pages). https://doi.org/10.1155/2021/8924087

Suryani R (2019) Outlook for chili for agricultural commodities in the horticulture sub-sector. Pusat Data dan Sistem Informasi Pertanian Sekretariat Jenderal Kementerian Pertanian, Jakarta. 9-22. (In Indonesian).

Timmis K, Ramos JL (2021) Editorial series: Contributions of microbial biotechnology to sustainable development goals. Microb Biotechnol. 14: 769–797.

Tiwery RR (2014) The effect of the use of coconut water (*Cocos nucifera*) on the growth of *Brassica juncae* L. Biopendix, 1 (1): 86–94. (In Indonesian).

Winarto B, da Silva JAT (2015) Use of coconut water and fertilizer for in vitro proliferation and plantlet production of Dendrobium 'Gradita 31'. In Vitro Cell Dev Biol. 51: 303–314.

Yenny RF, Rostini N, Hersanti, Anas (2019) Correlation between fruit characters with capsaicin content in F2 population of chili. IOP Conf Ser Earth Environ Sci. 334: 1–5.

Yong JWH, Ge L, Ng YF, Tan SN (2009) The chemical composition and biological properties of coconut (*Cocos nucifera* L.) water. Molecules. 14: 5144–5164.

Yong AG, Pearce S (2013) A beginner's guide to factor analysis: focusing on exploratory factor analysis. Tutor Quant Methods Psychol. 9 (2): 79–94.

Ziv C, Fallik E (2021) Postharvest storage techniques and quality evaluation of fruits and vegetables for reducing food loss. Agronomy. 11: 1–5.