International Journal of Recycling of Organic Waste in Agriculture (2020)9: 287-296
DOI: 10.30486/IJROWA.2020.1894411.1048

ORIGINAL RESEARCH

Optimization of BioPot compositions made from water hyacinth and coconut coir for improving the growth and yield of chili (*Capsicum annum* L.)

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Received: 08 March 2020 / Accepted: 03 August 2020 / Published online: 27 September 2020

Abstract

Purpose An attempt to improve the quality and quantity of chili production through good and effective nursery still needs some development and advancement. Polybag as seedling pot made from polyethylene has non-biodegradable properties that causes environmental impacts, so alternative biodegradable pot which is derived from renewable organic material, namely BioPot, is urgent. The suitable BioPot compositions to complete the nursery stage successfully still need further research and improvement. This research aimed at optimizing BioPot compositions made from water hyacinth and coconut coir for improving the growth and yield of chili.

Methods The experiment was carried out using simple RCBD, three replication, one control (polybag) and 5 BioPot compositions (percentage of water hyacinth and coconut coir) as treatments labelled as PO1 (40:60), PO2 (50:50), PO3 (60:40), PO4 (70:30) and PO5 (80:20). The data were analyzed by ANOVA (F-test), then by means of HSD (Tukey test) α 5% as well as response surface analysis.

Results The results showed that PO3 and PO4 showed no difference in all observations of the growth of chilli. The highest yield of chili was obtained using PO4 (70% water hyacinth and 30% coconut coir) although the number was not significantly different from PO3 and PO5 (60-80% water hyacinth and 20-40% coconut coir), except in fruit length variable.

Conclusion BioPot made from 70% water hyacinth and 30% coconut coir (PO4) was the optimum composition based on scatter plot, contour plot, and surface plot.

Keywords Agricultural waste, BioPot, Nursery, Seedling container

Introduction

National chili production of Indonesia reached 1.045 million tons and 123 thousand hectares of harvest area in 2016 (Ministry of Agriculture Republic of Indonesia 2017). The expansion of harvest area indicated the need for a large quantity of uniform seedling which has implications on increasing polybag use as a pot or seedling container. Besides, the quality of seedlings influences the growth and yield of plants (Ibrahim et al. 2013), thus an improvement of quality and quantity of chili production through good and effective nursery needs to be further developed.

Polybag made from polyethylene is non-biodegradable and contains resin that can contaminate the soil and harm the environment if the waste is not handled properly (Akinro et al. 2012; Kasirajan and Ngouajio 2012). In addition, tearing the polybag during transplanting has caused the medium breakdown and root damage that potentially stagnate the seedling after transplanting. Biodegradable pot is one of the solutions to avoid the stress that might arise when transplanting due to the use of polybags. The advantages of biodegradable containers are easily decomposed, allowing nutrient release from the pot, and contributing organic matter contents to the soil (Jirapornvaree et al. 2017). BioPot supports the development of root structure with good branching and secondary root growth which plays a role in the absorption of water and nutrients for plants (Santagata et al. 2017).

Biodegradable pot from bio-based materials had been researched and patented, i.e. the combination of rice straw and coconut coir sprayed with latex (patent number US7685770B2), rice straw, corn stalk, and cow manure mixed with a starch adhesive (Tian et al. 2019), keratin processed from feather fiber resin enriched with copper (Codling et al. 2019), banana peel powder combined with biomaterials (tapioca starch, vinegar, and

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glycerol) (Mohd Rafee et al. 2019), as well as rice husk and corn starch modified with urea formaldehyde-cornstarch adhesive (Sun et al. 2017). The procedures of making biodegradable pot in the previous research and patent are mostly difficult to adopt by small-scaled famers and the price is too expensive for the commercial biodegradable pot. Besides, some of them have not provided the optimum composition and seedling testing of the formulated materials yet. Simple procedure of making biodegradable pot was reported by Nugroho et al. (2013) using water hyacinth and coconut coir as raw materials and resulted in satisfying mechanics trait but did not test for the seedling yet. Water hyacinth is an aquatic weed with biomass accumulation more than 200 tons dry matter/ha/year (Tumolva et al. 2013); while coconut coir is a by-product of coconut post-harvest processing in an abundant amount (Main et al. 2014). In this current research, low cost raw materials (water hyacinth and coconut coir) and simple procedure of making biodegradable pot (BioPot) were tested as well as the implementation for the crop seedling, i.e. chili. The objective of this research was to optimize BioPot composition made from water hyacinth and coconut coir for improving the growth and yield of chili.

Materials and method

This research was conducted at Menganto, Mojowarno, Jombang, East Java, Indonesia with an altitude of 500 meters above sea level and rainfall ranging from 1750-2500 mm per year. Materials used in this research were raw materials of BioPot (water hyacinth petiole and coconut coir), polybag, chili seed (*Capsicum annum*), fertilizer, and insecticides. The procedures of making BioPot comprised cutting and weighing, pulping, molding, and drying. Preparation included cutting the water hyacinth petiole and coconut coir into small pieces. Each mold (8 cm height and 5 cm diameter) needs 100 g of raw material from composition treatments. The water hyacinth petiole, added by water, was boiled for 20 minutes (water:water hyacinth ratio (v/v) was 2:1) before pulping. Drying was done under sunlight until BioPot could be removed from the mold.

Experimental design

This research was carried out using a simple randomized complete block design (RCBD) with one control (polybag) and five treatments (BioPot compositions) and repeated three times. The treatments were various BioPot compositions (the percentage of water hyacinth and coconut coir) labelled as PO1 (40:60), PO2 (50:50), PO3 (60:40), PO4 (70:30) and PO5 (80:20).

Measured variables and data analysis

Measured variables included the development of seedling, plant growth, and plant yield. Development of seedling and plant growth variables were seedling/plant height (cm), number of leaves, and stem diameter (mm). Plant yield variables were number of fruits per plant, fruit weight per plant (g), fruit length (cm), fruit diameter (mm), fruit fresh weight per fruit (g), and fruit dry weight per fruit (g).

The data were analyzed using an analysis of variance (ANOVA) to determine the effect of the treatment, then by means of HSD (Tukey test) α 5% to find out the best treatment. Response surface method analysis was also carried out to analyze the optimum BioPot compositions based on growth data (plant height, number of leaves, and stem diameter) and yield data (fruit weight per plant, number of fruits, and fruit length) using Minitab v19.

Results and discussion

Effects of BioPot compositions on the development of chili seedling

Biopot composition treatment did not show significantly different effects on seedling height, number of leaves, and stem diameter at 3 WAS (weeks after sowing) although there were significant differences of PO3 and PO5 compared to control (P0) on the seedling height (Table 1). These results differed from the previous research reported by Tsakaldimi et al. (2005) that oak seedlings (*Quercus ilex* L. and *Quercus coccifera* L) grown in paper-pot (biodegradable paper) showed significantly higher seedling height, stem diameter, and biomass than quick-pot and plantek (rigid re-usable plastic containers). In addition, the seedling survival rate in the field grown in paper-pots was greater than quick-pots and plantek. Generally, biodegradable pot or container made from raw materials that degraded relatively quickly in the soil would be suitable for short-cycle crops; while bio-container made from slowly degraded-based material would be more suitable for the long-cycle crops. Pepper (*Capsicum annuum* 'Autumn Bell') requires seedling containers with long durability (HDPE, PLA + 20% lignin, PHA + 20% lignin) to produce good quality seedling and transplant establishment (Kratsch et al. 2015; Schrader et al. 2015). BioPot compositions did not affect the growth of chili seedling and there was similar growth between BioPot and polybag. This can be explained through studies reported by Bali et al. (2013) and Dominguez-Lerena et al. (2006) that seedling container volume, diameter, depth, and growing density had more effect on seedling growth, physiology, and morphology than growing medium and container type.

Table 1 Seedling height, number of leaves, and stem diameter of chili seedling (*Capsicum annum*) grown in various BioPot compositions on two and three weeks after sowing (WAS)

Treatment	Seedling height (cm)		Number of leaves		Stem diameter (mm)	
	2 WAS	3 WAS	2 WAS	3 WAS	WAS 2	WAS 3
P0	4.46±0.10 b	9.40±0.31 b	4.22±0.11 a	7.28±0.28 a	0.12±0.002 b	1.53±0.18 a
PO1	5.23±0.05 ab	10.33±0.67 ab	4.39±0.06 a	7.50±0.44 a	0.12±0.001 b	1.14±0.01 b
PO2	5.09±0.39 ab	10.17±0.33 ab	4.50±0.10 a	7.56±0.15 a	0.15±0.011 a	1.19±0.03 ab
PO3	5.24±0.13 ab	11.12±0.43 a	4.28±0.20 a	7.67±0.26 a	0.10±0.000 b	1.19±0.06 b
PO4	5.66±0.17 a	10.23±0.47 ab	4.61±0.20 a	8.11±0.46 a	0.10±0.000 b	1.13±0.01 b
PO5	5.48±0.34 a	11.29±0.28 a	4.39±0.20 a	7.72±0.36 a	0.11±0.000 b	1.19±0.06 ab
HSD 5%	0.86	1.27	0.77	1.80	0.02	0.38

Values were expressed as means ± standard error.

The mean value which was followed by the same letter in the same column showed that the difference was not significant based on Tukey's test with 5% significance level.

Treatments: P0 control (polybag), PO BioPot compositions (the percentage of water hyacinth and coconut coir) labelled as PO1 (40:60), PO2 (50:50), PO3 (60:40), PO4 (70:30), and PO5 (80:20).

Effects of BioPot compositions on the growth of chili

BioPot made from 70% water hyacinth and 30% coconut coir (PO4) showed significantly higher plant height than the control and other BioPot compositions on 1 until 12 weeks after planting (WAP) as shown in Table 2.

BioPot made from 40-50% water hyacinth and 50-60% coconut coir (PO1 and PO2) showed significantly more numbers of leaves than the control; while BioPot made from 70% water hyacinth and 30% coconut coir (PO4) showed more numbers of leaves than other BioPot compositions even though the numbers were not significantly different from BioPot made from 60%

Table 2 Plant height of chili (*Capsicum annum*) grown in various BioPot compositions on 1st until 12th weeks after planting (WAP)

Treatment	Plant height (cm) on WAP					
	1	2	3	4	5	6
P0	14.28±1.84 b	19.50±1.00 b	22.06±0.80 c	24.61±0.72 c	26.56±0.53 c	27.56±0.53 c
PO1	17.67±0.17 a	21.94±0.74 a	24.56±0.15 b	27.22±0.53 bc	30.67±0.42 b	31.67±0.42 b
PO2	16.11±0.29 ab	21.78±0.53 a	24.61±0.20 b	28.33±0.35 b	31.00±0.35 b	32.00±0.35 b
PO3	17.50±0.51 a	22.44±0.77 a	25.06±0.44 b	28.50±0.54ab	31.94±0.43 b	32.94±0.43 b
PO4	18.17±1.08 a	23.22±0.73 a	27.78±0.24 a	31.78±0.96 a	35.83±1.46 b	36.83±1.46 a
PO5	16.83±0.67 a	23.00±0.44 a	25.83±0.59 b	28.89±0.53 ab	31.67±0.44 a	32.67±0.44 b
HSD 5%	3.71	2.11	2.32	3.29	3.69	3.59
	7	8	9	10	11	12
P0	29.56±0.53 c	30.56±0.53 c	31.56±0.53 c	34.83±1.80 c	35.33±2.02 c	36.33±2.02 c
PO1	33.67±0.42 b	35.00±0.10 b	37.67±0.42 b	45.00±2.00 b	46.00±2.00 b	47.00±2.00 b
PO2	34.00±0.35 b	35.33±0.42 b	38.00±0.35 b	44.72±1.00 b	45.72±1.00 b	46.72±1.00 b
PO3	34.94±0.43 b	36.28±0.20 b	38.94±0.43 b	47.00±1.80 ab	48.00±1.80 ab	49.00±1.80 ab
PO4	38.83±1.46 a	40.17±1.25 a	42.83±1.46 a	51.00±2.29 a	52.00±2.29 a	53.00±2.29 a
PO5	34.67±0.44 b	36.00±0.73 b	38.67±0.44 b	44.28±2.28 b	45.28±2.28 b	46.28±2.28 b
HSD 5%	3.61	3.45	3.59	4.34	4.54	4.53

Values were expressed as means ± standard error.

The mean value which was followed by the same letter in the same column showed that the difference was not significant based on Tukey's test with 5% significance level.

Treatments: P0 control (polybag), PO BioPot compositions (the percentage of water hyacinth and coconut coir) labelled as PO1 (40:60), PO2 (50:50), PO3 (60:40), PO4 (70:30), and PO5 (80:20).

water hyacinth and 40% coconut coir (PO3) on 1st until 12th WAP (Table 3).

The effects of BioPot compositions on the stem diameter of chili started to appear on 3 WAP. PO1 and PO2 showed insignificantly different stem diameter compared to the control; while PO4 showed wider stem diameter than other BioPot compositions even though it was not significantly different from PO3 on 3rd until 12th WAP (Table 4).

The main advantage of BioPot is its plantable characteristic in which there is no need to remove BioPot when transplanting, thereby reducing the potential stress of plant due to broken roots. An ideal Biopot is expected to maintain its shape and function during the nursery stage and degrade rapidly after being transplanted into the field. Accordingly, the roots do not suffer from stress and can grow well. Seedling grown using polythene tubes has high growth rate in nurseries, but the growth is overtaken by seedling grown in the biodegradable containers as after being transplanted, the seedling no longer suffers from shock (Muriuki et al. 2014). Besides, the cooling effect of biodegradable container can reduce the temperature of planting medium so that the circumstance of heat stress received by roots due to temperature rise can be avoided (Postemsky et al. 2016).

In general, the previous studies have shown that the use of different alternative seedling containers (plantable, compostable, and recycled plastic) has no significant effect on the growth and quality of the produced crops but showing better growth than plastic containers (Nambuthiri et al. 2015). McCabe et al. (2014) assert that differences in container materials, i.e. paper, coir, and peat fiber did not affect the dry weight of tomato, marigold, pepper, salvia, and petunia. Similar results were also reported by Kuehny et al. (2011) that there was no significant difference on the plant height and shoot dry weight of 'Red Score' geranium, 'Dazzler Lilac Splash' impatiens, and 'Grape Cooler' vinca due to different types of container, i.e. plastic containers (control) and bio-containers (coconut fiber and rice straw). However, the different compositions of bio-containers (the combination of biodegradable polyester and plant fibers) significantly affected the growth variables such as the number of leaves, wet weight and dry weight of plants shown in poinsettias (two years) although it did not significantly affect plant height (Castronuovo et al. 2015). Thereby, the different formulations of varying raw materials would have different effects if applied to the various types of plants (trees or crops even long- or short-cycle crops). The differences of raw material would affect the mechanics characteristics of biodegrad-

Table 3 Number of leaves of chili (*Capsicum annum*) grown in various BioPot compositions on 1st until 12th weeks after planting (WAP)

Treatment	Number of leaves on WAP					
	1	2	3	4	5	6
P0	9.28±0.28 b	13.28±0.28 b	17.28±0.28 c	21.28±0.28 c	25.28±0.28 d	31.28±0.28 d
PO1	9.50±0.44 b	13.50±0.44 b	17.50±0.44 c	23.39±0.36 b	27.39±0.36 c	33.33±0.35 c
PO2	9.56±0.15 b	13.56±0.15 b	17.56±0.15 c	23.44±0.06 b	27.44±0.06 c	33.44±0.06 c
PO3	11.67±0.26 a	15.67±0.26 a	21.67±0.26 a	27.56±0.20 a	33.56±0.20 a	39.50±0.26 a
PO4	12.17±0.51 a	16.11±0.46 a	22.11±0.46 a	27.11±0.46 a	33.17±0.51 a	39.17±0.51 a
PO5	11.72±0.36 a	15.72±0.36 a	19.78±0.40 b	24.78±0.40 b	30.72±0.36 b	36.72±0.36 b
HSD 5%	1.81	1.82	1.63	1.62	1.71	1.63
	7	8	9	10	11	12
P0	37.28±0.28 c	38.61±0.84 c	39.28±1.16 d	41.28±2.15 b	44.28±1.16 c	45.78±0.89 c
PO1	39.39±0.36 b	41.39±0.36 bc	42.39±0.36 c	45.39±0.36 ab	47.39±0.36 bc	48.39±0.36 bc
PO2	39.44±0.06 b	41.44±0.06 b	42.44±0.06 c	45.44±0.06 ab	47.44±0.06 bc	48.44±0.06 bc
PO3	43.56±0.20 a	45.56±0.20 a	46.56±0.20 a	49.56±0.20 a	53.56±0.20 a	56.06±0.59 a
PO4	43.11±0.46 a	45.11±0.46 a	46.17±0.51ab	49.11±0.46 a	54.22±1.26 a	57.33±1.64 a
PO5	40.72±0.36 b	42.72±0.36 b	43.72±0.36 bc	46.72±0.36 a	48.72±0.36 b	50.72±0.36 b
HSD 5%	1.81	2.49	2.98	4.74	5.11	5.59

Values were expressed as means ± standard error.

The mean value which was followed by the same letter in the same column showed that the difference was not significant based on Tukey's test with 5% significance level.

Treatments: P0 control (polybag), PO BioPot compositions (the percentage of water hyacinth and coconut coir) labelled as PO1 (40:60), PO2 (50:50), PO3 (60:40), PO4 (70:30), and PO5 (80:20).

Table 4 Stem diameter (mm) of chili (*Capsicum annum*) grown in various BioPot compositions on 1st until 12th weeks after planting (WAP)

Treatment	Stem diameter (mm) on WAP					
	1	2	3	4	5	6
P0	2.46±0.04 a	2.93±0.07 a	3.14±0.01 b	3.62±0.07 ab	4.33±0.09 a	4.79±0.25 b
PO1	2.39±0.06 a	2.89±0.06 a	3.13±0.07 b	3.61±0.12 ab	4.37±0.10 a	4.83±0.25 b
PO2	2.49±0.03 a	2.99±0.03 a	3.38±0.08 ab	3.73±0.13 ab	4.51±0.24 a	4.97±0.07 ab
PO3	2.48±0.06 a	2.97±0.05 a	3.49±0.01 ab	3.91±0.01 ab	4.63±0.12 a	5.81±0.27 a
PO4	2.41±0.01 a	2.89±0.01 a	3.75±0.23 a	4.23±0.31 a	4.72±0.31 a	5.89±0.48 a
PO5	2.44±0.01 a	2.98±0.05 a	3.11±0.05 b	3.43±0.04 b	4.01±0.08 a	5.18±0.12 ab
HSD 5%	0.18	0.22	0.54	0.75	0.93	0.93
	7	8	9	10	11	12
P0	5.29±0.25 b	6.60±0.66 ab	7.26±0.55 bc	7.76±0.55 c	8.76±0.55 c	9.56±0.85 c
PO1	5.34±0.25 b	6.45±0.59 b	7.11±0.46 bc	7.61±0.±6 c	8.61±0.46 c	9.41±0.79 c
PO2	5.47±0.07 ab	6.33±0.38 b	6.99±0.36 c	8.09±0.36 c	9.09±0.36 c	9.89±0.50 c
PO3	6.31±0.27 a	7.29±0.34 ab	7.96±0.21 ab	9.06±0.21 ab	10.06±0.21 ab	10.86±0.55 ab
PO4	6.39±0.48 a	7.60±0.64 a	8.55±0.26 a	9.65±0.26 a	10.65±0.26 a	11.45±0.59 a
PO5	5.68±0.12 ab	6.45±0.29 b	7.12±0.18 bc	8.22±0.18 bc	9.22±0.18 bc	10.02±0.49 bc
HSD 5%	0.93	1.07	0.90	0.90	0.90	0.90

Values were expressed as means ± standard error.

The mean value which was followed by the same letter in the same column showed that the difference was not significant based on Tukey's test with 5% significance level.

Treatments: P0 control (polybag), PO BioPot compositions (the percentage of water hyacinth and coconut coir) labelled as PO1 (40:60), PO2 (50:50), PO3 (60:40), PO4 (70:30), and PO5 (80:20).

able pot, degradability, and nutrient added into the soil after being degraded. Furthermore, the better growth of chili from seedling grown in BioPot than polybag can be explained from the elimination of potential problems raised by the use of polybag such as root bound, root spiraling, and roots egressing into the beds. These problems resulted in poorly root system development that can decline the out planting survival and growth (Aldrete et al. 2002). In addition, root damage or root pruning, to correct root bound due to the use of container seedling, caused transplant shock that resulted in slower growth (Codling et al. 2019).

Effects of BioPot compositions on the yield of chili

BioPot composition influenced the number of fruits and weight of fruits per plant, fruit weight per fruit, fruit length and fruit diameter per fruit, but not on dry weight per fruit of chili (Table 5). BioPot made from 70% water hyacinth and 30% coconut coir (PO4) produced the highest value in all yield observation variables of chili although it was not significantly different from the treatment of PO3 and PO5, except for fruit length variable. The highest average of plant height and fruit length produced by PO4 indicated higher yield observation variable of chili compared to other BioPot compositions. It can be explained by the positive correlation between crop yield and plant height when harvesting, fruit length, number of fruits, and fruit diameter (Ullah et al. 2011; Usman et al. 2014).

The difference in BioPot materials and compositions will affect the nutrients added to the soil when being decomposed. Schrader et al. cited in Nambuthiri et al. (2015) suggested that removing, crushing, and placing soy-plastic containers into the soil near the root zone when transplanting increased fruit production, plant dry weight, plant volume, and plant quality index compared to the polypropylene plastic. Fresh water hyacinth contains 95.5% moisture, 0.04% N, 1.0% ash, 0.06% P_2O_5, 0.20% K_2O, and 3.5% organic matter. Based on dry ingredients, it contains 75.8% organic matter, 1.5% N, and 24.2% ash (the ash contains 28.7% K_2O, 1.8% Na_2O, 12.8% CaO, 21.0% Cl, and 7.0% P_2O_5) (Jafari 2010). The decomposed BioPot would add nutrients serving as a very good source of organic matters for rhizosphere microorganisms. Furthermore, coconut coir plays a role as fiber source that produces good characteristic pulp (Main et al. 2014). Overall, BioPot produced higher yield of chili than polybag, adding more nutrients into the soil after being degraded and contributing organic matters (Jirapornvaree et al. 2017). In addition, BioPot has supported the develop-

Table 5 Yield observation variables of chili (*Capsicum annum* L.) on various BioPot compositions

Treatment	Number of fruits per plant	Fruit weight per plant (g)	Fruit length (cm)	Fruit diameter (mm)	Fruit fresh weight per fruit (g)	Fruit dry weight per fruit (g)
P0	28.89±2.28 b	247.50±26.40 b	12.67±0.34 d	13.48±0.31 b	8.31±0.16 b	0.43±0.09 a
PO1	35.00±2.42 b	294.56±18.70 b	14.06±0.90 cd	14.86±0.22 ab	9.27±0.51 ab	0.60±0.12 a
PO2	33.44±1.64 b	302.17±12.70 b	15.88±0.33 ab	13.37±0.51 b	9.66±0.69 a	0.57±0.04 a
PO3	38.78±3.36 ab	349.11±21.40 ab	14.83±0.50 bc	15.34±1.23 ab	9.98±0.30 a	0.58±0.07 a
PO4	50.94±4.81 a	436.14±45.80 a	16.96±0.38 a	16.98±0.39 a	9.66±0.46 a	0.77±0.08 a
PO5	39.39±1.56 ab	318.93±22.60 ab	14.88±0.29 bc	15.57±0.35 ab	9.85±0.24 a	0.48±0.08 a
HSD 5 %	12.75	111.42	1.76	2.42	1.24	0.39

Values were expressed as means ± standard error.

The mean value which was followed by the same letter in the same column showed that the difference was not significant based on Tukey's test with 5% significance level.

Treatments: P0 control (polybag), PO BioPot compositions (the percentage of water hyacinth and coconut coir) labelled as PO1 (40:60), PO2 (50:50), PO3 (60:40), PO4 (70:30), and PO5 (80:20).

ment of root systems which plays a role in the absorption of water and nutrients for crops (Santagata et al. 2017), also provides suitable rhizospher for beneficial soil microbes. Furthermore, the long term use of BioPot is expected to improve the soil health especially on horticulture production.

Optimum BioPot composition analysis for the growth and yield of chili

Scatter plot was used to see the emerging trends based on the observational data obtained so that it could show the tendency of BioPot compositions which produced the highest fresh fruit weight per plant. Fig. 1 shows that fruit weight per plant tends to increase with the rise of water hyacinth and the reduction of coconut coir percentage and reach maximum at 70% water hyacinth and 30% coconut coir composition (PO4).

The response surface methodology (RSM) is a statistical technique to design experiments and build models while looking for the best conditions, assessing the effects of factors, reducing the number of experimental runs, and identifying possible interactions (Bezerra et al. 2008; Hill and Hunter 1966). RSM can be used to optimize the preparation of both the composition and process of making a product such as bio-composites, bio-plastic, and edible films (Araújo et al. 2018; Kijchavengkul 2010; Penjumras et al. 2015; Thakur et al. 2017).Therefore, it is possible to optimize the composition of BioPot for the growth and yield of chili using RSM.

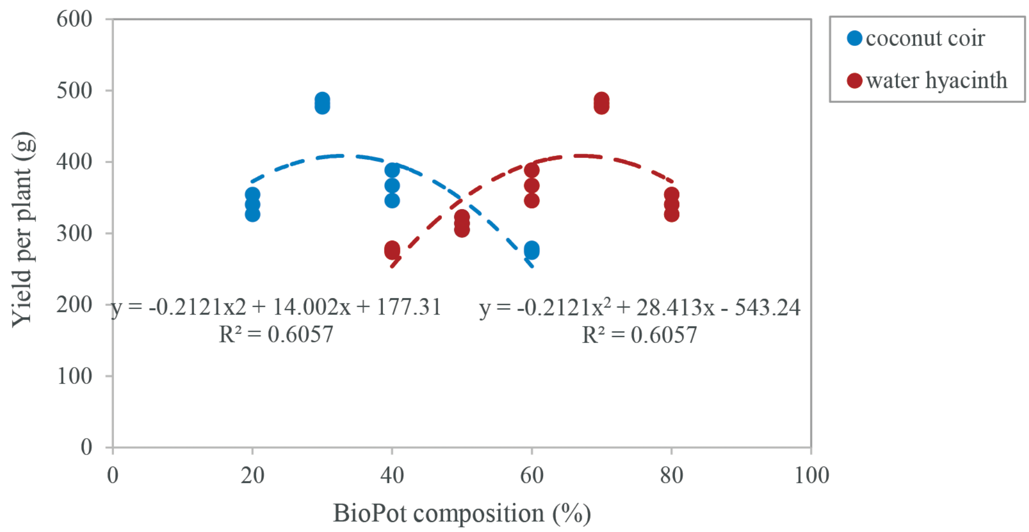

Fig. 1 Relationship between BioPot compositions and yield per plant

Contour plots show how the fitted response relates to continuous variables. A contour plot provides a two-dimensional view where all points that have the same response are connected to produce contour lines of constant responses. A surface plot displays the three-dimensional relationship in two dimensions, with the variables on the x- and y-scales, and the response (z) variable represented by a smooth surface (Antony 2014; Minitab Inc 2007). The contour plot in Fig. 2 shows that higher growth variable (number of leaves and stem diameter) was obtained with the higher coconut coir percentage than water hyacinth; while the higher yield variable (number of fruits and fruit length) was attained on the higher water hyacinth percentage than coconut coir. Based on 3D surface plot in Fig. 3, the optimum composition of BioPot for the growth (plant

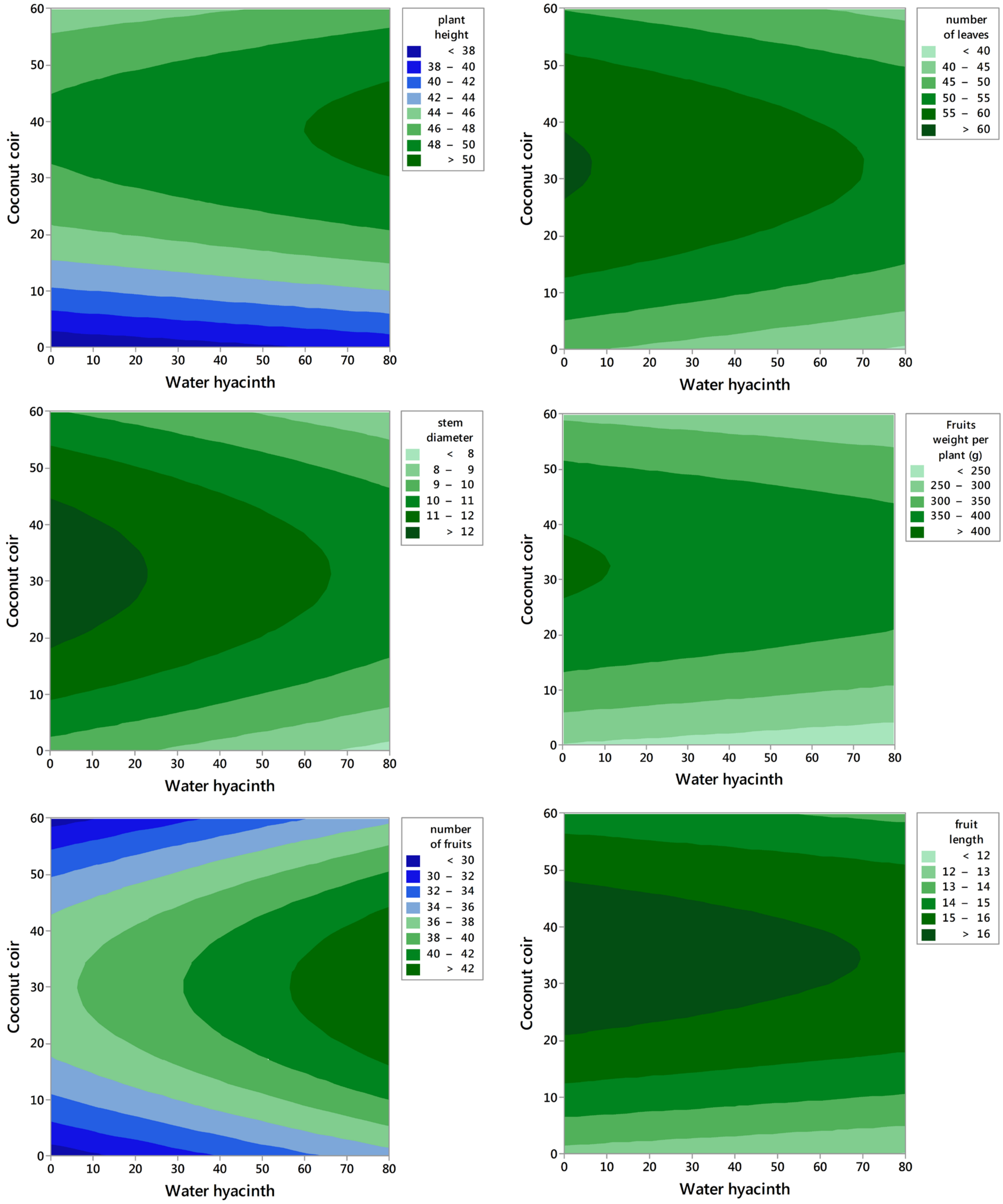

Fig. 2 Contour plot for the effects of BioPot compositions (the percentage of water hyacinth and coconut coir) on the growth and yield of chili

height) and yield of chili was obtained at 79% water hyacinth and 30-38% coconut coir. In conclusion, the optimum BioPot composition for improving the growth and yield of chili (based on plant height, fruit weight per plant, and number of fruits) obtained using RSM was 80% water hyacinth and 33% coconut coir.

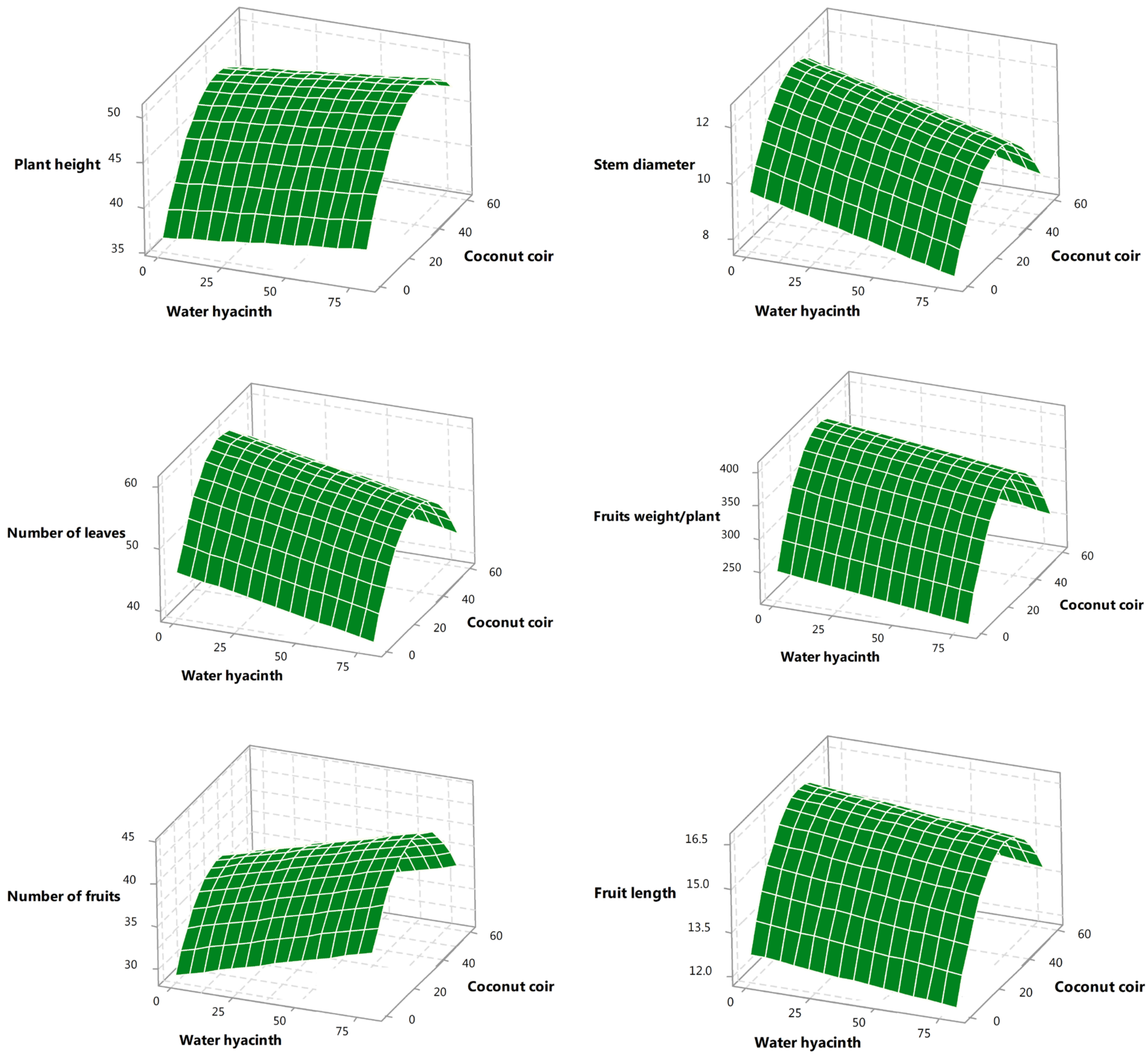

Fig. 3 Surface plot for the effects of BioPot compositions (the percentage of water hyacinth and coconut coir) on the growth and yield of chili

Conclusion

BioPot made from 60-70% water hyacinth and 30-40% coconut coir produced relatively higher chili growth than other BioPot compositions. The highest yield of chili was obtained using PO4 (70% water hyacinth and 30% coconut coir) although the number was not significantly different from PO3 and PO5 (60-80% water hyacinth and 20-40% coconut coir), except in fruit length variable. BioPot made from 70% water hyacinth and 30% coconut coir (PO4) was the optimum tested composition based on scatter plot and RSM. This research revealed that the use of BioPot produced better growth and yield of chili than polybag. The implication of this finding is the use of BioPot as biodegradable seedling pot or container for crop production that supports green and sustainable agriculture practices, and thus the sustainable development will be achieved.

Acknowledgements We gratefully acknowledge Agrotechnology Department, Faculty of Agriculture and Animal Science, University of Muhammadiyah Malang for supporting this research.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest associated with this study.

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