IMPROVEMENT OF GROWTH AND YIELD OF ORGANIC BROCCOLI (*Brassica oleracea* var. Italica) BY APPLICATION OF DIFFERENT ORGANIC MATERIALS COMBINATION

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ABSTRACT

A pot experiment was conducted to evaluate the effect of organic materials combination on the improvement of growth and yield of organic broccoli. There were 19 treatments in total consisting of four types of organic materials that were azolla (A), vermicompost (V), cow dung (S), and chicken manure (F) applied in combination, blank control, and inorganic fertilizer as a comparison standard. The experiment results showed that the application of organic materials combination significantly increased plant growth, diameter head and broccoli yield compared with untreated soil and inorganic fertilizer treatment.The addition of dolomite into the organic materials combination decreased the growth and yield of broccoli than no addition of dolomite. However, adding chicken manure into the combination showed higher growth and yield of broccoli. The best combination of organic materials in raising the growth and yield of broccoli was azolla, and chicken manure (A+F).

Keywords: organic material, vermicompost

INTRODUCTION

Indiscriminate use of chemical fertilizers and pesticides has led to soil fertility, environmental quality, and deterioration of human health. They resulted in crop production to be leveling off. As stated by Department of Agriculture of Indonesia (Departemen Pertanian, 2004), many farmers complained that there was no more significant effect of types and dosages of fertilizers applied on the yield of crops. It is due to the depletion of soil organic matter and microorganisms in the soil. Soil productivity and capability depend on the activity of soil microorganisms. : The leveling off in land productivity, and environmental degradation promotes organic farming practices as an alternative farming system that can produce free contaminant synthetic substances and maintain soil health. In recent more farmers and researchers who have been involved in investigating organic farming systems have shown more positive effects of organic farming on soil biodiversity and species abundance (Bengtsson *et al*., 2005), increasing organic carbon and avoiding nitrogen (N) leaching (Drinkwater *et al*., 1995). Besides mentioned above, low fertilizer use efficiency (FUE), and chemical fertilizers' synthesis consume a lot of energy and money. Through Department of Agriculture, the Indonesian government has propagandized Go Organic program 2010. At that moment, National Standardization Agency (Badan Standarisasi Nasional, BSN) also determined Indonesia's National Standard (Standar Nasional Indonesia, SNI) number 120 the year 2002 about an organic agricultural product. , The abundance of natural resources in Indonesia and the increased consciousness of public health lead to the raised demand for organic products that can be a chance for entrepreneurs to meet either domestic or export demand. Organic farming is a production system that avoids or largely excludes synthetic fertilizers, pesticides, growth regulators, and livestock feed additives (Yadav *et al*., 2013). Organic farming aims to balance inter-connected systems such as soil organisms, plants, animals, and humans (Berova, *et al.,* 2010). Productivity in organic farming practices, however, commonly tends to be low. Organic farming practices rely on organic materials as a source of plant nutrients to meet a demand for plant nutrients, where organic materials' nutrient content is usually low, far less than that of synthetic chemical fertilizer. Chicken manure compost contains an average of 4.5% N, 5.9% P_2O_5, and 3.1% K_2O (Indriyati, 1995; Indriyati, 2013). The nutrients are equivalent to 97.2 kg urea, 164.7 kg superphosphate 36 (SP36), and 51 kg KCl for each 100 kg of chicken manure compost, respectively. In addition, organic materials in soil have to decompose first and mineralize before the nutrients in organic material are available for plants. Mineralization process of nutrients contained in organic material depends on the chemical composition of organic material (Indriyati, 1995; Cattanio *et al*., 2008; Shi, 2013). This experiment was carried out to study the effect of various organic sources of plant nutrients on the growth and yield of broccoli.

MATERIAL AND METHODS

The research was carried out in pots at Pasir Sarongge, Regency of Cianjur, West Java, Indonesia, at an altitude of 1200 m above sea level (asl) from June to September 2017. Composite topsoil samples of Andisol were collected from the upland at a depth of 25 cm. Equivalent to 8 kg oven-dry basis of soil was mixed thoroughly with the number of various sources of organic materials as per the treatment. The treatments consisted of combinations of four different sources of organic materials that are vermicompost (V), azolla (A), cow dung (S), and chicken manure (F). Samples of amended soil were thoroughly mixed with the various sources of organic materials, including inorganic treatments as standard comparison resulting in nineteen treatments: (a) V+A, (b) V+S, (c) V+S, (d) A+F, (e) A+S, (f) V+A+S, (g) V+A+S, (h) V+A+F+S, (i) V+A+D, (j) V+S+D, (k) V+S+D, (l) A+F+D, (m) A+S+D, (14) V+A+F+D, (n) V+A+S+D, (o) V+A+F+S,+D, (p) NPK, (q) NPK+D, (r) Control (untreated soil). The amount of each organic material added in combination to soil as at a rate of 5 ton ha-1 for

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vermicompost, cow dung, and chicken manure, respectively, and at a rate of 1 ton ha^{-1} for azolla. The treatments of different sources of organic materials were compared to that of untreated control and chemical fertilizer. Pot treated with chemical fertilizer was as the standard of comparison for inorganic fertilizer. The amount of N added to soil is equivalent to 72 kg urea ha^{-1} and 314 kg ha^{-1} of ZA as a source of N and S, 200 kg ha^{-1} of KCl as a source of K_2O, 250 kg of SP36 ha^{-1} as a source of P_2O_5, and 2000 kg dolomite ha^{-1} as a source of Ca and Mg. -third of the dosage of urea, ZA and KCl were applied at 10, 20, and 35 days after planting (dap), respectively, while half the dosage of SP36 was used twice at 10 and 20 dap (day after planting). A seedling of broccoli (*Brassica oleracea* var. italica) at 30 days was planted a week after organic material was applied to soil. Vegetative growth attributes measured were plant height and leaf number per plant at three times of crop cycle. All broccoli heads of each pot were harvested at the marketable stage, and the yield attributes measured were head yield (kg ha^{-1}) and head diameter (mm). The experiment was laid out in randomized complete block design (RCBD) with 19 treatments replicated thrice. Analysis of variance (ANOVA) was done on every measured plant attribute (parameter) to determine the significance of differences between means of treatments. Means for each parameter were separated by the least significant difference (LSD) test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Characteristics of Andisol used in this experiment are indicated in Table 1. The soil reaction of Andisol used in this experiment was acid, organic C, and total N were low, while bases content was in the of medium to very high range. Total P in soil was high, but available P in soil was low. The low available P in soil might be due to high sorption of P. The physical characteristic of Andisol from Pasir Sarongge was clay due high clay content (more than 40%), and the soil texture of Andisol is clay loam.

Table 1. Characteristics of Andisol from Pasir Sarongge, Regency of Cianjur, West Java, Indonesia

Parameter	Unit	Value
pH H_2O	-	5.73
pH KCl	-	5.19
Organic-C	%	0.98
Total N	%	0.08
Available P	ppm	12.04
Total P	ppm	607.98
Exch-Ca	$cmol^{(+)}\ kg^{-1}$	9.87
Exch-Mg	$cmol^{(+)}\ kg^{-1}$	2.34
Exch-K	$cmol^{(+)}\ kg^{-1}$	1.24
Exch-Na	$cmol^{(+)}\ kg^{-1}$	0.98
CEC	$cmol^{(+)}\ kg^{-1}$	28.72
Base Saturation	%	50.24
Fe	ppm	0.04
Cu	ppm	0.10
Zn	ppm	1.69
Mn	ppm	10.05
Sand	%	25.73
Silt	%	32.21
Clay	%	43.06

The Growth of Broccoli Plants

Attributes of plant growth of broccoli as height of plant and number of leaves were shown in Table 2 and 3. Treatment of organic materials application significantly affected height and number of leaves of the broccoli. Height of broccoli in all treatment of organic materials application was significantly higher than untreated soil (Control). At 10 weeks after planting (wap), the height of the plant for treatment of A+F showed the highest. It increased the height of broccoli significantly by an average of 59.8%, 73.5%, and 125.6% compared with inorganic fertilizers treatment (NPK and NPK+D) and Control (untreated pots), respectively.

The number of leaves per plant was recorded for 4, 7, and 10 weeks after planting (Table 3). Organic materials application significantly increased the number of leaves per plant. The number of leaves per plant showed the same pattern with height of plant, which at 10 wap the greatest leaf number was found in A+F treatment, and it was significantly higher than inorganic treatments (NPK and NPK+D). The combination of organic materials treatment containing azolla (A) and chicken manure (F) was consistently higher than the other organic material treatments, except for treatments containing dolomite (D). The growth of broccoli plants treated with organic materials plus dolomite tended to be wap lower than the other organic treatments. Control had the shortest and the fewest leaves.

Yield of Broccoli Head

The application of organic materials significantly increased the diameter of broccoli head compared with untreated soil and NPK treatment by 168% to 905% and 45% to 442%, respectively (Figure 1). The largest head diameter was found in the combination of vermicompost, azolla, chicken manure, and cow dung (V+A+F+S). However, the application of vermicompost and chicken manure combination (V+F) showed as the same diameter as V+A+F+S, although the treatment of V+F contained less amount of organic materials than V+A+F+S treatment.

Organic materials application showed significant effect on yield of head. Yield of head in organic materials applied pots were higher than inorganic fertilizers, and inorganic fertilizers treatment showed no significant difference with Control. Treatment of A+F and V+A+F+S indicated significant differences with NPK on yield of head. In general, the addition of dolomite in the organic materials treatments showed lower yield of head than that of organic materials treatments without dolomite, their yield reduction of head ranged 19% to 61%. The yield of broccoli head tended to be higher in organic combination contained chicken manure than the other organic combination, and there were no statistical differences in yield of head between treatments contained chicken manure (F) in their organic materials combination (Figure 2). It seemed that chicken manure applied to soil gave positive effect to growth and yield of broccoli head.

Relative agronomic effectiveness (RAE) of various combination of organic materials applied to soil are shown in Figure 3. It appears that most of combination of organic materials showed RAE more than 100%, which the highest RAE generated by treatment of V+A+F+S was followed by A+F which gave the RAE value more than 200%. The lowest RAE generated by treatment of NPK+D. The addition of dolomite to organic materials combination

treatment tended to decrease broccoli's growth and yield. It seems that adding chicken manure in the treatment of organic materials combination could improve the growth and yield of broccoli, as shown by their RAE ranged 129% to 233%. Although the application amount of A+F treatment was less than V+A+F+S, the growth and yield of broccoli affected by A+F application was not significant difference with V+A+F+S.

Table 2. The height of broccoli affected by the application of various organic materials

No.	Treatment	Height of Broccoli (cm)		
		4 wap	7 wap	10 wap
1	V+A	5.3 efg	8.3 cd	13.3 cde
2	V+F	6.3 abcde	10.7 ab	16.3 bc
3	V+S	6 abcde	10.7 bc	15.3 bcd
4	A+F	6.3 ab	11.7 ab	20.3 a
5	A+S	5.3 efg	8.3 cd	13.3 cde
6	V+A+F	7 a	13 a	18 ab
7	V+A+S	5.7 abcde	10.7 bc	15 bcde
8	V+A+F+S	6 abc	11.3 bc	16.3 bc
9	V+A+D	6 cdefg	9 bc	13.3 cde
10	V+F+D	6.3 ab	12.3 ab	18.3 ab
11	V+S+D	6 defg	8.7 bc	12 def
12	A+F+D	6 bcdef	10.3 bc	17.7 ab
13	A+S+D	5.3 fg	8 cd	12.3 def
14	V+A+F+D	6 abcd	11 bc	15.7 bcd
15	V+A+S+D	5.3 abcde	10.7 cd	15 bcde
16	V+A+F+S+D	5.7 bcdef	10.3 bc	15.7 bcd
17	NPK	4.3 cdefg	9 e	12.7 de
18	NPK+D	4.7 efg	8.3 de	11.7 ef
19	Control	4.3 g	7.7 e	9 f
	LSD (5%)	0.96	2.35	3.66
	CV (%)	10.2	14.2	14.9

Table 3. Number of Leaves per Plant Affected by Application of Various Organic Materials.

No.	Treatment	Number of leaves per plant		
		4 wap	7 wap	10 wap
1	V+A	24 cd	39.3 efg	48.3 cde
2	V+F	30.3 ab	52.3 abcde	59.3 bc
3	V+S	28.3 bc	42.3 abcde	55.7 bcd
4	A+F	34.3 ab	55.3 ab	68 a
5	A+S	24.3 cd	36 efg	47.7 cde
6	V+A+F	35 a	55 a	62.7 ab
7	V+A+S	27.3 bc	44.3 abcde	56 bcde
8	V+A+F+S	34 bc	56.3 abc	65 bc
9	V+A+D	28.7 bc	39 cdefg	51 cde
10	V+F+D	34.3 ab	54 ab	63 ab
11	V+S+D	28 bc	41.7 defg	51 def
12	A+F+D	27.7 bc	50 bcdef	66 ab
13	A+S+D	27.3 cd	32 fg	46.7 def
14	V+A+F+D	29.7 bc	48.3 abcd	59.3 bcd
15	V+A+S+D	29 cd	50.7 abcde	54.3 bcde
16	V+A+F+S+D	30.3 bc	53.7 bcdef	42.7 bcd
17	NPK	20.7 e	38.3 cdefg	51.3 de
18	NPK+D	22.7 de	38.3 efg	43.7 ef
19	Control	21 e	28.3 g	42.3 f
	LSD (5%)	0.96	2.35	3.66
	CV (%)	10.16	14.17	14.92

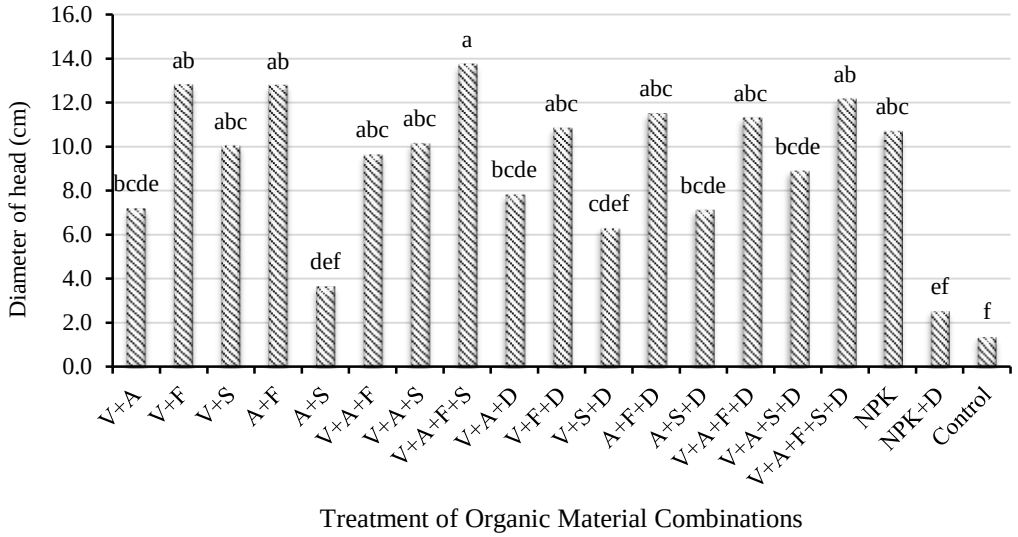

Figure 1. Effect of different organic materials combination on the diameter of the broccoli head

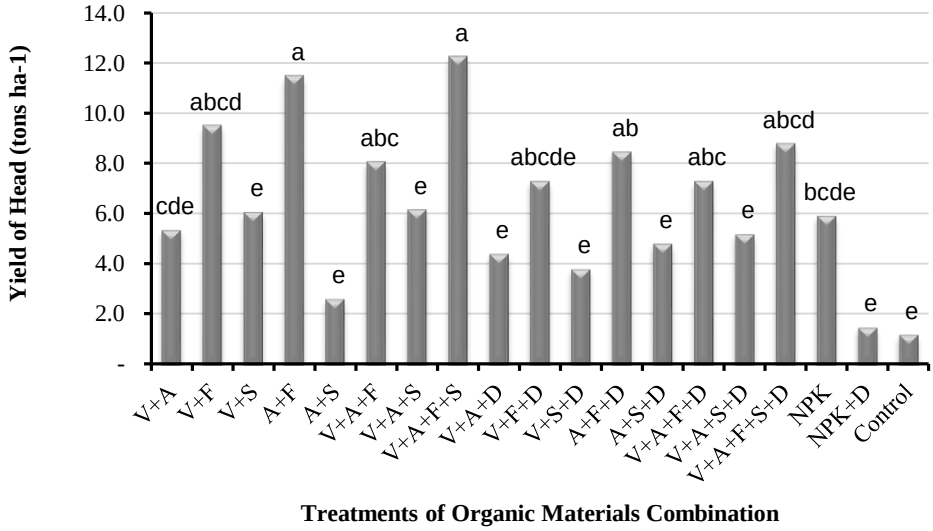

Figure 2. Yield of Broccoli Head Affected by Different Organic Materials Combination.

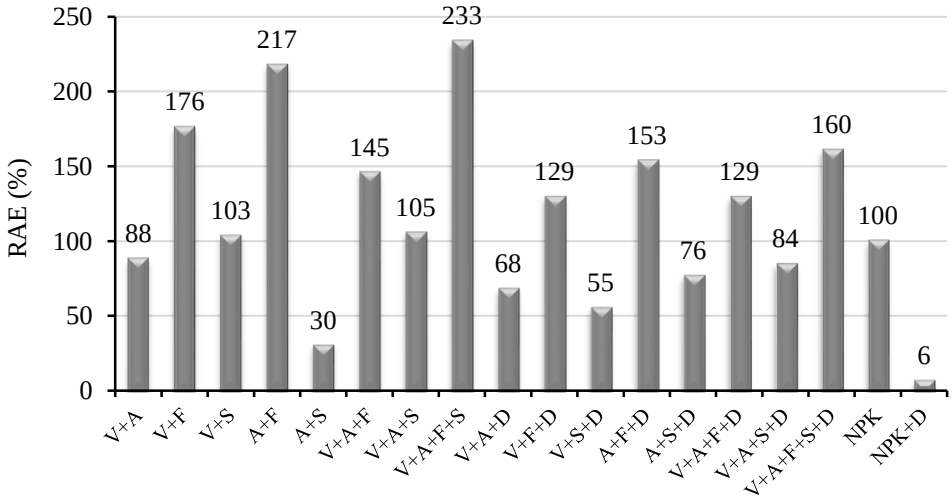

Figure 3. Effect of Different Organic Materials Combination on Relative Agronomic Effectiveness

Discussion

The increased plant growth and yield of head of broccoli resulted from organic materials application may be attributed to presence more available form of nutrient for plants. It also enhanced other plant nutrients, such as micronutrient, and water holding capacity of soil. Organic material offers good environment condition for roots systems development of broccoli plants. Indriyati *et al*. (2015) revealed that irrespective of the type of organic materials, organic materials application significantly decreased exchangeable aluminum (Al) in acid soil at the different level and increased significantly soil organic C. Better availability of nutrients in soil and favorable condition of soil for plant growth, resulted in healthy vegetative plant growth that leads to higher yield. The application of chicken manure in organic material combination gave higher yield. It might attribute to presence of readily available nitrogen and phosphor for plants. Indriyati (1997; 2014) showed that chicken manure contained large mineralizable organic nitrogen so its decomposition rate was faster than cow dung and swine manure. In addition the application of chicken manure attributed the decreased of Al in acid soil and increased the activity of phosphatase enzyme which it raised the soil P availability for plant (Indriyati *et al*., 2015). Chicken manure (F) is a concentrated source of P and its application improves plant growth. Soil microorganisms act on added organic amendments, decompose organic molecules and release inorganic P by phosphatase enzymes thus improve the phosphate availability in the soil for plant growth (Browne *et al*., 2009). Andisol have high content of total P but the availability of P to plants was limited (Table 1). Anions of phosphate (HPO_4^{2-} or $H_2PO_4^-$) are very reactive and become unavailable to plants due to fixation or precipitation with aluminum and iron in acidic soils (Hao *et al*., 2002; Dorahy *et al*., 2004). Untreated soil (Control) showed the lowest growth and yield of broccoli head due to the limited nutrients that was available for plants.

CONCLUSION

The application of organic materials combination significantly increased plant growth, diameter head, and broccoli yield compared with untreated soil and inorganic fertilizer treatment. The addition of dolomite into the organic materials combination decreased the growth and yield of broccoli than no addition of dolomite. The addition of chicken manure into the combination showed higher growth and yield of broccoli. The best combination of organic materials in improving the growth and yield of broccoli was azolla and chicken manure (A+F).

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