Enhancing bush beans quality by applying Brown Algae (Ascophyllum sp) organic fertilizer

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Abstract. Agriculture could be a solution for climate change by the widespread adoption of mitigation and adaptation actions. This happens with the help of best management practices such as organic fertilizer. The types of organic fertilizer will affect beans’ production and their quality characteristics, both physically and their nutrient content. The purpose of this study was to determine the effect of brown algae extracts as organic fertilizer applied to bush beans’ quality. The study was conducted in October 2017, on IVEGRI’s experimental field, Lembang, Indonesia about 1200 m above sea level. The experiment used 10 treatments (and 3 replications), which were a variation dose of NPK and Liquid Organic Fertilizer (LOF). The physical and chemical characteristics of testing consisted of length, diameter, texture, water content, TSS, fibre, and vitamin C. The quantitative and qualitative analyses were used to determine the beans’ shelf life. Freshness test parameters were consisting of colour, texture, and appearance. Panelists provided a score of 1 (strongly like) to 5 (strongly dislike). Data were statistically analysed, followed by Tukey's test (5%). The results showed that LOF with standard NPK dosage can increase vitamin C and fiber content of bush beans. Higher LOF dose usage can reduce the change rate of bush beans’ quality on shelf life. LOF from brown algae can reduce the chemical fertilizers used in the soil, so it will slowly create environmentally friendly vegetable production.

1. Introduction
Legumes are one type of vegetables as a great source of protein. One type of legumes are beans which have a slightly sweet flavour and rich in nutrients such as vitamins and minerals. Beans cultivation is suitable in the medium to high plains. The ideal height for planting beans is 1000-1500 meters above sea level with a temperature of 20-25°C. This plant is suitable to be cultivated at the end of the rainy season and early dry season [1]. However, climate change also affects the cultivation time of bush beans. Therefore, efforts to improve technology and inputs for bean cultivation need to be done. Organic fertilizer from algae can be one of many solutions to enhance the growth and production of beans to be more optimal in facing climate change.

Chemical content in nuts generally contains phenolic acids, flavonoids, anthocyanins, and tannins [1]. Genetic factors affect the protein content of carbohydrates, fats, fibre, vitamins, and phenolic compounds; however, the geographical environment factors also affect the content of these substances [2]. The chemical composition in foodstuffs is determined by genetic and environmental factors and the interaction between them [3]. The antioxidant content of beans is fairly high among legumes such as peas or snake beans. Beans are rich in vegetable protein and vitamins; it can help lower blood pressure...
and escort sugar metabolism in blood to fit consumed by those who are suffering from diabetes or hypertension. Tocopherol content in beans can stimulate the production of insulin by the pancreas. Insulin controls sugar levels in the body.

An effort to increase the production of vegetables is by fertilization. Soil pollution was the result of salts accumulation derived from inorganic fertilizers usage that can inhibit the absorption of nutrients that plants need [4]. Pollution of agricultural soil which can degrade the quality of the field and the existence of beneficial microbes in the soil is a threat to the sustainability of agriculture. To meet the plants’ nutrient needs, in addition to the provision of inorganic fertilizers, additional organic fertilizer is also needed [4].

The use of organic/biofertilizer on vegetable crops seems to be able to support the development of environmentally-friendly vegetable production. In farming, organic fertilizer usage is a basic requirement in addition to NPK inorganic fertilizers usage. This is proven from a series of studies of organic fertilizer usage on vegetable crops [5]. On tomatoes, peppers, potatoes, cabbage, and beans, organic fertilizers are generally derived from animal manure 20-30 t/ha is sufficient to increase the yield of these vegetables [6]. The problem in using organic fertilizer derived from manure is that it will face the material limitations along with the needs of the growing organic fertilizer for their agricultural policy that is environmentally-friendly.

One of the potential alternatives as a source of organic material is brown algae. The utilization of seaweed/algae, especially in Indonesia, now days is still limited as food products and semi-finished products such as gelatin paper, alkali-treated cottonii (ATC), jelly-product, and some cosmetic products. Seaweed extract has been widely marketed as an additional ingredient in plant’s fertilizer that its advantages and the benefit of its usage have been widely reported [7]. The amount of Potassium, Nitrogen, accelerating growth hormones, and micronutrients contained in seaweed (Fucus, Laminaria, Ascophyllum, Sargassum, etc.) make it a very good fertilizer because it is environmentally-friendly (biodegradable ), non-toxic and harmless to humans and animals [8]. The treatment of brown algae material in spinach roots during the vegetative phase can increase the brightness of colors and reduce weight loss in spinach leaves. The concentration usage of 1 g/L showed the best result [9]. Results of other studies indicate that there is an increase in phenolic and flavonoids in onions, while application on potatoes, a significant difference was detected only in flavonoid content. Differences were not statistically significant even though the application on potato crops resulted in higher yields. These results show the potential for brown algae extract in improving the phytochemical content of vegetables [10].

Brown algae extract application on bush beans is expected to increase crop productivity and quality of the vegetables and reduce the chemical fertilizers used in the soil, so it slowly will create the environmentally-friendly vegetable production. The study aims to determine the effect of organic fertilizer application from brown algae extract of the bush bean’s quality characteristics.

2. Materials and methods
The study was conducted in October 2017. The planting was done in an experimental field of Indonesian Vegetables Research Institute Lembang, Bandung (IVegRI), at 1200 m height above sea level. The experiments were performed with a randomized block design with three replications. The material used was 10 treatments, namely A: Without fertilizer, B: 1 NPK standard (STA NPK) + Horse Manure (customary local farmers), C: 1 Liquid Organic Fertilizer (LOF) 100%, D: ¼ STA NPK + 1 LOF, E: ½ STA NPK + 1 LOF, F: ¾ STA NPK + 1 LOF, G: 1 STA NPK + 1 LOF, H: 1 STA NPK + ¼ LOF, I: 1 STA NPK + ½ LOF, J: 1 STA NPK + ¾ LOF. Physical characteristics testing of length, diameter, texture, and chemical characteristics parameters include water content, TSS (Total Soluble Solute), fiber, and vitamin C. The quantitative analysis (with tools) and qualitative analysis (freshness test) were used to determine the shelf life of beans. A freshness test was done for color, texture, and appearance
parameters. Panelists provide an assessment of a score of 1 (very like) to 5 (strongly dislike). Statistical analysis using PKBT STAT and followed by Tukey's test at 5% level.

3. Results and discussion

3.1. Quality characteristic of bush bean

Freshness directly affects the appearance quality which is a component of quality that was first noted by consumers. A Fresh commodity indicates the age of post-harvest whether it is new or has not overripe. Texture (stiffness), shape, size, and nutrition content were critical to the quality of the vegetables. Organic fertilizer treatment of algae material did not significantly affect the length and texture parameters of bush beans but has a significant effect on beans diameter (Table 1). The beans’ length ranged from 13.40 to 15.97 cm, where beans with treatment B had the longest size compared to other treatments. The beans’ diameter at the treatment I was 8.54 mm and significantly different from treatment C and D. Some types of vegetables have different quality based on the length and diameter. The texture is the main attribute of quality used in the fresh and processed food industry to assess product quality and consumer acceptance. Among the characteristics of texture, stiffness (rigid) is one of the most important parameters of fruits and vegetables, which are often used to determine the freshness of the food. The values ranged from 1.15 to 1.33 mm bean texture/g/sec. The most rigid texture was in treatment H, while the most lenient texture was in treatment G.

The content of micro and macronutrients contained in fertilizer can cause an increase in plant growth and can increase the grain yield of rice plants because these nutrients have a considerable role in plant growth and yield. Micro-nutrients serve as an enzyme system activator or in the process of plant growth, such as photosynthesis and respiration. Also, the content of macronutrients that are adequate for plants can improve panicle length and increase grain yield of rice plants, because these nutrients have a considerable role in the plant growth and yield. The combination treatment of solid organic fertilizer and liquid organic fertilizer did not significantly affect plant growth variables, but significantly affect rice yields [11].

Table 1. Quality characteristic of bush bean.

| Treatment | Length (cm) | Diameter (mm) | Texture (mm/g/sec) | Water content (%) | TSS (°Brix) | Vitamin C (mg/100 g) | Fiber (%) |
|-----------|-------------|---------------|-------------------|------------------|-------------|----------------------|----------|
| A         | 15.40       | 7.40<sup>ab</sup> | 1.21              | 91.80<sup>b</sup> | 4.00<sup>a</sup> | 27.50<sup>d</sup>     | 0.90<sup>ab</sup> |
| B         | 15.97       | 7.00<sup>ab</sup> | 1.20              | 92.31<sup>ab</sup> | 4.00<sup>a</sup> | 28.68<sup>d</sup>     | 0.85<sup>bc</sup> |
| C         | 14.50       | 8.10<sup>ab</sup> | 1.23              | 92.66<sup>a</sup> | 4.07<sup>a</sup> | 35.19<sup>bc</sup>    | 0.84<sup>bc</sup> |
| D         | 14.60       | 6.73<sup>b</sup>  | 1.26              | 92.25<sup>ab</sup> | 4.20<sup>a</sup> | 34.29<sup>c</sup>     | 0.89<sup>ab</sup> |
| E         | 14.17       | 6.50<sup>b</sup>  | 1.32              | 92.37<sup>ab</sup> | 4.20<sup>a</sup> | 36.66<sup>bc</sup>    | 0.88<sup>ab</sup> |
| F         | 14.03       | 7.85<sup>ab</sup> | 1.24              | 92.53<sup>a</sup> | 4.00<sup>a</sup> | 41.99<sup>a</sup>     | 0.80<sup>cd</sup> |
| G         | 15.03       | 7.70<sup>ab</sup> | 1.15              | 92.82<sup>a</sup> | 4.20<sup>a</sup> | 37.84<sup>b</sup>     | 0.79<sup>cd</sup> |
| H         | 13.47       | 7.17<sup>ab</sup> | 1.33              | 92.60<sup>a</sup> | 4.20<sup>a</sup> | 38.14<sup>b</sup>     | 0.84<sup>bc</sup> |
| I         | 13.40       | 8.54<sup>a</sup>  | 1.29              | 92.59<sup>a</sup> | 4.00<sup>a</sup> | 36.37<sup>bc</sup>    | 0.77<sup>d</sup>  |
| J         | 14.67       | 7.05<sup>ab</sup> | 1.30              | 92.49<sup>a</sup> | 4.13<sup>a</sup> | 37.27<sup>bc</sup>    | 0.94<sup>a</sup>  |

The main component of plant tissue is water. The highest water content was in treatment G 92.82%), while treatment A (91.80%) has the lowest water content. Sources from the USDA nutrient database reports that the moisture content of beans per 100 g is 90.32%. The fiber content in all treatments ranged from 0.77 to 0.94%. Treatment J has the highest fiber content. The fiber content was lower than the fiber content based on the USDA standard database that is 2.7%. The total soluble solids in the beans that
were tested ranged from 4.00-4.20°Brix. The highest content of vitamin C was in treatment F (¾ STA NPK + 1 LOF) which was 41.99 mg/100 g, while the lowest was in treatment A (without fertilizer) which was 27.50 mg/100 g. The average content of vitamin C beans tested was higher than the standard amount of vitamin C by the USDA, which was at 12.2 mg/100 g.

Brown algae extract application research on spinach with a concentration of 1 g/L can increase the content of flavonoids. The antioxidant activity and total anthocyanin content were higher than the control. Treatment of brown algae of 0.5 g/L and hormone growth regulators can increase crop yield and fruit size but had no significant effect on pH, acidity, and total soluble solids [12]. In mild drought conditions, the application of brown algae extracts can promote the growth of spinach and reduce stomata restrictions, causing extensive large leaves and a high rate of photosynthesis, but has no effect on the content of phenolics, flavonoids, carotenoids, and antioxidants.

3.2. Characteristics of bush bean in storage
During storage, the respiration continues to run and the degradation of the starch compounds into sugar and sugar into carbon dioxide, water, and energy was still ongoing, so weight loss would increase during a long time of storage. There was a correlation between water loss and an increase in asparagus total soluble solids (TSS) during storage. Too much loss of water in stored products would help increase TSS [13].

| Treatments | Weight Loss (%/day) | Texture (mm/g/sec) | Shelf Life (day) |
|------------|---------------------|--------------------|-----------------|
| A          | 4.40                | 0.23               | 2.55            |
| B          | 4.13                | 0.25               | 2.48            |
| C          | 4.60                | 0.23               | 2.57            |
| D          | 4.16                | 0.19               | 2.83            |
| E          | 4.52                | 0.16               | 2.83            |
| F          | 4.48                | 0.16               | 2.55            |
| G          | 4.18                | 0.23               | 2.64            |
| H          | 4.46                | 0.21               | 2.55            |
| I          | 4.18                | 0.26               | 2.62            |
| J          | 4.00                | 0.18               | 2.40            |

In addition to weight loss and wilting, loss of water can also cause physiological changes in plant tissue. The sensitivity of a commodity against water loss due to evaporation depends on the water vapor pressure deficit of the surrounding atmosphere and the structure of the surface layer of the commodity. During storage, treatment J (1 STA NPK + ¾ LOF) has the lowest change rate of weight loss (4.00%/day), while the change rate of treatment C showed a high weight loss which ranges from 4.60%. Treatment D (¼ STA NPK + 1 LOF) and E (STA ½ NPK + 1 LOF) has the longest shelf life, which was 2.83 days (Table 2). The deterioration of watermelon and nectarines was delayed and their shelf life was significantly prolonged in Ascophyllum nodosum treated fruits compared to the control [14].

Transpiration is the process of water loss in the form of gas on living tissues or a mass transfer process where moisture moves through the surface of tissue materials into the surrounding air. The factors that affect transpiration is the material’s surface area, natural coating surface, the thickness of the skin, and tissue’s mechanical injury. The transpiration process causes an increase in weight loss during storage. Weight loss of 5% will affect the appearance of the product, so it withered and wrinkled.
quickly while the majority of horticultural products will lose their freshness when experiencing weight loss of 3-10% [15].

The loss in fresh weight and visual quality (color and turgor) of spinach leaves during storage was reduced by the pre-harvest application of Ascophyllum nodosum. Lipid peroxidation was significantly reduced in Ascophyllum nodosum treated leaves. The total chlorophyll content and ascorbate content in the control and treated leaves were, however, identical over the storage period and decreased at a similar rate. A negative correlation was observed between visual quality and lipid peroxidation. Pre-harvest Ascophyllum nodosum application through root drench, especially at 1.0 g/L, enhanced post-harvest storage quality of spinach leaves [16]. Respiration processes lead to temperature increases, which affect metabolism. During the ripening process, the sugar turns into starch, sweetness reduced, a decrease in water content, and increase fiber was also perceived. Beans contain flavonoids, alkaloids, saponins, triterpenoids, steroids, amino acids, starch, vitamins, and minerals. Pure flavonoid compounds such as anthocyanins and tannins are antioxidant compounds. A preference test (hedonic) was conducted to choose one product among other products directly. The use of hedonic scale can be used to understand the difference and it is often used to assess similar products by organoleptic [17].

4. Conclusion
LOF with standard NPK dosage can increase vitamin C and fiber content in bush beans. Higher LOF dose usage can reduce the change rate in bush beans’ quality. LOF from brown algae can reduce the chemical fertilizers usage in the soil. Thus, it will help create an environmentally friendly vegetable production.

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