Determination of growth and production responses of shallot (Allium cepa L.) due to corona plasma irradiation

I Puspitasari[1]*, E Prihastanti[1], D T Sugianto[2], A I Susan[3], E Yulianto[3], F Arianto[2,3], E Sasmita[3] and M Nur[2,3]

[1] Biology Department, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia
[2] Physics Department, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia
[3] Center for Plasma Research, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia

*indahpuspitasari0007@gmail.com

Abstract. Research on the effect of plasma radiation on the growth and production of shallot plants has been done. This study aims to observe the effect of plasma irradiation duration and determine the optimal irradiation duration for the growth and production of shallot. The study is conducted by using a corona plasma reactor with a multiple point to plane configuration, with the distance between electrodes is 3 cm and the applied voltage is 14 KV. Variations of irradiation time applied were 0, 15, and 30 minutes. The research results shows that plasma radiation can increase the growth and production of shallots. The percentage of plant height increasing is 9.53% at 15 minutes irradiation compared to non-irradiated samples. The leaf color level of irradiated plants is more green than those in the control sample, it is due to the content of chlorophyll in the leaves increases up to 26.73%. In addition, the wet and dry weight of the irradiated onion tubers also increased up to 17.44% and 22.19%, respectively. Furthermore, the optimal irradiation time obtained to increase the shallots growth and production is 15 minutes

1. Introduction

Shallot is one of the vegetable commodities that have high economic value in terms of the fulfillment of national consumption, farmer income source and its potential as a producer of foreign exchange [1]. Based on data from BPS, Indonesia in 2017 has exported onion reaches 657.3 tons. Previously, in 2016 total exports of onions as much as 735.7 tons and no imports. Total production of shallots in 2017 rose to 1.68 million tons, while the demand is only 1.25 million tons [2]. The data shows that there is an increase in onion production in Indonesia, thus the onion production should be improved to keep the onion production stable to meet domestic demand and to increase the export of shallots.

Onion cultivation process in Indonesia still encountered various obstacles, both technical and economic constraints [3]. Constraints of onion production include declining soil fertility, high incidence of plant-disturbing organisms, low quality seedlings and expensive seedlings [4]. One of the constraints of onion production is the provision of high quality onion seedlings that have high prices, this is because farmers are very dependent on imported seeds compared to local seeds. According to [5], the motivation factor of farmers to use imported seeds are due to the suitability of seedlings with local agro ecosystem conditions, ease of use and seed treatment, long shelf life, high productivity, resistance to pest and good selling price and attractive appearance, the shape of a round tuber and large size. While the inhibiting factors of farmers not using local onion seeds are they are less resistant to pests and plant diseases, low shelf life and low productivity. The use of imported onion seeds by farmers causes local onion seeds to be less desirable, so there is a need to improve the quality of local onion seeds.

One effort to improve the quality of production and accelerate the growth of local onion seed is by the radiation of nitrogen ions from the air. Radiation of nitrogen ions from the air can be applied with the use of plasma radiation used to increase the growth of the solids with the presence of N sources inside them. According to [6] explains that plasma technology is used as an N + ion generator from free air. The presence of Nitrogen content in plasma can help local onion farmers to accelerate growth and improve the quality of local onion production. Based on these problems, the research on the growth and onion production response of local onion plants (Allium cepa L.) is due to the difference of plasma radiation time.

2. Materials and methods

2.1. Provision of shallot
The shallot seeds used are local onion seeds that have been stored for 3 months. Seeds of shallot are selected which have uniform size and weight.

2.2. Radiation process of shallot
Seeds of shallot that have been prepared then given plasma radiation treatment that is 15 minutes and 30 minutes while the other treatment is control that is without radiation with fertilization and without fertilization. The irradiation is done by way of uniformly selected onion seeds then placed on the field electrode with the position of the base of the onion bulbs on top. The magnitude of the current at the plant is 350 mA and the voltage is 14kV. The distance between the point electrode and the electrode of the field is 3 cm. The tool used is plasma corona discharge flux, where once irradiation can accommodate as many as 88 seeds of shallot.

The quantitative data, in the form of percentage of growth and production, has been analyzed statistically with data tabulation stage, Analysis of Variance (ANOVA) at 95% significance level. If there is a real difference tested further by using DMRT Test (Duncan's Multiple Range Test) to determine the best effect. Also, the data obtained are analyzed descriptively in the form of leaf color and leaf fracture.

3. Result and discussion

3.1. Growth
The results of nitrogen ion radiation from plasma to plant height, number of leaves, number of roots, root number, root length and total chlorophyll on shallot plant (*Allium cepa* L.) are presented in Table 1. Based on ANOVA (Analysis of Variance) results 95% significance level of nitrogen radiation from plasma has significant effect on plant height and total chlorophyll of onion plants and no significant effect on leaf number, root number and root length of shallot plant.

Table 1. Average number of leaves per hill, plant height, number of roots per hill, root length and total chlorophyll onion plant.

Treatment	Plant's Height (cm)	Total Chlorophyll (mg/g)	Leaf Number (sheet)	Root Number (root)	Root Length (cm)
K1 (Control)	$38{,}5^{c}$	2.02^{c}	$37{,}33^{a}$	33,83	9,83
K2 (Radiation 15 Minutes)	$42{,}17^{a}$	2.56^{a}	$27{,}5^{c}$	28,67	8,5
K3 (Radiation 30 Minutes)	$39{,}67^{bc}$	2.22^{bc}	$30{,}5^{bc}$	36,33	9,33

Description: The number followed by the same letter in the same column shows no significant different effect based on the Duncan test with 95% confidence level.

K2 and K3 treatments showed higher total plant and total chlorophylls compared to K1. This suggests that the use of nitrogen ion radiation from plasma shows better results on plant growth than K1 treatment (without radiation). In the parameter of leaf number, root number and root length of nitrogen ion radiation from plasma showed no significant effect on onion plants (*Allium cepa* L.).

Nitrogen ion radiation from plasma has a significant effect on the height of shallot plant as presented in Table 1. The high average yield of shallot plant can be seen in Figure 1.

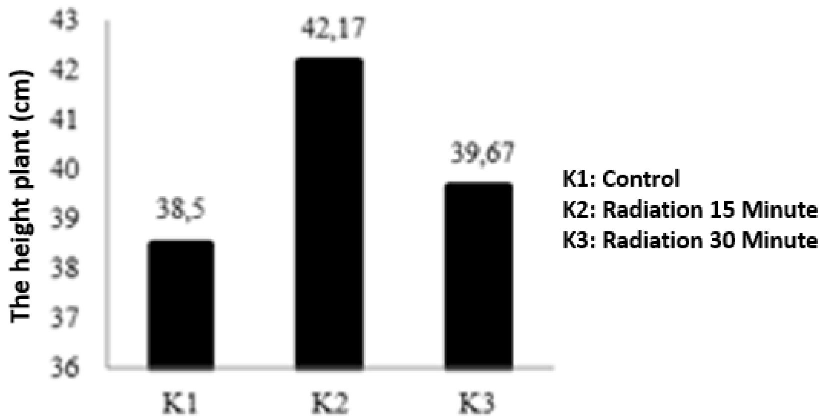

Figure 1. Histogram of high onion (*Allium cepa* L.) after giving of nitrogen ion radiation from plasma.

Treatment in K1 (control) has a lower plant height than the nitrogen ion radiation treatment of plasma (K2 and K3), this is because in the control treatment (K1) have no addition of nitrogen elements that originate from plasma radiation.

According to [7], nitrogen deficiency will show symptoms of deficiency, as for the symptoms that resulted is the growth of dwarf, leaves color getting yellow and production decreased.

Nitrogen is a very important element for plant growth. Nitrogen is part of the protein, an important constituent part of protoplasm, an enzyme, a biological catalyst agent that speeds up the process of life. Nitrogen is also present as part of the nucleoproteins, amino acids, amines, sugars, polypeptides and organic compounds in plants. In order to prepare food for the plant, the plant needs chlorophyll, sunlight energy to form carbohydrates and fats from C, water and nitrogen compounds. The other N roles for plants are contributing to vegetative growth of plants, giving color to plants, and carbohydrate use [8].

Figure 2. Height of onion plants at 42 HST.

The parameter that affects plant growth is the total amount of chlorophyll. The result of ANOVA (Analysis of Variance) showed that the giving of nitrogen ion radiation from plasma had an effect on the total chlorophyll of total leaf of shallot plant. The average yield of total corn plant chlorophyll can be seen in figure 3.

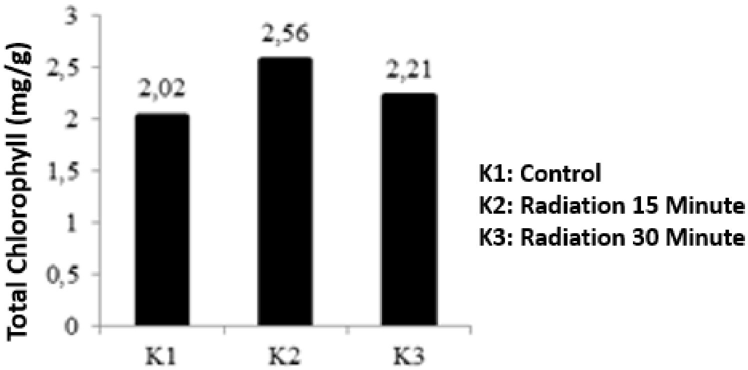

Figure 3. Average histogram total chlorophyll total of shallot (*Allium cepa* L.) after radiation of nitrogen ion from plasma.

The result shows that the total chlorophyll content of K2 leaf onion (radiation 15 minutes) and K3 (radiation 30 minutes) is significantly different with K1 (control). The test results data show that the use of nitrogen ion radiation from plasma produces more total chlorophyll count than the control. The average difference of total chlorophyll number of onion leaf leaves to control (K1) in the treatment of radiation 15 minutes (K2) 26, 73% and treatment of radiation 30 minutes (K3) 9.4%.

The presence of nitrogen is also very important, especially in relation to the formation of chlorophyll on the leaves of plants. According to [9], chlorophyll is a green pigment that plays a role in the process of photosynthesis by absorbing and converting light energy into chemical energy. Chlorophyll will synthesize carbohydrates that will support plant growth. The existence of nitrogen in the structure of plants is influenced by several factors, especially the availability of water, nutrients, especially nitrogen. The intensity of light affects the activity of photosynthesis. To form chlorophyll, a high enough ATP (energy) is needed and for CO2 assimilation is also necessary enzyme that is largely protein.

The next parameter is the number of leaves. The result of ANOVA (Analysis of Variance) at 95% significance level shows that nitrogen ion radiation from plasma has no significant effect on the number of leaves of onion plants. The average yield of leaves onion plant can be seen in figure 4.

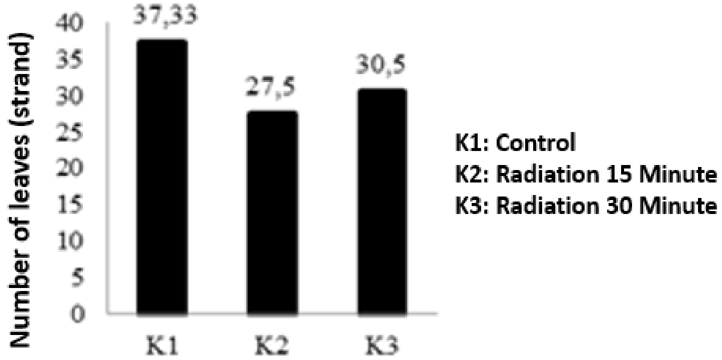

Figure 4. Histogram of the average number of leaves of onion plants (*Allium cepa* L.) after administration of nitrogen ion radiation from plasma.

Observation of plant growth can also be seen from the physical condition of leaves of onion plants through the color of leaves and foliage. The treatment of K1 (control) has a more yellow, pale, smaller leaf color and higher leaf fracture compared with treatment using nitrogen radiation. Treatment with nitrogen radiation from plasma (K2 and K3) shows a more green leaf color and larger leaves. Leaf color yellowing before harvest time is suspected that plants experience macro and micro nutrient deficiency symptoms. According to [10], nutrient deficiency is a material shortage (material) in the form of food for plants to carry on his life. Nutrient deficiency symptoms cause pale yellow leaves, chlorosis, wilts, dwarfs, and abnormal growth of stems and roots.

This is the same as the opinion of [11] who states that nitrogen is one of the nutrients that play a role in the growth of leaves, so that the leaves become wider, greener and more qualified. This is in line with the opinion of [12] who states that the shoot formation of a plant is affected by the nitrogen element. [13] States that elements of N have uses for plants, among others, make plants more fresh green and contain lots of chlorophyll that has a role in the process of photosynthesis.

The next parameter is the number of roots and the length of the root. The result of ANOVA (Analysis of Variance) at 95% significance level shows that nitrogen ion radiation from plasma has no significant effect on root number and root length of shallot plant. The average yield of roots and root length of shallot plant can be seen in figure 5 and figure 6.

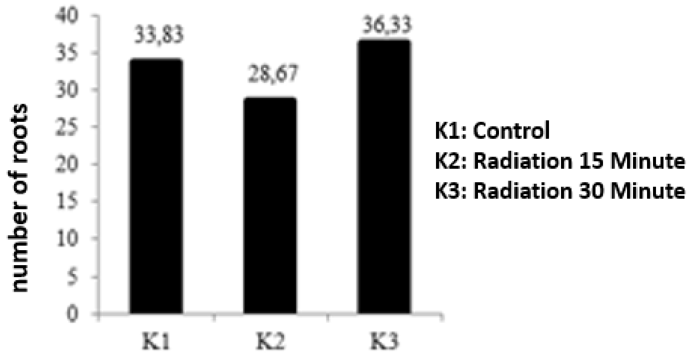

Figure 5. Histogram average number of roots of onion plants (*Allium cepa* L.) after administration of nitrogen ion radiation from plasma.

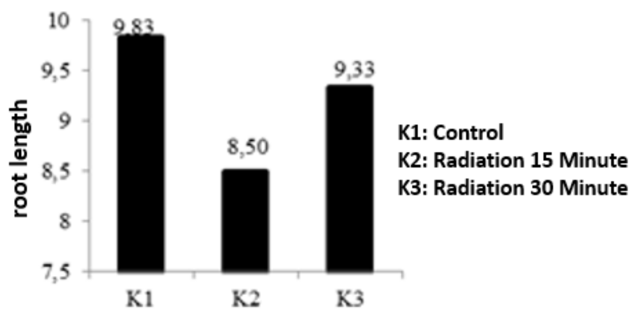

Figure 6. Histogram of long roots onion roots (*Allium cepa* L.) after the radiation of nitrogen ions from plasma.

The results of radiation treatment of nitrogen ions from plasma on the number of roots of onion plants on radiation 30 minutes (K3) shows more results than control. This is because according to [14] who states that optimal N granting can increase plant growth, increase protein synthesis, chlorophyll formation that causes leaf color to be greener, and increase the ratio of root shoots.

3.2. Production

The result of ANOVA (Analysis of Variance) at 95% significance level of nitrogen ion radiation from plasma has significant effect on tuber diameter, wet weight and dry weight of onion plant and no significant effect on the number of onion crop tubers.

Table 2. Mean of diameter of tubers per hill, number of tubers per hill, wet weight, and dry weight of shallot plant.

Treatment	Diameter of tuber (cm)	Number of tuber (tuber)	Wet Weight/Clump (g)	Dry Weight/Clump (g)
K1 (Control)	0,96^{c}	11,5^{a}	14,33^{b}	10,5^{b}
K2 (*Radiation 15 Minutes*)	1,46^{a}	9,17^{bc}	16,83^{a}	12,83^{a}
K3 (*Radiation 30 Minutes*)	1,29^{bc}	7,5^{c}	14,17^{b}	10,23^{b}

Description: The number followed by the same letter in the same column shows no significant different effect based on the Duncan test with 95% confidence level.

The result of ANOVA (Analysis of Variance) at 95% significance level shows that nitrogen ion radiation from plasma has significant effect on diameter of onion tuber. The average diameter of onions yielded from the radiation of nitrogen ions from the plasma can be seen on Figure 7.

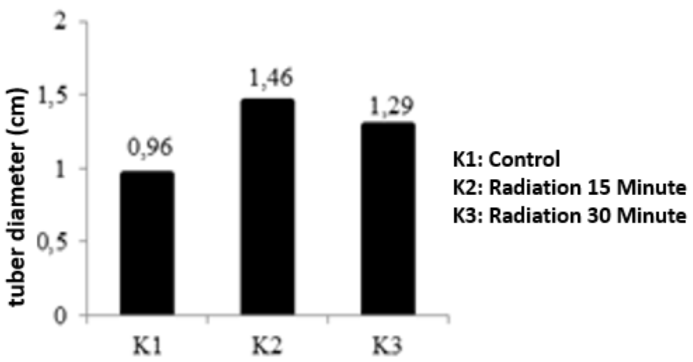

Figure 7. Histogram od average diameter of onion bulb (*Allium cepa* L.) after administration of nitrogen ion radiation from plasma.

The results shows that average diameter of K2 onion (Radiation 15 minutes) is significantly different with K1 (Control) and K3 (Radiation 30 minutes). While K3 does not give significant difference with K1 (control). Mean difference of tuber diameter of onion to control at K2 52,08% and at K3 34,37%.

The formation of this shallot tuber comes from the enlargement of the layer - the layer of scales on the bulbs that enlarged and fused. The formation of the enlarged layer is formed from the working mechanism of element N. According to [15], the formation of onion tuber comes from the layer of scales on the bulbs that enlarged and fused. The formation of the enlarged layer is formed from the working mechanism of nutrients N. N element causes a chemical process that produces nucleic acid, which plays in the cell nucleus in the process of cell division, so that the layers of the leaves can form well which later developed into onion bulbs . Cell division and enlargement become obstructed when nutrient deficiency N [16], so tuber yield decreases. [8] Also stated that adequate N-nutrient administration can increase the number of tillers and onion bulb yield. P nutrient deficiency can reduce root and leaf growth and development, reduce tuber size and tuber yield, and slow maturity [17]. The high K content causes the large amount of K + ions that bind water in plants to accelerate and optimize the process of photosynthesis. The optimal process of photosynthesis causes plants to stay fresh and avoid wastage. The results of photosynthesis can stimulate the formation of shallot tubers become larger.

Figure 8. Local shallot production (*Allium cepa* L.).

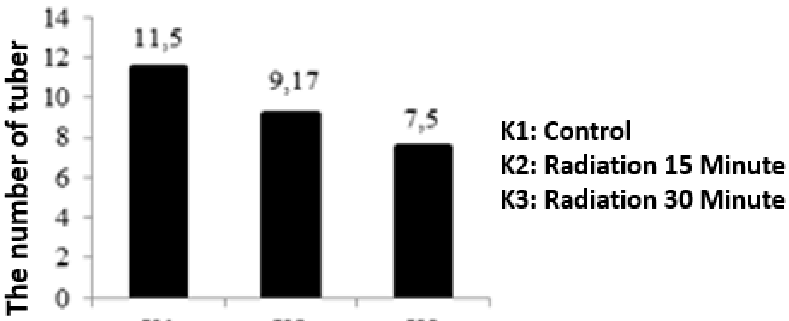

Figure 9. Histogram of average number of onion bulbs (*Allium cepa* L.) after administration of radiation of nitrogen ions from plasma.

The results shows that the average number of tuber of K2 (radiation 15 minutes) and K3 (radiation 30 minutes) is not significantly different to K1 (Control). The average yield of tubers in tuber control treatment (K1) is 11.5 tubers, K2) 9.17 bulb and radiation treatment 30 minutes (K3) 7.5 bulbs. This is because, according to [15], the formation of onion tuber comes from the enlargement of layers of leaves that later develops into onion bulbs. The number of tubers produced based on the number of tillers produced by plants. The more number of tillers the more number of tubers produced.

The next parameter is wet weight and dry weight. The result of ANOVA (Analysis of Variance) at the 95% significance level shows that plasma nitrogen ion radiation has significant effect on wet weight and dry weight of shallot. The average weight of wet onion can be seen in figure 10 and the average dry weight of shallot can be seen in figure 11.

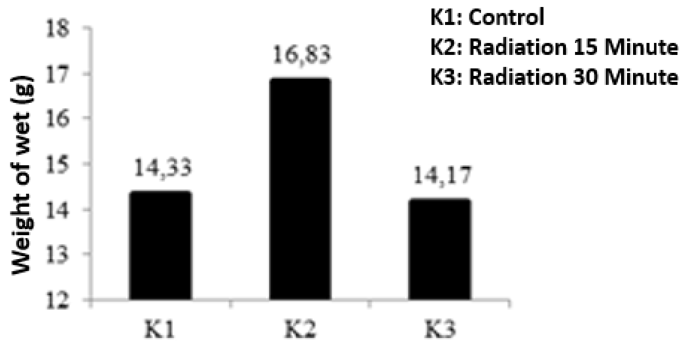

Figure 10. Histogram of average weight of wet onion (*Allium cepa* L.) after administration of nitrogen ion radiation from plasma

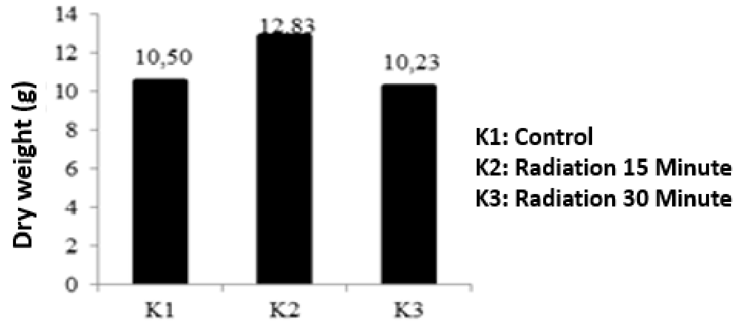

Figure 11. Histogram of average of dry onion (*Allium cepa* L.) after the radiation of nitrogen ions from plasma.

The result shows that dry weight of K2 onion (radiation 15 minutes) is significantly different with K1 (control) and K3 (radiation 30 minutes). While K3 does not give significant difference with K1 (Control). On average dry weight of onion on control at K2 22,19% and K3 -2,57%.

Tuber yields from plants treated with nitrogen ion radiation from plasma have higher wet weight and dry weight than control treatment. Provision of nitrogen ion radiation from plasma increases the nutrient content needed by plants as macro nutrients that support the growth and development of plants. According to [18] nitrogen nutrients are required for the formation or growth of vegetative parts of plants such as stems, leaves and roots. Nitrogen element also plays an important role in synthesis and increase chlorophyll so as to affect the increase of photosynthesis results. The growth of roots, stems and leaves will be faster if the food supply for the process of organ formation in sufficient quantities so that the effect on wet weight and dry weight of plants.

4. Conclusion

Based on the results of research conducted, it can be concluded that plasma nitrogen ion radiation can increase the growth and production of onion plants. Growth of nitrogen ion radiation from plasma can increase plant height with presentation of 9,53 % increase, while production can increase wet weight and dry weight of shallot bulb per hump reaches 17,44% and 22,19%. The most optimal nitrogen ion radiation for growth and local onion production (*Allium cepa* L.) is 15 minutes.

IOP Conf. Series: Materials Science and Engineering **434** (2018) 012022 doi:10.1088/1757-899X/434/1/012022

References

[1] I F Febrian 2011 *Essay Faculty of Mathematics and Natural Sciences*
[2] BPS 2016 *Central Bureau of Statistics of the Republic of Indonesia*
[3] N Sumarni and A Hidayat 2005 *Indonesian Vegetable Research Institute*
[4] E Dovas, Crisostomos, Hatziloukas, Salomon, R Barg, E Y Shiboleth and N I Katis 2001 *European Journal of Plant Pathology* **107** 677-684
[5] V Theresia, A Fariyanti and N Tinaprilla 2016 *Extension Journal* **12** 74-88
[6] M Nur, I Nasruddin, J Wasiq and Sumariyah 2013 *Riptek* **7** 15-26
[7] Salisbury and Ross 1995 Plant Physiology Volume II ITB Bandung
[8] Y Abdiss, T Tekallign and L M Pant 2011 *Journal of Agriculture* **14** 3252-58
[9] I Suharno, Mawardi, Setiabudi, N Lunga and S Tjitrosemito 2007 *Biodiversity* **8** 287-294
[10] Kusuma 2013 *Agricultural Development Efforts* (Gramedia)
[11] Wahyudi 2010 *Agromedia Pustaka*
[12] A Fanindi, S Yohaeni, E Sutedi and Oyo 2009 *Soil Research Institute*
[13] Novizan 2002 *Effective Fertilization Guidelines* (Agromedia Pustaka)
[14] Engelstad 1997 *Technology and Fertilizer* (Use UGM Press)
[15] F Anisyah, R Sipayung and C Hanum 2014 *Online Journal of Agroecotechnology* **2** 482- 496
[16] E Sumiati and O S Gunawan 2007 *Journal of Horti* **1** 34-42
[17] Brewster J L 1994 Onion and other vegetable Alliums Cab International Cambrige
[18] Fariyanti A and N Tinaprilla 2016 Farmers Decision Making Against the Use of Local Red Onion Seeds and Imports in Kabupaten Cirebon (West Java Tesis Department of Agribusiness Faculty of Economics and Management, Bogor Agricultural University) **1** 2