Application of Controlled Release Fertilizer (CRF) in Supporting the Growth and Productivity of SS Sakato Shallot

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Application of Controlled Release Fertilizer (CRF) in Supporting the Growth and Productivity of SS Sakato Shallot

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Abstract: The development of controlled release fertilizer (CRF) is carried out to support the productivity of shallot by controlling the released of nutrient. CRF is a complete fertilizer contains of macro, micro, and trace element needed for the shallot. Nitrogen, Phosphate, and Potassium are the main component of the fertilizer, while others nutrient used are Sulphur, Magnesium, and Calcium. Some trace element are also used in helping the shallot to attain its optimum productivity. CRF is also developed based on the availability of nutrients in the soil. In this research, CRF is also coated by using humic acid to improve the characteristic and properties of the fertilizer. The performance of CRF is studied by doing the efficacy test to the SS Sakato shallot on an area of 2100 m^2, located in Kuningan, West Java. 2 formulas of CRF were used with one or two times fertilizer application, and 3 varieties of fertilizer dosage. The effect of these variables on plant height, number of bulbs as well as shallot yield, were then observed. Statistical analysis was also carried out using correlation methods to study the interactions between variables. Statistical analysis was also carried out using correlation methods to study the interactions between variables. The highest shallot yield was achieved with a two-time fertilizer application of CRF1 at a dose of 800 kg/ha. Treatments with CRF1, CRF2, and NPK fertilizer substantially raised shallot yield when compared to non-fertilization treatment. According to the correlation plot of all fertilizer types, in which frequency of fertilization or application time (AT) and dosage (D) are inputs, indicated that the fertilizer dosage was moderately related to plant height and the number of shallot bulbs as confirmed by its correlation coefficient.

Keywords: shallot; fertilizer; CRF; nutrient; statistical

1. Introduction

Agriculture is a very strategic sector in improving Indonesian economy, along with ensuring the food security[1, 2, 3]. Agriculture industry is highly significant and prominent in worldwide[4]. Horticultural agriculture, especially shallot farming is one of strategic sector that is being developed by the government. Shallots are one of the leading vegetable commodities that are widely used as a spice in cooking and traditional medicine[5]. This commodity is in high demand, particularly for household and commercial uses[6]. The productivity of Indonesian shallots from data of Ministry of Agriculture continues to decline from year to year. Until now, the productivity of shallots has not yet reached the optimum value. More over, due to low domestic shallot production, imports covered up to 14% of domestic needs on an annual basis[6].

To satisfy the growing demand for shallots, an innovation in agriculture technology that can increase shallot production is required. As a result, one option for increasing shallot productivity is to create the appropriate fertilizer[7]. Fertilization is one solution that can be done to increase the productivity of shallots. In general, shallot farmers are usually use excessive inorganic fertilizers to boost crop yields. Inorganic fertilizers are designed to contribute to the availability of nutrients in the soil, particularly macroelements such as N, P, K, and S[8].

However, excessive use of fertilizers can also cause soil damage in physical, chemical, and biological properties[9], environmental pollution, and reduce the quality of agricultural products[10]. Furthermore, excessive and inappropriate fertilization escalates the possibilities of nitrate and phosphate release into groundwater or surface water, elevates production costs, and has a negative impact on onion quality[11].

Another problem is the low efficiency of conventional fertilizers that have been used by farmers. The efficiency of conventional fertilizers is generally less than 50%. This might happens due to the loss of nutrient from the volatilization process, microbial degradation, or volatilization or washing by surface water run off. The main nutrient that must be controlled is actually nitrogen because it is easily dissolved in water. In an effort to increase the efficiency of fertilizers, fertilization, and also to improve the characteristics of the fertilizers produced, it is necessary to develop fertilizers that are able to meet the nutrient needs according to the type of plant and the availability of nutrients in the soil during the growth time. Controlled release fertilizer (CRF) are often used to reduce nutrition losses[12] and extend nitrogen availability[13]. Moreover, zeolite is able to adsorb the ammonium released by the fertilizer and releases it back when the ammonium concentration in the soil decreases[14].

Controlled release fertilizers are granules that are specifically developed to release nutrients in a managed, delayed manner according to plant needs for nutrients[15]. This fertilizer is able to change urea's high water-solubility into a new fertilizer with a controlled N release rate into the soil[6] by combine it with material such as zeolite which is chemically capable of absorbing and trapping cations, such as ammonium due to urea hydrolysis[16]. Another advantage of controlled release fertilizer is the reality that the fertilizer has the ability to keep the mineral content in soil solution low, lowering the possibility of salt damage[17].

CRF developed in this research is a complete fertilizer with macro, micro and trace element nutrients, produced with a coating technology that allows the availability of nutrients according to plant needs. Nitrogen, Phosphate, and Potassium are the main component of the fertilizer, while the micro nutrient used are Sulphur, Magnesium, and Calcium. Sulphur (S) plays a significant role in the nutrition of onion plants for flavor and taste development[18]. Some trace element are also used in helping the shallot to attain its optimum productivity since the plant needs selected nutrients to grow, other than water dan sunlight[19]. CRF is also coated by using humic acid to improve the characteristic and properties of the fertilizer.

Humic acid can affect directly and indirectly on plants. Humic acid will improve soil fertility in both physical, chemical, and biological soil properties[20]. Humic acid is able to optimize nitrogen fertilization and reduce nitrogen leaching, thereby increasing crop yield[21]. The use of humic acid as a coating for fertilizer can have a significant effect on plant growth and also the productivity. Therefore, the combination of zeolite and humic acid are used and is expected to improve the efficiency of fertilizer. This research aims to study the effect of different formula, dosage and application time of CRF for shallot growth and production.

2. Materials and methods

The materials that were used in this research consisted of Urea (as nitrogen source), Diammonium Phosphate (as phosphate and nitrogen source), Potassium Chloride (as potassium source), while for micro nutrient such as sulphur was obtained from Zwavelzure Ammonium, magnesium from Magnesium Oxide, and calcium from Calcium Carbonate. All fertillizer raw materials were technical grade and obtained from local market, while Humic Acid was from Bogor Agricultural Institute (IPB).

CRF was produced according to the process described by Noor et al. (2022)[22] by using NPK fertilizer pilot plant at National Research and Innovation Agency, KST BJ Habibie, Puspiptek. Humic Acid was used as the coating material and zeolite as matrix. Two formulas of CRF produced were CRF1 14-7-9-6-4-2 (N P K S Ca Mg) and CRF2 :16-7-10-6-2 (N P K S Mg). Different persentage of macro nutrient were utilized. CRF1 contains complete nutrients with lower N elements, whereas in CRF2 Ca nutrients was eliminated, but contains higher N elements. This was performed to investigate the impact of Ca on shallot plants. Each raw material was ground to a mesh size of 60. Using a pan granulator, the fine raw materials were granulated until it attained a grain size of 3-5 mm and then dried utilizing rotary dryer. The fertilizer granules were then coated by spraying humic acid and continued with second drying.

The 2 formulas of CRF used were CRF1 : 14-7-9-6-4-2 (N P K S Ca Mg) and CRF_2 :16-7-10-6-2 (N P K S Mg). The CRF used then will be compared with the commercial NPK 15-15-15. Fertilizer doses were varied 600, 800, and 1000 kg per hectare, with one and two times of fertilizer application at 10 – 15 and 30 – 35 days after planting. According to Geisseler et al. (2022)[11], split applications of fertilizer, can be scheduled to correlate the N accessibility with the crop's N need, minimizing the fertilizer's residence time in soil.

The shallot variety used in this research was SS Sakato, obtained from Solok, West Sumatra. The efficacy test was carried out in Kuningan, West Java with an area of 2100 m^2. The design of the CRF fertilizer efficacy test is shown as follows.

Table 1. CRF fertilizer efficacy test.

No.	Parameter	Code
1	One time fertilizer application	A1
2	Two times fertilizer application	A2

3	CRF1 : 14-7-9-6-4-2	P1
4	CRF2 : 16-7-10-6-2	P2
5	NPK Phonska 15-15-15	P3
6	Fertilizer dose : 600 kg/ha	D1
7	Fertilizer dose : 800 kg/ha	D2
8	Fertilizer dose : 1000 kg/ha	D3

Table 2. Combination of treatments for each replication.

No.	Code for Combination of Treatments		
1	A1P1D1	10	A2P1D1
2	A1P1D2	11	A2P1D2
3	A1P1D3	12	A2P1D3
4	A1P2D1	13	A2P2D1
5	A1P2D2	14	A2P2D2
6	A1P2D3	15	A2P2D3
7	A1P3D1	16	A2P3D1
8	A1P3D2	17	A2P3D2
9	A1P3D3	18	A2P3D3

All parameters were varied so that it was obtained 18 combination of treatments for each replication, where in this research 4 replications were carried out. The efficacy test area of 2100 m^2 is divided into test plots with a plot size of 1.2 x 5 m according to the number of test variations above. The efficacy test was carried out from January to March 2021, where the test land was initially cultivated to remove weeds, loosed the soil, formed the test plots, and applied the compost fertilizer. The seeds are first cut at the top of the shallot in order to promote and speed up plant growth as well as the growth of tillers[23)], and then planted on the ground with a spacing of 15 x 20 cm between the shallot. Plant growth observations are carried out periodically by measuring plant height, number of shallot and plant conditions.

In order to evaluate the interaction between the observed variables and the effects of input variables on the outputs, statistical analysis was performed using the correlation method. Correlation method has often been used as statistical analysis to investigate the relationship between variables in a system, including in research related to shallot[24,25)]. Reference on the range of interpretation of correlation values that are often used by many researchers was described in detail in a study conducted by Schober et al. (2018)[26]. In the statistical analysis carried out, the plot was created based on the data obtained from the research, where frequency of fertilization or application time (AT) and Dosage (D) were input variables and Height (H), Number of Bulbs (NoB), Wet Yields (WY) or wet weight and Net Yield (NY) or dry weight were output variables. The findings of this statistical analysis, along with the outcome of the research, are presented in the results and discussion section.

3. Result and discussion

3.1 Plant height

Plant height can be one of salient parameter in plant growth since leave itself has an important function in capturing sunlight and is the site of the photosynthesis process which can support the yield of shallot. In addition, plant height also affects the parameters of the wet and dry weight of the harvest[27)]. Plant height measurements were carried out at the age of shallots 15, 30 and 45 days after planting and measured for 5 samples in each plot. The effect of the CRF fertilizer formula, the type of fertilizer used, the dose of fertilizer, and the frequency of fertilization on the growth of shallot plant height can be seen in the following figure.

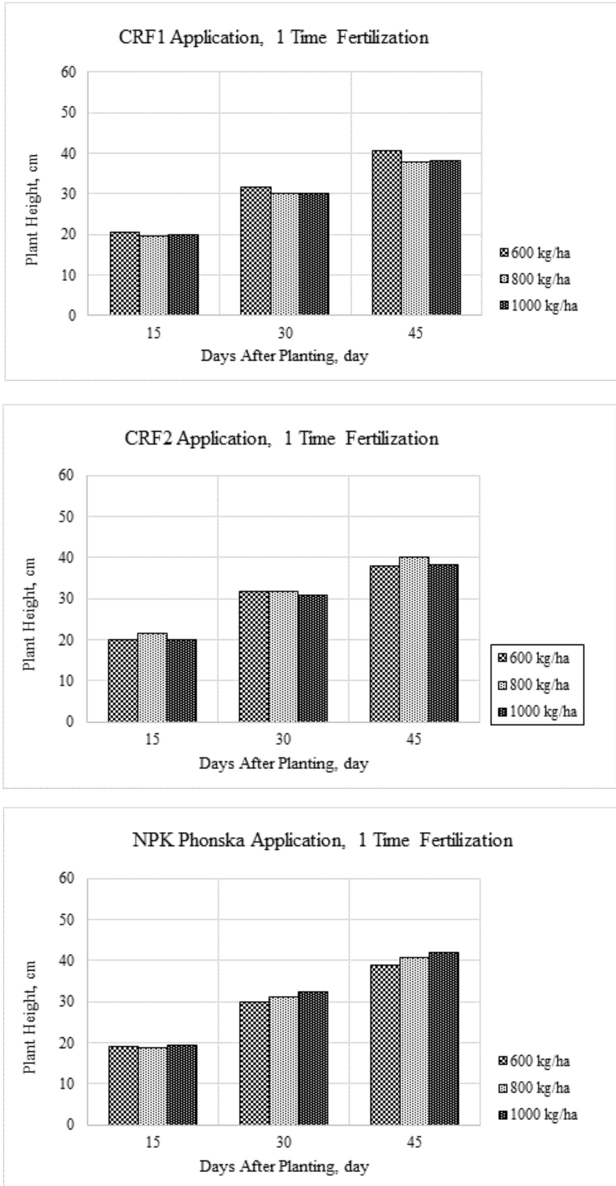

Fig. 1: Shallot height at the frequency of 1 time fertilization

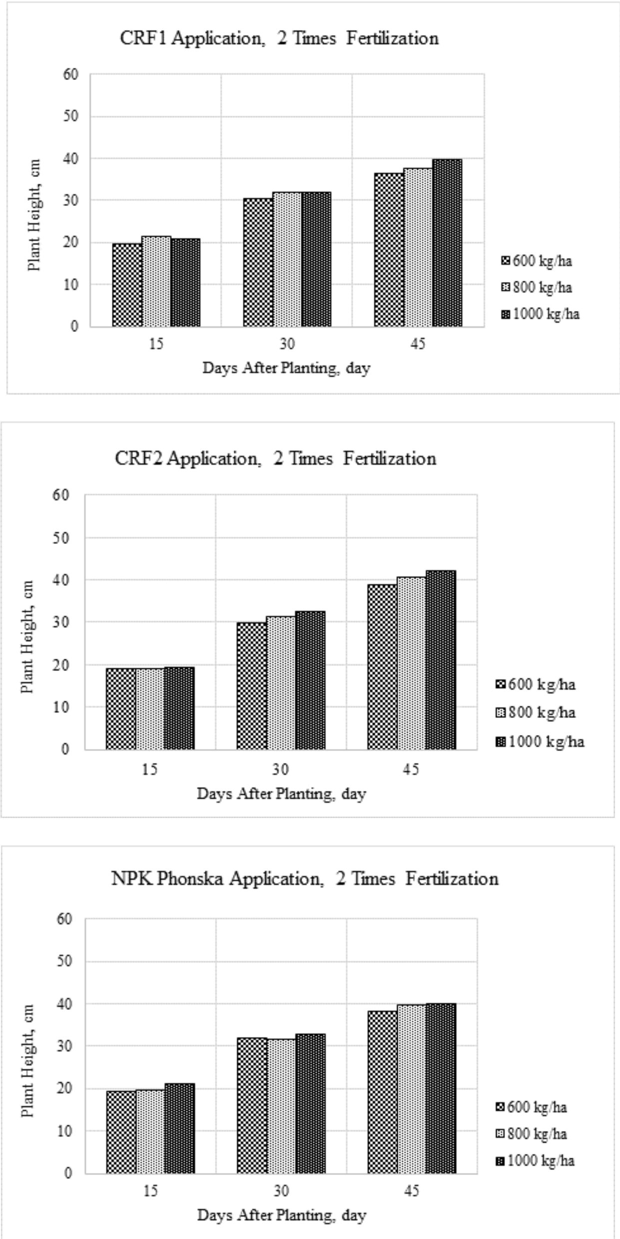

Fig. 2: Shallot height at the frequency of 2 times fertilization

From the figures above, it can be seen that all treatments data tended to have the same pattern. The treatment with fertilizer was significantly affected the height of plant compared to the treatment without fertilizer in 2 control plots which value shows in Table 3 below.

Table 3. Height of shallot without fertilizer.

No.	Test Plot	Height, cm		
		15 DAT*	30 DAT*	45 DAT*
1	Control 1	12.14	24.34	26.76
2	Control 2	13.10	25.54	26.50

*DAT : days after planting

The use of CRF formula 1 (CRF1), formula 2 (CRF2) and phonska NPK fertilizer gave a good effect in increasing the height of shallot. The plant growth was rising fast at the first month after planting which was marked by the height of shallot that increased by an average of about 50% for all treatments and slow down to 25% at the second month. The data on increasing the height of shallot up to day 45 after planting for all treatments can be seen in Fig. 3.

The highest height was achieved for A1P3D3 treatment which is 42.04 cm at 45 days after planting by using NPK Phonska fertilizer, 1 time fertilizer application, and fertilizer dose of 800 kg/ha. However, that plant height in general was only slightly different from the plant height in other treatments. After 45 days, the height of plants reached a height of more than 35 to 40 cm, where the height of the SS Sakato shallots generally varied in the range of 24 - 44 cm, so that when referring to this value, the growth of the SS Sakato shallots in terms of height was satisfied.

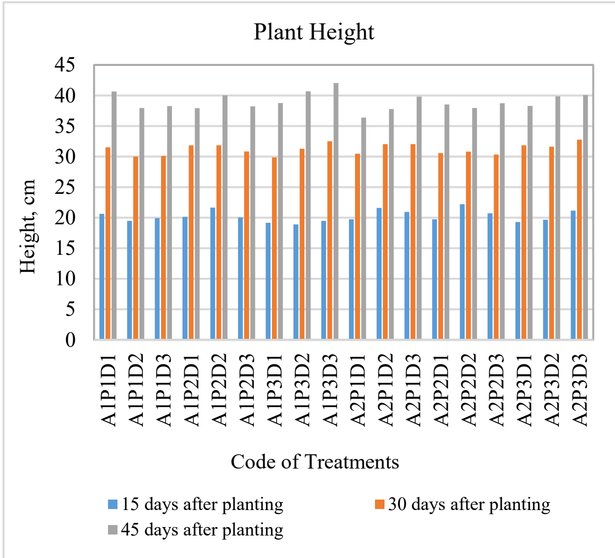

Fig. 3: The plant height for all treatments

The increasing of plant height is dominantly related to the application and avaibility of nitrogen[28] and potassium fertilizer which can raise the rate of plant growth. Nitrogen can help in supporting develop the plant, enhancing the protein synthesis, forming of chlorophyl which then gives green color to the leaves, and increasing root shoot growth[29]. While deficiency in nitrogen will limit cell division and enlargement which will then inhibit the increasing in plant height and cause the leaves to turn pale green or yellow. In addition, potassium helps in metabolic processes such as photosynthesis and respiration which also greatly affect the plant growth[30].

Although the increasing in plant height is quite fast especially in the first month, the fertilizer types, doses, and fertilization frequencies did not give significant difference in results between treatments. This could be due to the fact that the nitrogen content of the three types of fertilizers used were only slightly different and already met the requirement for vegetative growth of SS Sakato shallot.

According to Leghari et al's study (2016)[31)], nitrogen is crucial in many biological processes, including increasing the amount of leaves, plant height, and various other vegetative growth. The percentage of nitrogen in each fertilizer, respectively, is 14, 16, and 15%. Other factors that also play important role in plant growth such us environment, nutrients content in soil, and plant response. Moreover, plant needs for various nutrients during growth and development phase are not same for each plant[27)].

3.2 Number of shallot bulbs

The number of shallot bulb from efficacy test by using 3 types of fertilizers and the difference in the frequency of fertilization can be seen in Fig. 4 and 5 below.

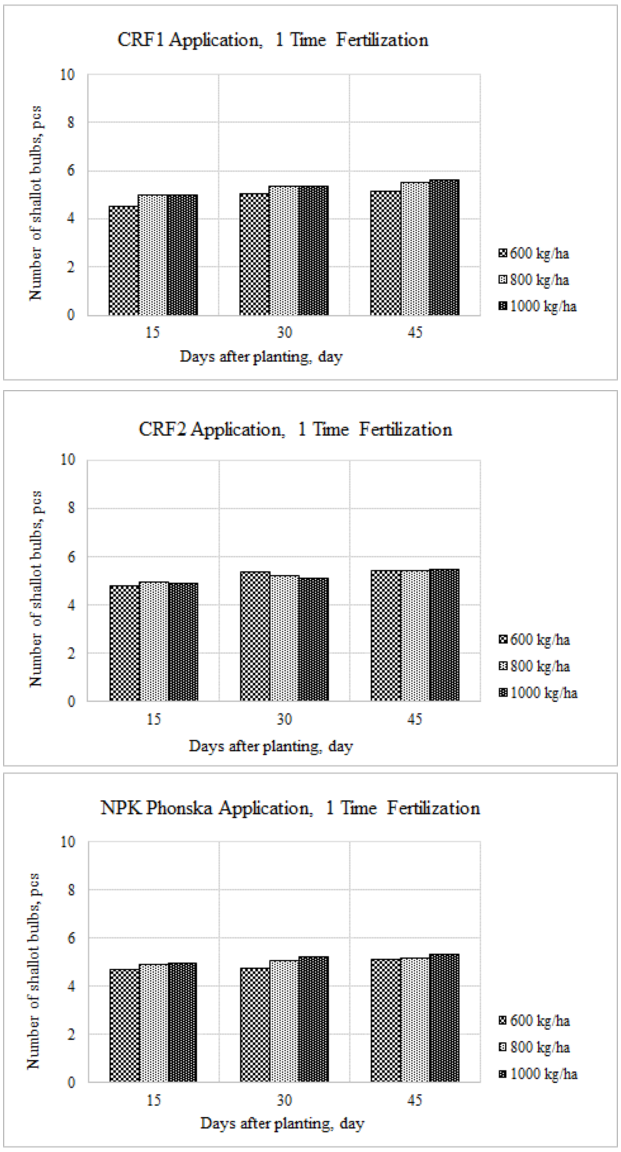

Fig. 4: Number of shallot bulbs at the frequency of 1 time fertilization

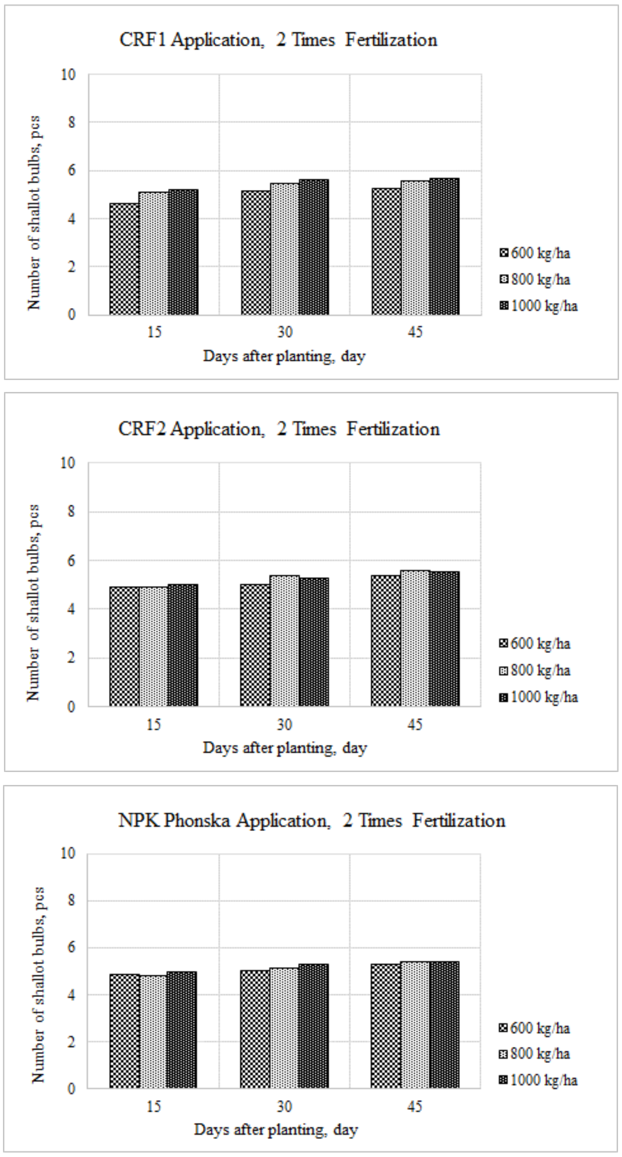

Fig. 5: Number of shallot bulbs at the frequency of 2 times fertilization

From the figure above, at the age of 15 to 45 days after planting, it can be seen that all treatments can affect positively on increasing the number of SS Sakato shallots. The number of SS Sakato shallots on average ranged from 4.5 to 5.67 pieces, with small differences between treatments. Increasing the dose of fertilizer for each type of fertilizer increases the number of shallot bulbs. While, the increasing in the frequency of fertilization did not have a significant effect on the number of shalllot bulb. The number of shallot bulb for the control plots (without fertilization) at the planting age of 15, 30, and 45 days after planting were 3.2 – 4.1 pieces. Therefore, the use of CRF as well as NPK fertilizer were able to increase the number of SS Sakato shallot bulbs. The nutrients content, particularly nitrogen and sulphur[32)], in fertilizers are giving the significant influence on the number of leaves, plant height, as well as number of shallot bulb, while the diameter of bulb is mostly affected by potassium content[33] which supporting the photosynthesis process and enhancing photosynthate transfers to plant segments, resulting in improving the weight of shallot[34, 35].

3.3 Yield of SS Sakato shallot

The effect of using the CRF and NPK fertilizers on the yield of SS Sakato shallots can be seen in the following figure.

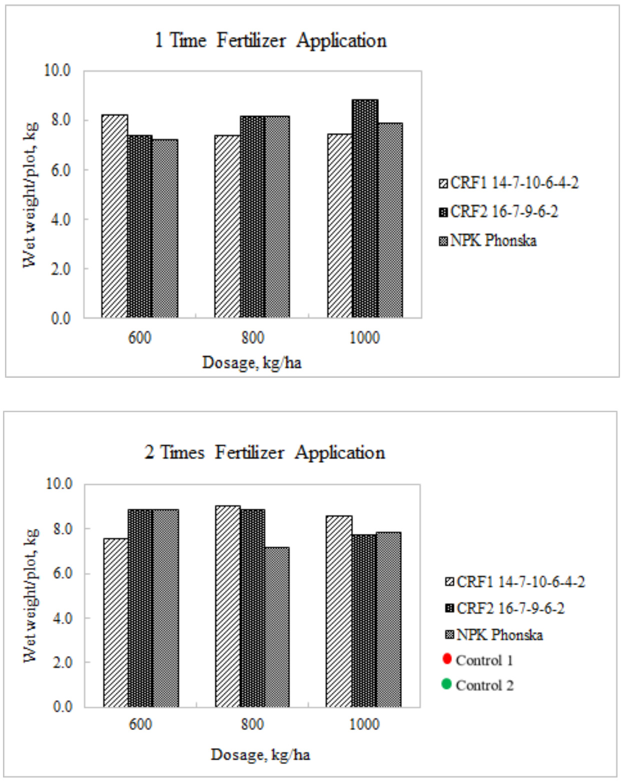

Fig. 6: Wet weight of SS Sakato shallot from efficacy test

The harvested shallots were tied and then weighed to obtain the wet weight, show in Fig. 6. The data is then recorded according to the wet weight per test plot. In order to obtain the dry weight, the shallots were then dried under the sun approximately for 7 up to 10 days, where the result was shown in Fig. 7. Control 1 and Control 2 indicated the plot that were not given any fertilizer treatment, and used as a comparison to other treatments.

From the harvest data based on the highest average number, was achieved for treatment code of A2P1D2 (2 times fertilizer application, CRF1, dose 800 kg/ha) with wet weight of 9.05 kg/plot or 15.08 kg/plot and dry weight of 5.48 kg/plot or 9.14 kg/plot. While for the same fertilizer and dose but with one time fertilizer application (code A1P1D2), the wet weight obtained is 7.37 kg/plot or 12.28 tons/ha an dry weight of 4.73 kg/plot or 7.88 ton/ha.

When compared with the control plot (without fertilization), where for the 2 control plots the dry weight of shallot were 1.23 kg/plot and 2.20 kg/plot, respectively, for one time fertilization application, the use of CRF1 and CRF2 fertilizers was able to increase yield up to 1.5 – 2 times compared to the dry weight of control plot, while the use of NPK fertilizer increased yield in the range of 1.35 – 1.5 times. As for the two times fertilization application, the use of CRF1 and CRF2 fertilizers were able to increase the dry weight of the yield up to 1.65 - 2.19 times compared to the treatment without fertilization, while the application of NPK fertilizer increased the yield by 1.46 - 1.63 times.

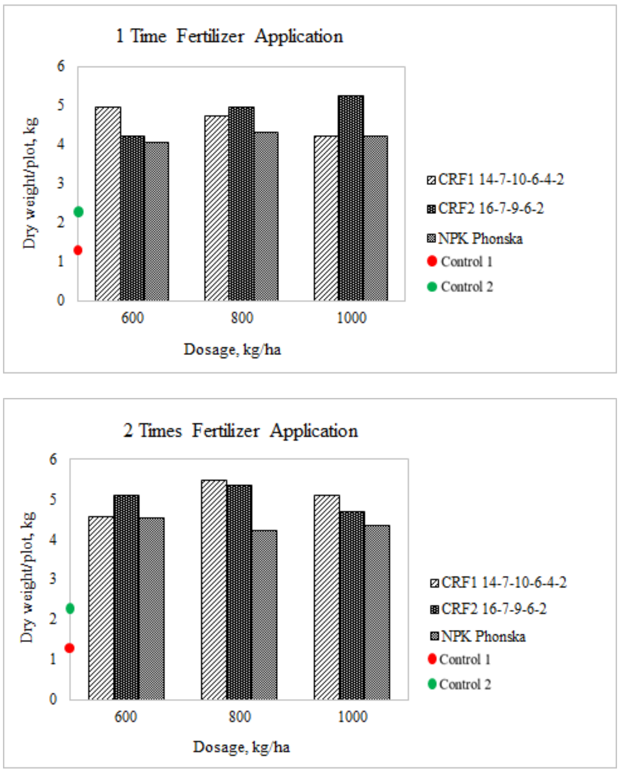

Fig. 7: Dry weight of SS Sakato shallot from efficacy test

In treatments one and two times of fertilization, the dry weight of shallot using CRF fertilizer gave higher yield than the use of NPK fertilizer. CRF is an excellent a solution to soluble fertilizer (SF) to enhance fertilizer usage efficiency and reducing nutrient losses[36]. Moreover, according to Hartatik et al. (2018)'s study[37], zeolite matrix in CRF1 and CRF2 fertilizers are able to trap nitrogen nutrient in the alumino silicate structure so that it is not easily lost due to leaching and volatilization and is slowly released from time to time to be absorbed by plants. Zeolite plays a role in temporarily holding nutrients in the root area so that the fertilizer given is more efficient and the fertilizer residue in the zeolite cavity can be utilized by plants.

The use of humic acid as coating agent in CRF1 dan CRF2 fertilizer also can help retain nutrients, reduce nitrogen loss, improve porosity and increase water holding capacity[38]. The implementation of conventional N fertilizers, particularly if carried out only once, leads to excessive amounts in the early growth stages and inadequate amount in the later stages. Fertilizer should be applied in the right time so that the nutrient are available when it is needed by plants. The nutrient supply will provide optimal nutrition for plant growth and reduce losses by processes competing with the plant for nutrients[39)]. Each plant needed to be fertilized with the proper dose in order to reach the nutrients balance in the soil that supports plants to grow, develop properly and produce its optimum yield[40)].

The formation of bulbs in shallots is highly dependent on the results of plant photosynthesis. The element that plays an important role in the formation of tubers is phosphorus. Phosphorus functions in the formation of roots, and increases the yield of grains and tubers. Good absorption of phosphate can support the formation of tuber enlargement as well. In addition, element K is also an indispensable component in the formation of tubers in plants. Elemental K is used by plants in photosynthesis, transport and increase of carbohydrates and sugars, and protein synthesis[27)]. The better the results of the photosynthesis process, the bigger the tubers formed[41)]. Therefore, phospor and potassium contributed a substantial part in enhancing vegetative growth of plants, such as plant development, bulb enlargement and lengthening, which impacted the onion weight. in according with the research done by Napitupulu et al. (2010)[29)]. Dry weight of a crop is further influenced by the size of the photosynthetic system and the duration of the growth period throughout which photosynthesis occurs[42)].

The difference in tuber size for the control plot (without fertilization) and the test plot can be seen in the following figure.

Fig. 8: SS Sakato shallot from efficacy test without fertilizer (left) and with fertilizer (right) application

From the picture above, it is noticeable that shallots with fertilizer application showed better yields with larger bulb sizes and has purplish red color with a higher intensity than the shallots without fertilization treatment. As mentioned by Sofyan et al. (2023)[43)], shallot quality is defined by indicators such as red purplish color, dense bulb with an oval shape, spicy taste, and distinct aroma. Forney et al. (2010)[44)] in her research identified that nutrient S is important in the formation of thiosulfate compounds, which play a significant role in color formation in shallots (Sukasih et al., 2018)[45)].

The use of CRF fertilizer enriched with S has an effect on the color of shallots by giving red purplish color (right picture) as shown in the Fig. 8 above. Meanwhile, shallots that receive no fertilizer have a pale purple color (left picture), most likely because shallots receive merely nutrient S from the soil, which does not necessarily fulfill the need of nutrient S for shallots. As a result, the formation of thiosulfate compounds is relatively modest, affecting the color of the shallots. This color characteristic is essential considering the consumers prefer shallots with a purplish red color with high intensity (Sukasih et al., 2018)[45)].

The complete nutrient content both macro and micro incorporated in fertilizer, in addition with important trace element, combined with the use of zeolite and humic acid were believed to give the positive effect for both growth and yield of SS Sakato shallot which also indicates that fertilization has a major influence on SS Sakato shallots. Application of fertilizer can increase growth, tuber size, and increase the productivity of shallots. The right formula and dose of inorganic fertilizer can create ideal conditions that strongly promote shallot growth and generate a high photosynthate. A significant portion of photosynthate translocated to the bulb, creating a much greater dry weight and larger shallot bulb[8)].

3.4 Statistical analysis

The statistical analysis of fertilizer type, frequency of fertilization, and fertilizer dosage was performed and displayed in the Fig. 9, where frequency of fertilization or application time (AT) and Dosage (D) are inputs and Height (H), Number of Bulbs (NoB), Wet Yields (WY) or wet weight and Net Yield (NY) or dry weight are outputs. This analysis resulted in some correlation coefficients which are then approached with interpretation based on research carried out by Schober et al. (2018)[26)]. A number of methods have been proposed to translate the correlation coefficient into categories such as “weak,” “moderate,” or “strong” interactions, based on the table below

Table 4. Interpretation of correlation coefficients

Absolute magnitude of the observed correlation coefficient	Interpretation
0.00 – 0.10	Negligible correlation
0.10 – 0.39	Weak correlation
0.40 – 0.69	Moderate correlation
0.70 – 0.89	Strong correlation
0.90 – 1.00	Very strong correlation

Based on the correlation plot of all fertilizer types in Fig. 9, where frequency of fertilization or application time (AT) and dosage (D) are inputs, reveal that fertilization frequency has insignificant impact on plant height, as indicated by correlation coefficient resulted from statistical analysis, which has a value of -0.03. While the adding of fertilizer dosage was moderately correlated with plant height as confirmed by the correlation coefficient of 0.44. The results of this statistical analysis are in accordance with the results of field tests where the height of shallot plants showed significant growth in the early days after planting. This is also supported by a study conducted by Leghari et al (2016)[31) , which found that the availability of nitrogen at the start of plant growth has the greatest influence on the height of shallot plants.

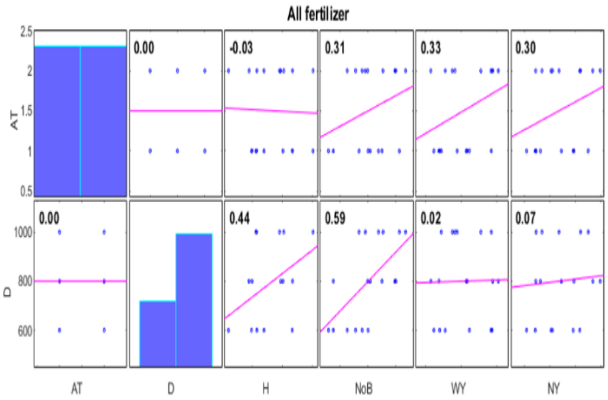

Fig. 9. Correlation plot of all fertilizer types

Moreover, analysis of correlation for number of shallot bulbs shows that frequency of fertilization has a fairly low influence, which is shown by a correlation coefficient value of 0.31, indicating the weak correlation of frequency of fertilization with number of shallot bulbs. Whereas the fertilizer dosage is at the moderate correlation with number of shallot bulbs, as evidenced by a correlation coefficient of 0.59. These statistical findings are in line with the tests and data that have been discussed and illustrated in Fig. 4 and 5, where improving the dose of each type of fertilizer can increase the number of shallot bulbs and on the contrary, the addition of the frequency of fertilization has no apparent impact on number of shallot bulbs. According to Nasreen et al. (2007)[32)], the amount of nutrients in fertilizer possesses a substantial effect on the number of shallot bulbs produced. As a result, the fertilizer dosage has a stronger impact than the frequency of fertilization because the higher the dose, the more nutrients are contained in the fertilizer.

The correlation analysis was also carried out for wet and dry weight of the shallot. The statistical analysis of fertilization frequency implies correlation coefficient values of 0.33 and 0.30 for wet and dry weight, respectively, indicating a weak correlation between these variables. Along with that, statistical analysis of fertilizer dosage also corresponding to minor impact on the wet and dry weight of the shallot with the correlation coefficient of 0.02 and 0.07, illustrating a negligible correlation among these variables.

In contrary, according to the research field test illustrated in Fig. 6 and 7, both fertilization frequency and fertilizer dosage had a fairly good influence on yield, since both variable were able to raise the crop yield. Based on study conducted by Schober et al. (2018)[26)], two variables may display a high degree of correlation while also contrasting immensely. As a result, researchers should not only depend on the correlation coefficient, yet additionally plot the data for an in-depth visualization of the interaction.

Conclusion

The highest shallot yield was obtained for the treatment of two times fertilizer application by using CRF1 with the dose of 800 kg/ha, giving the dry weight of shallot 9.14 kg/plot. Compared to control plot (without fertilization), treatments by using CRF1, CRF2, and NPK fertilizer significantly increased the yield of shallot. Application of CRF1 as well as CRF2 produced higher yield compared to NPK fertilizer, due to the complete component both macro and micronutrient, the use of zeolite as matrix for giving the slow release effect and also humic acid which helps to enhance the characteristic of fertilizer. While, for plant height and number of bulbs, the implementation of all fertilizer did not greatly affect that parameters and the increasing of fertilization frequency was just slightly influence the plant height, number of shallot bulbs, and also shallot yield. Further more, from the appearance of with and without fertilizer treatment, the effect of using fertilizer is clearly observed by the larger bulb size, having purplish red color color with higher intensity, and more bulbs produced. From the statistical analysis, the correlation coefficient implies that fertilizer dosage was moderately related to plant height and the number of shallot bulbs, meanwhile statistical analysis for the yield variable leads to disparate findings. However, according to the research findings plotted on Fig. 6 and 7, either fertilization frequency and fertilizer dosage had a fairly favorable impact on shallots yield.

Acknowledgements

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Nomenclature

CRF	Controlled release fertilizer
IPB	Bogor Agricultural Institute
LPDP	Indonesia Endowment Fund for Education
PRN	National Priority Program
BRIN	National Research and Innovation Agency

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