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THE CORRELATION BETWEEN GROWTH CHARACTERS AND YIELD OF SHALLOT (ALLIUM ASCALONICUM L.) DUE TO THE APPLICATION OF NITROGEN, PHOSPHATE AND POTASSIUM FERTILIZERS

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ABSTRACT
The research was aimed to evaluate the correlation between growth characters and yield components of shallot (*Allium ascalonicum* L.) on several dosages of nitrogen, phosphate and potassium fertilizers. It was conducted on experimental farm and laboratory of Plant Physiology of Department of Agronomy Faculty of Agriculture, University of Sriwijaya in 2018. The research was consisted of two experiments and each experiment used Block Randomized Design with 3 replicates. First experiment was the combination of nitrogen (N) and phosphate (P) application, while second experiment was the combination between N and potassium (K). Same dosages of N fertilizer were used for both experiments consisting of N1 = 100 kg ha^{-1}; N_2 = 150 kg ha^{-1}; N_3 = 200 kg ha^{-1}; and N_4 = 250 kg ha^{-1}. Four dosages of P fertilizer was applied in the first experiment consisting of P_1 = 160 kg ha^{-1}; P_2 = 220 kg ha^{-1}; P_3 = 280 kg ha^{-1}; and P_4 = 330 kg ha^{-1}. While K fertilizer dosages in second experiment were K_1 = 50 kg ha^{-1}; K_2 = 100 kg ha^{-1}; K_3 = 150 kg ha^{-1}; and K_4 = 200 kg ha^{-1}. Results showed that positive significant correlation was found between vegetative characters and generative characters in both experiments such as between plant height and shallot bulb number, and between total bulbs dry weight per clump and bulb dry weight. The correlation between tiller number per clump and bulb number per clump was only resulted from first experiment. The highest bulb dry weight per clump was resulted from the combination of 150 kg N ha^{-1} and 160 kg P ha^{-1} and combination of 200 kg N ha^{-1} and 200 kg K ha^{-1}.

KEY WORDS
Nitrogen fertilizer, phosphate fertilizer, potassium fertilizer, shallot.

Horticulture development in Indonesia has been prioritizing on two commodities, chilli pepper and shallot, since these two commodities not only become basic food ingredients but also have a significant role in affecting inflation in Indonesia. Shallot is one of the leading vegetable commodities that have been intensively cultivated by farmers. It is categorized as complementary spices utilized as food seasoning and traditional medicine. This commodity is also considered as a source of income and employment opportunities that contribute significantly to regional economic development. The prospect of Indonesian shallot development is quite promising since Indonesia is one of shallot exporters in the world. According to data from Food and Agriculture Organization (FAO), Indonesia was ranked in fourth position as shallot exporters after New Zealand, France and Holland, and ranked first among ASEAN countries in the period of 2010 to 2014 (Agricultural Research and Development Agency, 2005).

Based on the data from Center for Agricultural Data and Information (2016), there were 4 provinces of shallot production center in Indonesia considering the average yield from 2011 to 2015. They were Central Java, East Java, West Java and West Nusa Tenggara. These provinces contributed around 85.33% of shallot total average production in Indonesia. The largest was Central Java with 40.59% and average production of 432,813 tons. East Java

contributed 23.16% with 246,927 tons per year. West Java and West Nusa Tenggara contributed 11.10% and 10.48% respectively. The rest of 14.67% was from other provinces.

Central Statistics Agency of South Sumatra (2015) stated that total shallot production in South Sumatra was 150 tons in 2014, decreasing for about 67 tons (30.87%) compared to 2013. The decline in production was caused by a decrease in harvest area and decreased productivity. During 2014, shallot production area in South Sumatra was only in four regencies consisting of Ogan Komering Ulu (OKU), Muara Enim, Musi Rawas and South OKU with 65, 18, 65, and 2 tons of production respectively.

Agriculture intensification through either organic or inorganic fertilizing was among the efforts for increasing shallot production in South Sumatra. Shallot is a nutrient sensitive plant where the symptoms would immediately appear due to both deficiency and excess of nutrients. Many studies of fertilizer application on shallot plant has shown good results. A study by Deden (2014) reported that urea application with the dosage of 200 kg ha^{-1} or equivalent to 80 kg N ha^{-1} significantly affected the average plant height. Sumarni et al. (2012) added that the application of 120 kg P_2O_5 ha^{-1} would result the highest bulb fresh weight and bulb dry weight compared to other treatments with 35.02 and 25 g per plant respectively. Highest bulb dry weight was also resulted by the combination of 250 kg N ha^{-1} and 150 kg K ha^{-1} with 64.69 g per clump as reported by Napitupulu and Winarno (2010). Furthermore, the dosage of 100 kg K ha^{-1} would increase bulb diameter, fresh weight per bulb and dry weight per bulb (Uke et al., 2015).

Thus, this research was aimed to evaluate the application of several dosages of N, P, and K fertilizers on growth and yield of shallot (*Allium ascalonicum* L.).

METHODS OF RESEARCH

The research was conducted in experimental farm and laboratory of plant physiology of Department of Agronomy, Faculty of Agriculture, University of Sriwijaya in 2018. The research was consisted of two sets of experiments and both used Block Randomized Design with 3 replicates. First experiment was the combination of N and P fertilizer, while the second was the combination of N and K fertilizer. Same dosages of N fertilizer were applied in both experiments consisting of N_1 = 100 kg ha^{-1}; N_2 = 150 kg ha^{-1}; N_3 = 200 kg ha^{-1}; and N_4 = 250 kg ha^{-1}. Dosages of P fertilizer in first experiment consisted of 4 levels: P_1 = 160 kg ha^{-1}; P_2 = 220 kg ha^{-1}; P_3 = 280 kg ha^{-1}; and P_4 = 330 kg ha^{-1}. While K fertilizer dosages in second experiment consisted of K_1 = 50 kg ha^{-1}; K_2 = 100 kg ha^{-1}; K_3 = 150 kg ha^{-1}; and K_4 = 200 kg ha^{-1}.

Shallot bulb of Bima variety from Central Java weighed around 4 to 6 grams was used as plant material. The bulb was first soaked in fungicide solution containing Azoxystrobin and Difenoconazole for about 15 minutes then was cut at the size of 1/3 of bulb length. The bulb then was planted about 3 cm of depth on the mix of alluvial soil and manure with the ratio of 2:1 (v:v) in a 20 cm x 40 cm of polybag. Each polybag contained about 10 kg of planting media with the height media of 23 cm. The fertilizers were applied based on the treatments and the application was carried out twice. Half dosage was first applied 10 days after planting, and another half dosage was given 30 days after planting.

The parameters observed consisted of plant height, leaf number per clump, tiller number per clump, bulb number per clump, fresh weight per bulb, total bulb fresh weight per clump, bulb dry weight, total bulb dry weight per clump, and leaf chlorophyll. Leaf chloropyll was measured using a destructive method (Hall and Rao, 1987). It was carried out by extracting about 0.25 g of leaf powder with 80% acetone. The dissolved chlorophyll solution then was filtered using Whatman filter paper and was put on spectrophotometer with 645 and 663 nm wavelength to determine the absorbents. Total chlorophyll content was calculated by using the formula below:

$$Total\ chlorophyll = (17.3 \times A645) + (7.18 \times A663)\ mg/l$$

The analysis of leaf chlorophyll was conducted in the laboratory of plant physiology in Department of Agronomy, Faculty of Agriculture, University of Sriwijaya.

Shallot bulbs were harvested at 60 days after planting. During harvest, fresh bulbs were first weighed and then were air-dried for 7 days which later were weighed to obtain the data of dry weight per bulb.

RESULTS AND DISCUSSION

Growth characters. The application of N and P fertilizer showed different response in the parameters of plant height, leaf number and tiller number. The highest result for plant height was obtained from N_2P_1 treatment with 40.64 cm and the lowest was 32.10 cm in N_2P_3. N_1P_1 treatment resulted the highest number of leaf with 32.56 of leaves, while the lowest was 22.46 in N_2P_3. The highest tiller number was found in N_1P_1 with 6.74 tillers and the lowest was in N_1P_3 with 4.35 tillers (Table 1).

Table 1 – The application of N and P fertilizer on growth characters of shallot

N treatments	P treatments			
	P_1	P_2	P_3	P_4
		Plant height (cm)		
N_1	40.32±0.47	36.07±4.49	31.31±9.45	33.07±4.98
N_2	40.64±4.34	33.59±1.24	32.10±4.03	35.53±9.95
N_3	36.00±4.16	32.90±7.47	35.50±3.33	36.54±3.29
N_4	34.89±6.02	33.10±6.63	32.92±0.80	39.34±3.03
		Leaf number		
N_1	32.56±2.74	25.54±3.79	21.59±4.18	26.69±3.73
N_2	29.43±5.46	25.20±3.56	22.46±4.99	26.63±10.28
N_3	26.19±3.37	25.98±8.79	25.89±2.80	25.74±2.80
N_4	24.67±6.89	25.57±2.39	25.54±1.64	25.28±3.86
		Tiller number		
N_1	6.74±1.13	5.76±1.12	4.35±0.28	5.76±0.33
N_2	5.72±0.64	5.37±0.18	5.06±0.99	5.31±0.32
N_3	5.70±0.46	6.65±0.22	5.44±1.25	5.98±1.12
N_4	5.35±0.26	5.44±0.40	5.59±1.00	5.31±0.42

Plant responses to the application of N and K fertilizer were also different as seen in plant length, leaf number and tiller number (Table 2). The treatment with highest plant length was N_2K_4 with 42.08 cm and the lowest was 32.34 cm in N_4K_3. Plant with most leaf number was found in N_1K_1 and N_4K_2 with 34 leaves, while the least was in N_4K_1 with 22 leaves. Highest tiller number was in N_2K_4 with 6.74 tillers and the lowest was in N_4K_3 with 4.19 tillers.

Tabel 2 – The application of N and K fertilizer on growth characters of shallot

N treatments	K treatments			
	K_1	K_2	K_3	K_4
		Plant height (cm)		
N_1	39.91±5.70	38.04±2.23	33.88± 2.47	34.76±1.87
N_2	39.88±3.15	38.67±0.88	40.38± 1.67	42.08±2.46
N_3	38.78±5.17	36.53±2.57	34.83± 5.84	38.57±2.73
N_4	39.56±1.77	38.53±4.47	32.34±10.88	40.76±3.88
		Leaf number		
N_1	34±12.08	30±9.22	25±8.46	23±4.55
N_2	33±8.19	23±5.01	29±13.50	30±6.29
N_3	25±7.84	23±6.17	29±13.12	31±8.28
N_4	22±3.91	34±9.38	31±8.06	32±11.24
		Tiller number		
N_1	5.59±1.07	5.54±0.42	5.54±0.92	4.94±0.15
N_2	6.61±0.67	5.19±0.67	5.20±0.61	5.70±1.28
N_3	5.39±0.73	4.52±0.50	4.89±1.27	5.39±0.72
N_4	5.56±0.80	5.02±0.59	4.19±1.00	5.33±0.38

The combination of N with P and K with the highest plant height and the most leaf number was obtained in the same N dosages with 150 kg ha^{-1} and 100 kg ha^{-1}, respectively. While for tiller number, best results were obtained in the combination of P with 100 kg ha^{-1} N dosage and in the combination of K with 150 kg ha^{-1} of N dosage (Table 2). Pramitasari et al. (2016) reported that N supply would affect the growth, appearance, color, and yield of plants. The application of N would initiate the green color as it was the structural element of chlorophyll which later contributed in photosynthesis.

Yield components. Table 3 shows the effect of N and P application on yield components. It was resulted that bulb number per clump was around 5.78 – 8.42 bulbs. The highest number was obtained from N_1P_1 and the lowest was from N_2P_3. Similar to this, Suwandi et al. (2015) reported that Katumi variety shallot could result 9 bulbs per clump, while Bima variety resulted 5 – 8 bulbs. So in this case, the number of both bulbs and tillers was likely influenced by the genetic factor. Basuki (2009) added that the number of either bulbs or tillers would be affected by the size of planting bulb. The bigger bulb planted, the smaller the tiller number.

The combination of 100 kg ha^{-1} N fertilizer and 160 kg ha^{-1} P fertilizer (N_1P_1) showed the highest results for total bulb fresh weight per clump and fresh weight per bulb with 9.81 g and 8.53 g, respectively. It was assumed that the mix of planting media between soil and manure had provided sufficient nutrients. Sumarni et al. (2012) reported that excess P application (more than 180 kg ha^{-1}) would decrease fresh weight per bulb due to excess P in soil abrupting soil nutrients balance. N_1P_1 treatment also resulted the highest total bulb dry weight per clump with 49.38 g. However, the highest dry weight per bulb was obtained from the combination of 150 kg ha^{-1} N fertilizer and 160 kg ha^{-1} P fertilizer (N_2P_1) with 6.43 g. The application of P with the dosage higher than 120 kg ha^{-1} would not likely increase shallot yield since excess P in soil would surpress micro nutrients availability (Sumarrni et al., 2012).

Table 3 – The application of N and P fertilizer on yield components of shallot

N treatments	P treatments			
	P_1	P_2	P_3	P_4
		Bulb number per clump		
N_1	8.42±1.52	6.88±0.76	5.89±0.70	7.22±1.38
N_2	8.11±1.84	6.78±0.84	5.78±1.50	7.67±2.52
N_3	6.89±2.34	7.67±1.53	6.89±2.01	7.33±2.33
N_4	6.76±0.66	7.11±1.90	7.67±1.52	7.11±1.69
		Total bulb fresh weight per clump (g)		
N_1	69.81±12.25	44.27±12.80	30.12±21.72	34.88±12.91
N_2	63.07±4.83	36.92±13.40	39.86±16.60	53.67±31.91
N_3	42.76±21.40	48.39±32.03	52.37±13.81	37.84±17.73
N_4	48.45±25.49	47.00±12.24	42.95±14.31	51.21±22.98
		Fresh weight per bulb (g)		
N_1	8.53±0.32	6.96±1.02	4.96±3.45	4.65±1.55
N_2	8.02±1.69	5.66±2.21	6.95±1.68	6.44±2.93
N_3	5.92±1.74	6.11±3.78	8.04±1.04	5.47±3.31
N_4	7.04±3.55	7.38±2.11	6.62±0.38	7.12±2.04
		Total bulb dry weight per clump (g)		
N_1	49.38±7.78	27.39±10.93	18.72±13.47	25.95±14.52
N_2	49.26±0.96	20.65±11.42	24.19±13.62	36.32±26.35
N_3	28.95±14.20	34.17±21.99	33.91±16.95	25.81±14.38
N_4	29.81±17.80	29.82±11.90	23.83±7.69	34.79±13.24
		Dry weight per bulb (g)		
N_1	6.08±0.46	3.90±1.46	3.02±2.30	3.02±1.16
N_2	6.43±1.96	2.89±1.16	3.98±1.89	4.25±2.73
N_3	3.99±1.41	4.21±2.35	4.49±1.10	3.67±2.59
N_4	4.27±2.39	4.60±1.58	3.64±0.63	4.82±1.13

The effect of N and K application on yield components is given in Table 4. Based on the results, it was found that bulb number was related to tiller number. Similar to this, a study by Basuki (2009) resulted that bigger bulb would produce less tiller number. The highest total bulb fresh weight per clump and fresh weight per bulb was obtained from the combination of

250 kg ha^{-1} N fertilizer and 100 kg ha^{-1} K fertilizer (N_4K_3) with 50.63 g and 9.14 g, respectively. According to Napitupulu and Winarno (2010), the application of high dosage N and K fertilizer would provide enough amount of nutrients to increase fresh weight per bulb. Lower fresh weight per bulb was probably caused by less N and K supply for bulb development. Fikri et al. (2015) stated that balance amount of potassium would positively affect assimilate translocation from leaves to the storing organs, including shallot bulbs.

Highest total bulb dry weight per clump was resulted from N_2K_1 treatment with 38.21 g. While for dry weight per bulb, the highest was obtained in N_3K_4 with 6.84 g. It was assumed that the combination of N fertilizer with lower dosage of K fertilizer did not affect total dry weight per bulb since high N dosage would cause a more watery bulb. Napitupulu and Winarno (2015) had reported that the application of high N dosage fertilizer without K fertilizer caused the plant become succulent and did not increase plant dry weight.

Table 4 – The application of N and K fertilizer on yield components of shallot

N treatments	K treatments			
	K_1	K_2	K_3	K_4
		Bulb number per clump		
N_1	6.00±1.00	5.70±0.58	5.03±2.08	6.00±1.00
N_2	6.00±1.73	5.30±1.53	6.00±1.00	6.30±1.53
N_3	6.00±0.00	4.70±1.53	5.00±1.00	5.30±1.15
N_4	5.70±1.53	6.00±0.00	5.00±1.00	6.00±1.00
		Total bulb fresh weight per clump (g)		
N_1	43.41±18.64	48.22±24.15	32.76±10.48	30.03±4.19
N_2	50.31±18.87	35.80±10.52	36.02±24.88	48.64±4.58
N_3	47.90±17.97	31.63±18.34	36.28±16.98	44.42±8.65
N_4	40.87±6.35	50.63±13.17	41.72±5.26	44.17±15.34
		Fresh weight per bulb (g)		
N_1	7.66±2.47	8.56±3.84	6.18±1.24	5.32±0.64
N_2	8.30±1.97	7.20±1.81	5.99±3.63	7.93±2.05
N_3	8.15±3.44	6.61±2.43	6.38±1.77	8.91±1.98
N_4	8.73±4.29	9.14±2.34	8.59±2.32	7.30±2.37
		Total dry weight per bulb (g)		
N_1	37.50±13.38	35.70±14.16	21.76± 8.74	19.40±5.11
N_2	38.21±15.36	25.67±12.40	28.38±14.57	33.42±0.56
N_3	31.04±15.61	23.60± 8.82	30.26±16.84	35.30±7.23
N_4	25.51± 0.83	33.83±10.32	31.99± 1.20	35.32±8.18
		Dry weight per bulb (g)		
N_1	6.58±2.27	6.20±2.60	3.64±0.63	3.30±0.32
N_2	5.98±2.07	5.04±2.84	4.76±2.43	5.46±1.59
N_3	5.34±3.47	4.96±1.19	5.57±3.32	6.84±1.34
N_4	5.14±2.05	6.02±2.52	6.56±1.21	5.94±1.99

Correlation between vegetative characters and yield components. Based on correlation analysis among parameters due to fertilizer combinations treatments (Table 5 and 6), it was resulted that plant height was significantly positive correlated with leaf number and bulb number per clump with r = 0.747 and r = 0.710 for N and P combination treatments, and r = 0.678 and r = 0.684 for N and K treatments. Deden (2014) reported that higher plant height and more number of leaves would increase shallot production as seen in bulb number per clump. Rahayu and Berlian (2004) added that well-grown shallot was characterized by having longer and more number of leaves so that it would produce bigger bulbs resulting in higher yield production. Higher plant was believed would produce more photosynthates which later be translocated to the storing organs and would initiate bigger bulb development (Arifin *et al*., 2014). Leaf number was significantly positive correlated to tiller number, total bulb fresh weight per clump and total bulb dry weight per clump. The more number of shallot leaves, the more photosynthates produced and the more carbohydrates translocated to the storing organs or to other developing organs Khoiroh, 2014).

From N and P combination treatments, significant correlations were resulted from plant height to leaf number, bulb number, total bulb dry weight per clump and dry weight per bulb (Table 5). Limbongan and Monde (1999) reported that leaf number of a variety would related

to bulb number due to more photosynthates produced. More photosynthates would also lead to more tiller number. For leaf number parameter, it was significantly positive correlated to tiller number, bulb number, total bulb fresh weight per clump, total bulb dry weight per clump and dry weight per bulb. While tiller number correlated with bulb number. Shallot plant with more tiller number would also produce more number of bulbs. Similar to this result, Kusmana et al. (2009) reported that Tanduyung shallot variety with the most number of tillers had produced the most number of bulbs. Total bulb fresh weight per clump significantly correlated to total bulb dry weight per clump. Research finding by Mayun (2007) also showed similar result where fresh weight per bulb affected air-dried bulb weight.

Table 5 – Correlation among parameters due to the application of N and P fertilizer

No	Parameters	Plant height	Leaf number per clump	Tiller number per clump	Bulb number per clump	Total bulb fresh weight per clump	Fresh weight per bulb	Total bulb dry weight per clump	Dry weight per bulb
1	Plant height	1	0.747*	0.605ns	0.710*	0.778ns	0.600ns	0.816*	0.797*
2	Leaf number per clump		1	0.869**	0.916**	0.809**	0.521ns	0.843**	0.716*
3	Tiller number per clump			1	0.769*	0.582ns	0.380ns	0.591ns	0.488ns
4	Bulb number per clumo				1	0.764*	0.392ns	0.839**	0.676*
5	Total bulb fresh weight per clump					1	0.855**	0.959**	0.936**
6	Fresh weight per bulb						1	0.730*	0.849**
7	Total bulb dry weight per clump							1	0.943**
8	Dry weight per bulb								1
r 5% = 0.666, r 1% = 0.798									

Table 6 – Correlation among parameters due to the application of N and K fertilizer

No	Parameters	Plant height	Leaf number per clump	Tiller number per clump	Bulb number per clump	Total bulb fresh weight per clump	Fresh weight per bulb	Total bulb dry weight per clump	Dry weight per bulb
1	Plant height	1	0.678*	0.726*	0.684*	0.552ns	0.331ns	0.464ns	0.262ns
2	Leaf number per clump		1	0.716*	0.637ns	0.728*	0.441ns	0.779*	0.517ns
3	Tiller number per clump			1	0.628ns	0.433ns	0.211ns	0.322ns	0.040ns
4	Bulb number per clumo				1	0.523ns	0.132ns	0.343ns	-0.013ns
5	Total bulb fresh weight per clump					1	0.831**	0.855**	0.712*
6	Fresh weight per bulb						1	0.665ns	0.772*
7	Total bulb dry weight per clump							1	0.887**
8	Dry weight per bulb								1
r 5% = 0.666, r 1% = 0.798									

Table 6 shows significant positive correlation was found between growth parameters, such as plant height and leaf number, to shallot yield due to the application of N and K fertilizers. However no significant response was resulted from all parameters for both growth and yield characters based on the analysis of variance (data not shown). Positive correlation

was found between plant height and leaf number since shallot height was vertically measured the highest leaf so that it assumed that plant height would increase following the increase in leaf number. The increase in leaf number would benefit the plant regarding the enhanced sunlight interception and CO_2 fixation for photosynthesis (Ni'am and Bintari, 2017).

Leaf number also significantly positive correlated with tiller number, total bulb fresh weight per clump, and total bulb dry weight per clump. It was clearly understandable that plant with more tiller number would also have more leaf number leading to the improved in photosynthetic rate resulting in better accumulation of photosynthates. Similar to this, a study by Eki et al. (2016) resulted that plant fresh and dry weight was increased following the increase in leaf number and leaf area. Bulb dry weight would greatly depended on bulb fresh weight as reported by Yusniwati et al. (2014).

CONCLUSION

Plant height was significantly positive correlated with bulb number, total bulb dry weight per clump and dry weight per bulb for either N and P combinations or N and K combinations. Tiller number was only significantly positive correlated with bulb number per clump on N and P combinations, and had no correlation for all yield paramaters on N and K combinations.

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