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Growth and yields of shallot (*allium cepa* l.) as responses to the combination of inorganic and organic fertilizers enriched with functional microbes

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Growth and yields of shallot (*allium cepa* l.) as responses to the combination of inorganic and organic fertilizers enriched with functional microbes

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Abstract. The use of inorganic fertilizers combined organic fertilizer is commonly applied by farmers to increase shallot production. Research was conducted to determine the proper dosage of organic fertilizer which can reduce the use of inorganic fertilizer. The research was conducted at Tawangargo Village, Karangploso district, Malang. The fertilizers were organic fertilizers, enriched with N-fixing bacteria and P solvent bacteria. The research used RCBD where the treatments were combinations of organic and inorganic fertilizers. The dose of organic fertilizer enriched functional microbes was set at 2 t/ha, while the dose for inorganic fertilizer is a combination of 600 kg/ha NPK+200 kg/ha SP36+400 ZA+100 kg/ha ZK. As comparison, farmers applied organic fertilizer from cow manure and without fertilization as control. The results showed that standard dose 100% inorganic fertilizer (1,300 kg/ha) + 100% standard dose (2,000 kg/ha) microbial-enriched organic fertilizer increased RAE 2% that produced 12.50 t/ha dry shallots in comparison with the farmer control. By dose of 2 t/ha of organic fertilizer enriched with functional microbes, the results will be equivalent to local organic fertilizer of 10,000 kg/ha and it is more effective than local organic fertilizers from cow manure.

1. Introduction

Fertilizer application is a strategy which is applied by the farmers to increase soil and crop productivities. Raw materials for most of the commercial fertilizers in the marketplace are classified into inorganic (chemical) and organic fertilizers. Farmers prefer inorganic fertilizers to organic fertilizers because they show quick responses to growth and yields. Some findings of the research indicated that most of the intensive farming land have degraded and decreased land productivity, particularly that related to lower C-organic level in the soil, <2 %, and most of them are found on intensive lands in Java. In order to gain optimal productivity, C-organic >2 % is required. One of alternative solutions to add C-organic is the application of organic fertilizer. Organic fertilizers stimulate plant growth and more efficiency than just chemical fertilizer application [1]. Organic fertilizers will be able to increase productivity of farming commodities, both quality and quantity, and be able to reduce environmental pollution, as well as to increase land quality continuously [2]. Organic fertilizers are able to stimulate the growth of roots and crops by increasing microorganism population in the soil, so that organic fertilizers are included in fertilization program to increase the harvest yields.

Inorganic fertilizers provide from one type of nutrient (single fertilizer) to several types of nutrients (complex fertilizers) for the crops, but they do not provide carbon compound, which is able to improve physical and biological properties of the soil, and most of them do not provide micronutrients. [3] suggested that the application of nitrogen without other macronutrients will reduce dry matter of the bulb/tuber for about 4%; furthermore, [4] suggested that *rendemen* (sucrose content of sugar cane) and quality of the shallots are highly affected by types of fertilizer, and the highest yields are obtained by the application of chicken dropping.

The observed organic fertilizers have met the standard and enriched with functional microbe, so that they are required further research in the field, [5] the main study is the use of organic and inorganic integrated fertilizers combined with biological fertilizers. Balanced fertilization by combining the use of chemicals, organic / biological fertilizers must be developed [6]. Objective of the research was to study the effect of combination of organic and inorganic fertilizers enriched with Nitrogen-binding bacteria and Phosphor solvent bacteria to growth and yields of shallots.

2. Materials and methods

The research was conducted on the farmer land at Kalang of Tawangargo Village, Karangploso district, Malang Regency from March to June 2018 at the altitude of 750 m asl (above sea level) at 24-29^{0}C. Based on soil analysis results, cation exchange capacity of the soil was high along with soil texture which is dominated by clay fraction. Phosphor and calcium are very high and low organic material content.

The shallot seeds used in the research were from Bauji variety. Doses of the inorganic fertilizers, which are commonly used by local farmers are as follow: 200 kg/ha SP36 + 600 kg/ha NPK Mutiara + 400 kg/ha ZA + 100 kg/ha ZK. For the control, it refers to the treatment without fertilizer and the comparative one is local organic fertilizer, compost from cow manure.

Table 1. Dosages of the Inorganic and Organic Fertilizers

No	Code	Treatment	Dose (kg/ha)				
			SP36	NPK	ZA	ZK	Organic Fertilizer
1	Control	Without Fertilizer	0	0	0	0	0
2	Standard	1 CF Standard + 10 t/ha Local Organic Fertilizer	200	600	400	100	0
3	A	1 CF Standard + 100 % Organic Fertilizer	200	600	400	100	2000
4	B	0.75 CF Standard + 100 % Organic Fertilizer	150	450	300	75	2000
5	C	0.5 CF Standard + 100 % Organic Fertilizer	100	300	200	50	2000
6	D	0.25 CF Standard + 100 % Organic Fertilizer	50	150	100	25	2000
7	E	1 CF Standard + 75 % Organic Fertilizer	200	600	400	100	1500
8	F	1 CF Standard + 50 % Organic Fertilizer	200	600	400	100	1000
9	G	1 CF Standard + 25 % Organic Fertilizer	200	600	400	100	500
10	H	0.75 CF Standard + 75 % Organic Fertilizer	150	450	300	75	1500
11	I	0.5 CF Standard + 50 % Organic Fertilizer	100	300	200	50	1000
12	J	0.25 CF Standard + 25 % Organic Fertilizer	50	150	100	25	500

Info: CF = chemical fertilizers

Results for quality test of the organic fertilizers enriched with N-binding bacteria and P solvent bacteria are: Organic Carbon 19.15%, C/N ratio 16.95, Total N + P_2O_5 + K_2O 8.11%, Water Content 18.84%, Arsenic 0.07 ppm. Mercury 0.08 ppm, pH 9, available Fe 103.9 ppm, Mn 455.3 ppm, and Zn 256.3 ppm

Method of the research applied Randomized Block Design, 12 treatments along with 3 replications (Table 1). Parameters of the observation include plant height, numbers of leaf/clump, numbers of tuber per clump, wet weight of tuber, and dry weight of tuber. In order to find out effect of the treatments, F-test was applied by trust interval 5 %. Effectiveness of the organic fertilizers to the growth of the shallots was obtained through RAE (Relative Agronomic Effectiveness) analysis by the equation as follows:

$$RAE = \frac{\text{Results of the tested fertilizer - control x 100 \%}}{\text{Results of the standard fertilizers - control}}$$

3. Results and discussion

Data analysis of the observation on height of the shallots at 45 DAP (days after planting) showed that substitution of 10,000 kg/ha local manure with 2,000 kg/ha organic fertilizer is not potential to reduce plant height significantly on combined treatment of the same inorganic fertilizers 1,300 kg/ha. Substitution of local manure with organic fertilizer in combination with 1,300 kg/ha standard fertilizers has resulted significant plant height. Based on results of the study, the application of organic and inorganic fertilizers affected the growth and productivity of the sweet corn [7] and shallots [8].

Table 2. Effect of the fertilizer application on height and numbers of leaf in Shallots

No	Code	Plant Height (cm)			Number of Leaf per Clump		
		15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP
1	Control	18.67 f	28.27 f	41.17 g	23.47 ab	41.27 e	60.57 g
2	Standard	24.87 a	38.00 b	48.37 ab	24.63 a	55.43 a	78.30 ab
3	A	24.33 ab	40.73 a	48.73 a	24.27 ab	53.87 ab	76.00 ab
4	B	24.86 a	35.33 bc	48.07 abc	24.50 a	50.50 c	75.63 ab
5	C	22.93 cd	34.90 cd	47.27 abcd	23.00 b	49.87 c	69.27 def
6	D	22.57 cd	36.63 bc	46.13 de	22.43 b	45.73 d	71.20 cde
7	E	24.10 ab	36.53 bc	47.03 bcde	24.47 a	53.37 b	73.90 bc
8	F	25.53 bc	37.10 bc	47.70 abcd	24.23 ab	50.73 c	72.33 cd
9	G	24.50 ab	36.13 bc	46.57 cde	23.57 ab	50.50 c	71.30 cde
10	H	22.20 d	34.23 cd	45.50 e	24.00 ab	49.33 c	71.77 cde
11	I	21.83 d	32.37 de	43.07 f	23.57 ab	45.70 d	68.60 ef
12	J	20.97 e	31.03 e	42.83 f	23.47 ab	44.07 d	67.37 f

In general, addition of organic fertilizer by dose 2,000 kg/ha has been able to substitute the application of local organic fertilizer 10,000 kg/ha. Reduction of inorganic fertilizer 0.25-0.5 from the standard dose with the same application of organic fertilizer (2,000 kg/ha) will reduce numbers of the shallot plantlets. In the combination treatment of inorganic fertilizer with the same dose as the standard one (1300 kg/ha), reduction of organic fertilizer has reached 25 %, and it would not reduce numbers of the plantlet. It means that addition of inorganic fertilizers is required. During the observation at 30 DAP and 45 DAP, the application of fertilizers have affected on numbers of leaf. According to [5], the application of inorganic and organic fertilizers enriched with microbe will be able to maintain fertility and quality of the soil, as well as the plant growth and according to research results [9] Liquid organic fertilizer can increase the number of spring onions.

In combination treatment with standard dose of inorganic fertilizer (1,300 kg/ha), the application of organic fertilizer could be reduced from 1,500 kg/ha to 1,000 kg/ha without decreasing numbers of leaf. Reduction of inorganic fertilizer 75%, 50%, and 25% will significantly reduce numbers of leaf. It conforms to the suggestion of previous research that the application of organic and inorganic fertilizers with NPK by proper dose will be able to increase growth and yield of the shallots [10].

The combined fertilizer treatment has significantly affected on parameter in numbers of tuber per clump, production of wet tuber and dry tuber. [11] concluded that the application of organic fertilizer has not only improved soil structure, but also modified ability of the soil to retain much water, stimulate root development, growth and numbers of tuber/plantlet. Based on results of the research by

[12] and [13], response of organic and inorganic fertilizers application is able to increase growth as presented in parameters on numbers of leaf and tuber weight of the shallots.

Table 3. Effect of the fertilizer application on numbers of plantlet/tuber and numbers of the harvested tuber of shallots

No	Code	Number of Plantlet per Clump (Tuber)			
		15 DAP	30 DAP	45 DAP	Harvest
1	Control	4.96 d	5.73 f	6.50 f	23.47 ab
2	Standard	7.50 a	8.10 a	10.53 a	24.63 a
3	A	7.47 a	8.17 a	10.47 a	24.27 ab
4	B	6.70 bc	7.40 b	10.23 a	24.50 a
5	C	6.13 c	7.00 c	8.00 abc	23.00 b
6	D	6.07 c	6.40 de	7.67 e	22.43 b
7	E	7.40 ab	8.03 a	9.00 b	24.47 a
8	F	6.83 abc	7.93 a	8.93 bc	24.23 ab
9	G	6.80 abc	6.93 c	8.73 bcd	23.57 ab
10	H	6.20 c	6.50 d	8.37 bcde	24.00 ab
11	I	5.00 d	6.33 de	8.00 cde	23.57 ab
12	J	5.00 d	6.10 e	7.80 de	23.47 ab

Combination of organic fertilizer 2,000 kg/ha and inorganic fertilizer was started from standard dose (1,300 kg/ha), and then reduced to 0.5 times (650 kg/ha) have not affected on numbers of tuber. The highest numbers of tuber were resulted from treatment A or combination of inorganic fertilizer by standard dose (1,300 kg/ha) and organic fertilizer 2,000 kg/ha. The application of inorganic fertilizer as recommended and the compost has produced maximum biomass of shallots [14].

Pattern of the fertilizer application effect that was tested on parameter of wet tuber and dry tuber was alike. The lowest yield of dry tuber, 5.16 t/ha, was resulted from the control, while the highest yield was resulted from treatment A, a package of standard inorganic fertilizer (1,300 kg/ha) plus 100% organic fertilizer (2,000 kg/ha) that produced 12.50t/ha dry tubers. The application of organic fertilizer has produced the same yields as the application of local organic fertilizer 10,000 kg/ha.

Table 4. Effect of the Fertilizer Application on Weight of Wet Tuber, Dry Tuber, and RAE Value

No	Code	Harvest Yield (t/ha)		RAE (%)
		Wet Tuber	Dry Tuber	
1	Control	9.56 g	5.90 f	-
2	Standard	15.63 abc	12.38 ab	100
3	A	16.06 a	12.50 a	102
4	B	15.52 abc	11.57 abc	88
5	C	14.65 cd	10.78 c	75
6	D	1.21 f	8.81 e	45
7	E	15.95 ab	11.75 abc	90
8	F	15.45 abc	11.12 c	81
9	G	14.34 de	10.99 c	79
10	H	14.98 bcd	11.48 bc	86
11	I	13.55 e	9.85 d	61
12	J	11.64f	8.53 e	41

Dose of organic fertilizer 2,000 kg/ha, which was combined with 0.75 times dose of standard inorganic fertilizer (975 kg/ha) in treatment B, did not significantly reduce the yield. The equal yields were shown in treatment E, the combination of inorganic fertilizer (1,300 kg/ha) and 75 % dose of organic fertilizer (1,500 kg/ha). The decreasing dose of inorganic fertilizer, 0.5 doses or 0.25 times of the standard dose, has significantly reduce the yields. [15] concluded that the mixture of organic and

inorganic fertilizers will be able to increase growth of the shallots tubers. It is also supported by results of the research by [16] which showed that the addition of compost has significantly affected on the increase of growth and produce the highest yield on chili. [12] research result The application of chemical fertilizers and compost gives the maximum plant biomass of onions.

The highest dose of organic fertilizer (2,000 kg/ha) along with the addition of inorganic fertilizer are still required to obtain equal yields as the recommended dose. Dose of organic fertilizer/local compost was previously 10,000 kg/ha, if it applied sufficient organic fertilizer by dose 2,000 kg/ha to obtain the equal yields. Organic fertilizer is able to increase C-organic of the soil, which is soluble, particularly organic acids that increase P available in the soil as well as yield of the tubers [17] and [18]. Organic fertilizers suitable for increasing soil fertility and plant growth can be incorporated into fertilization programs to increase crop yields [19] and the application of chicken manure with microbes obtained the highest yield of shallots [20].

RAE value was gained by comparing the tested treatments and standard treatments of inorganic fertilizers (200 kg/ha SP36 + 600 kg/ha NPK+400kg/ha ZA+100 kg/ha ZK + local organic fertilizer 10,000 kg/ha) with the control. Yield of dry tuber in the treatment was used as standard of RAE value. Organic fertilizer enriched with N solvent bacteria and P have produced dry weight 12.50 t/ha with RAE value 102 %. According to [21], the application of organic fertilizer bio-urine 1,000 liter/ha and inorganic fertilizer have increased growth and yield of shallots, Filipina variety.

4. Conclusion

The application of organic fertilizer combined with inorganic fertilizer by standard dose (1,300 kg/ha) in diverse comparison (1; 0.75 and 0.5) has affected on plant height, numbers of plantlet, and numbers of leaf. Those doses have significantly affected on numbers of tuber, yields of wet and dry tubers. The application of organic fertilizer 2,000 kg/ha has been able to substitute local organic fertilizer (bokashi/compost of the farmer) 10,000 kg/ha, with higher yield, 12.5 t/ha and the highest agronomic effectiveness with RAE value 102 %. The recommended application of organic fertilizer is 2,000 kg/ha combined with 1300 kg/ha standard inorganic fertilizer or with 0.75 times of the inorganic fertilizer dose (975 kg/ha) for alternative of the recommended fertilizer application, which is environmentally friendly.

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