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Effectiveness of Plant Growth Promoting Rhizobacteria and NPK Inorganic Fertilizer on the Growth and Yield of Shallot Plants

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Abstract

Using a combination of inorganic fertilizer and plant growth-promoting rhizobacteria is expected to reduce the residue of inorganic fertilizer use, improve soil fertility, and increase the growth and yield of shallot plants. This study aimed to determine the effectiveness of PGPR doses and their combination with inorganic fertilizer NPK in reducing the dosage of inorganic fertilizers on the growth and yield of shallot plants. This research was conducted in Maja Selatan Village, Maja District, Majalengka Regency, West Java Province. The research was carried out from September to November 2021. The materials used were: The red onion seeds of the Batu Ijo variety, Liquid PGPR containing Pseudomonas fluorescence: 9.3 x 108 CFU/ml and Rhizobium sp: 3.4 x 108 CFU/ml and also enriched with Azospirilum sp: 7.3 x 108 CFU/ml, Aspergillus niger: 3.4 x 107 CFU/ml and Trichoderma harzianum: 1.3 x 107 CFU/ml, for inorganic fertilizers use NPK Mutiara compound fertilizer. The research design used was a non-factorial Randomized Block Design (RAK), namely giving a combination of doses of NPK Mutiara fertilizer and PGPR with five treatments and five repetitions for each Treatment so that there were 25 planting holes with a distance of 15x15 cm, as follows: Treatment A = 100% Dose NPK compound fertilizer and 0% PGPR, Treatment B = Dosage of 75% NPK compound fertilizer and 25% PGPR, Treatment C = Dose of 50% NPK compound fertilizer and 50% PGPR, Treatment D = Dosage of 25% NPK compound fertilizer and 75% PGPR and Treatment E = Dosage of 0% NPK compound fertilizer and 100% PGPR. The data were analyzed using non-factorial RAK; if the Innova was found to have an effect, then it would be continued with a further test using LSI. Variables observed included plant height, Number of leaves, flowering time and tuber fresh weight. A regression analysis was carried out to determine the effectiveness of using PGPR. The results showed that all observational variables affected the administration of a combination of PGPR and inorganic fertilizers. The best combination was shown by the Treatment of 25% NPK and 75% PGPR on plant height, Number of leaves, flowering age and tuber fresh weight. The regression analysis results showed that increasing the dose of NPK correlated negatively, meaning that the higher the dose, the lower the yield. In contrast, the addition of PGPR was positively correlated, meaning that the higher the dose, the higher the shallot yield. The combination of NPK and PGPR fertilizers can reduce the use of inorganic fertilizers by up to 25%.

Keyword : Anorganic fertilizer; plant growth-promoting bacteria; red onion (Ascending)

Introduction

Shallots (Allium ascalonicum L) are a vegetable plant widely used by the community, so they are a superior crop that many farmers cultivate intensively (Tuhuteru et al., 2019). The thing that hampers shallot production is the lack of good microbes in the plant's root area, causing the plant to be attacked by various root diseases. Apart from that, it is also caused by a lack of nutrients available in the soil and the low ability of the roots to absorb the nutrients available to the plant (Fitriatin et al., 2023) Using inorganic fertilizers to increase agricultural yields has been successful so far. However, the continuous use of inorganic fertilizers can be detrimental to the sustainability of agricultural businesses in terms of price and environmental impact (Umbola et al., 2020). This is also one of the factors causing low soil fertility and insufficient crop nutrition. Combining biological and inorganic fertilizers is expected to improve soil and plant quality and maintain shallot production in Indonesia. Apart from functioning to reduce the residual effects of inorganic fertilizers, biological fertilizers can add macro and micronutrients to the soil, improving the soil's physical, chemical and biological properties (Duan et al., 2023). One of the biological fertilizers that has a role in improving soil fertility and plant production is Plant Growth Promoting Rhizobacteria (PGPR).

PGPR are soil microbes around planting roots that directly or indirectly stimulate plant growth and development (Khoso et al., 2024). PGPR stimulates plant growth by producing growth hormones, vitamins and various organic acids and increasing plant nutritional intake (Rosyida & Nugroho, 2017; Wulandari et al., 2021). PGPR stimulates plant growth by producing growth hormones, vitamins, and organic acids and increasing nutritional intake (Saeed et al., 2021; Dos Santos et al., 2020). Apart from that, PGPR can also change the root system, induce antioxidants, produce exopolysaccharides (EPS) and siderophores, regulate plant hormones and mineral absorption and control plant pathogens (Arora et al., 2020). Various studies have shown that PGPR affects the growth and yield of various vegetable crops. A PGPR concentration of 5 ml/L in leek plants shows good results (Sukarno, 2014). Marom et al. (2017) reported that PGPR bacteria could increase the production and quality of peanut seeds with PGPR concentrations consisting of 0 ml/L, 7.5 ml/L, 10 ml/L and 12.5 ml/L. The research results of Novatriana and Hariyono (2020) showed that administering PGPR at a dose of 30 ml increased plant height, Number of leaves, leaf area, fresh weight, dry weight, Number of bulbs and diameter of shallot bulbs.

The results of previous research by Sukmasari and Nurmaladiyanti (2020) using PGPR 10 ml/l and NPK Mutiara 0.6 g/l increased the average growth and yield of shallots in paddy fields. Utami et al. (2017) also reported that PGPR application can reduce the amount of inorganic fertilizer used on cut chrysanthemum plants. Research conducted by Putra et al. (2023) regarding the Effect of Using PGPR and a balance of Organic and Inorganic Fertilizers on the Flowering and Yield of Shallots results shows that the interaction of using PGPR with a balance of organic and inorganic fertilizers does not have a real effect on plant growth components—flowering of plants and components of shallot crop yields. The effect of using biological fertilizer is slower than inorganic fertilizer, so fertilizer management by combining biological fertilizer with inorganic fertilizer is considered ideal in plant cultivation (Sondang et al., 2019). Research shows that PGPR application can reduce inorganic fertilizer doses, especially on horticultural crops. This research aims to determine the effectiveness of PGPR dosage and its combination with NPK inorganic fertilizer in reducing inorganic fertilizer dosage on the growth and yield of shallot plants.

Research Methods

This research was conducted in South Maja Village, Maja District, Majalengka Regency, West Java Province, 600 meters above sea level, with a type C (Slightly Wet) agroclimate. The research was carried out from September to November 2022. The materials used were: Batu Ijo variety shallot seeds, Liquid PGPR containing Pseudomonas fluorescence: 9.3 x 108 CFU/ml and Rhizobium sp: 3.4 x 108 CFU/ml and also enriched with the microbes Azospirilum sp: 7.3 x 108 CFU/ml, Aspergillus niger: 3.4 x 107 CFU/ml and Trichoderma harzianum: 1.3 x 107 CFU/ml, for inorganic fertilizer using NPK Mutiara compound fertilizer. Meanwhile, the tools used were a hoe, measuring tape, sickle, hand sprayer, vernier calliper, plastic rope, calculator, scales, camera, stationery, and treatment nameplate.

Research design

The research design used was a non-factorial Randomized Block Design (RBD), namely treatment a combination of NPK Mutiara and PGPR fertilizer doses with five treatments and five replications of each Treatment so that there were 25 planting holes with a distance of 15x15 cm, as follows.

Treatment A = Dose of 100% NPK compound fertilizer and 0% PGPR

Treatment B = Dose of 75% NPK compound fertilizer and 25% PGPR

Treatment C = Dose of 50% NPK compound fertilizer and 50% PGPR

Treatment D = Dose of 25% NPK compound fertilizer and 75% PGPR

Treatment E = Dose of 0% NPK compound fertilizer and 100% PGPR

Each Treatment was repeated five times so that there were 25 experimental units. Each plot measures 1 m x 1 m with a distance between plots of 25 cm and a planting distance of 15 x 15 cm.

Data analysis

The data is analyzed using non-factorial RAK; if an influence is found in ANOVA, it will be continued with further LSI tests. Differences in mean responses were tested using the LSI test.

LSI = t_a √2KTG/r

Information :

t_a	= t table value at the 5% level
KTG	= Middle Square Error
R	= Number of repetitions

Next, regression and correlation tests were carried out at a test level of 5%.

Experiment Implementation

1. Land preparation

Soil is prepared by ploughing with a hand tractor, then destroying and levelling it. After processing, the land is divided into two groups, assuming everything is evenly distributed, and the distance between plots is 25 cm. Each plot measures 1 m x 1 m.

2. Seeding and Planting

Twenty-five shallot seeds each are sown in the seeding container until the seeds sprout and grow into seedlings. The shallots that are seven days old are then moved to the prepared planting area.

3. Providing Treatment

Treatment in the form of PGPR and NPK compound fertilizer was applied to shallot plants with varying doses as detailed in the Treatment. Inorganic fertilizer is applied by sprinkling it around the root area, while PGPR is sprayed into the hole at the edge of the plant. NPK and PGPR compound fertilizers are applied four times during the growing season, namely after sowing, 14 DAP, 28 DAP and 42 DAP based on the predetermined treatment dose.

4. Maintenance and Care

Weed control: Weed control is done physically by pulling out the weeds and submerging them again. Control is carried out according to field conditions. Watering can be done twice daily, every morning and evening until the plants are ten days old. Furthermore, the watering frequency can be daily until the plant is 60 days old.

5. Harvest

Determining the harvest time for shallots can be done by:

a. Visually, by looking at the physical development of the plant, for consumption purposes, the characteristics are that the leaves are starting to turn yellow, the leaves are drooping, the tubers appear to protrude from the surface of the soil, the colour of the tubers looks reddish. For seed purposes, the plant leaves are completely drooping (more than 30% yellowing).

b. Computationally, for consumption purposes, the age of plants from planting depends on the variety/cultivar, weather/season, and plant maintenance. (The green stone variety in the highlands is harvested at 65-70 HST.

The variables observed in this research included plant height, Number of leaves, flowering age, tuber wet weight, tuber dry weight and plant N and P nutrient uptake.

Results And Discussion

Soil analysis

The soil analysis results showed that the soil at the experimental site had low soil fertility status, as seen from low physical, chemical, and biological properties (Table 1). Soil fertility is the quality of the soil in which plants are cultivated, which is determined by the physical, chemical and biological properties of the soil in which plant roots live (Javed et al., 2022). Soil pH tends to be acidic, and organic C is also very low, indicating low fertility in this experimental land. According to Ramadhana et al. (2019), low soil fertility status is caused by a limiting factor: low soil C-organic content. Soil organic C content greatly influences soil fertility and productivity through soil microorganisms' activity. Adding organic matter is one of the most appropriate ways because soil organic matter is important for soil fertility.

The soil analysis results also show that the total N content of the soil is very low, so giving NPK and PGPR together will provide optimal nutrition for plants. Providing PGPR will stimulate nitrogen availability through N fixation by bacteria in PGPR. Vacheron et al. (2013) revealed that several groups of bacteria in PGPR, such as Azospirillum sp (Cummings, 2009), act as bacteria that fix N2 in the air. Apart from that, Table 1 also shows that the availability of P in the soil is high, but only a small amount is available and can be absorbed by plants. It is appropriate to provide soil microbes through PGPR to maximize the decomposition of phosphorus bound in the soil so that it is available and can be absorbed by plants. The bacteria in PGPR can dissolve phosphorus fertilizer, thereby maximizing the absorption of phosphorus nutrients (Etesami et al., 2021).

Table 1. Soil Analysis Results Before Experiment

No	Parameter	Unit	Results	Criteria
1.	pH: H2O	-	5,68	Sour
2.	pH: KCl l N	-	4,44	-
3.	C-Organic	(%)	0,86	Low
4.	N-total	(%)	0,08	Very low
5.	C/N	-	11	Currently
6.	P_2O_5 HCl 25%	(mg/100g)	48,15	Tall
7.	P_2O_5 Bray	(ppm P)	2,06	Very low
8.	K2O HCl 25 %	(mg/100g)	27,37	Currently

Source: Soil Science Laboratory, Unpad

Growth Components

The results of the F test analysis at the 5% level showed that the combination of inorganic fertilizer and plant growth-promoting rhizobacteria (PGPR) affected all observation variables carried out, namely plant height, Number of leaves and flowering age of shallots. The dose combination treatment A showed significantly different results from the combination treatments B, C, D and E in the plant height variable. At the same time, the Number of leaves in Treatment A was not significantly different from Treatments B, C and E. However, treatment E was not significantly different from D. flowering age, and combination treatment A was not significantly different from B but significantly different from C, D and E.

Table 2. Application of PGPR and NPK on plant height growth, Number of leaves and flowering time of shallot plants

Treatment	Plant Height (cm)	Number of Leaves	Flowering Age
A = Dose of 100% NPK and 0% PGPR	29,24 [a]	10,40 [a]	28,60 [a]
B = Dose of 75% NPK and 25% PGPR	31,44 [b]	10,40 [a]	27,80 [a]
C = Dose of 50% NPK and 50% PGPR	31,92 [b]	10,60 [a]	27,40 [b]
D = Dose of 25% NPK and 75% PGPR	33,88 [c]	12,80 [b]	25,60 [c]
E = Dose of 0% NPK and 100% PGPR	31,34 [b]	11,40 [ab]	27,40 [b]

Note: Superscripts with different letters in the same column indicate significant differences between treatments ($P<0.05$).

Regarding growth components, plant height, Number of leaves and flowering age, application of 100% NPK and 0% PGPR gave the lowest results. In comparison, the highest results were obtained when applying 25% NPK and 75% PGPR. This indicates that the large NPK dose given to plants can only increase yields if PGPR accompanies it. PGPR has a role in increasing the ability of plants to absorb nutrients from the soil through nitrogen fixation and phosphate solubilization (Choudhary et al., 2011). Just by giving NPK alone, plants are not able to maximize the existing nutritional intake because the nature of nutrients is easily leached or easily bound in the soil, so even though in this Treatment there is an additional dose (Table 2), the large dose of NPK added is not efficient and effective in nutrient uptake for plants. Abbasi and Sepaskhah (2023) stated that nitrogen is more easily leached by water flow, so plants cannot utilize it. In contrast, according to Johan et al. (2021), most of the P is combined with metal elements such as Al and Fe, so P is unavailable in the soil for plant growth. Adding PGPR can overcome this problem because the bacteria in PGPR can provide N for plants through nitrogen fixation and phosphate dissolution by producing organic acids (Widawati & Suliasih, 2019). Amri et al. (2022) stated that the direct effect of PGPR in promoting plant growth occurs through various mechanisms, including fixation of free nitrogen for plant use, formation of siderophores which absorb iron (Fe) and make it available to plants, assisting the process of phosphate solubilization and synthetic phytohormones (A. T. Cahyani et al., 2017). Several research results (Syamsiah & Rayani, 2014; Novatriana & Hariyono, 2020) also show that applying PGPR to various plants produces a better growth response than the control. However, applying PGPR with various concentrations affects growth and shows different responses. Differences in plant growth, namely plant height, fresh weight, Number of leaves and Number of roots.

Table 2 also shows that giving 25% NPK and 75% PGPR provided the best results on the average of the observed variables; however, the addition of PGPR to 100% without giving NPK also showed a decrease in growth for all observed variables. This shows that more than PGPR is needed to increase crop yields; NPK is still needed to meet nutrient needs. Because these two fertilizers have different properties, they can complement each other's existence. Fast response to inorganic fertilizers allows nutrients to be met and can be directly utilized by plants (Haryadi et al., 2015). When PGPR is not working optimally due to its slow-release nature, This is in line with Sofyan and Sara (2018), who argue that the application of inorganic fertilizer quickly increases nutrient availability for plants. Combining biological and inorganic fertilizers can help maximize plant growth because organic materials improve soil conditions and make nutrients more easily available to plants (Iqbal et al., 2021). At the same time, providing inorganic fertilizer is necessary to increase the nutrient requirements of shallot plants quickly (Hazra, 2016).

From the analysis results in Table 2, all growth observation variables provide a good response at all levels of PGPR dosage compared to those without PGPR. The microbes in PGPR, such as N-fixing microbes and P-solubilizing microbes, can fix and dissolve P so plants can absorb it (Cahyani et al., 2018). In line with the results of research by Widiyawati et al. (2014) on lowland rice plants, giving PGPR had a good effect on increasing plant height, root dry weight, Number of filled grains per panicle, leaf greenness, as well as N uptake and content in plants. Apart from that, the applied PGPR can perform other functions as a producer of phytohormones to increase growth. Lehar et al. (2023) stated that PGPR also plays a role as a producer of growth hormones that stimulate plant growth. According to Thakuria et al. (2004), the type and capacity of rhizobacteria contained in PGPR influence the production of IAA as a growth hormone. The research results of Wulandari et al. (2020) show that PGPR bacteria isolated from people's rubber plantations produce the hormone IAA. In line with Wahyuningsih et al. (2017), PGPR can stimulate the formation of IAA and gibberellins, which act as growth hormones. Also, at flowering age, Treatment with PGPR causes flowering to be faster than without PGPR application. Fischer and Wilson (2015) revealed that PGPR increases plant resistance to stress so that carbohydrate reserves become greater and allows plants to flower and bear fruit more quickly.

Shallot Yield Components

The analysis showed that the wet and dry weight of the tubers had the best results in the combination treatment of 25% NPK and 75% PGPR, while the lowest results were shown in the 100% NPK treatment without PGPR. Meanwhile, treatments B, C and E showed better results than the 100 NPK dose without PGPR but not better than the 25% NPK and 75% PGPR treatments.

The result parameters show an increase as the dose of PGPR increases. This is likely because the availability of nutrients in the soil also increases in line with the increase in PGPR concentration. This is also in line with the research results of Marfuah and Majid (2017), who found that the PGPR application gave the best results on the total weight of kale plants. The same results were shown in research by Komansilan et al. (2023) that 15 ml/litre PGPR was able to increase the production of dry milled upland rice by 1.62 kg/plot. The adequate need for N, P and K nutrients due to the provision of nutrients from the NPK fertilizer provided and together with the help of bacteria from PGPR in plant tissue, can be absorbed by plants for metabolic processes such as the formation of carbohydrates, most of which are translocated for tuber formation and in this phase Potassium plays a role in the formation and enlargement of tubers (Tuhuteru, 2016).

Table 3. Application of PGPR and NPK inorganic fertilizer on wet weight and dry weight of shallot plant bulbs

Treatment	Tuber Wet Weight (g)	Tuber Dry Weight (g)
A = Dose of 100% NPK and 0% PGPR	13.00 ^{a}	3.74 ^{a}
B = Dose of 75% NPK and 25% PGPR	14.32 ^{b}	4.11 ^{ab}
C = Dose of 50% NPK and 50% PGPR	14.32 ^{b}	4.51 ^{b}
D = Dose of 25% NPK and 75% PGPR	16.08 ^{c}	5.34 ^{bc}
E = Dose of 0% NPK and 100% PGPR	14.58 ^{b}	4.77 ^{b}

Note: Superscripts with different letters in the same column indicate significant differences between treatments ($P<0.05$).

The existence of bacteria such as Azospirilum sp and Bacillus sp contained in PGPR, which has the function of fixing nitrogen, can facilitate the availability of N, which is very important for plants. Nitrogen functions in the formation of chlorophyll, where chlorophyll plays a role in the photosynthesis process (Fathi, 2022). N deficiency can cause chlorosis in plants and reduce leaf chlorophyll so leaf formation and plant dry weight are hampered (Lihiang & Lumingkewas, 2020). Nitrogen deficiency often inhibits plant growth at various growth phases. Plant dry weight is also related to the photosynthesis results that plants can absorb (Li et al., 2019). This is consistent with research by Putrie (2016), which shows that using PGPR applications increases seed vigour, plant height, and fresh and dry weight. Apart from nitrogen-fixing bacteria, PGPR also contains phosphorus and potassium-solubilizing bacteria. The quantity and quality of the yield components of a plant are closely related to the presence of the element phosphorus. Phosphorus plays a role in plant generative processes, including the formation of flowers, fruit and carbohydrate synthesis (Khan et al., 2023). The availability of P nutrients for plants will increase plant growth. It will be used in the photosynthesis process to produce photosynthesis and will be translocated to the plant organs, namely tubers. Sufficient potassium in this phase also affects the quantity and quality of crop yields. According to Ho et al. (2020), the K element for plants plays a role in the translocation of sugar in forming starch and protein and improves fruit size and quality in the generative phase. PGPR is also a biocontrol agent widely tested to be effective and used in controlling various plant pathogens (Jiao et al., 2021).

Apart from being influenced by the dosage of NPK and PGPR, the increase in plant tuber weight may be influenced by adequate water uptake by plant cells and an increase in the rate of photosynthesis. Increasing the rate of photosynthesis will increase the formation rate of carbohydrates and other food substances (Kurniasih & Soedrajat, 2019). The good results shown in the yield component are also directly proportional to the results in the growth component. These two components are closely related to each other because the results of the generative component are a manifestation of the growth component. Komansilan et al. (2023) said that production results from vegetative growth as indicated by the dry weight of the crop harvest and the physiological and metabolic functions of the vegetative organs in supplying carbon compounds to the seeds.

N and P nutrient uptake

The plant nutrient uptake test results showed that the greater the dose of PGPR given, the greater the increase in plant nutrient uptake (Table 4). Adding 100% PGPR without NPK inorganic fertilizer still showed positive results on plant tissue N and P nutrient uptake. This aligns with research by Jannah et al., (2022) that found that N uptake increased in plants given PGPR biofertilizer compared to plants that only used 100% NPK fertilizer. This increase occurs because bacteria can bind N from the air while providing inorganic fertilizer, thus meeting the N nutrient needs of plants. Hendarto et al., (2021) also revealed that using biological fertilizer containing PGPR could reduce the use of NPK fertilizer by 25% of the recommended fertilizer dose. Likewise, P uptake showed increasing results in line with the increase in PGPR dose. Application without PGPR, only with 100% NPK dose, showed the lowest results.

Table 4. Application of PGPR and NPK on N and P nutrient uptake in shallot plants

Treatment	N Nutrient Uptake (mg/plant)	Nutrient P Uptake (mg/plant)
A = Dose of 100% NPK and 0% PGPR	65,00 ^{a}	18,93 ^{a}
B = Dose of 75% NPK and 25% PGPR	78,32 ^{b}	23,02 ^{b}
C = Dose of 50% NPK and 50% PGPR	129,82 ^{c}	23,32 ^{b}
D = Dose of 25% NPK and 75% PGPR	122,40 ^{c}	24,26 ^{bc}
E = Dose of 0% NPK and 100% PGPR	124,56 ^{c}	24,53 ^{bc}

Note: Superscripts with different letters in the same column indicate significant differences between treatments ($P<0.05$).

Apart from providing nutrients for plants, many research results report that PGPR can act as a biostimulant capable of producing growth hormones, one of which is the hormone indole acetic acid (IAA). Research by Diarta et al. (2016), which tested the ability of Bacillus subtilis and Pseudomonas fluorescens bacterial isolates as PGPR agents, respectively, was able to produce IAA concentrations of 1.09 ppm and 0.93 ppm. The results of research by Simanungkalit et al. (2006), who tested the bacterial isolate Azospirillum spp. Corn seeds can increase the length of plant roots and produce the IAA hormone as much as 2.04 ppm. The IAA hormone produces more lateral roots, root hairs and root hair branches (Insani et al., 2023). Optimal root growth will also optimize nutrient uptake in plants. Patten and Glick (2002) stated that bacteria capable of producing IAA can stimulate root growth, increasing the surface area of the roots and resulting in greater absorption of water and nutrients.

Fertilization Correlation

The results of correlating NPK and PGPR fertilizers with plant productivity show that NPK fertilizer has a very strong negative correlation with productivity with a coefficient of -0.709. In contrast, PGPR has a very strong positive correlation with a value of 0.709 (Table 5).

Table 5. Correlation of fertilization with productivity

Fertilizer	Productivity
NPK	-0.709
PGPR	0.709

Note: * = significantly correlated at the 95% confidence level, tn = not significantly correlated at the 95% confidence level

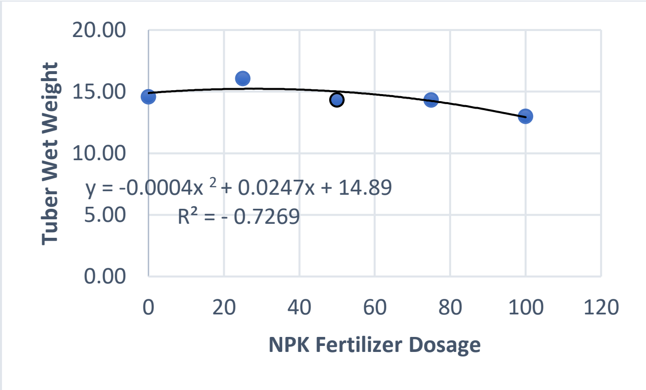

Figure 1. Regression graph of NPK and productivity

The relationship between the dose of NPK fertilizer and the yield of shallot bulbs at harvest age is shown in Figure 1. Figure 1 shows that the higher the dose of NPK fertilizer, the lower the production of onion bulbs, following a negative linear regression curve with an r-value of -0.709. Increasing the dose of NPK fertilizer by one g/plot means the tuber yield decreases by 0.3 gram. Excessive NPK fertilization can reduce sucrose levels because it decomposes to form the energy needed to convert mineral N into organic N (Jin et al., 2022). Apart from that, excessive doses of NPK will stimulate PGPR.

Meanwhile, giving PGPR has a very strong positive correlation with tuber yield. This means that the higher the dose, the better the results obtained in this study. This is related to the activity of microorganisms contained in PGPR as providers of nutrients for plants. Bachtiar et al. (2017) stated that the activity of microorganisms in the soil is very useful in providing nutrients to plants. The higher the dose, the higher the Number of microorganisms in the soil. Apart from being able to solubilize P, fix N, and provide phytohormones, these bacteria can also act as biocontrol agents that can improve root health and plant growth through protection against disease. In addition, PGPR microorganisms ensure the availability of important nutrients for plants and increase the efficiency of nutrient use (Nandal & Hooda, 2013).

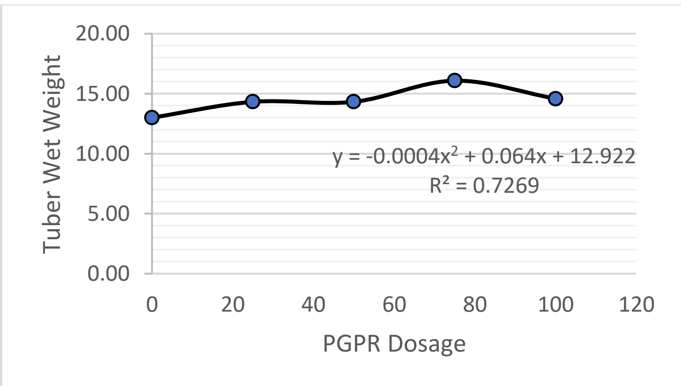

Figure 2. Regression graph of PGPR with productivity

Apart from that, the research results also show that the combination of PGPR and NPK inorganic fertilizer can reduce the use of NPK fertilizer by up to 75%. In line with research by Hindersah et al. (2018) that PGPR inoculation accompanied by a reduction in the dose of inorganic NPK fertilizer on long bean plants was not significantly different from the control treatment at the recommended dose, so PGPR inoculated on long beans was able to reduce the use of inorganic NPK fertilizer by up to 50% without reducing results.

Conclusion

From the research results, the combination of NPK inorganic fertilizer and PGPR biological fertilizer influences all observed variables on shallots. Giving a combination dose of 25% NPK inorganic fertilizer and 75% PGPR biological fertilizer showed the best results compared to other combination treatments, both in growth and yield and in N and P nutrient uptake.

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