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# Effect Of The Combination Of Liquid Biofertilizers And N, P, K Fertilizers On P-Available, P-Uptake, P-Solving Bacteria And Yield Of Sweet Corn On InceptisolsInJatinangor

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***Abstract***
*Liquid biofertilizers containing phosphate solubilizing bacteria are essential in increasing the nutrients plants need for growth and efficient use of inorganic fertilizers. This research aimed to determine the effect of the combination of liquid biofertilizers and N, P, K on P-available , P-uptake, phosphate solubilizing bacteria, and sweet corn (ZeamaysL. saccharata) yields. This research was conducted from June until September 2022 at the Laboratory of Soil Chemistry and Plant Nutrition Experimental Field, Faculty of Agriculture, UniversitasPadjadjaran, Jatinangor, Sumedang. This research used an experimental method with Randomized Block Design (RBD) consisting of nine treatments (control, two treatments of N, P, K fertilizers, six combinations of liquid biofertilizers and N, P, K fertilizers), and three repetitions. The results showed that the application of the combination of 100% liquid biofertilizer (5 L.ha$^{-1}$) and 75% N, P, K fertilizer (225 kg.ha$^{-1}$ Urea, 112,5 kg.ha$^{-1}$ SP-36, 75 kg .ha$^{-1}$KCl) gave the best results on soil available P (19,99 ppm P), P uptake (0,48%), phosphate solubilizing bacteria (1,12 x 108 CFU/g), and yield of sweet corn (weight of corn with cornhusk was 426,53 g plot$^{-1}$, the weight of Cob without cornhusk was 319,53 g plot$^{-1}$, cob diameter was 52,79 mm, cob length was 23,87 cm, and cob weight per plot was 12.45 kg plot$^{-1}$).*

***Keywords: Liquid Biofertilizers, N.P.K Fertility, Phosphate***

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## I. Introduction

Soil fertility plays a vital role in determining crop productivity. Fertile soil is seen from the adequacy of its nutrients and its physical and biological factors. According to Taisa et al. (2021), Plant productivity in Indonesia tends to decrease yearly due to low soil fertility due to washing, evaporation, and loss during harvest. One soil order that has problems with nutrient availability and soil fertility is Inceptisol soil.

Inceptisol soil can be developed as agricultural land because it has a wide distribution of 70.5 million ha or 37.5% of Indonesia's land area (Puslittanak, 2000). Plant growth and productivity in Inceptisol soil are not optimal because this soil has a low organic matter content (Widodo and Kusuma, 2018). Based on the results of the initial soil analysis, Inceptisol soil in Jatinangor has a pH = 6.26 (slightly acidic); 2.08% C-organic (moderate); C/N = 11 (low);0.13% N-total (low); 52.60 mg 100 g$^{-1}$$P_2O_5$(high); and 65.08 mg 100 g$^{-1}$ $K_2O$ (very high); So to improve the availability of nutrients in the soil is necessary fertilization.

Fertilization can be done to overcome the low availability of nutrients in Inceptisol soil by applying inorganic, organic, and biological fertilizers. In Indonesia, farmers still provide a lot of inorganic fertilizers, and the excessive use of inorganic fertilizers has a negative impact, resulting in decreased land productivity (Soekamto and Fahrizal, 2019). Reduce the use of inorganic fertilizers, which can be done using biological fertilizers.

Biological fertilizers are fertilizers that contain microbes that can improve plant nutrition and have the potential to provide nutrients such as nitrogen, phosphate, potassium, Mg, Zn, and Cu (Purba et al., 2021). One form of biological fertilizer is liquid biological fertilizers. Using biological fertilizers is vital for the quality of soil and plants. Certain microorganisms in biological fertilizers can improve the effectiveness of fixing certain nutrients and providing nutrients for plants (SriwahyuniandParmila, 2019). One of the microorganisms that can help provide nutrients is phosphate-solubilizing bacteria. Phosphate-solubilizing bacteria can trigger plant growth. Phosphate solubilizing bacteria are included in one type of Plant Growth Promoting

Rhizobacteria(PGPR) because they can produce growth hormones such as auxin, gibberellins, and cytokinins (Kartikawati et al., 2017). The composition of biological fertilizers usually used in phosphorus (P) solvents consists of the bacterium Pseudomonas sp. and Bacillus sp. These two bacteria have a role in dissolving P elements in the soil that are not available to become available.

One type of corn that is widely cultivated in Indonesia is sweet corn. According to Lahay et al. (2019), the productivity of sweet corn plants ranges from 10.3–15.9 tons.ha1, productivity is still lower than its potential, and one of the contributing factors is the degradation of planting land (Puspadewi et al., 2016). The research results reported by Sofyan et al. (2019) that the application of liquid biological fertilizers containing phosphate solubilizing microbes in the form of Pseudomonas sp., Bacillus sp., and Saccharomyces sp. combined with a dose of 50% of the recommended amount of single N, P, K gave the best effect on P uptake in sweet corn plants.

Based on the description above, a study was conducted to determine the effect of a combination of liquid biofertilizers and N, P, K on P available, P uptake, P solubilizing bacteria and yield of sweet corn (Zea mays L. saccharata) on Inceptisols in Jatinangor.

## II. Research Methods

### A. Time and Location

This experiment was carried out from June to September 2022 and was carried out at the Experimental Garden of the Laboratory of Soil Chemistry and Plant Nutrition, Faculty of Agriculture, Padjadjaran University, Jatinangor District, Sumedang Regency, at an altitude of 794 m above the sea level. Implementation of analysis of biological fertilizers, soil, and plants at the Laboratory of Soil Chemistry and Plant Nutrition, Department of Soil Science and Land Resources, Faculty of Agriculture, Padjadjaran University, Jatinangor, Sumedang Regency, West Java.

### B. Materials and Tools

The materials used in this experiment were planting media in the form of the soil of the order Inceptisols in Jatinangor, which belongs to the FluventicEutrudepts sub-group, hybrid sweet corn seeds of Talenta, N, P, and single K varieties: Urea 46% N, SP-36 36% $P_2O_5$, KCl 60% $K_2O$, biological fertilizer with a dose of 5 L.ha-1, and pesticides for controlling and eradicating pests and diseases.

The tools used in this experiment are divided into laboratory tools and field tools. The equipment used in the laboratory is a spectrophotometer instrument for measuring available P (889 nm) and P absorption (400 nm). Additional equipment was a shaker bottle, shaker machine, dispenser, spray flask, analytical balance, test tube, 2 ml pipette, filter paper, 50 ml shake bottle, oven, blender, and timer. The tools used in the field were treatment signs, rulers, tape measures, writing implements, calipers, and emrats—the tools needed in determining P solvent bakery analysis using Total Plate Count (TPC) media.

### C. Research Design

This experiment was carried out using a randomized block design (RBD), which consisted of nine treatments, namely one treatment as a control without applying fertilizer, two treatments with doses of N, P, K, and six combination treatments of biological fertilizers and N, P, K. Each treatment was repeated three times so that a total of 27 experimental plots.

Table 1.Treatment of Biofertilizers and N, P, and K on Sweet Corn

| Code | Treatment | Biofertilizers (ml plot$^{-1}$) | Urea (g plot$^{-1}$) | SP-36 (g plot$^{-1}$) | KCL (g plot$^{-1}$) |
|---|---|---|---|---|---|
| A | Control | 0,00 | 0,00 | 0,00 | 0,00 |
| B | 100% N, P, K | 0,00 | 225,00 | 112,50 | 75,00 |
| C | 75% N, P, K | 0,00 | 168,75 | 84,38 | 56,25 |
| D | 75% N, P, K + 50% Biofertilizers | 1,88 | 168,75 | 84,38 | 56,25 |
| E | 75% N, P, K + 100% Biofertilizers | 3,75 | 168,75 | 84,38 | 56,25 |
| F | 75% N, P, K + 150% Biofertilizers | 5,63 | 168,75 | 84,38 | 56,25 |
| G | 100% N, P, K + 50% Biofertilizers | 1,88 | 225,00 | 112,50 | 75,00 |
| H | 100% N, P, K + 100% Biofertilizers | 3,75 | 225,00 | 112,50 | 75,00 |
| I | 100% N, P, K + 150% Biofertilizers | 5,63 | 225,00 | 112,50 | 75,00 |

Information:
1. Control treatment is treatment without liquidbiofertilizers and inorganic fertilizers
2. The treatment for one dose of liquid biofertilizer is 5 L ha$^{-1}$ (Sofyan et al., 2019).
3. The recommended N, P, K treatment is the recommended dose of a single inorganic fertilizer for sweet corn according to Thanksgiving and Rifianto (2014) (single fertilizer dose of 300 kg ha$^{-1}$ Urea, 150 kg ha$^{-1}$ SP-36, 100 kg ha$^{-1}$KCl).

**D. Data Collection**

The data collected are (1) supporting data: initial soil analysis, weather conditions, attacks by plant-disturbing organisms, symptoms of nutrient deficiency; (2) primary data: soil pH, P available , P uptake, P solubilizing bacteria, and yield components of sweet corn.

**E. Data Analysis**

The experimental data were processed statistically using Fisher's test (F) at a 5% significance level using the SPSS version 25 application. If the effect is significant, the test is continued with Duncan's Multiple Range Test (DMRT) at a 5% significance level.

## III. results and discussion

**A. Supporting Observations**

**1. InceptisolJatinangor Initial Soil Analysis**

The results of the initial soil analysis of the Inceptisols in Jatinangor are presented in Table 1 below:

Table 1. Initial Soil Analysis Results (Before Treatment)

| No | Soil Properties | Score | Criteria |
|---|---|---|---|
| 1 | Soil pH | 6,26 | Slightly Acid |
| 2 | C-Organic | 2,08% | Moderate |
| 3 | N-Total | 0,13% | Low |
| 4 | $P_2O_5$ | 1,07 ppm | Very Low |
| 5 | Fraktion<br>Sand<br>Silt<br>Clay | <br>8%<br>20%<br>72% | Texture Clay |

Source: Laboratory of Soil Chemistry and Plant Nutrition, Department of Soil Science and Land Resources, Department of Soil Science, Faculty of Agriculture, Padjadjaran University.

Based on the data in Table 1 above shows that the Inceptisol soil in Jatinangor is nutrient poor and has a low fertility level.

**2. Weather conditions**

Data on weather conditions in the experimental field from June 2022 – September 2022 are presented in Table 2.

Table 2. Data on Temperature, Rainfall, Sunlight, Humidity

| Month | Average Temperature (°C) | Amount of Rainfall (mm) | Radiation Sun (%) | Average Humidity (%) |
|---|---|---|---|---|
| June | 22,4 | 169,5 | 64 | 91 |
| July | 22,5 | 62,0 | 83 | 89 |
| August | 22,0 | 26,5 | 87 | 86 |
| September | 22,4 | 48,5 | 78 | 87 |

Source: Padjadjaran University Climatology Station (2022)

Based on the data in Table 2, the results of climate data from June 2022 – September 2022 show that the temperature data for June 2022 – September 2022 has an average of 22.33°C and an average rainfall of 76.63 mm/month. The average relative humidity is 88.25%, and the average solar irradiance is 78%.

**3. Attack of Plant Pest Organisms**

The results of observations at the time of planting found pests that attack sweet corn plants, namely armyworm (*Spodopterafrugiperda*) and grasshoppers (*Locusta* sp.), with an attack rate of <5% and no harm. Control is done manually by turning off the caterpillars around the leaves and removing the eggs found on the leaves.

The dominant weeds found in the study were *Amaranthusspinosus* and *Galinsogaparviflora*. Control is done manually by pulling the weeds around the plant and then immersing it back into the soil.

**4. Symptoms of Nutrient Deficiency**

Symptoms of nitrogen deficiency were found in the control plot, which was indicated by the yellowing of the leaves of the sweet corn plant and forming of a V from the tip of the leaf to the midrib (Figure 1). According to Ernita et al. (2017), corn plants that experience a deficiency of nitrogen elements can inhibit their vegetative formation process, so the plants will become stunted.

Figure 1. Symptoms of Nutrient Deficiency

**B.Main Parameters**

**1. Soil Acidity, P Available, P Uptake, P Solubilizing Bacteria**

The research results on the effect of a combination of liquid biological fertilizers and N, P, K on soil pH, P available, P uptake, and P Solubilizing bacteriaonInceptisols in Jatinangor are presented Table 3.

Table 3. Soil pH, P Available, P uptake, P Solubilizing Bacteria After Treatment

| Code Treatment | Treatment | Soil pH | P-Available (ppm P) | P-Uptake (%) | P Solubilizing Bacteria (CFU/g) |
|---|---|---|---|---|---|
| A | control | 7,0 | 1,05 a | 0,17 a | $0,14 \times 10^8$ a |
| B | 100% N, P, K | 6,8 | 7,02 b | 0,25 b | $0,15 \times 10^8$ a |
| C | 75% N, P, K | 7,0 | 6,58 b | 0,24 b | $0,33 \times 10^8$ ab |
| D | 75% N, P, K + 50% Biofertilizers | 7,4 | 7,05 b | 0,31 c | $0,40 \times 10^8$ ab |
| E | 75% N, P, K + 100% Biofertilizers | 7,5 | 19,99 d | 0,48 d | $1,12 \times 10^8$ c |
| F | 75% N, P, K + 150% Biofertilizers | 7,6 | 9,37 bc | 0,33 c | $0,65 \times 10^8$ b |
| G | 100% N, P, K + 50% Biofertilizers | 7,1 | 8,62 bc | 0,32 c | $0,36 \times 10^8$ ab |
| H | 100% N, P, K + 100%Biofertilizers | 7,5 | 13,12 c | 0,34 c | $0,72 \times 10^8$ b |
| I | 100% N, P, K + 150% P. Biofertilizers | 7,5 | 10,77 bc | 0,34 c | $0,70 \times 10^8$ b |

Note: Numbers followed by the same letters do not show significant differences according to Duncan's multiple range test at a 5% level

Based on the results of the soil pH analysis in Table 3, the pH value of the soil treated with a combination of liquid biological fertilizers and N, P, and K was higher than in the initial soil analysis. The average pH of the treated soil was 7.3, while the initial soil pH was 6.26. This indicates that treating liquid biofertilizers combined with N, P, and K affects increasing soil pH.According to Nhu et al. (2018), microorganisms contained in biological fertilizers can change soil pH to neutral to make the soil optimal for planting plants. This situation is due to the content of microorganisms in biological fertilizers that can increase organic matter in the soil so that soil pH can increase (Li et al., 2021).The increase in pH indicates that the soil pH after being treated is optimal for corn plants. The Ministry of Trade (2014) stated that sweet corn growth is optimal on soils with an acidity of 5.6–7.

The research results in Table 4 show that the available P content using the Olsen method shows that the combined treatment of liquid biological fertilizers and N, P, K significantly affects available P. The E treatment plot (75% N, P, K + 100% biological fertilizer) showed the highest yield of available P with an average of 19.99 ppm. It was significantly different from the other treatments, and the lowest available P content found in treatment A ( control) was 1.05 ppm. In comparison, the available P content in the initial soil analysis has a value of 1.07 ppm, which is included in the low criteria.

The increased available P content was due to P-dissolving bacteria in biological fertilizers, namely Bacillus sp. and Pseudomonas sp. According to Yadav et al. (2016), Phosphate solubilizing bacteria produce organic acids which can lower soil pH so that the bonds between phosphate elements (P) and Al, Fe, Ca, and Mg are released. Organic acids will act as protons binding to elements Al, Fe, Ca, and Mg. After that, the removed P element will become available-P in the soil and increase the pH to be neutral. Treatment E (75% N, P, K + 100% biological fertilizer) is the best combination of biological fertilizers and N, P, K compared to other treatments because the nutrients N, P, K are available optimally for plants. According to Andrian et al. (2021), treatment of N, P, and K at 75% and 100% of biological fertilizers increased available P by 17.23 ppm.

The research results in Table 4 show that the combination treatment of liquid biofertilizer and N, P, K significantly increased P uptake by sweet corn plants. The E treatment plot (75% N, P, K + 100% biological fertilizer) had the best results compared to the other treatment plots, which had an average of 0.48%, significantly different from all treatments. In comparison, the control treatment (A) had the lowest yield, with an average of 0.17%. The treatment given with biological fertilizers had a higher P absorption value when compared to the treatment given only N, P, K, and control. This is caused by the lack of fulfillment of plant nutrient needs so that plants will produce root exudate, which can trigger microbial activity. According to Bachtiar et al. (2017), phosphate-solubilizing bacteria provide available P through dissolving phosphate so that the number of P nutrients that plants can absorb increases. Liang et al. (2020) also argue that phosphate-solubilizing bacteria play an essential role in the availability of P nutrients in plants so that they can increase P uptake.

The research results in Table 4 show that applying biological fertilizers and N, P, and K significantly affected the population of phosphate-dissolving bacteria. 12 x 108 CFU/g, and the lowest was found in the control treatment (A), 0.14 x 108 CFU/g. Based on the results of this analysis, the application of biological fertilizers affects the population of phosphate-solubilizing bacteria. The increase in the population of phosphate-solubilizing bacteria occurred because the biological fertilizers used in this study contained phosphate-solubilizing bacteria such as *Bacillus* sp. and *Pseudomonas* sp. The two genera are phosphate-solubilizing bacteria with the highest number (Prabhu et al., 2019). This is in line with the research by Timofeeva et al. (2022), which stated that applying biological fertilizers containing Bacillus sp. could increase phosphate-solubilizing bacteria in the soil. While in the control treatment (A), the people of phosphate-solubilizing bacteria decreased compared to the results of the initial soil analysis, caused by the absence of additional treatment, resulting in reduced populations of phosphate-solubilizing bacteria in the soil.The results of the research by Lovitna et al. (2021), the population of phosphate-solubilizing bacteria at harvest also decreased to 12.3 x 104 CFU/g when compared to the population of phosphate-solubilizing bacteria at 0 M.S.T. with a population of 16.2 x 104 CFU/g.

The researchresults also showed that the treatment with N, P, and K also increased the population of phosphate-solubilizing bacteria. According to Fitriatin et al. (2017), the use of SP-36 fertilizer had a positive effect on increasing the population of phosphate-solubilizing bacteria due to the presence of essential metal content, which functions for the proliferation of phosphate-dissolving bacteria. Microbial activity is not optimal if the availability of the P element in the soil is high because the microbes will be active if the plant has not fulfilled its nutrients so that the plant will produce root exudate. According to Prabhu et al. (2019), applying P fertilizer at a dose of 75% combined with phosphate-dissolving bacterial biofertilizers gave the highest bacterial population compared to the combined treatment of P fertilizers and other phosphate-dissolving bacterial biofertilizers.

## 2. Yield Components of Sweet Corn

The observed components of sweet corn yields consisted of cob weight per plot, cob weight with husks, shelled cob weight, cob diameter, and cob length. The average yield of sweet corn is presented in Table 4.

Table 4. Effect of the Combination of Liquid Biofertilizer and N, P, K on the Yield of Sweet Corn in Inceptisol in Jatinangor

| Code | Treatment | Cob weight per plot**(kg)** | Cob weight **(g)** | Peeled cob weight **(g)** | Cob diameter **(mm)** | Cob length **(cm)** |
|---|---|---|---|---|---|---|
| A | Control | 4,74 a | 309,40 a | 200,27 a | 43,15 a | 14,43 a |
| B | 100% NPK | 8,85 bc | 364,80 bc | 266,47 bc | 47,86 b | 16,80 b |
| C | 75% NPK | 8,28 ab | 352,93 b | 243,73 b | 47,06 b | 16,60 b |
| D | 75% NPK + 50% Biofertilizers | 8,08 bc | 370,90 bc | 270,80 bc | 48,71 b | 16,93 b |
| E | 75% NPK + 100% Biofertilizers | 11,64 d | 431,3 d | 329,53 d | 52,79 c | 24,53 d |

| | | | | | | |
|---|---|---|---|---|---|---|
| F | 75% NPK + 150% Biofertilizers | 8,74 c | 380,60 bc | 280,33 bc | 49,12 b | 17,27 b |
| G | 100% NPK + 50% Biofertilizers | 10,23 bc | 376,20 bc | 274,87 bc | 48,83 b | 17,00 b |
| H | 100% NPK + 100% P.hayati | 9,33 c | 393,07 c | 287,37 c | 49,29 b | 18,60 c |
| I | 100% NPK + 150% Biofertilizers | 7,51 c | 384,60 c | 286,13 bc | 48,89 b | 18,47 c |

Note: Numbers followed by the same letters do not show significant differences according to Duncan's multiple range test at the 5% level. BTPP = Cob weight per plot; B.T.B. = Cob weight; B.T.K. = Peeled cob weight; D.T. = Cob diameter; P.T. = cob length.

The statistical analysis results showed that the effect of the combination of liquid biofertilizer and N, P, K was significantly different compared to the control. In control, treatment yielded cob weight per plot (4.74 kg), cob weight (309.40 g), peeled cob weight (200.27 g), cob diameter (43.15 mm), and cob length (14. 43 cm). The average yield of sweet corn in the combined treatment plots of liquid biofertilizer and N, P, K had a higher value than the treatment that was only given N, P, K, while the cob weight parameter per plot was not lower than the 75% combination treatment. N, P, K, and 50% biological fertilizer.

Treatment E (75% N, P, K + 100% biofertilizer) produced better cob weight per plot, cob weight, peeled cob weight, cob diameter, and cob length than other treatments. This was caused by the application of biological fertilizers, which had an effect on the availability of P nutrients, according to Wahyudin et al. (2018) which stated that the application of biological fertilizers and N, P, K at a concentration level of 75% had the best effect on the yield components, namely P.T., the weight of 100 seeds, and weight of dry shelled seeds per plant. Andrian et al. (2021) also stated that the combination treatment of 100% biological fertilizer and 75% N, P, K produced the best sweet corn yields with a weight of 474.97 g, a weight without husk 358.20 g, a cob diameter of 54.68 mm, and cob length 20.97 cm. In addition, Purwani and Nurjaya (2020) stated that the combination of N, P, K 75% and 100% of biological fertilizers had yields that were significantly different from the control treatment, namely a weight of 168.14 g plot$^{-1}$ and a weight of 100 g of seeds of 31.71g.

## IV. Conclusions And Recommendations

### A. Conclusion

Based on the results of the research and discussion, the conclusions are drawn as follows:

1. The combination of liquid biofertilizers and N, P, K can increase P available, P uptake, P solubilizing bacteria and sweet corn yields on Inceptisol soil in Jatinangor.
2. Combination of 75% N, P, K fertilizer (225 kg.ha$^{-1}$ Urea, 112.5 kg.ha$^{-1}$ SP-36, 75 kg.ha$^{-1}$KCl) + 100% biological fertilizer (5 L.ha$^{-1}$) was the best dose for increasing P available (19.99 ppm P), P uptake (0.48%), P solubilizing bacteria (1.12 x 108 CFU/g) and yielding cob weight (426.53 g plot$^{-1}$), cob weight (319.53 g/slot), cob diameter (52.79 mm), cob length (23.87 cm), and cob weight per plot (12.45 kg plot$^{-1}$).

### B. Suggestion

Further research needs to be carried out using a different dose of 50% N, P, K. This is because this study only used 100% and 75% recommendations for N, P, K.

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