Agrotech Journal
Url: http://usnsj.com/index.php/ATJ
Email: editor.atj@usnsj.com

Growth and yield respons of mungbean to different level of organic and inorganic fertilizer in North Sumatera

AUTHORS INFO

Siti Fatimah Batubara
Research Center for Food Crops, Research Organization for Agriculture and Food, National Research and Innovation Agency (BRIN)
siti107@brin.go.id

ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 7 No. 1, June 2022
URL:
https://doi.org/10.31327/atj.v7i1.1771

Abstract

Integrated nutrient management is an alternative for the sustainable and cost-effective management of soil fertility by combined apply of organic with inorganic fertilizer resulting in rising soil fertility and productivity. This study aims (i) to determine the growth and yield respons of mungbean to different level of organic and inorganic fertilizer, and (ii) to measuring the effectiveness of organic fertilizer on mungbean production. The research was conducted at Pasar VI Kwala Mencirim Village, Sei Bingai District, Langkat Regency, North Sumatra in December 2020 to April 2021. This study used a Non-Factorial Randomize Complete Block design consisting of seven treatments and four replications, namely P0 (without fertilizer), P1 (100% dose of NPK fertilizer), P2 (75% dose of NPK fertilizer), P3 (50% dose of organic fertilizer + 75% NPK fertilizer) P4 (100% dose of organic fertilizer + 75% NPK fertilizer), P5 (150% dose of organic fertilizer + 75% NPK fertilizer), and P6 (1 dose of organic fertilizer + 100% NPK fertilizer). Plant height observations were carried out at 4, 6, and 8 weeks after planting and production observations were at harvest. Analysis of varian (ANOVA) was used to determined the effect of fertilizers treatment and followed by Duncan Multiple Range Test (DMRT) at 5% confidence interval for significant differences between treatment on plant growth and production. Organic fertilizer effectiveness was calculating using the Relative Agronomy Effectiveness (RAE). The results showed that organic fertilizer had a significant effect on mungbean growth and yield compared to controls. The highest mungbean production in P6 treatment of 1209 Kg/ha while the control treatment was 512 Kg/ha. Organic fertilizer was effective to increase mungbean production.

The highest relative agronomic efficiency (RAE) was 438% in the treatment of organic fertilizer fertilizer at P6 of 100% dose of organic fertilizer +100% NPK fertilizer

Keywords: mungbean, organic fertilizer, inorganic fertilizer, North Sumatera

A. Introduction

The use of inorganic fertilizer since green revolution has been increased to enhance crop production in agriculture. It gives a benefit on improved yields of crops however, unforeseen environmental impacts of soil health impacted negatively over the years (Chen, 2006; Farjana, S., Islam, M.A. and Haque, T., 2019). Organic fertilizers are environmentally friendly and improve soil health, water-holding capacity, high cation exchange capacity and low bulk density; and they foster a diverse population of beneficial soil microorganisms (Bulluck, L.R., Brosius, M., Evanylo, G.K. and Ristain, J.B. 2002; Akhter, A., Islam, M.A. and Karim, M.R. 2019).

Mungbean are one of the food crops that are a source of vegetable protein with protein content of 22% and ranks third after soybeans and peanuts (Purwono dan Hartono, 2005). Mungbeans are early maturing, drough tolerant, relatively few desease variations, can be planted on less fertile land and selling proce is relatively high and stable. Based on data from the central statistics agency (2020), the production of mungbean in North Sumatera was 1119 kg ha^{-1}. Based on variety description, the yield potential of Vima 1 mungbean variety is 1380 kg ha^{-1} (Balitkabi.litbang.go.id). Various factors cause a decrease in mungbean production including low soil fertility, land conversion, unsupportive climate factors, and inappropriate cultivation practices.

Efforts to increase the productivity of mungbean can be done by improving the efficiency of fertilization and the number of plants per planting hole. Integrated nutrient management is an alternative for the sustainable and cost-effective management of soil fertility by combined apply of organic with inorganic fertilizer resulting in rising soil fertility and productivity. This study aims (i) to determine the growth and yield respons of mungbean to different level of organic and inorganic fertilizer, and (ii) to measuring the effectiveness of organic fertilizer on mungbean production.

B. Literature Review

Organic fertilizers are fertilizer derived from dead plants, animal dung, and/or animal parts, and/or other organic wastes that have gone through an engineering process in solid or liquid form and can be enriched with mineral materials, and/or beneficial microbes to increase nutrient content and soil organic matter, as well as improving the physical, chemical and/or biological properties of the soil (Ministry of Agriculture, 2019).

Combined use of organic and inorganic fertilizers plays a significant role in sustaining soil fertility (Ali, M.E., Islam, M.R. and Jahiruddin, M. 2009) and the use of organic fertilizers together with inorganic fertilizers, has a higher positive effect on microbial biomass and enhances soil health (Elkholy, M.M., Samira, E., Mahrous and El-Tohamy, S.A. 2010) and improves the use efficiency of recommended inorganic fertilizer and reduces its cost (Ali et al. 2009; Abedi, T., Alemzadeh, A. and Kazemeini, S. 2010). Organic fertilizers also creating more air space and water retention within the soil and enhances soil nitrogen content, enhanced nutrient availability, releasing nutrients at a slower and more consistent rate, improves

nutrient mobilization and Protect the soil against rain and wind erosion (Akhtar et al. 2009).

Finding of several researchers showed that integrated use of chemical and organic fertilizer has proved to be significantly increases maize productivity (Efthimiadou, A., Bilalis, D., Karkanis, A. and Williams, B.F. 2010; Gemechu, B., Etana, A., Senbeta, F. and Tolossa, D. 2017; Wapa, J.M. Kwari, J.D. and Ibrahim, S.A.2014). A study by Mahmood, F., Khan, I., Ashraf, U., Shahzad, T., Hussain, S., Shahid, M., Abid, M. and Ullah, S. (2017) showed that mixed use of organic with inorganic fertilizers significantly ($p < 0.05$) increased maize yield than individual use of organic or inorganic fertilizer. Ayeni and Adetunji (2010) also reported that the integrated use of poultry manure along with NPK fertilizer was more successful in rising nutrient availability and maize yield than sole application of any of the fertilizer materials on sandy soil, loam texture with high proportion of coarse sand (84%). Similarly, Brar, B.S., Singh, J., Singh, G. and Kaur, G. (2015) reported that integrated use of inorganic fertilizer along with organic fertilizer (100% NPK + FYM) was improved soil physical conditions and increased in soil organic carbon might have resulted in higher maize yields. Another research by Abbas, G., Abbas, Z., Aslam, M., Malik, A. U., Ishaque, M., and Hussain, F. 2011 which also combined organic and inorganic fertilizer in mungbean reported that combination of organic and inorganic fertilizer were excellent for obtaining the maximum grain yield of mungbean.

C. Methodology

1. Research design

The research was conducted on farmers field in Pasar VI Village, Kwala Mencirim, Sei Bingai District, Langkat Regency, North Sumatra starting in December 2020 to April 2021. This study used a Non-Factorial Randomize Complete Block design consisting of seven treatments and four replications, namely P0 (without fertilizer), P1 (100% dose of NPK fertilizer), P2 (75% dose of NPK fertilizer), P3 (50% dose of organic fertilizer + 75% NPK fertilizer) P4 (100% dose of organic fertilizer + 75% NPK fertilizer), P5 (150% dose of organic fertilizer + 75% NPK fertilizer), and P6 (1 dose of organic fertilizer + 100% NPK fertilizer). Organic fertilizer was given at the planting time to the palnting hole. Inorganic fertilizers Urea, SP36, and KCl as inorganic fertilizer were given at 7 days after planting (DAP) and 30 DAP. Fertilizer dose showed in table 1.

Table 1. Dose of organic and inorganic fertilizer treatment

Code	Treatment	Dose of organic fertilizer t ha^{-1}	Dose of inorganic fertilizer (kg ha^{-1})		
			Urea	SP36	KCl
Control	None fertilizer	0	0	0	0
P1	100% NPK	0	50	100	50
P2	75% NPK	0	37,5	75	37,5
P3	50% organic + 75% inorganic	0,5 t/ha	37,5	75	37,5
P4	100% organic + 75% inorganic	1 t/ha	37,5	75	37,5
P5	150% organic +75% inorganic	1,5 t/ha	37,5	75	37,5
P6	100% organic + 100% inorganic	1 t/ha	50	100	50

2. Population and sample

This study used seven treatments (Table 1) and four replications. So that it has 28 experimental plots. The number of replications according to the formula (p-1)(u-1)≥15. Repeat 4 times where (7-1)(4-1)≥15.

3. Technique of data collection

Data were collected from each plot. Plant height observations were carried out at 4, 6, and 8 weeks after planting and production observations were at harvest. Plant height was measured in centimeters from the surface of soil to the tip of the highest leaf. After harvesting, the total biomass in plot was tied in bundles and brought into laboratory for weighment and the biological yield plot^{-1} was recorded in kilograms. Similarly on the basis of yield plot^{-1} the yield ha^{-1} was calculated. The seed yield (kg ha^{-1}) was worked out by using the following formula:

$$\text{Seed yield (kg ha}^{-1}\text{)} = \frac{\text{Yield plot}^{-1}\text{ (kg) x 10000}}{\text{Plot size (m}^2\text{)}}$$

4. Instruments

The materials used in this research were Vima 1 Varieties of mungbean, organic fertilizer, Urea, SP36, and KCl fertilizer and inorganic fertilizer (N, P, K fertilizer). The tools used include cultivation tools, namely hoes, rakes, sprayers, meters, scales, etc.

5. Technique of data analysis

Analysis of varian (ANOVA) was used to determined the effect of fertilizers treatment and followed by Duncan Multiple Range Test (DMRT) at 5% confidence interval for significant differences between treatment on plant growth and production. Organic fertilizer effectiveness was calculating using the Relative Agronomy Effectiveness (RAE) with formulation:

$$\text{RAE} = \frac{\text{Tested fertilizer yield} - \text{control yield}}{\text{Standart fertilizer yield} - \text{control yield}} x100\%$$

(Matchay, 1984)

D. Findings and Discussion

1. Findings

1.1. Organic fertilizer quality

Before application, the quality of organic fertilizer was analized in the laboratory. The result showed in Table 2.

Table 2. the result of organic fertilizer quality

Parameter	Unit	Value	Method
Water content	%	18,89	SNI 7763:2018
Organic C content	%	15,54	SNI 7763:2018
Total N	%	0,67	SNI 7763:2018
C/N	-	23,19	SNI 7763:2018
P_2O_5	%	3,76	SNI 7763:2018

K_2O	%	0,72	SNI 7763:2018
Total Fe	ppm	14.627,89	SNI 7763:2018
Fe available	ppm	7,62	SNI 7763:2018
Zn	ppm	182,32	SNI 7763:2018
Hg	ppm	0	SNI 7763:2018
Cd	ppm	0	SNI 7763:2018
Pb	ppm	16,44	SNI 7763:2018
As	ppm	0	SNI 7763:2018
Cr	ppm	td	SNI 7763:2018
Ni	ppm	td	SNI 7763:2018
pH	-	7	SNI 7763:2018
Eschericia coli	Mpn/g	(-)	SNI 7763:2018
Salmonella sp.	Mpn/g	(-)	SNI 7763:2018

1.2. Soil Characteristic

Soil analysis before the test was carried out at the North Sumatra AIAT Laboratory. The results of soil analysis (Table 3) showed that the total N content of the soil is moderate, the available P and K of the soil are low, the content of Ca is low and Mg is high, the content of micronutrients is sufficient, and the pH of the soil is acidic. These results indicate that the soil at the research site still lacks P and K nutrients, and N nutrients still need to be increased so that the growth and yield of mung bean can be maximized. The application of organic fertilizer is expected to increase soil fertility by increasing the availability of soil nutrients to increase the growth and production of mungbean. While the nutrients N, P, and K will be met by the application of inorganic fertilizers.

Table 3. Soil characteristic in site location

Type of analysis	Unit	Value	Method
Organic C	%	4,39	spektrofotometer
Total N	%	0,50	Kjeldahl
P available	ppm	1,65	spektrofotometer
K-exchange	me/100g	0,29	AAS
pH	-	5,50	Elektrometri
Al-exchange	me/100g	0,11	Titrimetri
Ca	me/100g	4,08	AAS
Mg	me/100g	3,79	AAS
Cu	ppm	2	AAS
Zn	ppm	4	AAS
Mn	ppm	9	AAS
Fe	ppm	27	AAS
Texture			Hidrometer
Sand (%)	%	80,41	
Silt (%)	%	17,14	
Clay (%)	%	2,45	
CEC	me/100g	27,78	destilation

1.3. Plant height (cm)

The effect of applying organic and inorganic fertilizer on plant height was observed at 4, 6, and 8 weeks after planting. The results of ANOVA and DMRT analysis on plant height are shown in Table 4. The results of ANOVA analysis showed that the application of combined organic and inorganic fertilizer significantly affected plant height at 4, 6, and 8 weeks compared to the control treatment. The highest plant height was in the P6 treatment at 4, 6, and 8 weeks with a dose of 100% dose of organic fertilizer and 100% dose of NPK fertilizer.

Table 4. Result of statistical analysis of plant height (week after planting)

Code	Treatment	Plant height		
		4 WAP	6 WAP	8 WAP
P0	0 fertilizer	18.5a	31.75a	38.75a
P1	100% NPK	21.1b	35.5b	49c
P2	75% NPK	20.6b	34ba	41.5b
P3	50% OF + 75% IOF	22.6b	38.75c	50.25c
P4	100% OF + 75% IOF	23.9c	41.125c	52.75d
P5	150% OF + 75% IOF	25.5c	42.125d	54.5d
P6	100% OF + 100% IOF	28.1d	47.625e	55.25e

Note : numbers with the same letters in the same column are not significantly different based on Duncan's Multiple Range Test (α0.05).

1.4. Yield (kg ha^{-1})

The results of ANOVA analysis and DMRT further testing on maize production showed that the application of organic and inorganic Fertilizer had a significant effect on Mungbean yield compared to the control treatment (without fertilizer) with the calculated F value higher than the F table value. The highest mungbean production was found in the P6 treatment of 1209 Kg ha^{-1} and the lowest was in the control treatment of 512 Kg ha^{-1}. The results of the Anova and DMRT tests on the effect of organic and inorganic fertilizer on mungbean production are shown in Table 5.

Table 5. Result of statistical analysis of mungbean production

Code	Treatment	Yield Kg plot^{-1}	Yield Kg ha^{-1}
P0	0 fertilizer	1.3a	512a
P1	100% NPK	1.7b	671b
P2	75% NPK	1.5b	610b
P3	50% OF + 75% IOF	2.0c	806c
P4	100% OF + 75% IOF	2.1c	854c
P5	150% OF + 75% IOF	2.5d	1,018d
P6	100% OF + 100% IOF	3.0e	1,209e

Note : numbers with the same letters in the same column are not significantly different based on Duncan's Multiple Range Test (α0.05).

1.5. Relative agronomy effectiveness (RAE)

Relative agronomic effectiveness (RAE) is a measure of the effectiveness of a fertilizer. A fertilizer be agronomic effective if it has a relative agronomic

effectiveness value > 95%. With a relative agronomic effectiveness value of more than 95%, it means that the fertilizer can increase yields greater than the treatment without fertilizers and compared to standard inorganic fertilizers.

The RAE value of the organic fertilizer treatment tested on the P2, P3, P4, P5, and P6 treatments, respectively 62, 185, 215, 318, and 438, which means that the P3, P4, P5 and P6 treatment passed effectiveness test criteria for organic fertilizer. Meanwhile, RAE of P2 was 62%, which is <95%, meaning that it does not meet the RAE value. The results of the calculation of RAE for all treatments are shown in table 6.

Table 6. Relative agronomy effectiveness (%)

Code	Treatment	RAE (%)
P0	0 fertilizer	-
P1	100% NPK	-
P2	75% NPK	62
P3	50% OF + 75% IOF	185
P4	100% OF + 75% IOF	215
P5	150% OF + 75% IOF	318
P6	100% OF + 100% IOF	438

2. Discussion

In this test, the use of combined fertilizers of organic and inorganic fertilizers can increase plant growth and yield of mungbean compared to the control treatment. The best dose of organic fertilizer was P6 treatment with dose of Organic fertilizer 1 ton ha^{-1} and 100% dose of inorganic fertilizer with a productivity of 1,209 kg ha^{-1}. This result is close to the average yield based on the variety description, which is 1,380 kg ha^{-1} (balitkabi.litbang.go.id). The yield of this research was higher than other research with the same variety in Belu District, NTT where the Vima 1 mungbean productivity only 923.73 kg ha^{-1} (Seran, Y. L., Kote, M., dan Benu, F. (2011). A study by Mahmood et al. (2017) showed that mixed use of organic with inorganic fertilizers significantly ($p < 0.05$) increased maize yield than individual use of organic or inorganic fertilizer.

The real effect of organic fertilizer treatment on the growth and production of mungbean is related to differences in soil fertility produced physically, chemically and biologically, and due to differences in doses of organic fertilizers given. It can be seen in the results of the DMRT test, where the higher dose of organic fertilizer, the growth and production of mungbean was also increases. The research of Syofia et al. (2014) showed that the application of solid and liquid organic fertilizers on mungbean increased plant growth and yield. The productivity of mungbean with solid and liquid organic fertilizer reached 1160 kg ha^{-1}. Combined use of organic and inorganic fertilizers plays a significant role in sustaining soil fertility (Ali et al. 2009) and the use of organic fertilizers together with inorganic fertilizers, has a higher positive effect on microbial biomass and enhances soil health (Elkholy et al. 2010) and improves the use efficiency of recommended inorganic fertilizer (Ali et al. 2009; Abedy et al. 2010).

According to soil characteristic (Table 1). The soil in site location is in acidic condition, still lacks P and K nutrients, N nutrients still need to be increased, and soil texture is sandy loam, where this condition is not favorable for plant growth. The crop production is inseparable from the quality of the soil and the availability of nutrients and their management (Rajiman, 2020). Sutanto (2002) stated that organic fertilizers improve the physical properties of the soil by making the soil

loose and loose so that it is better aerated and easily penetrated by plant roots. In sandy textured soils it will increase the binding between particles and increase the water binding capacity. Soil chemical properties are improved by increasing cation exchange capacity and nutrient availability, while the effect of organic matter on soil biology is to increase the energy needed for the life of soil microorganisms. Kriswantoro, H., E. Safriani., dan S. Bahri. (2016) reported that the higher dose of organic fertilizer increasing the growth and yield of the plant. Organic fertilizers improve soil conditions, provide nutrients for plant growth. According to Kresnatita, S., Koesriharti, & Santoso, M. (2013), good soil conditions will create a suitable growing environment for plant growth. Research on horticultural crops shows that soil that is given organic fertilizer and added a little inorganic fertilizer can have a positive effect on plant growth and yield.

Conclusion

The application of Organic fertilizers could increase mungbean growth and production compared to control treatment. Based on the calculation of relative agronomic effectiveness (RAE) it is known that all treatments of Organic fertilizers have RAE > 95%. The optimum dose of Organic fertilizer was 1ton ha^{-1} combined with 100% dose of inorganic fertilizer.

Acknowledgement

We would like to thank to CV. Raja Grafika for funding this study and the people of Desa Pasar VI Kwala Mencirim, Sei Bingai District, Langkat Regency, North Sumatra, Indonesia for their supports in the field works. We thank to North Sumatra Assessment Institute of Agricultural Technology, for laboratory facilities. Great thanks are also addressed to other parties who cannot be mentioned individually for giving us their hands to accomplish this work.

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