Sweet Corn Growth and Productivity on Several Levels Dosage of Liquid NPK Fertilizer

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Abstract. The purpose of the study was to determine the effectiveness of liquid NPK fertilizer with a composition of 12:9:7 on sweet corn plant. The research was conducted at the Mojosari Research Station, Mojokerto district, East Java, Indonesia, in September to December 2020, using a randomized complete block design with eight treatments and repeated four times. The treatments consisted of one treatment without fertilization (control), one treatment dose of 300 kg phonska + 300 kg urea per ha (recommendation), six treatments of liquid NPK fertilizer. Application of liquid NPK fertilizer is done by dissolving in water as much as 200 mL per plant. The results showed that the application of liquid NPK fertilizer had an effect on plant height, stem diameter, stover weight, cob length, ear diameter, and cob weight. The application of liquid NPK fertilizer at a dose of 12.5 cc L^{-1} gave the same or comparable response to the standard fertilization treatment with an agronomic effectiveness level > 95 %.

Keywords: Agronomic effectiveness, maize, non granular fertilizer, yield.

1 Introduction

Increasing yield more effectively with lower input remains an important challenge for modern agriculture. Modern technology in farming is needed to make farming easier and more effective. If fertilization is the priority, the balance between cost efficiency and ease of application of fertilizer is the most important. Until now, fertilizer is still one of the factors with the biggest costs for farmers, therefore the right type of fertilizer and the correct application method are very important.

The third largest corn (*Zea mays* L.) production in Indonesia in 2020 were East Java (5.37 $\times 10^6$ t), Central Java (3.18 $\times 10^6$ t), and Lampung (2.83 $\times 10^6$ t) [1]. Sweet corn (*Zea mays* saccharata Sturt) had an average productivity of 8.31 t ha^{-1} while the potential yield of sweet

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corn can reach 14 t ha^{-1} to 18 t ha^{-1} [2]. Data on the achievement of sweet corn production in 2015 was 19.83 × 10^{6} t or 97 % of the target. In 2016, corn production reached 23.16 × 10^{6} t, or 96.5 % of the set target [3].

The key to sustainable agricultural growth is more efficient use of land, labour and other inputs through technological progress, social innovation, and new business models. For agriculture and aquaculture to respond to future challenges, innovation would not only need to improve the efficiency which inputs were turned into outputs, but also conserve scarce natural resources and reduce waste [4]. A key strategy for achieving long-term increases in agricultural production in the region was sustainable agricultural mechanization, which can deliver multiple benefits, including improved in farming operations and increased efficiency of input use. In the longer term, mechanization would support the sustainable intensification of production systems [5, 6].

Future agriculture will use sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and GPS technology. These advanced devices and precision agriculture and robotic systems will allow farms to be more profitable, efficient, safe, and environmentally friendly [7]. In the era of modern agriculture, the use of sophisticated equipment in fertilization (eg using drones) requires that fertilizers be used in liquid form. Liquid fertilizer contains nutrients that are nano-sized so that they are quickly and easily absorbed by the plant. Less nutrients sit in the ground and more are actually absorbed into the plant [8].

There are two forms of fertilizer, namely solid (granular fertilizer) and liquid fertilizer. Although the shape is different, the main purpose is the same, namely providing plant nutrition [9]. Liquid fertilizers generally have lower nutrient content than solid fertilizers. The advantage of liquid fertilizer is that the concentration of fertilizer can be diluted or concentrated depending on needs and it is easy to apply [10], ease of handling, uniformity of application, faster acting, less nutrition loss, and easier to store [11]. The determining factor for the effectiveness of fertilizers is the level of solubility and availability of nutrients relative to timeliness and placement. The effectiveness of the two forms of fertilizer can be significantly different [9]. Liquid fertilizers have greatly increased in popularity in recent years, it can be either ground applied or foliar applied [12]. Budiono and Sudarwati [13] reported that liquid ornagic fertilizer combined with inorganic fertilizers had an effect on the growth and yield of sweet corn. To be able to produce well, corn plants need fertilizer [14], but Fadhillah *et al.* [15] stated that excessive application of fertilizers may not increase yield and may had a negative impact on the environment, therefore it is very important to determine the right dose of fertilizer for certain commodities.

Research on the effect of liquid NPK fertilizer on sweet corn had been carried out with different NPK nutrient compositions. The purpose of this study was to determine the effectiveness of liquid NPK fertilizer with a composition of 12:9:7 on sweet corn plant.

2 Materials and methods

2.1 Research design

The study was conducted using a randomized block design with eight treatments and four replications. The treatment consisted of six doses of liquid NPK fertilizer with a composition of 12:9:7 (Table 1).

Table 1. Fertilizer treatment.

Treatment	Fertilizer dosage		
	Liquid NPK fertilizer (cc L^{-1})	Phonska (kg ha^{-1})	Urea (kg ha^{-1})
Control	-	-	-
Standard	-	300	300
A	2.5	-	-
B	5.0	-	-
C	7.5	-	-
D	10.0	-	-
E	12.5	-	-
F	15.0	-	-

2.2 Materials and tools

The materials used in the research were liquid NPK 12:9:7 fertilizer, urea fertilizer, phonska fertilizer, sweet corn seeds of Talenta variety, and pesticides. The equipment used is hand tractor, hoe, wooden stick, hand sprayer, ruler, stationery, calipers, and scales.

2.3 Research location

The research was conducted at the Mojosari Research Station, Mojokerto district, East Java Province, Indonesia with an altitude of 28 m above sea level. The research location had a regosol soil type with low organic matter, low N and K nutrient, while the available P content was high, and the pH was neutral. The study was conducted in September to December 2020.

2.4 Observation and data analysis

Observations made after the plant were 15 DAP, with an interval of 7 d. The parameters observed included observations of plant growth and yield components, namely: plant height, number of leaves, stem diameter, number of cobs per plant, ear diameter, weight of cobs per plant, weight of stover and production per ha.

The data were analyzed statistically using the analysis of variance test and Least Significant Different (LSD) test at 5 % level. The effectiveness of fertilizer was calculated by Relative Agronomic Effectiveness (RAE) [12] in Equation (1)

$$\text{RAE} = \frac{\text{yield of tested fertilizer} - \text{yield on control}}{\text{standard fertilizer yield} - \text{yield on control}} \times 100\ \% \qquad (1)$$

3 Results and discussions

3.1 Liquid NPK fertilizer quality test results

Based on the results of the quality test on the water of NPK fertilizer used, the total content of liquid macronutrient fertilizer was 28.33 % with each element containing 12.3 % total N, P_2O_5 8.89 %, and K_2O 7.14 % (Table 2). The minimum technical requirements for inorganic fertilizer [16] were the amount of liquid macronutrient fertilizer content of at least 10 % with each element containing a minimum of 2 %. Thus, the new formulation of liquid NPK fertilizer used is included in the category of compound liquid inorganic fertilizer in accordance with the requirements.

Table 2. Quality test results of liquid anorganic NPK fertilizer.

Nutrient	Content (%)
Total nitrogen	12.3
P_2O_5	8.89
K_2O	7.14
Heavy metal	
Cadmium (Cd)	ND
Lead (Pb)	ND
Total arsenic (As)	ND
Total mercury (Hg)	0.117

3.2 Results of soil analysis before research implementation

The results of soil analysis at the research site showed that the level of acidity (pH) was neutral. The nutrient content of N and K was low, while the content of P was high. The source of water for irrigating plants is obtained from pump wells.

Table 3. Results of soil analysis (Mojosari Research Station, 2020).

Number	Parameter	Value	Unit	Method
1.	Water content	3.03	%	Gravimetry
2.	pH H_2O	7.0	-	(1:5), Elektrometry; pH meter
	pH KCl	5.7	-	(1:5), Elektrometry; pH meter
3.	C-organic *)	0.70	%	Walkley & Black; Spectrophotometer
4.	Nitrogen total *)	0.13	%	Kjeldahl; Titrimetry
5.	P_2O_5 available *)	77	mg L^{-1}	Olsen; Spectrophotometer
6.	Exchangeable cation (dd) *):			
	- K	0.42	cmol (+) kg^{-1}	Percolation NH_4-Ac 1 M, pH 7; AAS
	- Ca	6.28	cmol (+) kg^{-1}	Percolation NH_4-Ac 1 M, pH 7; AAS
	- Mg	3.40	cmol (+) kg^{-1}	Percolation NH_4-Ac 1 M, pH 7; AAS
	- Na	0.39	cmol (+) kg^{-1}	Percolation NH_4-Ac 1 M, pH 7; AAS
7.	Capacity exchangable cation (CEC) *)	19.60	cmol (+) kg^{-1}	Percolation NH_4-Ac 1 M, pH 7; AAS +NaCl 10 %; Titrimetry
8.	Texture *):			
	- Sand	45	%	Hydrometer
	- Dust	32	%	Hydrometer
	- Clay	23	%	Hydrometer
	Criteria	Clay		Texture triangle (USDA)

The values listed are valid only for the sample in question at the time of testing. Note: *) for oven dry samples 105 ºC.

3.3 Liquid NPK fertilizer effect on growth and yield of sweet corn

3.3.1 Plant height

The results of the analysis of plant height showed that at the age of 2 WAP there was not significant difference among treatments, then at the age of (4, 6 and 7) WAP, there was significant difference among treatments, especially against control.

The application of liquid NPK fertilizer at a dose of 10 cc L^{-1} to 15 cc L^{-1} was not significantly different with the standard, this indicated that the application of liquid NPK fertilizer in this doses had the same effect as standard fertilizer on corn plant height (Table 4).

Table 4. Plant height.

Treatments	Plant height (cm)			
	2 WAP	**4 WAP**	**6 WAP**	**7 WAP**
Control	9.35 a	26.30 c	118.80 c	153.20 c
Standard = (phonska 300 + urea 300) kg ha^{-1})	10.90 a	40.10 a	152.25 a	180.80 a
A = liquid NPK fertilizer 2.5 cc L^{-1}	9.15 a	31.40 bc	128.30 bc	163.15 bc
B = liquid NPK fertilizer 5 cc L^{-1}	10.25 a	32.95 abc	138.05 ab	165.85 b
C = liquid NPK fertilizer 7.5 cc L^{-1}	9.60 a	32.00 bc	131.65 bc	166.50 b
D = liquid NPK fertilizer 10 cc L^{-1}	9.30 a	34.70 ab	131.20 bc	166.55 b
E = liquid NPK fertilizer 12.5 cc L^{-1}	9.60 a	36.35 ab	142.95 ab	171.40 ab
F = liquid NPK fertilizer 15 cc L^{-1}	10.20 a	36.75 ab	144.20 ab	169.95 ab
Average	9.80	33.82	135.93	167.18
F value	ns	*	*	**
LSD (5 %)	1.78	7.62	17.42	11.96

The value in the same column followed by the same letter were not significantly different based on the LSD test at 5 %.

3.3.2 Number of leaves

Application of liquid NPK fertilizer did not significantly affect the number of leaves of sweet corn at the age of 2 WAP and 4 WAP, while at the age of 6 WAP it was very significant from the control. The effect of liquid fertilizer application can be seen at the age of 6 WAP (Table 5).

Table 5. Number of leaves.

Treatments	Number of leaves		
	2 WAP	**4 WAP**	**6 WAP**
Control	4.4 a	6.40 a	10.15 b
Standard = (phonska 300 + urea 300) kg ha^{-1})	4.5 a	6.85 a	11.45 a
A = liquid NPK fertilizer 2.5 cc L^{-1}	4.3 a	6.90 a	10.20 b
B = liquid NPK fertilizer 5 cc L^{-1}	4.6 a	6.55 a	10.13 b
C = liquid NPK fertilizer 7.5 cc L^{-1}	4.4 a	6.35 a	10.20 b
D = liquid NPK fertilizer 10 cc L^{-1}	4.4 a	6.50 a	10.20 b
E = liquid NPK fertilizer 12.5 cc L^{-1}	4.3 a	6.85 a	10.35 b
F = liquid NPK fertilizer 15 cc L^{-1}	4.4 a	6.90 a	10.45 b
Average	4.39	6.66	10.39
F value	ns	ns	**
LSD (5 %)	0.45	0.73	0.53

The value in the same column followed by the same letter were not significantly different based on the LSD test at 5 %.

3.3.3 Stalk diameter

Application of liquid NPK fertilizer significantly affected the stalk diameter. Corn stalk diameter observation at the age of 4 WAP to 8 WAP on the application of liquid NPK fertilizer 2.5 cc L^{-1} to 5 cc L^{-1} showed the same pattern with the control. The Liquid NPK fertilizer application which showed not significant different with the standard were at a dose of 12.5 cc L^{-1} and 15 cc L^{-1} (Table 6).

Table 6. Stalk diameter.

Treatments	Diameter of stalks (cm)			
	4 WAP	**6 WAP**	**7 WAP**	**8 WAP**
Control	19.5 d	20.6 c	19.1 c	19.5 d
Standard = (phonska 300 + urea 300) kg ha^{-1})	24.6 a	24.5 a	22.8 a	22.4 a
A = liquid NPK fertilizer 2.5 cc L^{-1}	21.5 bc	21.2 c	19.8 c	19.1 cd
B = liquid NPK fertilizer 5 cc L^{-1}	21.1 cd	21.9 bc	20.0 c	19.9 abcd
C = liquid NPK fertilizer 7.5 cc L^{-1}	21.2 bcd	21.5 bc	20.6 bc	19.7 bcd
D = liquid NPK fertilizer 10 cc L^{-1}	22.1 bc	21.6 bc	19.6 c	20.9 abcd
E = liquid NPK fertilizer 12.5 cc L^{-1}	24.0 a	23.5 ab	22.7 a	21.6 abc
F = liquid NPK fertilizer 15 cc L^{-1}	23.1 ab	24.5 a	21.9 ab	22.2 a
Average	22.15	22.41	20.78	20.54
F value	**	**	**	*
LSD (5 %)	1.9	2.2	1.7	2.6

The value in the same column followed by the same letter were not significantly different based on the LSD test at 5 %.

3.3.4 Sweet corn cobs

The parameters of weight, length, and diameter of the cobs (including the cob husk) showed the same pattern as the peeled corn cobs. The application of liquid NPK fertilizer 2.5 cc L^{-1} to 10 cc L^{-1} in a watered manner, was not significantly different from the control on the three parameters mentioned above and significantly different when compared to standard treatment. The application of 12.5 cc L^{-1} to 15 cc L^{-1} of liquid NPK fertilizer were not significant different with the standard (Table 7).

Table 7. Weight, length, and diameter of the cobs.

Treatments	Cobs + cobs husk			Peeled corn cobs		
	Weight (g)	**Lenght (cm)**	**Diameter (mm)**	**Weight (g)**	**Lenght (cm)**	**Diameter (mm)**
Control	143.9 d	22.37 bc	44.6 c	112.6 d	10.7 d	40.2 e
Standard = (phonska 300 + urea 300) kg ha^{-1})	251.5 a	23.33 ab	51.2 a	208.7 a	14.7 a	47.3 a
A = liquid NPK fertilizer 2.5 cc L^{-1}	146.5 d	21.23 c	43.2 c	117.5 d	11.5 cd	40.8 de
B = liquid NPK fertilizer 5 cc L^{-1}	178.5 cd	23.87 a	46.9 bc	138.7 cd	11.9 cd	42.6 cde
C = liquid NPK fertilizer 7.5 cc L^{-1}	185.1 bcd	22.37 abc	46.7 bc	153.1 bcd	12.8 bc	43.3 bcd
D = liquid NPK fertilizer 10 cc L^{-1}	186.1 bcd	21.90 bc	47.0 bc	151.5 bcd	13.0 bc	44.2 bc
E = liquid NPK fertilizer 12.5 cc L^{-1}	218.5 abc	23.27 ab	48.8 ab	179.3 abc	13.8 ab	45.3 abc
F = liquid NPK fertilizer 15 cc L^{-1}	230.7 ab	23.97 a	49.7 ab	187.5 ab	14.1 ab	46.2 ab
Average	192.6	22.77	47.26	156.10	12.62	43.74
F value	**	*	*	**	**	*
LSD (5 %)	48.46	1.62	3.84	41.99	1.62	3.08

The value in the same column followed by the same letter were not significantly different based on the LSD test at 5 %.

3.3.5 Weight of stover (biomass) and sweet corn yield per ha

The application of inorganic liquid NPK fertilizer had an effect on the weight of stover and sweet corn yield. The weight of stover at doses of 12.5 cc L^{-1} and 15 cc L^{-1} were not significant different with the standard treatment, while at the dose of 2.5 cc L^{-1} to 10 cc L^{-1} of inorganic liquid NPK fertilizer, the weight of the stover was lower than the standard treatment (Table 8).

Table 8. Weight of stover and sweet corn yield per ha.

Treatments	Weight of stover (t ha^{-1})	Yield (t ha^{-1})
Control	10.48 d	4.69 e
Standard = (phonska 300 + urea 300) kg ha^{-1})	19.11 a	13.73 a
A = liquid NPK fertilizer 2.5 cc L^{-1}	13.14 cd	7.39 d
B = liquid NPK fertilizer 5 cc L^{-1}	15.15 bc	8.15 d
C = liquid NPK fertilizer 7.5 cc L^{-1}	14.95 bc	9.24 c
D = liquid NPK fertilizer 10 cc L^{-1}	14.40 bc	10.22 b
E = liquid NPK fertilizer 12.5 cc L^{-1}	17.19 ab	13.35 a
F = liquid NPK fertilizer 15 cc L^{-1}	17.57 ab	13.39 a
Average	15.25	10.02
F value	*	**
LSD (5 %)	3.25	0.84

Table 8 showed that the highest yield of sweet corn was in the standard treatment. The application of liquid NPK fertilizer which gave equal yield to the standard treatment was in the treatment of 12.5 cc L^{-1} and 15 cc L^{-1}. The results of research that conducted by Maintang *et al.* [17] which combined liquid organic fertilizers and 75 % recommended inorganic fertilizers (15 mL per 2 L water or 7.5 mL L^{-1} + NPK phonska 300 kg ha^{-1} + urea 150 kg ha^{-1}) can be the recommended dosage for optimum maize production. Another research by Arifin [18] reported that liquid NPK fertilizer 4 mL L^{-1} combined with 300 urea kg ha^{-1} + 50 SP-36 kg ha^{-1} was effective to increasing the yield. Many applications of NPK liquid inorganic fertilizer have been carried out, one of which is cabbage [19]. Apart from vegetable crops, food crops (such as rice) also need NPK fertilizer to increase production [20].

3.3.6 Relative agronomic effectiveness (RAE)

The results of the relative agronomic effectiveness (RAE) analysis showed that the application of inorganic liquid NPK fertilizer was effective on sweet corn. The treatment that produce an RAE value > 95 % were application of liquid NPK fertilizer amount of 12.5 cc L^{-1} (RAE value of 95.82 %) and 15 cc L^{-1} (RAE value of 96.26 %) (Table 9).

Table 9. Relative agronomic effectiveness (RAE).

Treatments	RAE (%)
Control	-
Standard = (phonska 300 + urea 300) kg ha^{-1})	-
A = liquid NPK fertilizer 2.5 cc L^{-1}	29.85
B = liquid NPK fertilizer 5 cc L^{-1}	38.26
C = liquid NPK fertilizer 7.5 cc L^{-1}	50.36
D = liquid NPK fertilizer 10 cc L^{-1}	61.21
E = liquid NPK fertilizer 12.5 cc L^{-1}	95.82
F = liquid NPK fertilizer 15 cc L^{-1}	96.26

4 Conclusions

Application of inorganic liquid NPK fertilizer was significantly affected the growth and yield of sweet corn. Application at a dose 12.5 cc L^{-1} by watering, gave the same response or equal to the standard with the level of agronomic effectiveness > 95 %.

The authors would like to thank to the partner for funding this activity, to East Java AIAT Director for the permission given to carry out this research, and also to colleagues involved in the study, who can not be mentioned one by one.

References

1. T. Santia, *Daftar 10 Provinsi Penghasil Jagung Terbesar Indonesia, Mana Saja?* [List of Indonesia's 10 Largest Corn Producing Provinces, Which Ones?] [Online] from https://www.liputan6.com/bisnis/read/4449535/daftar-10-provinsi-penghasil-jagung-terbesar-indonesia-mana-saja (2021) [Accessed on Juli 25th 2021] [in Bahasa Indonesia]
2. M. Muhsanati, A. Syarif, S. Rahayu, Jerami, **1**,2: 87–91 (2008) [in Bahasa Indonesia] https://docplayer.info/81711225-Pengaruh-beberapa-takaran-kompos-tithonia-terhadap-pertumbuhan-dan-hasil-tanaman-jagung-manis-zea-mays-saccharata.html
3. M. Chafid. *Outlook komoditas pertanian sub sektor tanaman pangan jagung.* [Outlook for agricultural commodities in the sub sector of corn food crop]. Pusat Data dan Sistem Informasi Pertanian, Jakarta (2016). p.102. [in Bahasa Indonesia] https://www.scribd.com/document/357331967/Outlook-Jagung-2016#
4. M. Troell, R.L. Naylor, M. Metian, M. Beveridge, P.H. Tyedmers, C. Folke, et al., Perspective, **111**,37: 13257–13263 (2014) https://doi.org/10.1073/pnas.1404067111
5. FAO. *The future of food and agriculture – trends and challenges*. Food and Agriculture Organization of the United Nations, Rome (2017). p.163 https://www.fao.org/3/i6583e/i6583e.pdf
6. V. Saiz-Rubio, F. Rovira-Más, Agronomy, **10**,2: 1–21 (2020) http://dx.doi.org/10.3390/agronomy10020207
7. M.D. Clercq, A. Vats, A. Biel. *Agriculture 4.0: the future of farming technology* [Online] from https://www.oliverwyman.com/our-expertise/insights/2018/feb/agriculture-4-0--the-future-of-farming-technology.html (2018).
8. Sod Solutions. *Granular vs. liquid fertilizers* [Online] from https://sodsolutions.com/lawn-garden-nutrition/granular-vs-liquid-fertilizers/ [Accessed on March 23rd 2023]
9. Nebraska Corn Board. *Granular Vs. Liquid Fertilizer: What's Best For Corn Farmers* [Online] from https://nebraskacorn.gov/cornstalk/research/granular-vs-liquid-fertilizer-whats-best-for-corn-farmers/ [Accessed on April 15th 2023]
10. A. McCauley, C. Jones, J. Jacobsen, Nutrient Management, **10**: 1–20 (2009) https://apps.msuextension.org/publications/pub.html?sku=4449-10
11. Kynoch Fertilizer. *5 Exceptional benefits of using liquid fertilizer for your crops* [Online] from https://www.kynoch.co.za/5-benefits-of-using-liquid-fertilizer/ [Accessed on April 15th 2023)
12. J. Isleib. *Pros and cons of granular and liquid fertilizers* [Online] from https://www.canr.msu.edu/news/pros_and_cons_of_granular_and_liquid_fertilizers (2016) [Accessed on July 25th 2021].
13. R. Budiono, E. Sudarwati, *Pengaruh pupuk organik cair terhadap pertumbuhan tanaman jagung manis* (Zea mays saccarata L.). [Effect of liquid organic fertilizer on growth sweet corn plant (*Zea mays saccarata* L.)] Seminar Nasional Fakultas Pertanian

Universitas Muhammadiyah Purwokerto, (Purwokerto, Indonesia, 2019). Prosiding **12**: 457–470 (2020) [in Bahasa Indonesia]. https://digitallibrary.ump.ac.id/674/2/R2_13.%20Budiono%26Sudarwati_PPOC%20thd%20tanaman%20jagung%20manis_457-470.pdf

14. Z. Maulana, Z. Zaitun, J. Jumini, *The effect of bio liquid fertilizer application on the growth and yield of two varieties of maize* (Zea mays L.). The 8th International Conference of Chemical Engineering on Science and Applications (Banda Aceh, Indinesia, 2015). Proceeding of the 5th Annual International Conference Syiah Kuala University **5**,2: 224–227 (2015) https://jurnal.usk.ac.id/AICS-SciEng/article/view/5848/0
15. I.M. Fadhillah, D. Dasumiati, S. Sudjatmiko, *Growth and yield of sweet corn in response to the liquid organic fertilizer derived from* Tithonia diversifolia *and* Ageratum conyzoides. The 3rd International Seminar on Promoting Local Resources for Sustainable Agriculture and Development, (Bengkulu, Indonesia, 2022). E3S Web Conferences **373**,03010: 1–7 (2023) https://doi.org/10.1051/e3sconf/202337303010
16. Kementerian Pertanian. *Peraturan Menteri Pertanian No. 70/Permentan/SR.140/10/2011 tentang Pupuk Organik, Pupuk Hayati, dan Pembenah Tanah*. [Regulation of the Minister of Agriculture No. 70/Permentan/SR.140/10/2011 concerning Organic Fertilizers, Biological Fertilizers, and Soil Improvers]. Kementerian Pertanian, Jakarta (2011). p.109. [in Bahasa Indonesia]. https://psp.pertanian.go.id/storage/545/Permentan-No.-70-Th.-2011-ttg-Pupuk-Organik-Pupuk-Hayati-dan-Pembenah-Tanah.pdf
17. M. Maintang, F. Sudding, M. Asri, A.W. Rauf, *Application of liquid organic and inorganic fertilizer on growth and production of hybrid maize*. 1st International Conference on Sustainable Tropical Land Management, (Bogor, Indonesia 2020). IOP Confer. Ser. : Earth Environ. Sci., **648**,012140 : 1–11 (2021) https://doi.org/10.1088/1755-1315/648/1/012140
18. Z. Arifin, *The effect of liquid npk fertilizing on corn plants*. International Conference on Biology and Applied Science (Malang, Indonesia, 2019). AIP Conf. Proc., **2120**,030013: 1–10 (2019) https://doi.org/10.1063/1.5115617
19. Z. Sa'adah, R. Budiono, N. Istiqomah, *Effect of liquid fertilizer supplement (ppc) and anorganic fertilizer dosage on growth and yields of cabbage* (*Brassica oleraceae* L). International Conference on Life Sciences and Biotechnology (Jember, Indonesia, 2015). Proceeding 343–347 (2016) http://103.195.142.59/uploaded_files/temporary/DigitalCollection/ZGVlMTU4ZDRkOGQ2OGI4YTE0M2UzYjk1OTViYmUxNDlkYjM4ODdhZg==.pdf
20. R. Budiono, P.G. Adinurani, P. Soni, *Effect of new NPK fertilizer on lowland rice* (*Oryza sativa* L.) *growth.* The 2nd International Conference on Natural Resources and Life Sciences (Surabaya, Indonesia, 2018). IOP Conf. Ser.: Earth Environ. Sci., **293**,012034: 1–10 (2019) https://doi.org/10.1088/1755-1315/293/1/012034