East Asian Journal of Multidisciplinary Research (EAJMR)
Vol. 3, No. 9, 2024 : 4039 - 4050

Effect of Phosphate Fertilization and Liming on Ultisol Soil on Dry Corn Seed Yield (Zea *mays* L.) and Soybeans (*Glycine max* L.(Merr))

Charles Silahooy
Soil Science Study Program, Department of Agricultural Cultivation, Faculty of Agriculture, Pattimura University, Ambon
Corresponding Author: Charles Silahooy charlessilahooy@gmail.com

A R T I C L E I N F O

Keywords: Corn Zea mays L, Lime, Phosphate, Soybean Glycine max L. Merr, Ultisol

Received : 14, July
Revised : 27, July
Accepted: 28, Ausgust

A B S T R A C T

Fertilization of phosphate and lime on ultisol soils will increase the pH of the soil where a high soil pH causes an increase in nutrients. However, the fertilization carried out must pay attention to several things, namely the plants being fertilized, the type of soil, the type of fertilizer used, the dose given, the fertilization time and the method of fertilization. This study aims to obtain information on the effect of phosphate fertilization and liming on ultisol soil on the yield of dry corn (*Zea mays* L.) and soybean (*Glycine max* L.(Merr). This research was carried out in Halong Village, Baguala District, Ambon City, which took place from January to May 2024. Soil and plant analysis was carried out at the Soil Laboratory, Faculty of Agriculture, Pattimura University. The experimental design used in this study is a complete randomized design with a factorial pattern with three replicates. The factors studied were P fertilizer and lime, where the parameters studied were the weight of dry seeds, corn kernels and soybeans. The results showed that phosphate fertilization on ultisol soil could increase soil pH which led to an increase in dry seed weight of corn and soybeans and the best combination of phosphate and lime fertilizer dosage on ultisol soil for an efficient increase in dry seed weight of corn and soybean was 92.6 kg P_2O_5/Ha and 1.5 x Ald

DOI prefix: https://doi.org/10.55927/eajmr.v3i9.10294
ISSN-E: 2828 – 1519
https://journal.formosapublisher.org/index.php/eajmr

INTRODUCTION

Corn (*Zea mays* L.) is a cereal crop that originated in the Americas, precisely from the country of Mexico. This plant is a type of grass grass plant with a monocot seed type (Wulandari and Jaelani, 2019). Corn can grow in almost every type of soil, but in order to produce optimally, it is necessary to have land conditions with soil acidity (pH between 5.8-6.8), with nutrient content of N, P, K at medium-high criteria, and Al saturation <15% and not waterlogged. The availability of complete and balanced nutrients that can be absorbed by plants is a factor that determines plant growth and production (Prakoso *et al*., (2020). The same thing is experienced by soybean plants (*Glycine max* L. (Merr), where the productivity does not only depend on the type of soil used but also must pay attention to the nutrients contained in the soil. According to Subaedah *et al.,* (2021), soybeans are plants that require a lot of nutrients to obtain good fruit and seed production. The main nutrients that need to be added to the fertilization of soybean plants, one of which is phosphate. Phosphate is able to increase the rate of photosynthesis and produce high protein concentrations leading to increased productivity of soybean plants.

Ultisole soil is one of the soils with high levels of acidity and saturation of Al, low nutrient content and organic matter and sensitive to erosion. In addition, Ultisol has a pH (3.1 – 5). Ultisol, which has a pH of less than 4.5, is dominated by Al3+, which inhibits root growth and a pH of less than 5.0 can reduce the availability of nutrients. Plant growth in acidic soil is influenced by Al, where when the soil pH is low (4.0-5.0), the Al present in the soil solution is Al3+ with high activity. Efforts to increase Ultisol productivity are through calcification (Apriadi *et al*., 2022). Fertilization of phosphate and lime on ultisol soils will increase the pH of the soil where a high soil pH causes an increase in nutrients. Phosphate fertilization is usually carried out to meet the nutrient needs of plants, especially in soils with low P content. Phosphate fixation maintains pH 6.0 and 7.0 so that phosphate and its absorption increase leading to increased plant production. The application of phosphate fertilizer to soybean plants can stimulate the growth of new roots, the formation of a number of proteins, aid assimilation and respiration, stimulate the formation of flowers, fruits and seeds (Opala *et al*., 2018). In order to be more efficient, fertilization must pay attention to the proper dosage, type, time of application and placement of fertilizer (Flatian *et al*., 2018). The application of lime fertilizer improves the formation of root nodules of leguminosa plants and decreases the concentration of acid cations, increasing the size of seeds so that a high increase in pod yield is achieved (Anwar, 2019). Fertilization is carried out to maintain and increase the availability of substances containing one or more nutrients in the soil which are intended to replace nutrients that have been absorbed from the soil so that plants will grow well and are able to have maximum potential. The ability of plants to form seeds in pods is more determined by the status of nutrients available to plants (Santana *et al*., 2021).

The application of high doses of phosphate fertilizer can cause acidic soil, so certain measures are needed to reduce the dose so that phosphate fertilization can be more efficient, for example through soil pH regulation with liming. If the pH is below 6 and above 7, it greatly affects the growth and yield of various types of food crops such as corn and soybeans. This is because the efficiency of nutrient absorption by plants is highly dependent on the high pH of the soil. If the soil pH in ultisol soil increases, it is believed that the nutrient acquisition in corn and soybean plants will be sufficient so that it can increase the weight of dry corn and soybeans. However, according to Hawayanti *et al.*, (2022), fertilization is carried out by paying attention to several things, namely the plants being fertilized, the type of soil, the type of fertilizer used, the dose given, the time of fertilization and the method of fertilization. Based on this, it is necessary to conduct research on the effect of phosphate fertilization and liming on ultisol soil on the yield of dry corn (*Zea mays* L.) and soybeans (*Glycine max* L. (Merr).

THEORITICAL REVIEW

Ultisols, a major soil order in Indonesia, are characterized by low levels of available phosphorus (P), high acidity, and aluminum toxicity, which significantly limit crop productivity. Phosphate fertilization and liming are critical practices to mitigate these constraints and enhance soil fertility. This review aims to synthesize the effects of phosphate fertilization and liming on Ultisol soil, focusing on their impact on dry corn seed yield and soybean production.

Phosphate Fertilization

Phosphorus (P) is an essential macronutrient for plant growth, particularly during the reproductive stages of crops like corn and soybeans. In Ultisols, the low availability of P due to high fixation rates and low cation exchange capacity (CEC) necessitates the application of P fertilizers. Studies have shown that applications of 20 to 80 kg P/ha are sufficient to fertilize crops in rotation, with a residual effect lasting at least two years. This practice not only improves crop yields but also enhances the economic return of farming activities.

Liming

Liming is essential for correcting soil acidity and reducing aluminum toxicity in Ultisols. Aluminum saturation levels above 15% can significantly reduce plant growth, particularly for soybeans. Liming increases the pH of the soil, thereby reducing the availability of aluminum and increasing the availability of phosphorus. This process is crucial for improving soil fertility and plant nutrient uptake.

Combined Effects on Crop Yields

The combined application of phosphate fertilizers and lime can have synergistic effects on crop yields. For example, a study on soybean production in cambisol soil found that while liming contributed relatively less to increasing dry seed weight compared to phosphate fertilization, the combination of both practices significantly enhanced overall productivity[2]. Similarly, in a trial conducted over 21 years, phosphate fertilization and soil acidity correction through liming increased dry matter production and improved grassland quality.

Specific Effects on Corn and Soybeans

Corn (Zea mays L.) : Corn is a P-intensive crop, and its growth is significantly influenced by the availability of P. In Ultisols, the application of P fertilizers is crucial for achieving optimal yields. The critical aluminum saturation level for corn is around 29%, indicating that liming is necessary to maintain a favorable pH and reduce aluminum toxicity.

Soybeans (Glycine max L.(Merr)) : Soybeans are also P-dependent, and their growth is affected by the availability of P and the pH of the soil. The critical aluminum saturation level for soybeans is around 15%, indicating that liming is essential to reduce aluminum toxicity and improve P availability.

METHODOLOGY

Place, Tools and Materials, and Research Design

This research was conducted in a plastic house in Halong Village, Baguala District, Ambon City. Soil and plant analysis was carried out at the Soil Laboratory, Faculty of Agriculture, Pattimura University. The implementation of the research will take place from January to May 2024.

The materials used are ultisol soil, corn seeds of the C-1 hybrid variety and soybean seeds of the Willis variety, as the basic fertilizer used fertilizer (46%N) and KCL (60%K2O), as treatment materials used TSP fertilizer (46% P2O5) and dolomite lime material, pesticides are used when plants are attacked by pests, water for watering, and other materials for analysis purposes in the laboratory. Meanwhile, the tools used are hand sprayer, pH meter, scale, land map, destructive tools, hoes, shovels, plastic buckets, paralon pipes, 2 mm sieve, field knives, nameplates, and writing stationery.

The experimental design used in this study is a complete randomized design with a factorial pattern with three replicates. The factors studied were P fertilizer and lime. The dose of P fertilizer used was 278.04 kg P2O5/Ha, while the lime dose was based on the soil Aldd used.

1) The dosage of P fertilizer consists of four levels, namely:

P0 = Without P fertilizer
P1 = 92.6 kg P2O5/Ha
P2 = 185.3 kg P2O5/Ha
P3 = 278 kg P2O5/ha

2) Lime treatment consists of four levels, namely:

P0 = Without chalk
P1 = 0.5 x Aldd
P2 = 1.0 x Aldd
P3 = 1.5 x Aldd

Thus there are 16 treatment combinations. Each treatment was repeated 3 times (4 x 4 x 3) so that there were 48 experimental units for both corn and soybeans. The mathematical model is:

$$Yijk = u + Pi + Kj + PKij + Eijk$$

Where:

Yijk	=	Response variables
u	=	Effect of average treatment
Pi	=	Effect of the ith P fertilizer treatment
Kj	=	Effect of the j lime treatment
PKij	=	Effect of the interaction of the i-grade fertilizer treatment with the j-grade lime
Eijk	=	Experiment error

If the F test is real, it will be continued with the BNJ test at the level of 5%.

Variables of Response and Research Implementation

The response variables to be measured are:
1) Soil pH (H2O 1 : 2.5)
2) Corn dry seed yield
3) Soybean dry seed yield

The implementation of the research starts from soil preparation. The soil is taken from a depth of 0 - 30 cm, dPi let the air dry and sieve with a sieve of 2 mm. 1 kg of soil was taken for analysis of pH (H2O 1 : 2.5), Al + H,$_{P2O5}$, available, accompanied by sampling of whole soil for determination of content weight using a sample ring. From the results of this preliminary analysis, it is also used to determine the amount of lime that must be added according to the treatment, and for the treatment of regulating the uniformity of the content weight or soil density in the experimental pot. 8 kg of soil is put into the pot and the volume of the pot is arranged in such a way that the same weight of soil content as in the field is achieved.

After soil preparation, liming is carried out 2 weeks before planting. The lime is put into the test pot according to the treatment and then mixed until evenly distributed. Urea and KCL fertilization as basic fertilizers are applied simultaneously at the time of planting and applied in a tugal manner for all plants in each experimental pot with a distance of 10 cm from the plant and a depth of 5 cm. Likewise with the provision of TSP as a treatment. The fertilizer dose used was 49.06 kg N per hectare and 50.01 kg K2O per hectare.

Planting is carried out with a task system 3 cm deep and for each tugal 3 seeds are inserted. Before planting, soybean seeds are inoculated with rhizobin A according to the dose, which is 5 g $^{kg-1}$ soybean seed.

Plant embroidery is done after 1 week of age, along with thinning the plant by leaving one of the best plants per pot. The intention is to prevent competition for nutrients and sunlight. Weeding is carried out 2 times, the first time at the age of 15 days after planting and guarded so as not to damage the roots of the plant. The second weeding is when the plant is 30 days old and is carried out at the same time with loosening as necessary to maintain good soil aerase and draenase.

Irrigation can be provided at the same time as planting, and the moisture content is maintained at the capacity of the field. To prevent pest attacks on plants, the pesticide Sevin 85 S is used with a concentration of 2.5 cc $^{liter-1}$.

Corn harvesting is carried out when the corn is old enough, that is, when the corn husk is yellow. The same is the case with soybeans, namely when the pods are ripe enough and the leaves have fallen off. The harvest in the form of dried seeds is then weighed. At the end of the study, soil was taken in each unit of the experiment and left to air dry and sifted with a 2 mm sieve to analyze the content of available P (Olsen) and pH (H2O 1 : 2.5).

For analysis needs, 1 sample from each experimental pot has been taken (48 samples from corn pots and 48 samples from soybean pots). Soil pH analysis was carried out on 48 soil samples which were a combination of corn and soybean pot experimental units, to make anava and BNJ. The available P2O5 analysis was only performed on 16 soil samples which were a combination of each experimental replicate from a pot of corn and soybeans.

Soil and Plant Analysis

At the end of the study, soil was taken in each experimental unit and allowed to air dry and sifted with a 2 mm sieve to analyze the content of available P (Olsen) and pH (H2O 1 : 2.5).

In addition to soil analysis, analysis of dry corn and soybean kernels was also carried out. For this purpose, harvesting is carried out when the corn husks are yellow, while soybeans when the pods are ripe enough are marked by falling leaves. The harvest in the form of dried corn and soybeans is then weighed.

For analysis purposes, soil was taken 1 sample from each experimental pot (48 samples from corn pots and 48 samples from soybean pots). Soil pH analysis was carried out on 48 soil samples which were a combination of corn and soybean pot experimental units, to be made by Anava and BNJ. The available P2O5 analysis was only performed on 16 soil samples which were a combination of each experimental replicate from the corn and soybean pots.

RESULTS

1. ***Corn Dried Kernel Yield***

The results of diversity analysis showed that the yield of dry corn kernels was significantly affected by phosphate fertilization and the interaction of phosphate fertilization with liming, while the lime effect was not real. In the results of the average real difference test (Table 1), it was seen that at each level of lime treatment (k0, k1, k2, k3), increasing the dose of phosphate fertilization to p3 (p0 to p3) increased the yield of corn dry seeds and the real combination was k0p3 and k2p3. On the other hand, at each dose of P fertilizer, the combination with lime treatment has no real effect. This shows that phosphate fertilization plays a very important role in increasing corn seed yields.

Table 1. Test of the average difference in corn dry seed yield due to the interaction of phosphate fertilization with lime (gr)

Phosphate dosage (P)	Limescale			
	K0	K1	K2	K3
P0	0,000 A (A)	0,000 A (A)	0,000 A (A)	0,000 A (A)
P1	16,638 A (A)	7,375 A (A)	7,054 A (A)	33,685 A (A)
P2	8,931 A (A)	25,888 A (A)	30,683 A (A)	36,799 A (A)
P3	39,099 b (A)	31,289 A (A)	39,418 A (A)	13,267 A (A)

Information: The numbers followed by the same letter did not differ significantly in BNJ 0.05 (11.01). Uppercase letters for rows, lowercase letters for columns.
k0, k1, k2, k3: limescale of 0 x Aldd, 0.5 x Aldd, 1.0 x Aldd, 1.5 x Aldd.
p0, p1, p2, p3: sequential phosphate doses 0 kg P2O5/Ha, 92.6 kg P2O5/Ha, 185.3 kg P2O5/Ha, 278 kg P2O5/Ha

In the results of the average difference test, it was found that at each level of lime treatment (k0, k1, k2, k3) the combination with phosphate fertilization had a real effect on increasing soil pH. Without phosphate fertilization (p0), lime application had no significant effect on soil pH changes. This is suspected due to the application of lime 0.5 x Aldd, 1.0 x Aldd, 1.5 x Aldd without phosphate fertilization, the amount of Aldd that comes out of the adsorb complex and is deposited slightly. Thus the pH of the soil does not change much. In phosphate fertilization p1, p2, p3, it was seen that the combination with lime application at the k3 level had a real effect on soil pH changes. This is because although the application of lime at the k3 level the amount of Aldd that comes out of the adsorbation complex is suspected to be small, but the increase in the dose of phosphate fertilization also precipitates more Al so that it decreases the concentration of H+ ions.

Table 2. Test of the difference in the average soil pH due to the interaction of phosphate fertilization with lime

Phosphate dosage (P)	Limescale			
	K0	K1	K2	K3

Phosphate dosage (P)	Limescale			
	K0	K1	K2	K3
P0	5.05 A (A)	5.08 A (A)	5,06 A (A)	5.08 A (A)
P1	5.24 b (A)	5.33 b (AB)	5.39 b (B)	5.55 b (C)
P2	5.63 c (A)	5.77 c (AB)	5.85 c (BC)	5.98 c (C)
P3	6.15 d (A)	6.25 d (AB)	6.33 d (BC)	6.47 d (C)

Information: The numbers followed by the same letter did not differ significantly in BNJ 0.05 (11.01). Uppercase letters for rows, lowercase letters for columns.
k0, k1, k2, k3: limescale of 0 x Aldd, 0.5 x Aldd, 1.0 x Aldd, 1.5 x Aldd.
p0, p1, p2, p3: sequential phosphate doses 0 kg P2O5/Ha, 92.6 kg P2O5/Ha, 185.3 kg P2O5/Ha, 278 kg P2O5/Ha

The increase in soil pH due to the application of phosphate fertilizer (Table 2) is due to the release of a number of OH- ions into the solution due to the adsorption of some phosphate anions ($H2PO4^-$) by Al and Fe hydrate oxides so that the soil pH increases (Saragih and Sabrina, 2019). The application of phosphate fertilizer has an impact on increasing soil pH, where high soil pH causes phosphate to be available to plants so that plants are able to utilize N, P, K and other nutrients needed for plant growth (Nurmansyah, 2022). The high absorption of nutrients by plants causes the photosynthesis of corn plants to be optimal, resulting in the formation of assimilates in the form of carbohydrates. Maximum assimilates in plants can increase the grain weight of corn plants.

Although lime application had no effect, the combination of phosphate and lime of 92.6 kg P2O5/Ha and 1.5 x Aldd in ultisol soil had an effect on the increase in dry corn kernel weight. According to Apriadi *et al*., (2022), lime application has not had an effect on plant height, number of leaves, stem diameter, but it has an effect on increasing soil pH, and seed weight per plant. Plants utilize Element P obtained from phosphate fertilization and element P obtained from the role of Lime which increases soil pH so that plant productivity increases, characterized by the presence of most of the phosphate found in seeds and some of the rest in young plants (Gunawan, 2006 *in* Apriadi *et al*., 2022).

2. *Soybean Dried Seed Yield*

The results of diversity analysis showed that the yield of dried soybeans was significantly affected by phosphate fertilization treatment, liming and the interaction of phosphate fertilization with liming. In the results of the average differential test, it was seen that in the treatment of k0 and k3 lime, the increase in the dose of phosphate fertilizer to p3 had no real effect on the yield of soybean dry seeds. In k1 and k2 treatments, p2 and p3 phosphate fertilization significantly increased the yield of soybean dry seeds. At the dose of p0, p1, p2 fertilizer, lime treatment had no real effect on the yield of dry soybean seeds. Meanwhile, at the p3 dose, the calcification of k2 is significantly different from k0 and k1. Phosphorus is an essential macronutrient for plants, whose function cannot be replaced by other nutrients. The use of P fertilizer is to spur the growth of roots, flowers and seeds and function in the process of photosynthesis (Sirait and Siahaan, 2019).

Table 3. Test of the average difference in dry soybean yield due to the interaction of phosphate fertilization with lime (gr)

Phosphate dosage (P)	Limescale			
	K0	K1	K2	K3
P0	0.524 A (A)	0.169 A (A)	2,118 A (A)	0.655 A (A)
P1	5,320 A (A)	9,289 ab (A)	12,846 ab (A)	10,150 A (A)
P2	8,524 A (A)	12,297 b (A)	10,931 ab (A)	9,208 A (A)
P3	5,608 A (A)	1,919 ab (A)	20,868 b (B)	10,855 A (AB)

Information: The numbers followed by the same letter did not differ significantly in BNJ 0.05 (11.01). Uppercase letters for rows, lowercase letters for columns.
k0, k1, k2, k3: limescale of 0 x Aldd, 0.5 x Aldd, 1.0 x Aldd, 1.5 x Aldd.
p0, p1, p2, p3: sequential phosphate doses 0 kg P2O5/Ha, 92.6 kg P2O5/Ha, 185.3 kg P2O5/Ha, 278 kg P2O5/Ha

Phosphate fertilization has the effect of increasing soil pH (Table 2), where increasing soil pH causes an increase in nutrients that affect plants in increasing the yield of dry soybeans (Table 3). According to Sumbayak and Gultom (2020), the supply of nutrients available to plants is used in the photosynthesis process, then the results will be transferred in pod formation. The more pods that are formed, the more pods they contain. With more photosynthes formed, the filling of pods (seeds) can run well, because the results of photosynthesis will be transferred to the pods in the pod development phase. This is in line with Nuryani *et al*., (2019) who stated that increasing nutrient uptake can optimize the photosynthesis process in plants, so that it will increase the formation of assimilates in the form of carbohydrates and proteins which will then be translocated to the food reserve, namely pods and will affect the weight of pods per plant. The availability of sufficient assimilates in plants causes an increase in seed weight (Irawaty *et al*., 2019). The photosynthesis process increases due to the large number of leaves that grow because of the increasing amount of light that is captured, so that the potential assimilates from the process will be translocated to the seeds, causing the seeds to enlarge and increase the weight of the seeds (Zainal *et al*., 2014). This leads to an increase in the seed weight of soybean plants.

The best combination of phosphate and lime fertilizer doses in ultisol soil for efficient soybean weight increase was 92.6 kg P2O5/Ha and 1.5 x Aldd. This is in line with the research of Lusiana and Adiwijaya (2022), which showed that the combination of phosphate and lime fertilizer had an effect on increasing the seed weight of soybean plants. Phosphate fertilization must be balanced with lime fertilization, because phosphate and lime play a role in increasing nutrients and soil pH. An increase in soil pH causes an increase in nutrients including phosphates, where the abundance of nutrients including the availability of phosphate can increase high yields, in this case increasing the weight of soybeans.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the discussion regarding research that has been carried out, the best combination of phosphate and lime fertilizer doses in ultisol soil for efficient soybean weight increase, including:

1. Phosphate fertilization of ultisol soils can increase soil pH leading to an increase in the dry grain weight of corn and soybeans.

2. The best combination of phosphate and lime fertilizer doses on ultisol soils for an efficient increase in dry grain weight of maize and soybeans was 92.6 kg P2O5/Ha and 1.5 x Aldd

FUTURE STUDY

Optimization of Phosphate and Lime Fertilizer Doses for Different Crop Types :

- Investigate the optimal combination of phosphate and lime fertilizer doses for various crops grown in Ultisol soils, including soybeans, maize, and other staple crops.
- Analyze the impact of different fertilizer combinations on soil pH, nutrient availability, and crop yields.

REFERENCES

Anwar K. 2019. Manfaat Pengapuran Dan Dampak Pengapuran Berlebihan Bagi Tanah. *Cybext*. http://cybex.pertanian.go.id/mobile/artikel/73161/Manfaat-Pengapuran-Dan-Dampak-Pengapuran-Berlebihan--Bagi-Tanah/

Apriadi A. S., Muktamar Z., Supanjani. 2022. Aplikasi Kapur Dolomit Dan Pupuk Fosfat Untuk Meningkatkan Pertumbuhan Dan Hasil Tanaman Kacang Hijau (*Vigna radiata* L.) Pada Ultisols Di Kota Bengkulu. *Prosiding Seminar Nasional Pertanian Pesisir (SENATASI), Jurusan Budidaya Pertanian Fakultas Pertanian Universitas Bengkulu*. 1(1):46-58

Flatian A. N., Slamet, S., Citraresmini A. 2018. Perunutan Serapan Fosfor (P) Tanaman Sorgum Berasal dari 2 Jenis Pupuk yang Berbeda Menggunakan Teknik Isotop (32P). *Jurnal Ilmiah Aplikasi Isotop Dan Radiasi*, 14(2):109–116.

Hawayanti E., Astuti D. T., Afrizal H. A., Tambunan S. 2022. Efek Aplikasi Jarak Tanam dan Cara Pemupukan Terhadap Pertumbuhan dan Hasil Kedelai. *Jurnal Agroekoteknologi Tropika Lembab*. Vol. 4 No.2. Hlm 128-136

Irawaty R. E., Rahni N. M., Gusnawaty, Hasid R. 2019. Respons Tanaman Kedelai (*Glycine max* L.) terhadap Aplikasi Bokhasi Plus Pada Lahan Kering Marjinal. *Jurnal Berkala*. 7(1):45-64.

Lusiana, Adiwijaya H. D. 2022. Kombinasi Takaran Kapur Dan Pupuk Fosfat Terhadap Pertumbuhan Dan Hasil Tanaman Kedelai (*Glycine max* (L.) Merrill) Kultivar Anjasmoro. *AGRIVET Jurnal Ilmu Pertanian dan Peternakan*. 10(1):153-161

Nurmansyah M. 2022. Pentingnya Pengukuran pH Tanah. https://distanpangan-ev.sabangkota.go.id/berita/kategori/pendidikan-pelatihan/pengukuran-ph-tanah-di-jaboi

Nuryani, Eka *et al*. 2019. Pengaruh Dosis dan Saat Pemberian Pupuk P Terhadap Hasil Tanaman Buncis (*Phaseolus vulgaris* L) Tipe Tegak. *Jurnal Ilmu Pertanian Tropika dan Sub Tropika*. 4(1):14-17.

Opala P. A., Odendo M., Muyekho F. N. 2018. Effects of Lime and Fertilizer on Soil Properties and Maize Yields in Acid Soils of Western Kenya. *Agricultural Research*. 13(13):657-663

Prakoso T., Sulistyaningsih E., Purwanto B. H. 2020. Effect of humic acid on the growth and yield of two maize (*Zea mays* L.) cultivars on andisol. *Ilmu Pertanian* (*Agricultural Science*). 5(1):25-34

Santana F. P., Ghulamahdi M., Lubis I. 2021. Respons Pertumbuhan, Fisiologi, dan Produksi Kedelai terhadap Pemberian Pupuk Nitrogen dengan Dosis dan Waktu yang Berbeda. *Jurnal Ilmu Pertanian Indonesia* (*JIPI*). 26(1):24-31

Saragih M. I., Sabrina F. T. 2019. Aplikasi Biochar dan Pupuk Kandang sebagai Amelioran dan SP-36 Terhadap Peningkatan P- Tersedia, Serapan P dan Pertumbuhan Jagung (Zea mays L.) di Tanah Ultisol. *Jurnal Online Agroekoteknologi*. 7(3):532-541

Sirait B. A., Siahaan P. 2019. Pengaruh Pemberian Pupuk Dolomit dan Pupuk SP-36 Terhadap Pertumbuhan dan Produksi Tamanan Kacang Tanah (*Arachis hypogeaea* L.). *Jurnal Agrotekda*. 3(1):10-18.

Subaedah St., Netty, Ralle A. 2021. Respons Hasil beberapa Varietas Kedelai Terhadap Aplikasi Pupuk Fosfat. *Agrotechnology Research Journal*. 5(1):12-17

Sumbayak R. J., Gultom R. R. 2020. Pengaruh Pemberian Pupuk Fosfat Dan Pupuk Organik Terhadap Pertumbuhan Dan Hasil Kedelai *Glycine max* L. Merill). *Jurnal Darma Agung*. 28(2) : 253 – 268

Wulandari B. A., Jaelani L. M. 2019. Identifikasi Fase Pertumbuhan Tanaman Jagung Menggunakan Citra SAR Sentinel-1A (Studi Kasus: Kecamatan Gerung, Lombok Barat, NTB). *Jurnal Penginderaan Jauh Indonesia*.1(2):52-59

Zainal M., Nugroho A., Suminarti N. E. 2014. Respon pertumbuhan dan hasil tanaman kedelai (*Glycine max* (L.) Merril) pada berbagai tingkat pemupukan N dan pupuk kandang ayam. *Jurnal Produksi Tanaman*. 2(6):484-490.