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Effectiveness application of fertilizer on maize: The case study of maize farmers in West Pasaman Regency

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Abstract. West Pasaman is one of the regencies in West Sumatera which is the center of maize. The aimed was to determine the income and habits of maize farmers using fertilizers, as well as the role of fertilizers and soil amendments in increasing the growth of maize crops. This research was carried out in 2 experimental stages, the first stage was farmer interviews and the second stage was a trial of fertilizer types in the field carried out in a factorial form, on various types of macro and micro fertilizers for Pioneer 32's maize, including; Rock Phosphate (RP) (28% P2O5); Urea (46% N), Zeolite as a soil amendment and micro-fertilizers are derived from Unitas Super's Liquid Fertilizer. The comparison treatment plots, namely; 300 kg ha-1 NITROPHOSKA and 200 kg ha-1 Zeolite + 300 kg ha-1 NITROPHOSKA. The results of this comparison treatment were presented in a bar chart. The data were statistically analyzed using the F test with a significance level of 5% and further tested using an LSD level of 5%. The concluded that 50% of farmers already have incomes exceeding the Regional Minimum Wage. There were about 39% of them applied fertilizers of 300 to 450 kg ha-1, 87.5% applied a combination of Urea+ PHOSKA, 12.5% PHOSKA only, and 12.5% of farmers added SP36, for cultivation in maize. As a result of field experiments, it was determined that the most appropriate application was 50 kg ha-1 urea + 50 kg ha-1 Zeolite + 200 kg ha-1 RP fertilizer and 100 ml L-1 liquid fertilizer.

1 Introduction

West Pasaman Regency is one of the maize-producing districts which is expected to meet the food and industrial needs in West Sumatra, with an average yield of 6.4 t ha^{-1} on a harvested area of 36.977 hectares. Several sub-districts that develop maize cultivation include Sungai Aur District with an average yield of 6.39 t ha^{-1}, on an area of 1,252 hectares [1]. Sungai Aur District is bordered to the north by North Sumatra Province, to the south by the Indonesian

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Ocean, to the west by Lembah Melintang District, and to the east by Gunung Tuleh District. Altitude of Sungai Aur Subdistrict: 521 meters above sea level [2]. West Pasaman is one of the locations that is used as a maize cultivation center which is dubbed the Food Estate area in West Sumatra. In 2019 maize production in West Pasaman reached 311,576 tons, this yield was much higher than production in 2020, which only reached 282,234 tons with a maize planted area of 43,907 hectares, with an average yield of 5.88 t ha^{-1} [3].

The provision of fertilizer was an effort to provide the primary needs of food crops or other crops so that they can live normally and are able to produce as expected. The fertilizer provided can come from artificial fertilizers sold at fertilizer shop, both macro fertilizers containing N, P, and K elements, as well as micro fertilizers containing B, Fe, Mn, Zn, Cu nutrients, and so on. Artificial fertilizers are very popular among farmers, especially maize farmers. Some of the artificial fertilizers that are widely sold at fertilizer shop include; single macro fertilizers such as Urea (46% N), SP36 (36% P2O5) or Rock Phosphate (RP) (26-28% P2O5), and KCl (60% K2O) [4] and compound fertilizers such as NPK PONSKA (15-15-150; (15-10-12), Mutiara (15-15-15), NITROPHOSKA (15-15-15) and others [4]. There are several types of crops which really need large amounts of artificial fertilizers and there are crops that are more resistant to the application of minimal artificial fertilizers. It is also necessary to know the dose and type of fertilizer that farmers always use in providing fertilizer for maize crops , therefore the data must be obtained through the provision of questionnaires to the farmer group.

To find out whether or not it is important to give fertilizer, the right dose and type of fertilizer should be given, it is necessary to try it out. The experiments carried out were using various types of macro and micro fertilizers and soil amendment such as Zeolite (SiO2), which plays a role in increasing the Cation Exchange Capacity (CEC) of the soil [5, 6]. Farmers are still not familiar with using fertilizers, even though this zeolite is written on the fertilizer packaging named TSP 36 but it is not clear the reason for using TSP 36 literacy, because it can deceive farmers. Zeolite as a soil amendment is not a source of P fertilizer. It is also necessary to know whether it is true that Zeolite is needed together with artificial fertilizers.

Nutrient N needs to be given to soils with low N content so that crops do not experience stunting during their vegetative growth period. The impact of N deficiency, among others, is pale plant leaves due to limited leaf chlorophyll formation, making it difficult for crops to carry out photosynthesis. Thus, elemental P fertilizer is a fertilizer that is classified as macro needed by crops, phosphate fertilizers are widely sold but the price is very expensive. There are phosphate fertilizers that are rather cheap, namely Rock Phosphate (RP) the price can be 50% lower, but this is different in quality compared to orthophosphate fertilizers. Chan et al [7] explained that the role of SP36, TSP, and RP fertilizers was the same for crops, both contributing nutrients, but the quality of the fertilizers is different [8]. RP fertilizer is a ground natural stone that has good solubility, especially in acid soils. Therefore, the application of RP is suitable for Ultisol soil in the Sungai Aur, West Pasaman Regency. The aimed was to determine the income and habits of maize farmers using fertilizers, as well as the role of fertilizers and soil amendments in increasing the growth of maize crops.

2 Methodology

This research was conducted in Sungai Aur Village, Sungai Aur District, West Pasaman Regency, West Sumatra Province. The location of the activity is 195 km from Padang City to the west. This research was carried out in 2 stages, the first stage was a survey to collect data from farmers in Sungai Aur District, West Pasaman Regency by distributing questionnaires about income from maize cultivation and the types of livelihoods and the second was knowing the various types and doses used for maize cultivation. Furthermore,

the second stage had been carried out to make field experiments for maize cultivation on Ultisol soil pH 5.5.

Pioneer 32 maize cultivation experiments were carried out in the field in a factorial form, by testing various types of macro fertilizers, including; Rock Phophate (RP) (28% P2O5); Urea (46% N), Zeolite (51.71% SiO2, CEC 112.57 cmol kg^{-1}, 96.35% fineness) and micro-fertilizers were derived from Unitas Super Liquid Organic Fertilizer with the following chemical composition; pH 7.82; 0.01512% Fe; 0.01026% Zn; 0.00523% Co; 0.01476% Cu; 0.0140% B and 0.00687% Mn.

The first factor is the provision of macro fertilizers with types and combinations, among others; P0 (0 kg ha^{-1} Fertilizer); P1 (100 kg ha^{-1} Rock Phosphate.); N1 (50 kg ha^{-1} Urea + 50 kg ha^{-1} Zeolite); P2 (200 kg ha^{-1} RP); N2 (100 kg ha^{-1} Urea + 100 kg ha^{-1} Zeolite); N3 (N2 (150 kg ha^{-1} Urea + 150 kg ha^{-1} Zeolite). The second factor was the application of Unitas Super liquid organic fertilizer as micronutrient fertilizer given in 3 levels, namely; C0 (0 ml L^{-1}); C1 (50 ml L^{-1}); C2 (100 ml L^{-1}). The treatment was repeated 3 times so that 6 x 3 x 3 = 54 experimental plots were obtained and 6 NITROPHOSKA treatment plots were added. The data were statistically analyzed using the F test with a significance level of 5% and further tested using Least Significant Different (LSD) level 5%, if the treatment has a significant effect.

The experiment above was then compared with maize crops of the same variety, given macro-compound fertilizers, namely; 300 kg ha^{-1} of NITROPHOSKA (15-15-15) and Z POSKA fertilizers (200 kg ha^{-1} Zeolite + 300 kg ha^{-1} NITROPHOSKA) This treatment was only used as a comparison to determine whether the application of NPK compound fertilizer was better than single fertilizer. The results of this treatment comparison are presented in a bar graph.

Parameter observation there were 2 parts. Part 1 was the resulted of survey of using fertilizers carried out by farmers, then maize cultivation was used as a livelihood as a main or side job. The second part was the observation of plant growth carried out at 45 DAP, determined among others; plant height (by measuring from the base of the stalk to the tip of the leaf and the diameter of the stalk measuring the diameter of the stalk at a position 10 cm above the soil surface.

3 Results and discussion

The results of the questionnaire from the experiences of farmers who have been conducted in Sungai Aur District, West Pasaman Regency, on the habit of cultivating crops, especially maize, where West Pasaman is also a maize center, then the Sungai Aur sub-district, especially Nagari Sungai Aur has its own policy for growing maize. There are 42% of farmers who cultivate maize as their main livelihood, and 58% of farmers cultivate maize only as a side income (Figure 1a). However, if it is related to their economic income related to maize cultivation, it turns out that the average income is < 4 million rupiah, although some even exceed 7 million rupiah. This shows that even though maize cultivation is a farmer's side business, if you are serious about it, your income can be optimal and already exceeds the minimum regional average wage (RAG) and it reaches 50% of the population of farmers in West Pasaman of Rp. 2,484,041,- [6]. Therefore, 50% of farmers who earn <UMR, there needs to be an extension effort to increase their income from maize cultivation in order to achieve as expected or exceed the URM. This reason could be due to the narrow ownership of land so that efforts are needed to develop land area by renting and carried out in an intensive way so that it is not detrimental, and even gets a significant profit.

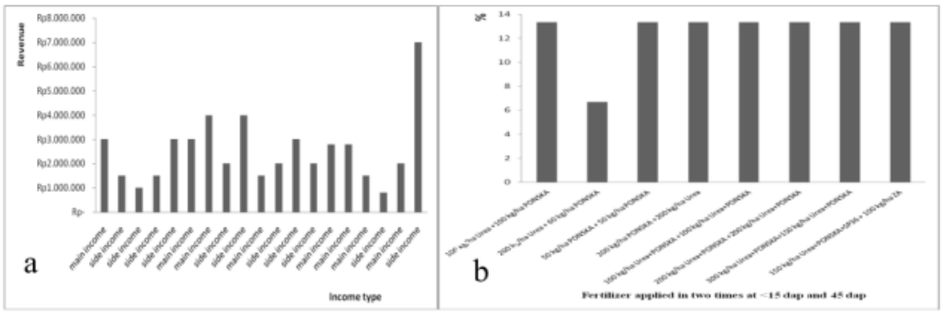

Fig. 1. a. The relationship between respondents' occupations in maize cultivation and their income. b. Farmers who use artificial fertilizers by type and dose by farmers in Sungai Aur District, West Pasaman Regency.

The total range of fertilizer utilization doses is from 100 kg ha^{-1} to 450 kg ha^{-1}. There are about 39% of farmers using fertilizers ranging from 300 to 450 kg ha^{-1} and 61% applying fertilizers with doses < 300 kg ha^{-1}. The results of the study [10, 11] urea 200 kg ha^{-1}, KCl and SP-36 each 100 kg ha^{-1}. 87.5% of farmers used single PONSKA and only 12.5% of farmers had added SP36 fertilizer to maize cultivation. According to Syofia and Munar [9] the use of 350 kg ha^{-1} Urea + 200 kg ha^{-1} SP-36 + 100 kg ha^{-1} KCl and 50 kg ha^{-1} ZA. If using compound fertilizer NPK (15-15-15) enough to provide 400 kg ha^{-1}. Previously, [3] stated that Balitbangtan recommended 400 kg ha^{-1} of NPK compound fertilizer (15-15-15) + 270 kg ha^{-1} Urea + 80 kg ha^{-1} SP-36, which was given 2 times at 10 and 45 dap.

The interaction of macro and micro fertilizers significantly affected the growth of maize plant height at 45 DAP (Table 1). Application of RP did not affect the growth of maize height, but it was different from the administration of Urea + Zeolite. If given 100 ml L^{-1} POC as a micro fertilizer accompanied by a dose of 50 kg ha^{-1} Urea + 50 kg ha^{-1} Zeolite, it can provide the highest plant growth at 45 days after planting. Lin et al [12] also found that low doses of N, P, K fertilizers were able to increase plant growth because these fertilizers could be used optimally by crops to form components of maximum yield. The importance of a given zeolite must meet the following criteria; > 50% zeolite mineral content; > 100 me/100 g CEC; < 10% moisture content; + 40-80 mesh grain size [5]. The high Cation Exchange Capacity (CEC) of the given zeolite has been able to reduce losses due to leaching, nutrients from fertilizers. Although Zeolites are not classified as fertilizers, they are very effective in providing nutrients for crops.

Table 1. Effect of fertilization treatment accompanied by micro fertilizer on height maize crop at 45 dap.

Macro fertilizer application	**Micro fertilizer application (ml L^{-1})**		
	0	**50**	**100**
	----------cm----------		
0 kg ha^{-1} Rock Phosphate (RP)	196,00 ^{Ba}	194,33 ^{Ca}	195,00 ^{Ba}
100 kg ha^{-1} RP	196,33 ^{Ba}	191,67 ^{Ca}	196,67 ^{Ba}
50 kg ha^{-1} Urea + 50 kg ha^{-1} Zeolit	225,00 ^{Ab}	227,33 ^{ABb}	259,00 ^{Aa}
200 kg ha^{-1} RP	192,67 ^{Ba}	202,00 ^{Bca}	199,00 ^{Ba}
100 kg ha^{-1} Urea + 100 kg ha^{-1} Zeolit	213,67 ^{Ba}	227,00 ^{Aba}	207,33 ^{Aba}
150 kg ha^{-1} Urea +150 kg ha^{-1} Zeolit	250,67 ^{Aa}	248,67 ^{Aa}	224,00 ^{Aa}

The data on the superscript followed by the same letter in each column and row were not significantly different in the LSD test with a significance level of 5%.

Zeolite is able to reduce heavy metal pollution is the use of adsorbents to adsorb heavy metals. One of the adsorbents used is zeolite. Adsorption is the process of adsorption of substances on the surface of other substances. The substance that absorbs is called the adsorbent and the substance that is absorbed is called the adsorbate. Adsorption occurs on the surface of a solid due to the attraction of atoms or molecules on the surface of the solid. The surface of a solid in contact with a solution tends to accumulate a surface layer of solute molecules, this occurs due to an imbalance of surface forces. This adsorption event is widely used to remove unwanted substances or compounds [13].

The application of 50 kg ha^{-1} of Zeolite was very effective accompanied by the application of 50 kg ha^{-1} of Urea accompanied by 100 ml L^{-1} of microfertilizers to achieve maximum height growth. Zeolite plays a role in saving the use of N fertilizer, because it can inhibit high leaching due to soluble N fertilizer. It has been explained [12] that zeolite given together with fertilizers can produce slow release of fertilizers, increase water holding capacity and increase soil biodiversity. Therefore, fertilizers given with zeolite can reduce the loss due to intensive leaching due to high rainfall. It turns out that crops that get the element N will produce faster height growth than crops that get RP (P) fertilizer.

The effect of liquid fertilizer as a source of micronutrients is very good on the growth of maize crops, up to a dose of 100 ml L^{-1}, and should indeed be given together with N fertilizer. The results of the study [7] that the application of synthetic micro fertilizers did not show a single effect of macro fertilizers on plant growth, but there was an effect on increasing the diameter and length of sweet maize cobs. The advantage of giving Urea (46% N) compared to POSKA (15-15-15) can be calculated as follows: 50 kg Urea means that there is a N contribution of 46/100 x 50 kg = 23 kg ha^{-1} N contributed by Urea, and there is a 15/100 x 300 kg = 45 kg N ha^{-1} contributed by POSKA for maize. If we look at the N contribution from POSKA, it is almost 2 times higher than that from Urea, but why is the application of Urea + Zeolite and micro fertilizers far superior. The role of micro elements in crops is more to increase enzyme activity so that metabolism runs smoothly, so that it has an impact on increasing assimilation. Samosir et al [10] stated that microelements are important to improve growth and if they are not available, usually the shoots of crops will die, so that crops do not grow and develop properly. The dose of N is given 50% lower, but the crops also get sufficient micronutrients. If the plant does not get micro nutrients, then the provision of 150 kg ha^{-1} Urea equivalent (46/100 x 150 kg = 69 kg ha^{-1} N) is also superior to crops that get POSKA. This condition can be explained that the N nutrient content is 1.5 times higher than the N nutrient content of POSKA. This is because the height of crops given POSKA and crops given zeolite+POSKA (ZPOSKA) are almost the same.

It turned out that with fertilizer or not, the crops showed normal height growth. However, the effect of fertilizer not only on plant height growth will also have an impact on the growth of other parts. The application of macro fertilizers has an effect on the size of the maize stalk diameter, but the application of micro fertilizers and their interactions has no significant effect (Table 2). The RP treatment has a larger stalk diameter, this is an indication that it will produce larger cobs. RP increased the diameter of maize stalks compared to crops that received Urea + Zeolite fertilization. The application of RP was generally effective in producing larger stalk diameters of maize than the administration of Urea + Zeolite. However, the administration of high doses of 150 kg ha^{-1} Urea + 150 kg ha^{-1} Zeolite was not significantly different from the administration of RP on stalk diameter. Natural phosphate rock or RP which contributes element P to crops plays a role in increasing the volume of root cells, stalks, and increasing fruit formation, reducing flower fall. The P element will be needed if the plant's metabolism was going well because the crops also get other elements

such as microelements that are given through liquid fertilizer. Microelements are derived from liquid fertilizer that has been given, although little was needed by crops, however, these elements are involved in the formation of enzyme activity that can accelerate a reaction in crops. Samosir et al [10] have explained that organic waste made of liquid fertilizer will contain various types of microelements, including; Fe, Cu, Zn, and Mn, which are useful for plant growth.

Table 2. The effect of fertilization treatment accompanied by micro fertilizers on the size of the stalk diameter of maize crops at 45 dap.

Macro fertilizer application	Micro fertilizer application (ml L^{-1})			
	0	50	100	Mean
	----------mm----------			
0 kg ha^{-1} Rock Phosphate (RP)	21,70	21,27	20,73	21,23 ^{A}
100 kg ha^{-1} RP	21,50	20,47	21,23	21,07 ^{A}
50 kg ha^{-1} Urea + 50 kg ha^{-1} Zeolit	17,40	17,80	18,13	17,78 B
200 kg ha^{-1} RP	21,27	22,20	22,17	21,88 ^{A}
100 kg ha^{-1} Urea + 100 kg ha^{-1} Zeolit	18,63	17,13	17,53	17,77 ^{B}
150 kg ha^{-1} Urea + 150 kg ha^{-1} Zeolit	19,43	19,63	17,50	19,43^{AB}

The data in the same superscript were not significantly different in the LSD test with a significance level of 5%.

4 Conclusion

There was 42% of farmers cultivate maize as their main livelihood, the rest as a side income. There are 50% of the farming population whose income from maize cultivation has exceeded the minimum regional wage (UMR). There are around 39% of farmers use fertilizers ranging from doses of 300 to 450 kg ha^{-1}, and 61% still use doses < 300 kg ha^{-1} of artificial fertilizers. There are 87.5% of farmers use a combination of Urea and POSKA fertilizers simultaneously, only 12.5% use POSKA and only 12.5% of farmers supplement their fertilizers with SP36, for growing maize. By the results it was known that the application of Urea + Zeolite fertilizer and P (RP) fertilizer is important to help the agronomy of maize plant growth.

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