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Improvement of Maize Growth and Production through a Combination of Leaf Defoliation and SP-36 Dosage in a Close Cropping System

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Abstract. The high demand for Maize encourages various agricultural innovations. The study aims to examine the effect of defoliation and P fertilizer application on the growth and production of the Madura 3 Maize variety which is grown in the close cropping system. This study used a randomized block design consisting of two factors with three replications. The parameters observed were stem diameter, root weight, cob fresh weight, cob dry weight, dry seed weight, and 100 seed weight. The results showed that there was a significant interaction between the defoliation factor and the dose of SP-36 on cob diameter, where the highest diameter (4,75 cm) was found in the combination of non-defoliation and SP-36 150 kg.ha^{-1}. Overall, the non-defoliation of an SP-36 of 250 kg.ha^{-1} showed the best result on Maize growth and production. The addition of the dose of SP-36 also needs to pay attention to the needs of plants.

Keywords: close cropping system; defoliation; fertilizer; maize

INTRODUCTION

Maize plants (Zea Mays, L) are food crop commodities in Indonesia that are ranked second after rice. Maize has an important role because of its considerable potential in meeting food needs or industrial raw material needs. Based on BPS (2022a), national Maize production reached 30 million tons. Meanwhile, in 2020 national Maize production was 24.95 million tons (Pusdatin, 2021). The decrease in Maize production is caused by land use change so that the Maize harvest area is reduced and a decrease in the source of nutrient absorption needed by plants in promoting growth. North Sumatra Province as one of the Maize producers in Indonesia has decreased in harvest area from 321,273 ha in 2020 to 273,703 ha in 2021 (BPS, 2022b). Along with the increasing demand for Maize in Indonesia, both for food raw materials and feed, it must be balanced with an increase in production so that there is no gap between the supply and the need for Maize.

Strategies continue to be carried out to get optimal production. One of them is implementing a tight planting system for Maize plants. Maize is usually planted with a planting distance of 70 x 20 cm, with the application of a tight planting system the Maize planting distance becomes 50 x 20 cm. A tight cropping system can increase plant populations in a certain area, planting distances of 50 x 20 cm are quite effective in increasing the population of Maize plants (Irawan et al., 2019). It remains to pay attention to the intensity of light received by cultivated plants. The light intensity of 1,127 lux can provide good results on the growth of Maize plants (Nababan et al., 2018). Maize plants will show plastic properties in the form of higher plant populations, the leaf area will also increase to maximize the absorption of sunlight (Jaya et al., 2015).

Denser plant populations will cause competition between plants in the fulfillment of sunlight. Defoliation of leaves on the bottom can be done to reduce competition between plants, reduce humidity, and increase crop yields. The lower leaves are not active in photosynthesis so they compete with seeds in utilizing assimilate produced from the process of photosynthesis (Herlina & Fitriani, 2017). Through a reduction in the number of leaves, it is expected that the results of plant photosynthesis are focused on seed filling. Defoliation of lower leaves carried out at the age of Maize plants more than 50 HST can have a real effect on increasing the weight and length of Maize cobs (Sumajow et al., 2016).

The application of this treatment is expected to be able to optimize Maize crop production. Through leaf defoliation, it is

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expected that the results of photosynthesis will focus on fruit formation and filling. So, leaf defoliation can be done to increase production yields. Therefore, it is necessary to research increasing the growth and production of Maize (*Zea Mays*, L) through leaf defoliation and by using a tight cropping system.

METHODS

Research Design

The research design used in this study was a factorial group randomized design with 2 treatment factors. The first factor is the defoliation of the lower leaf blades of Maize with 3 treatment levels: P0: No Defoliation; P1: Defoliate 50%; P2: Defoliate 100%.

The second factor is the addition of P elements through the application dose of SP-36 fertilizer with 4 levels of treatment, namely: S0: 100 kg.ha^{-1} (21 g/plot size 140 cm x 120 cm); S1: 150 kg.ha^{-1} (31.5 g/plot size 140 cm x 120 cm); S2: 200 kg.ha^{-1} (42 g/plot size 140 cm x 120 cm); S3: 250 kg.ha^{-1} (52.5 g/plot size 140 cm x 120 cm).

The two factors were combined so that 12 treatments were obtained. Each treatment combination was repeated 3 times where the repetition was considered a block, resulting in 36 experimental units.

Table 1. Combination of Defoliation Treatment and SP-36 Fertilizer Dosage

Leaf defoliation (P)	Fertilizer dosage SP-36			
	S0	S1	S2	S3
P0	P0S0	P0S1	P0S2	P0S3
P1	P1S0	P1S1	P1S2	P1S3
P2	P2S0	P2S1	P2S2	P2S3

Note:
- P0S0: No defoliation and SP-36 dose 100 kg.ha^{-1}
- P0S1: No defoliation and SP-36 dose 150 kg.ha^{-1}
- P0S2: No defoliation and SP-36 dose 200 kg.ha^{-1}
- P0S3: No defoliation and dose SP-36 250 kg.ha^{-1}
- P1S0: Defoliate 50% of lower leaf blades and dose of SP-36 100 kg.ha^{-1}
- P1S1: Defoliate 50% of lower leaf blades and dose of SP-36 150 kg.ha^{-1}
- P1S2: Defoliate 50% of lower leaf blades and dose of SP-36 200 kg.ha^{-1}
- P1S3: Defoliate 50% of lower leaf blades and dose of SP-36 250 kg.ha^{-1}
- P2S0: Defoliate 100% of lower leaf blades and dose of SP-36 100 kg.ha^{-1}
- P2S1: Defoliate 100% of lower leaf blades and dose of SP-36 150 kg.ha^{-1}
- P2S2: Defoliate 100% of lower leaf blades and dose of SP-36 200 kg.ha^{-1}
- P2S3: Defoliate 100% of lower leaf blades and dose of SP-36 250 kg.ha^{-1}

Research Implementation Methods

Planting preparation

Tillage is carried out through soil reversal so that the soil becomes loose, soil aeration becomes good, and able to control weeds. The treated soil is then made into beds with a size of 140 cm x 120 cm with a distance of 50 cm between beds and a distance between blocks of 100 cm. In the soil, manure, and dolomite with a dose of 2 tons.ha^{-1} and Madura 3 corn seeds for further planting.

Planting

Corn seeds are planted using a planting distance of 50 x 20 cm. Planting seeds is carried out by *tugal* with a planting hole depth of ±5 cm and each planting hole is filled with 3 corn seeds. With a plot size of 140 x 120 cm, there are 42 plant populations with 5 sample plants in the middle.

Plant maintenance

Maintenance of corn plants is carried out with activities, namely: (1) Embroidery can be done when there are seeds that do not grow. Done by planting embroidery plants that have been prepared in advance and planted at the initial planting point carried out at 7 HST; (2) Fertilization of corn plants can be applied 2 times, namely at 15 HST and 30 HST. The fertilizers used include Urea fertilizer 200 kg.ha^{-1}, KCL 100 kg.ha^{-1}. Furthermore, the application of SP-36 fertilizer is carried out according to the treatment dose (100 kg.ha^{-1}, 150 kg.ha^{-1}, 200 kg.ha^{-1}, 250 kg.ha^{-1}); (3) Thinning is done when the plants are 2 MST old by uprooting

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one of the plants and leaving the best 2 plants; (4) Seasoning is carried out when the plant is 3-4 MST old by loosening the soil around the plant area, then piling the soil at the base of the stem to stimulate root growth and strengthen the plant so that it does not fall easily; (5) Foliar pruning is carried out when the corn plant is 60 HST. Leaf pruning is carried out on 3-5 lower leaves where pruning is adjusted to the treatment used, namely pruning 50% leaf blades and 100% lower leaf blades; (6) Irrigation is carried out by relying on rainwater because it is planted in the rainy season, and when it does not rain, irrigation is carried out according to its needs. The period of corn plants that require sufficient amounts of water is when the plant is four-leaved (early growth) and in its generative phase; (7) Control of pests is carried out when plants show symptoms of downy mildew attack and spraying using fungicides. There are weeds and they are mechanically controlled and herbicides are used; and (8) Harvesting can be done at the age of ±90 HST when it is physiologically ripe and characterized by dry, yellowish corn leaves. The seeds have been hard and the color of the seeds is shiny, if pressed with the thumb no longer found traces of pressure on the seeds.

Observation Parameters

Plant Height

Measurement of Maize plant height can be done by measuring Maize plants from the soil surface to the highest leaf tip using a cm unit meter. Plant height measurements were carried out in the vegetative phase at the age of 14 HST, 21 HST, 28 HST, 35 HST, 42 HST, and before harvest.

Rod Diameter

Stem diameter measurements were made on all sampled plant stems which were then averaged. Measurement of stem diameter using calipers on rootstocks ±10 cm from the growing point of the plant. Measurement of the diameter of the stem is carried out 7 days before harvest.

Plant root length

The root length parameter is observed after harvesting by pulling out the roots. Then the roots are cleaned and measured from the base of the root to the tip of the longest root using a ruler.

Plant Root Weight

Observation of the weight of the roots is carried out after harvesting by pulling out the roots. Then the roots are cleaned and weighed using analytical scales for further drying and re-measuring the dry weight of the roots.

Maize Cob Diameter

Cob diameter measurements were made on all cobs formed from sample plants and then averaged. Measurement of the diameter of the cob using a caliper in the middle of the cob.

Fresh Weight of Maize Cobs

Observation of the fresh weight of cobs was obtained by weighing Maize cobs obtained from sample plants and then averaged on each treatment plot. Weighing is done when Maize is harvested before drying.

Maize Cob Length

Observation of the length of the cob can be made when it is time to harvest. How to measure the length of the cob is to measure from the cob stalk to the tip of the Maize cob using a ruler or tape measure.

Dry Weight of Maize Cobs

The dry weight of the cobs was obtained by weighing all the Maize cobs obtained from the sample plants and then averaging them on each treatment plot. Weighing is carried out when the Maize has been dried using analytical scales.

Dry Maize Pill Weight

Observation of the weight of dry Maize is carried out by weighing the seeds of each treatment plot that has been dried in the sun. Then the weighing results are converted to t/ha units.

Weight per 100 seeds

Weights per 100 seeds are carried out by weighing as many as 100 seeds that have been dried in the sun randomly from each plot. Weighing is carried out using analytical balances.

Data Analysis

Data that have been obtained from subsequent observations are analyzed using

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the ANOVA (Analysis of Variance) test. If there is a noticeable difference, then proceed with a further DMRT test at the level of 5%, and if a very noticeable difference is carried out further test of DMRT at the level of 1%. Using Dunnett's follow-up test, the 1% level in different single treatments is very real and the 5% level in different is real.

RESULTS AND DISCUSSION

Based on the results of various analyses, observations were obtained on several observation variables including plant height, stem diameter, root length, header weight, cob diameter, fresh cob weight, cob length, cob dry weight, dry pile weight, and weight per 100 seeds. The results of these observations are analyzed variously, the following is a recapitulation of the results of various analyses obtained from several observation variables.

Table 2. Recapitulation of analysis of various observational variables

No	Observation variables	Defoliation (P)	SP-36 Dosage (S)	Interaction (PxS)
1	Plant height	ns	**	ns
2	Rod diameter	ns	**	ns
3	Root length	ns	ns	ns
4	Root weight	ns	**	ns
5	Cob diameter	*	ns	*
6	Fresh weight of cobs/plant	ns	**	ns
7	Cob length	ns	ns	ns
8	Cob dry weight/plant	ns	**	ns
9	Dry piling weight/plant	ns	ns	ns
10	Weight per 100 seeds	ns	ns	ns

Note: The notation shows different results are not real (ns), different real (*), and very real different (**)

From the observational data on the height parameters of corn plants that have been analyzed variously, results were obtained that showed a very real difference (**) in the SP-36 dose factor. Therefore, Dunnet's further test was carried out with a level of 1%. From the results of Dunnet's further tests, the 1% level that has been carried out shows that the S2 treatment gives the highest result, which is 212.93 cm. These results are significantly different from S0, which is 195.65 cm. The S2 treatment showed different results from S3, namely with an average height of 212.93 and 212.57 cm.

Observational data on the diameter of corn stalks that have been analyzed variously obtained results that show a very real difference (**) in the dose factor of SP-36 fertilizer. Therefore, Dunnet's further test was carried out with a level of 1%. The results of Dunnet's follow-up test level of 1% that has been carried out shows that the S3 treatment gives the highest results on the diameter of the stem with an average of 2.13 cm, where the S3 treatment shows a real difference from the S0 treatment with an average of 1.70 cm, but the S3 treatment is not significantly different from the S2 treatment with an average of 2.03 cm. Data from the Anova test results obtained results that showed that different root lengths were not real (ns) in each treatment, so further tests could not be carried out.

From the results of root weight observations, variance analysis was obtained which showed a very real difference (**) in the dose factor of SP-36 fertilizer, therefore Dunnet further tested at the level of 1% on a single factor of SP-36 fertilizer dose on plant root weight. Dunnet's follow-up test results at the level of 1% on a single factor of SP-36 fertilizer dose on root fresh weight parameters obtained the highest results in S3 treatment which differed markedly from S0 with an average root fresh weight of 152.74 g and 102.59 g, while S0 differed

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insignificantly from S1 and S2 treatments with average values of 108.74 g and 120.30 g. Dunnet's follow-up test results of 1% on the dose factor of SP-36 fertilizer on root dry weight also resulted in an average S3 treatment significantly different from S0 of 76.17 g and 47.37 g, but S3 treatment showed an unreal difference with S1 and S2 with an average value of root dry weight of 54.59 g and 60.11 g.

The results of the variety analysis on the cob diameter parameter showed an interaction between defoliation and SP-36 fertilizer dose with really different results (*). Therefore, further DMRT tests were carried out at the level of 5% in combination treatment of cob diameter parameters. The best results in both the combination of defoliation and SP-36 fertilizer dose obtained the best treatment, namely P0S1 (without defoliation and SP-36 dose 150 kg.ha^{-1}) by producing a cob diameter of 4.30 cm. The combination is significantly different from the combination of P1S1 treatment (defoliation of 50% of the lower leaf blades and fertilizer dose of 150 kg.ha^{-1}) which results in an average cob diameter per plant of 4.16 cm.

Observation of fresh weight of cobs per plant obtained the results of analysis of different varieties very real (**) on the dose factor of SP-36 fertilizer. Therefore, Dunnet's further test was carried out at a level of 1%. Dunnet's follow-up test results of 1% on the fresh weight parameters of cobs per plant at several doses of SP-36 fertilizer obtained significantly different results between S3 and S0 with an average of 142.76 g and 104.33 g, but the S0 treatment was not significantly different from S1 and S2 with an average of 124.94 g and 128.90 g. The results of the analysis of variance on the cob length parameter per plant were produced differently not real (ns) in all treatments, therefore no further tests were carried out.

Observation of the dry weight of cobs per plant obtained the results of analysis of different varieties very real (**) on a single factor of SP-36 fertilizer dose. So Dunnet's further test was carried out at a level of 1%. Dunnet's follow-up test results of 1% level on the dose factor of SP-36 fertilizer on the dry weight parameter of cobs per plant obtained results that differed markedly between S3 and S0 with an average of 68.76 g and 50.39 g, while S0 differed insignificantly from S1 and S2 with an average of 60.04 cm and 63.04 cm. The results of observations on the weight parameter of dry piles per plant obtained different results not real (ns) in all treatments, so further tests could not be carried out. The results of observations on the weight parameter per 100 seeds obtained different results not real (ns) in all treatments, so further tests could not be carried out.

The community's food needs for Maize are quite high after rice. Meeting these needs can be overcome by high Maize production. The high production of Maize is influenced by several factors such as genetic, environmental, and cultivation techniques. The use of land area, seeds, and fertilizer use are important factors that affect the level of Maize production (Habib, 2013).

This study applied defoliation techniques and the use of several doses of SP-36 fertilizer. Defoliation is carried out to create plant balance through leaf pruning so that the vegetative growth of plants can be balanced with their generative growth (Lubis, 2019). The results of the P content test in the soil with a value of 48.05 mg/kg of soil are classified as moderate so that the addition of P elements in Maize cultivation can increase maize growth and production (Wahyudin et al., 2017). This study showed no influence of defoliation interaction and addition of the P element on several observation parameters except on the cob diameter parameter. In addition, a single factor of defoliation also showed significantly different results on the diameter of the Maize cob alone, there was no real effect on the other parameters.

According to Aryadi et al. (2013), defoliation carried out after the vegetative growth process of photosynthates is more widely used for the process of filling cobs rather than plant growth. The treatment of

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adding doses of SP-36 fertilizer showed significantly different results on the parameters of plant height, stem diameter, plant root weight, fresh cob weight, and cob dry weight but showed unreal different results on the parameters of root length, cob diameter, cob length, dry pile weight and weight of 100 seeds.

SP-36 fertilizer dose treatment of 200 kg.ha^{-1} (S2) gives an average plant height yield of 212.93 cm. An increase in the dose of P application will be in line with the increase in P available in the soil so that it is easily absorbed by plants and can affect plant height (Hasibuan et al., 2014). Element P through metabolic reactions into various forms of phosphate in plant cells in the form of nucleotide units, and nucleotides are one of the bonds that play a role in the development of plant cells so element P affects growth (Lovitna et al., 2021). The results of observations of the diameter of the stem of Maize plants also showed very real different results in the treatment dose of SP-36 fertilizer 250 kg.ha^{-1} (S3) with the highest average of 2.13 cm, this is because there is cell division that is quite good in supporting plant growth at the enlargement of the stem diameter. According to Batubara (2017), element P is a nutrient that plays an important role in plant metabolic processes because phosphate is useful as an energy source in cell division and cell enlargement. The size of the stem diameter is smaller than the seed description because tightly planted plants will reduce the circumference of the stem but increase the height of the plant to get optimal sunlight (Irawan et al., 2019).

Roots are very important plant organs with their role in absorbing water and nutrients needed by plants. In the observation parameters of the root, length showed different results not noticeable in all treatments. The root weight observation parameter showed very real different results on a single factor of SP-36 fertilizer dose (Amir et al., 2022).

The treatment dose of 250 kg.ha^{-1} (S3) resulted in a fresh root weight of 152.74 g and a dry root weight of 76.17 g. This is because root growth is more in forming root fibers than root elongation so root weight produces a very noticeable difference in the treatment dose of SP-36 fertilizer. Supported by Prakoso et al. (2022), essential nutrients such as P play a major role in carrying out plant growth and development, especially the roots produced. The availability of P in the soil is absorbed by the roots to maximize plant growth and production, so the availability of P in the soil stimulates the growth of plant roots (Sari et al., 2016).

The existence of good plant growth is expected to optimize crop production. In this study, there are several production parameters including cob diameter, cob length, fresh cob weight, cob dry weight, dry pile weight per plant, and weight of 100 seeds. There is an interaction between defoliation treatment and SP-36 dose, namely a combination of P0S1 treatment (without defoliation + SP-36 dose 150 kg.ha^{-1}), it shows that with defoliation and the addition of P element the diameter of Maize cobs decreases. This can be influenced by the P (phosphorus) content in the soil is sufficient so that the development of cob diameter at a dose of 150 kg.ha^{-1} sp-36 is better (Genesiska et al., 2020). Without defoliation, the diameter of the cob produces the highest average, this is because leaf pruning causes wounds that can produce ethylene and ethylene can cause photosynthate accumulation in the wound, while Maize cobs require more supply of photosynthesis products.

In the generative phase, the results of photosynthesis are higher in cob enlargement (Shodikin & Wardiyati, 2017). In addition, defoliation singly shows a real difference in the diameter of Maize cobs due to changes in the moisture content of Maize cobs and kernels, so that in treatment with defoliation there is a shrinkage in the diameter of the cob due to a reduction in water content in Maize cobs (Pamungkas et al., 2019).

The cob length parameter showed no noticeable difference in all treatments, either

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singly or in combination with defoliation and SP-36 dose. This condition is suspected to be the level of photosynthetic activity that can increase the photosynthates formed to be subsequently sent to the cob as a food reserve that can affect the length of the cob (Damanhuri et al., 2018). Defoliation treatment that aims to focus the results of photosynthesis in increasing Maize production also has an intangible influence on the cob length parameter because defoliation focuses more on photosynthates in the Maize grain filling process (Indawan et al., 2020). After all, the morphology of the cob is also influenced by plant genetic properties (Shodikin & Wardiyati, 2017).

The parameters of the fresh weight of cobs and dry weight of cobs produce a very noticeable difference in the dosage factor of SP-36 fertilizer, where the highest average fresh weight of cobs and dry weight of cobs in the dose treatment of SP-36 fertilizer is 250 $kg.ha^{-1}$ (S3) with a fresh weight of 142.76 g and dry weight of cobs 68.76 g.

The weight parameters of dry seeds and the weight of 100 Maize kernels showed different results not noticeable in all treatments. The weight of the dry piles showed intangible different results with an average of 43.94 g/plant (8.79 $tons.ha^{-1}$) which can be due to the more dominant role of element P in the enlargement of Maize cobs alone. Phosphorus nutrients are used by plants to form flowers because Maize cobs are the development of female flowers, and female flowers affect the size of Maize cobs (Marschner, 2012).

pH adjustment also affects the absorption of phosphor which plays a role in seed filling, in soil pH measurements produced a pH of 6.4. At a neutral pH phosphor is more easily absorbed by plants and reduces the absorption of phosphor by acid-causing cations such as Al and Fe, a neutral pH between 6.5-7.2 is very suitable for influencing the availability of P in the soil (Firdausi et al., 2016). In addition, the quality of seeds decreases allegedly due to environmental conditions where the intensity of rain is high enough to cause a lack of sun intensity which results in disruption of the photosynthesis process so that the uniformity of seeds is less than the maximum with a weight of 100 seeds is still below the description of the variety (Pratikta et al., 2013).

The intensity of rainfall that is too high can inhibit the growth of Maize plants which can cause a decrease in production to cause crop failure (Herlina & Prasetyorini, 2020). The dry weight of the seeds is also related to the high transfer of photosynthates into the seeds, high photosynthate transfer in the fruit results in the formation of cobs and seed filling takes place properly so that the seeds formed have good quality and larger size (Rahni, 2012).

In the yield parameters, defoliation factors do not have an influence either singly or interactions between treatments, this is suspected because the planting distance is too tight disrupting photosynthesis activities due to high humidity due to the tight planting system, so without defoliation or with the application of lower leaf defoliation, competition still occurs between plants in the row (Rahma et al., 2022).

CONCLUSION

There is an interaction between leaf defoliation and the addition of P elements. In the combination of treatments between no defoliation and 150 $kg.ha^{-1}$ SP-36 which differs markedly in the diameter parameters of the cob with the highest average of 4.75 cm. Treatment without defoliation leaf defoliation had a noticeable effect on the diameter of the cob with an average of 4.51 cm. The addition of element P at a dose of 250 $kg.ha^{-1}$ showed a very distinct effect on several parameters with an average stem diameter (2.13 cm), fresh weight of roots (152.74 g), dry weight of roots (76.17 g), fresh weight of cobs (142.76 g) and dry weight of cobs (68.76 g). However, it showed an intangible effect on the weight of dry shells and the weight of 100 seeds with an average dry grain yield of 43.94 g/plant (8.79 $tons.ha^{-1}$).

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The application of defoliation should pay attention to the growth phase of Maize plants. The addition of the dose of SP-36 also needs to pay attention to the needs of plants. So further research is needed relating to the role of P in the pattern of seed filling in Maize plants.

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