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Research Paper

Growth performance of maize (*Zea mays*) in the initial stage under shallow water conditions to determine the best planting season in lowland area

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Abstract
Maize crop is one of the agricultural commodity crops that have an important role in the agricultural sector because maize crop are needed in the supply of food, feed, livestock and other industrial needs. The condition of maize plants with high rainfall can result in the risk of flooding of corn plants, if the maize are always flooded continuously it will result in a decrease in maize production. Stagnant water is an abiotic stress that must be considered because it can result in an increase in H_2O and a decrease in O_2 in stagnant plants. Stagnant water or excessive water stress can result in decreased plant development and production. The aim of the research was to asses of the growth conditions of maize plants under various high groundwater levels. The best performance was achieved in treatment P5 (groundwater table in 30 cm below the soil surface) that is 212.67 cm and the lowest results were in treatment P2 (groundwater table under 5 cm from the soil surface) with a plant height of 61.50 cm

Keywords
Maize, lowland, water table

1. INTRODUCTION

Maize is one of the agricultural commodity crops that has an important role in the agricultural sector, hence corn are needed for food supplies, livestock feeding and other industrial needs. The condition of corn with high intensity of rainfall could giving a risk of flooding the corn field, if the corn field is always flooded with water continuously it will decrease corn production (Surwati et al., 2013). To increase the factor that supports corn production is suitability with the growing season. The suitability of growing seasons such as rainy and dry seasons is very difficult to determine due to global warming. If the rainfall is in high intensity, it can cause inundation on the corn field, but if it experiences drought on the corn field, it can cause the corn to lack of water and result in inhibition of the growth of the corn plant.

Maize cultivation in Indonesia is mostly depends on rainwater as a source of water, because it is one of the factors inhibiting the rate of development of agribusiness for corn. Inappropriate or inadequate water availability during the growing process can cause disruption of plant physiological processes or plant growth and threaten maize productivity. Therefore the availability of water is very important in the cultivation of corn, especially on marginal dry land. Reported by Rizzoo et al. (2018) Cultivating maize in areas with a shallow groundwater table is more likely to produce stable production. In dry land conditions, it even has 24% greater production than in dry land. Similary maize cultivation in Argentina also shows more stable production in areas with shallow water table (Ruiz et al., 2021). However corn is a plant that cannot stand inundation, flooded conditions for more than 6 days can result in a reduction in production of up to 20% (Daku et al., 2022).

Maize is one of the crops with a moderate level of water use ranging from 400-500 mm (FAO 2001). Maize cultivation is constrained by the availability of water in the right amount and at the right time. Rainfed lowland rice fields with a greater amount of soil moisture will disrupt the corn growth. Delay in planting time will result in water stress during the growth phase. Therefore, proper water management technology is needed. For this reason, maize cultivation in lowland area requires land drainage engineering to control the ground water table according to stage development of crop (Imanudin et al., 2020).

Water is an essential requirement for the corn growth. And depends on climatic conditions, the irrigation method used and the variety of corn planted. According to Dahlan (2001) in order to grow corn require an average rainfall of 25 mm/week. In flooded conditions it can cause high intensity of rainfall and poor land drainage arrangements. Flood stress causes an obstacle to the supply of oxygen to the roots, through inhibition of root respiration, can cause several decreases in the energy status of root cells and affect vital plant metabolic processes (Kumutha et al., 2008).

Studies regarding the response of corn to waterlogging are important to pursuit the effective of screening techniques. In general, corn will experience inhibition and death if grown on land that is continuously waterlogged throughout the day. However, there are several genotypes that are able to develop adaptive mechanisms to overcome these stresses (Zaidi et al., 2008). The oxygen contentration in the root zone was not sufficient for root respiration in 6-7 days inundation. Effect of inundation is very sensitive at the beginning of growth, namely the period of 14-20 days (Huang et al., 2022).

The research aims to determine the effect of the maize response at the initional stage of growth to variations in the height water table of the inundation. And also to get the optimum water table for the early growth that maize stil survipe growth. As well as being able to determine the depth limit of the groundwater table that can still be planted for corn.

2. EXPERIMENTAL SECTION

2.1 Time and Place

The place for this field practice was on Jalan Soak Permai Sukabangun II, Palembang by making a plastic house. This field practice activity was carried out from April to June 2020.

2.2 Research Design

The materials used in this study are: 1) Water; 2) Corn seeds; 3) Land; 4) Compost Fertilizer; 5) As well as soil analysis materials. Meanwhile, the tools used in this study are: 1) Stationery; 2) Sieve; 3) Bricks; 4) Bucket; 5) Meter; 6) Scales; 7) Polybags; 8) As well as soil analysis tools.

This study used a completely randomized design (CRD) as follows: P1 = without treatment or control (flush system), P2 = groundwater table 5 cm from the soil surface, P3 = groundwater table 10 cm from the soil surface, P4 = water table soil 20 cm from the ground surface, P5 = Groundwater table 30 cm from the ground surface to the extent of the bricks. With 3 replications, so there are 15 treatment combinations.

2.3 Field Activities

The field activities begins with taking soil media. The soil taken is ultisol which is in the top layer (Top Soil). 90 kg of soil was taken from the ATC Field of the Faculty of Agriculture, Sriwijaya University. The soil was then sieved using a 4.75 mm soil sieve. Seeding is done by planting corn seeds which are seeded for one week or 7 days already have 2 leaves, ready to be transplanted into polybags. Planting should be done in the afternoon or when the weather is not too hot, by being careful when picking up the seeds that have been sown so that the corn roots don't break off.

The preparation for planting maize crop was carried out as follows:

- The soil used is Ultisol top soil.
- Soil taken first in dry air, then sifted.
- Soil that has been sifted is put as much as 6 kg into 15 polybags.
- Soil that has been put into polybags is given as much as 2 kg of compost. Then in field capacity so that the soil and compost are evenly distributed.
- After that, put the polybag into the bucket containing the bricks. Then fill with water that has been determined (variations of puddle height: 5 cm, 10 cm, 20 cm, 30 cm from the ground surface and without inundation or control treatment). Reported by Fidantemiz et al. (2019) on the early growth, food crop coulg grow well at a water depth of 30 cm without the need for irrigation.
- Seeds that have been sown are transferred to each polybag. Each polybag planted 1 seed.
- Then observe the growth of the plant.

The parameters observed were plant height, number of leaves, root length, soil pH and soil texture. Plant height and number of leaves were measured every day for 2 months. The data obtained was statistically processed using Completely Randomized Variance. If the results of the variance show a significant effect, it will be continued with further tests. Further test studied namely the Least Significant Difference (LSD) test, Student-Newmann Keuls (SNK), and Duncan's New Multiple Range (DNMR).

3. RESULTS AND DISCUSSION

3.1 Soil pH Analysis Results

The results of the analysis of determining soil pH can be seen in Table 1.

Table 1. The avarege results of soil pH analysis

Treatment	pH H2O
P1	5,75 a
P2	5,89 a
P3	5,91 a
P4	6,06 a
P5	6,85 b
BNT 5%	1,07

Based on the results of table 1 that in the P1 treatment (without treatment or flush system) the soil pH was 5.75 for H2O. In the P2 treatment (groundwater table 5 cm from the soil surface) the soil pH was 5.89 for H_2O. In the P3 treatment (groundwater table 10 cm from the soil surface) the soil pH was 5.91 for H_2O. In the P3 treatment (groundwater table 20 cm from the soil surface) the soil pH was 5.91 for H_2O. In the P4 treatment (groundwater table 20 cm from the soil surface) the soil pH was 6.06 for H_2O. In the P5 treatment (groundwater level 30 cm from the soil surface or limited to bricks) the soil pH was 6.85 for H_2O. According to Prasetyo and Kasno (2001) this soil has a pH level that is classified as very acidic because the land is inundated for a long time so that the nutrients in the soil are leached so the soil becomes acidic. The presence of water in the soil affects the properties and characteristics of the soil so that the soil has a high pH. According to Dat (2004) in Rachmawati and Retnaningrum (2013) plants in flooded conditions experience low oxygen stress (hypoxia), anaerobic conditions trigger plant cellular responses such as a decrease in pH.

According to Warisno (2007) the degree of soil acidity that is best for corn is in the range of 5.5-7.0. If the pH is neutral, the nutrients needed by corn are widely available in the soil. If the pH is less than 5.5, liming or fertilizing is recommended to raise the pH. So from the data obtained that the land used was suitable for maize crops.

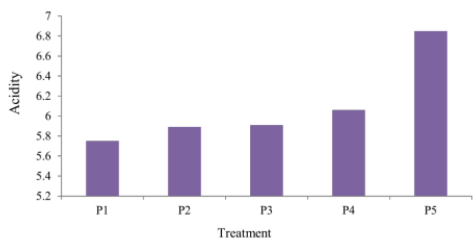

Figure 1. The degree of soil acidity (pH) in various treatments

Based on Table 2, the soil analysis shows that the soil used has a loamy sand texture which is dominated by sand. This results in changes in texture due to the influence of the groundwater table which causes these changes. Texture changes occur because the soil is continuously flooded with water. According to Prastomo and Odie (2018) the sand fraction which is more dominant in soil texture can make the provision of water given to the soil easier for plants to use because it is easy for roots to penetrate the soil, but the ability of the soil is less. According to Haridjaja et al., (2013) in Prastomo and Odie (2018) that soil texture greatly affects the ability of soil to hold water, clay-textured soil holds water more than sand-textured soil, this is due to its adsorptive surface area, the finer The texture is the greater the water storage capacity. Added by Soylu et al (2014) that soil physical properties had effect to the dynamics of water table in the lowland areas. Water storage capacity and water losses was depend on the soil water retention characteristic and hydorulic conductivity. Control drainage optios for maintenance water table was necessery applied for achieving crop water requirement.

Soil was caharacterized by loamy sand was medium suitable for maize cultuvation. It was due to the high percolatioan rate. Reported by Imanudin et al. (2023) that maintenance water level in 50-60 cm beow soil surface was more suitable for maize in vegetative growth. And in the initial phase the crop was still surfive in 30 water level. Control drainage was the best option, farticulary for area having shallow water table.

3.2 Influence on the Height of Corn Plants

Measurement of plant height is carried out once a week starting after one week in plants up to 8 weeks or 2 months of observation. Based on the observations that have been made (Table 3), the growth height of corn varies. Based on the results of table 4.3, the height growth of corn plants varies from each treatment. At P1 (without treatment or surface irrigation system) it was high loss of water because the plants experienced a lack of water to meet their evapotranspiration needs. High room temperature conditions cause the soil to quickly lose water. Crop growth shows best in the treatment of the depth of the groundwater table 20-30 cm below the soil surface. This condition is caused by the movement of water in a capillary rise was sufficient to meet the crop evapotranspiration (Mejia et al., 2000). Added by Creze and Madramootoo (2019) that controlled drainage is required in wetlands agrivulture to create optimum conditions. Groundwater depth of 50-100 cm is able to make a real contribution to plant water needs through capillary water movement. Besides that, it can increase the efficiency of fertilization.

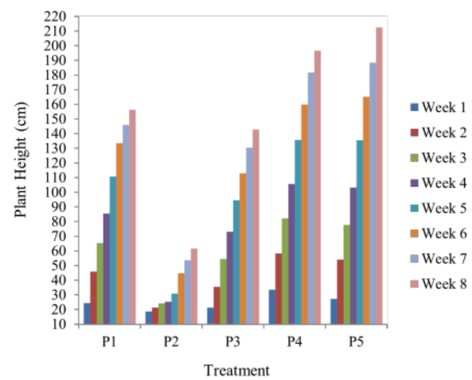

Figure 2. Average Yield Height (cm) of Maize Plants Per Week

In treatment P1, the plants were watered 2 times a day

Table 2. Average Results of Soil Texture Analysis

Treatment	R1	R2	%Sand	%Dust	%Clay	Texture
P1	3	1	89%	4%	7%	Loamy Sand
P2	2	1	91%	2%	7%	Sand
P3	3	1	89%	4%	7%	Loamy Sand
P4	4	1	87,5%	5,5%	7%	Loamy Sand
P5	8	1	79%	14%	7%	Loamy Sand

Table 3. Average weekly corn plant height (cm)

Treatment	Observation of Plant Height Weekly (cm)							
	1	2	3	4	5	6	7	8
P1	24,33 a	45,83 a	65,43 a	85,50 a	110,70 a	133,50 a	146,00 a	156,43 a
P2	18,67 a	21,37 a	24,17 a	25,33 a	30,93 a	44,67 a	53,67 a	61,50 a
P3	21,40 a	35,43 a	54,50 a	73,00 a	94,50 a	113,00 a	130,50 a	142,83 b
P4	33,50 b	58,33 b	82,17 b	105,67 b	135,80 b	159,83 b	181,83 a	196,67 a
P5	27,27 a	54,10 a	77,67 a	103,17 a	135,43 a	165,17 a	188,33 b	212,67 b
BNT 5%	8,19	27,18	42,95	61,34	79,21	83,67	85,23	79,68

in the morning and in the evening, each watering using 1 litter of planting water. At P2 (groundwater level 5 cm from the soil surface) the plants experienced inhibition of plant height growth because in this treatment experienced extreme water stress where the water almost inundated the soil surface, the treatment of the 5 cm groundwater table was a very slow growth treatment compared to another treatment. The soil condition at P2 is in a water saturated condition. Under shallow water table and in stagnant water conditions, the roots will be injured. Continuous poor aeration causes cell death and even root death. For a measurable short term help to start root and leaf growth rate soom in 1-12 hours, but will recover quickly in 2-3 days (Lauer, 2008).

3.3 Number of Corn Plant Leaves

Efforts to lower the groundwater level were carried out in the P3 treatment, where the groundwater level was at 10 cm from the ground surface. In this condition the plants experience a slight inhibition because the water inundates half of the planting media or polybags which causes a slight inhibition of growth due to excess water in the plants. At P4 (groundwater level 20 cm from the soil surface) the plants did not experience inhibition of plant growth because the water supply was sufficient, but the water inundated a quarter of the planting media or polybags. Tall and fertile plants are at P5 (groundwater table 30 cm from the soil surface). soil surface or limited to bricks) in this treatment can thrive and do not experience inhibition of plant height because the water supply is sufficient (does not experience water shortages and excess water). It can be concluded that those that can grow optimally are at P5 with a groundwater table of 30 cm from the soil surface and plants that are difficult to grow or have stunted growth at P2 with a groundwater table of 5 cm from the soil surface. Corn plants cannot live or are difficult to grow with too much water.

Counting the number of plant leaves is done once a week starting after one week on the plant up to 8 weeks or 2 months of observation. Based on the observations that have been made, it was found that the number of leaves for corn growth was at Table 4. In P1 (without treatment or flush system) experienced a standard growth in the number of leaves. At P2 (groundwater table 5 cm from the soil surface) experienced growth in the number of old leaves because in this treatment extreme inundation or excess water can result in slow plant growth. At P3 (groundwater table 10 cm from the soil surface) plants experience slow growth as in P2 resulting in slow leaf growth. At P4 (groundwater table 20 cm from the soil surface) there was no inhibition of growth because in this treatment the plants got enough water or water was not excessive. At P5 (groundwater level 30 cm from the ground surface or limited to bricks) in this treatment experienced rapid growth and did not experience growth inhibition because the water supply was sufficient. Reported by Florio et al. (2014) when the water table rise, it can lead to water excess in the root zone, that can negatively affect seed germination, crop establishment, and/or performance of established crops due to anoxia, root diseases, or indirect effects associated with nutrition status. Then the maize growth performance was inhibited. Surface drainage in the field was required. Micro drainage channel with 8-10 m drainace spacing was succesfully used for meize cultivation in the tidal lowland area (Imanudin et al., 2021).

Table 4. Average results of the number of leaves of corn plants per week

Treatment	Observation of Number of Plant Leaves per Week (Strands)							
	1	2	3	4	5	6	7	8
P1	3,33 a	5,00 a	5,67 a	7,67 a	9,00 a	8,67 a	9,67 a	9,67 a
P2	2,67 a	3,00 a	3,00 a	3,67 a	4,00 a	5,00 a	6,00 a	6,33 a
P3	4,00 a	5,33 a	6,00 a	6,67 a	6,33 a	6,67 a	7,33 a	7,67 a
P4	4,00 a	5,67 a	7,00 a	9,33 a	10,00 a	10,33 a	10,67 a	10,67 a
P5	4,00 b	6,00 b	7,33 b	9,33 b	11,00 b	11,33 b	12,00 b	12,33 b
BNT 5%	1,13	2,64	3,82	5,29	6,38	4,85	4,37	2,98

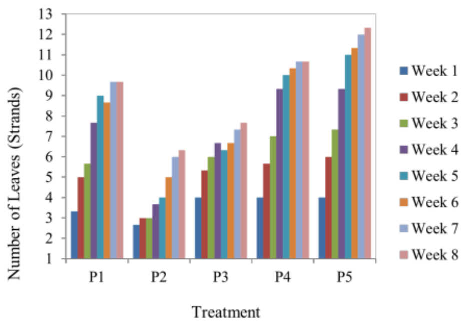

Figure 3. Number of maize crop leaf development

It can be seen from table 4.5. the longest root length was in treatment P5 with a groundwater table of 30 cm from the soil surface or limited to bricks and the shortest root length was in P2 with a groundwater table of 5 cm from the soil surface. It can be seen that the more water that stagnates the soil the growth of corn plants is hampered. The amount of water absorbed by plant roots is highly dependent on the water content of the soil which is determined by the ability of soil particles to hold water and the ability of the roots to absorb it.

According to Nikita et al. (2014)Nikita stated that soils with higher proportions of macro-agaragates and good soil structure can serve as a medium for optimal root growth. According to Sugito (1999) in Nikita et al. (2014) when conditions are saturated all soil pore spaces are filled with fast-moving water and nutrients can be leached through it, if this condition continues to occur it will have an impact on poor soil aeration and root respiration and aerobic microbial activity such as ammonification bacteria and nitrification will be disturbed. Oxygen is closely related to the respiration of plant roots and soil microorganisms. The entry of plant root respiration to get energy and will be utilized by the roots to absorb nutrients in the soil. If the soil is under conditions of excess water, there will be disturbances in the absorption of nutrients. One example of a symptom that occurs as a result of water saturation conditions is yellowing of the leaves. This condition occurs due to an inhibited nitrification process so that the availability of N nutrients in the soil (in the form of NO_3^-) is reduced, this occurs by the process of changing nitrite (NO_2^-) to nitrate (NO_3^-) requiring oxygen.

3.4 Response of Plants to Shallow Groundwater

In the control treatment or without a water table (P1) the plants did not grow very well because the availability of water was insufficient and evaporation occurred. In this treatment the availability of water is obtained through watering. In the treatment of a groundwater table of 5 cm or an extreme (P2) the plants could not be planted on the land because with an extreme groundwater table the plants experienced growth inhibition. In the 10 cm groundwater table (P3) treatment, the plants experienced a slight growth retardation due to excess water, so the plants were not suitable for growing with a 10 cm water table and the land was not ready if the plants wanted to transplant to land with a ground water table of 10 cm. In the treatment of the groundwater table of 20 cm (P4) farmers can already cultivate crops on the land because in this observation the groundwater table in the land has adequate water availability. The best treatment was the 30 cm groundwater table (P5), in this treatment corn could thrive. This 30 cm groundwater table does not require irrigation. Optimum water-table depths for maize cultivation in the lowland area range frome 0.76 to 0.86 meters and 0.46 to 0.61 (Williamson and van Schilfgaarde, 1965). The need for irrigation water decreases with increasing groundwater depth. At a depth of 50-60 cm the plants do not require irrigation. Surface irrigation water is still needed by 20% when the groundwater depth is 90-100 cm, especially on soils with light textures. Increasing the water depth from 30-90 cm can increase crop production from 79 and 71% (Odili et al., 2023). Added by Fidantemiz et al. (2019) that maintenance of the water table under 70-90 cm gets the best results in soybean production. Kosoluchukwu et al. (2023) to create stable groundwater conditions, a controlled drainage system is needed. Maintenance the water level in the canal in 50 cm was the best way during dry season period. This system is also able to increase fertilization efficiency and reduce greenhouse gas emissionon.

4. CONCLUSIONS AND SUGGESTION

4.1 Conclusions

The conclusions that can be drawn from the implementation of this field practice are:

- The average soil analyzed is loamy sand textured which is dominated by sand because the soil is always flooded with water.
- The best treatment is at a groundwater depth of 30 cm or P5 (30 cm of water from the ground surface or limited to bricks) in this treatment can thrive and not.
- Inhibits plant height due to sufficient water supply (does not experience water shortages and excess water).
- At P2 (5 cm waterlogging from the soil surface) the plants experienced inhibition of plant height growth because in this treatment corn experienced extreme water stress where the water almost inundated the soil surface, the 5 cm waterlogging treatment was a very slow growth treatment compared to the previous treatment, hence. This treatment is actually not ready for planting plants.
- The highest soil pH was at P5(6.85) while the lowest was at P1 (5.75).

4.2 Suggestion

The advice that can be given by researchers is if corn grows in land with extreme water, it is best to transfer them to land that is not too waterlogged because corn is difficult to grow in land with excess water. It is better to discuss the scale of comparison with the height of the puddle used and the different plants and experiments with more diverse soils are needed.

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