AGROLAND: The Agricultural Sciences Journal
Vol. 9, No. 1 June (2022), 36 - 43
P-ISSN : 2407- 7585 & E-ISSN : 2407- 7593, Published by Tadulako University

Original Research **Open Access**

GROWTH AND PRODUCTIVITY OF SWEET CORN *(ZEA MAYS SACCHARATE STRUT)* AT VARIOUS PLANTING DISTANCES AND NPK FERTILIZER IN PEATLANDS

Maulidi[1)], Warganda[1)]

[1)] Department of Agrotechnology, Universitas Tanjungpura, Pontianak, Indonesia

Correspondence author's: Maulidi
Email: maulidi@faperta.untan.ac.id

Submit: 27 October 2021, Revised: 12 April 2022, Accepted: June 2022
DOI : https://doi.org/10.22487/agroland.v0i0.1218

ABSTRACT

Cultivation of cereals on peatlands has constraints. The use of fertilizers and planting methods is important in optimizing the growth and productivity sweet corn. This study aimed to analyze the need for NPK fertilizer based on the growth and yield of sweet corn plants at various planting spacings on peatlands in Rasau Jaya. The study was conducted on peatlands in Rasau Jaya 2, Kubu Raya District, for about 8 months. This study used a Split Plot Design with a randomized block design (RBD) as the basic statistical design. Spacing was determined as the main plot, consisted of 3 levels: j1 (planting distance 75×25 cm), j2 (planting distance 75×40 cm) and j3 (planting distance 80×20 cm), with NPK fertilizer as subplots consisting of 3 levels: p1 (300 kg NPK/ha), p2 (400 kg NPK/ha), and p3 (500 kg NPK/ha). It was repeated 3 times for each combination. There were 5 plant samples as the unit of observation per plot. The study showed that plant spacing had a significant effect (α = 0.05) on the weight of the cobs without husks, the weight of the cobs with husks, the greenness of the leaves, the diameter of the cobs, length of the cobs, and weight of the cobs per plot. NPK fertilizer significantly affected root volume, leaf area, plant dry weight, and leaf greenness at =0.05; meanwhile, an interaction was found on the use of NPK fertilizer and plant spacing on the cob diameter. According to the results, sweet corn's best spacing for growth and productivity was 75×25 cm and 80×20 cm. The best dose of NPK fertilizer was 500 kg/ha or 125% of the recommended dose. Planting spacing of 75×40 cm + NPK fertilizer 400 kg or 100% of the recommended dose and spacing of 75×25 cm + NPK fertilizer 500 kg or 125% of the recommended dose were the best treatment on the diameter of the cob.

Keywords*:* Sweet corn, Plant spacing, NPK fertilizer, Peatlands.

INTRODUCTION

Sweet corn *(Zea mays saccharata Strut*, has long been consumed worldwide, including in Indonesia. This cereal has different characteristics from other corn, and this type is generally used as main dishes or side dishes. Having a short planting age or early maturing, sweet corn is now popularly cultivated because the relatively short planting period or gestation period will be profitable for farmers.

Domestic demand for corn is currently increasing due to the development of livestock that requires this cereal as feed and the increase in consumption of corn as one of the staple foods and supporting materials for industrial products. The need for corn cereals in Indonesia in 2018, was 15.5 million tons of dry shells (Kementan, 2018). Currently, the Indonesian government states that the production of this cereal is relatively high and can meet the needs of the Indonesian people (Panikkai et al., 2017). The stability and availability of this cereal require cultivation techniques following the characteristics of the agricultural land.

Peatland characteristics are very specific and require different treatment from agricultural land in general. Peatlands tend to be irreversible drying and subsidence due to their bearing capacity and low density of land against pressure on the surface (Camporese et al., 2006; Kechavarzi et al., 2010). Peatlands in tropical areas such as Indonesia is not conducive to agriculture due to acidity and water-saturated land conditions. Likewise, in sweet corn cultivation in West Kalimantan, which is dominated by peatlands, specific cultivation techniques are required to achieve optimal growth and productivity.

Sweet corn cultivation techniques often carried out by farmers on peatlands, located in Rasau Jaya Village, West Kalimantan, have used relatively narrow planting distances to obtain a high number of plants per unit area even though it is not balanced with adequate plant nutrients needed. The use of relatively narrow spacing to get a high population per unit area will result in competition for nutrients in the soil for plants and competition for sunlight received by the leaves and will have implications for the small leaf index (Sangoi, 2001). On the other hand, the use of relatively infrequent spacing results in low population size. If this is not balanced with productivity capacity per plant, production per unit area will be reduced.

Plant population per unit area affects the amount of fertilizer needed. NPK fertilizer is formulated by combining Phosphorus, Nitrogen, and Potassium contribute chemically to plants. The suitability of fertilizers, both type and amount or dose, will effectively affect plants' development, growth, and even productivity.

Table 1. Variables of Observation and Treatment.

Variable	**Level code**	**Description**
Planting spacing	j1	Planting distance 75×25 cm
	j2	Planting distance 75×40 cm
	j3	Planting distance 80×20 cm
NPK Fertiliser	p1	Dose 300 kg NPK/ha
	p2	Dose 400 kg NPK/ha
	p3	Dose 500 kg NPK/ha

The purpose of this study was to analyze the need for NPK fertilizer based on physiological responses, productivity, and growth of sweet corn plants with different spacings planting on peatlands, Rasau Jaya Village, West Kalimantan.

METHOD

The research was conducted on peatland, particularly Rasau Jaya 2 Village, Kubu Raya Regency, West Kalimantan. The duration of the observation was 8 months.

The study was conducted based on a Split Plot Design with a Randomised Block Design (RBD) as the basic design. The spacing was determined as the main plot consisted of 3 levels, namely j1 (planting distance 75×25 cm), j2 (planting distance 75×40 cm) and j3 (planting distance 80×20 cm). Meanwhile, NPK fertilizer as a subplot consisting of 3 levels, namely p1 (300 kg NPK/ha), p2 (400 kg NPK/ha), and p3 (500 kg NPK/ha) (Table 1). Each treatment combination was repeated 3 times. There were 5 plant samples as the unit of observation per plot.

Observation variables included leaf area, number of leaves, plant height, root volume, leaf greenness, plant dry weight. Observational data from each variable were analyzed statistically with Analysis of Variance (ANOVA). If the treatment had a significant effect, followed proceed with the DMRT test at a 5% level.

RESULTS AND DISCUSSION

Setting the spacing with a certain density aims to provide space for each plant to grow well. Plant spacing will affect the density and efficiency of sunlight use and competition between plants in obtaining water and nutrients to affect crop production. At low densities, plants compete less with others so that individual plant performances are better. Conversely, at high density, the competition among plants for light, water and nutrients is getting tighter, influencing the plant growth to become short (Kuai et al., 2015; Mahrus, 2020; Zhang et al., 2014).

Improper spacing leads to a decrease in the production of a plant. It is due to fellow plants competing for nutrients, competing for light, competing for growth, competing for water and minerals, and much more, which results in losses for farmers who make improper and incorrect spacing. In addition to spacing, other factors also determine the success of sweet corn production, mainly soil fertility. Other elements cannot replace the function of plant nutrients, and if these elements are not present completely, the plant's metabolism will be disrupted, or metabolic activities will stop. NPK fertilizer contains nitrogen, phosphorus, and potassium, which are useful in fulfilling plant nutrition.

Nitrogen (N) is one of the main nutrients in the soil that plays an essential role in stimulating growth, giving green color to leaves, and supporting protein formation. Lack of nitrogen in the soil causes the growth and development of plants to be disrupted, and crop yields decrease because the formation of chlorophyll for the photosynthesis process is disrupted (Leghari et al., 2016). In peatland soil, N levels are relatively high, but some of the nitrogen is in organic form, so it must require a mineralization process to be used by plants (Kelemen et al., 2006).

Phosphorus (P) is a nutrient that is needed in large or macro quantities. The uniqueness of this element is that although the amount is the least compared to its two others, nitrogen and potassium in plants, phosphorus is considered the "key of life". The characteristic of phosphorus that distinguishes it from other elements is that it is not easily dissolved in water, and phosphorus tends to be slow to move in the soil. For this reason, this element can be contained in large quantities in the soil compared to other macro elements. The function of phosphorus is for cell division, albumin formation, flower, fruit and seed formation. In addition, phosphorus also accelerates fruit ripening, strengthens stems, root development, improves plant quality, metabolizes carbohydrates, forms nucleoproteins (as constituents of RNA and DNA), and stores and transfers energy such as ATP. Phosphorus also serves to increase disease resistance. If the plant lacks phosphorus, the symptoms that arise are stunted plants, short stem segments, purplish or reddish leaf edges, and reduced fruit and seed formation (Elliott et al., 1997; Grant et al., 2005; Xiao et al., 2009).

Potassium is found in large quantities in the soil, but only a small part is used by water-soluble or exchangeable (in soil colloids). The K element has several functions. Elemental K is not a constituent element of plant tissue, but plays a role in the formation of starch, activates enzymes, stomata opening (regulates respiration and evaporation), physiological processes in plants, metabolic processes in cells, affects the absorption of other elements, enhances drought resistance, In addition, the disease also plays a role in root development. Other uses of nutrient K for plants are activating the work of several thiokinase acetic enzymes, aldolase, pyruvate kinase, glutamylcysteine synthetase, formyl tetrahydrofolate synthetase, succinyl Co A synthetase, nitrate reductase induction, flour synthesis, ATPase. Potassium also stimulates the translocation of carbohydrates from leaves to other plant organs, especially carbohydrate-storing plant organs, such as sweet corn cob. Besides that, potassium is also an essential component in the osmotic regulation mechanism in cells and directly affects the level of membrane semipermeability and phosphorylation in the chloroplast. Other experts also mention that the role of element K for plants is crucial in every metabolic process in plants, including the synthesis of amino acids and proteins from ammonium ions, in the process of photosynthesis, because of a lack of potassium in the leaves. The rate of assimilation of carbon dioxide (CO_2) will reduce. Thus, K helps the formation of protein and carbohydrates, hardens straw and woody parts of plants, increases disease resistance and fruit quality (Anschütz et al., 2014; Ashley et al., 2006; Wang et al., 2013).

In this study, statistically, plant spacing had a significant effect on leaf greenness, the weight of cobs with the husks, weight of cobs per plot, and weight of cobs without husks, while the other variables had no significant effect. NPK fertilizer significantly affected plant dry weight, root volume, leaf area, and leaf greenery, while the other variables had no significant effect. It was found that there was an interaction between the use of NPK fertilizer and plant spacing on the cob diameter. The results of the DMRT difference test at α= 0.05 to examine the difference between treatments, presented in Table 2, Table 3, and Table 4.

Table 2. DMRT Test of Various Distances of Sweet Corn Planting on Peatlands toward Greenness of Leaves (Spad Unit), Weight of Cob with Husks, Weight of Cobs without Husks, and Weight of Cobs per Plot.

Planting spacing	LG (*spad unit*)	Cwithhusk (g)	Cnonhusk (g)	Cperplot (kg)
75×25 cm	46.12 b	426.15 a	277.15 ab	9.42 a
75×40 cm	50.90 a	450.52 a	285.11 a	5.82 b
80×20 cm	48.09 ab	350.04 b	239.19 b	9.62 a

Note: Different letters show a significant difference at α =0.05. LG = greenness of leaves (spad unit), Cwithhusk = weight of cob with husks, Cnonhusks = weight of cobs without husks, Cperplot = weight of cobs per plot

Based on the DMRT test (Table 2), the greenness level of plant leaves at a spacing of 75×40 cm was significantly different from the level of the greenness of plant leaves at a spacing of 75×25 cm, but not significantly different from the level of the greenness of leaves at a spacing of 80×20 cm.

The weight of sweet corn cobs without husks and weight of sweet corn cobs with husks at the spacing of 75×40 cm was significantly different from the weight of sweet corn cobs without husks and weight of sweet corn cobs with husks at a spacing of 80×20 cm, but not significantly different from the weight of corn cobs without husks and weight of sweet corn cob with husks at a spacing of 75×25 cm.

The cobs weight per plot at 80×20 cm was significantly different from the weight of the cob per plot at 75×25 cm, but not significantly different from the weight of the cobs per plot at 75×40 cm.

The DMRT test (Table 3) showed that leaf area, root volume, dry weight and weight of cobs without husks at the application of 500 kg NPK (125% of the recommended dose) were significantly different from dry weight, root volume, leaf area, and weight cobs without husks on the application of 300 kg NPK (75% of the recommended dose), but not significantly different from dry weight, root volume, leaf area, and weight of cobs without husks on the application of 400 kg NPK (100% of recommended dose).

The level of the leaves greenness at the application of 500 kg NPK (125% of the recommended dose) was significantly different from the level of leaves greenness of 400 kg NPK (100% of the recommended dose), but not significantly different from the level of leaves greenness on the application of 300 kg NPK (75% of the recommended dose).

The weight of cob with husks and weight cob per plot, when applied with 500 kg NPK (125% of the recommended dose), were significantly different from the weight of cob with husks and cob weight per plot when applied with 300 kg NPK (75% of the recommended dose) and 400 kg NPK (100% of recommended dose).

Table 3. DMRT Test of NPK Fertilizer Treatment on Leaf Area (LA), Root Volume (RV), Dry Weight (DW), Leaf Greenness (LG), Cob Weight with Husks (Cwithhusk), Cob Weight without Husks (Cnonhusks) and Cob Weight per Plot (Cperplot).

NPK Fertilizer level	LA (cm^2)	RV (cm^3)	DW (g)	LG (*spad unit*)	Cwithhusk (g)	Cnonhusk (g)	Cperplot (kg)
300 kg/ha (75% recommended dose)	3,919.90b	46.89b	57.90a	48.29ab	379.74c	255.59b	7.80c
400 kg/ha (100% recommended dose)	4,471.10a	55.33a	73.70ab	47.33b	408.52b	264.59ab	8.26b
500 kg/ha (125% recommended dose)	4,862.10a	56.67a	83.13a	49.49a	438.44a	281.259a	8.81a

Note: Different letters show a significant difference at $\alpha = 0.05$. LA = leaf area, RV = root volume, DW = dry weight, LG = leaf greenness, Cwithhusk = cob weight with husks, Cnonhusks = cob weight without husks, Cperplot = cob weight per plot.

Table 4. DMRT Test on Various Planting Spacing and NPK Fertilizers on Corn Cob Diameter in Peatlands

Planting Spacing	NPK Fertiliser			Total	Average
	75%	100%	125%		
75×25 cm	43.69 ab	43.33 ab	44.80 a	131.82	43.94
75×40 cm	43.11 ab	45.34 a	41.68 ab	130.13	43.38
80×20 cm	41.67 b	43.85 ab	43.65 ab	129.17	43.06
Total	128.47	132.52	130.13	391.12	
Average	42.82	44.17	43.38		43.46

Note: Different letters show a significant difference at =0.05

The DMRT test (Table 4) shows that the diameter of corn cobs at a spacing of 75×40 cm + 100% NPK and corn cobs diameter at a spacing of 75×25 cm + 125% NPK was significantly different from the diameter of corn cobs at a spacing of 80× 20 cm + 75% NPK. Meanwhile, the other treatments were not different.

The spacing strongly influences the plant population. The close spacing between plants at a spacing of 75×25 cm and 80×20 cm resulted in more population than the spacing of 75×40 cm. The level of competition that occurs between plants at close spacing was also higher. The sunlight received by plants at a wide spacing would be higher, increasing the photosynthesis process. The photosynthate production was increasing and optimally affecting growth, including the cob weigh with husks or without husks and the intensity of the green leaves.

The planting at a spacing of 75×40 cm resulted in a lower population than the total population at a spacing of 75×25 cm and 80×20 cm. Plant population at a wide spacing of 75×40 cm, the side of the hallway had a lot of open areas and provided flexibility for plants to get nutrients, water, and sunlight that are useful for plant metabolism and photosynthesis. Then, open areas around the plant, causing a decrease in root competition at the bottom of the soil surface and leaves that do not protect each other. Sitompul & Guritno (1995) states that water and nutrients that plants can obtain depend on the opportunity to obtain both growth-supporting elements from the soil. Gardner et al. (1991) found that it is not only genetic (internal), but also stimulant factors are influenced by biological factors (pests and weeds), soil, and climate. It is known that weeds and pests can elevate competition between species. Furthermore, according to Fitter & Hay (1991), reducing the supply of nutrients to plant shoots is caused by root competition, which inhibits the flow of assimilated products to the roots. In addition, this results in a decrease in the root and generative function of the plant in the future.

The weight of the cobs per plot at the two close spacings of 75×25 cm and 80×20 cm resulted in the highest mean compared to the wide spacing (75×40 cm). It was presumed that the population size greatly determines the number of cobs, and the weight of the cobs per plot produced. A higher population at a spacing of 75×25 cm and 80×20 cm resulted in the cob weight with or without husks being low per plant, in contrast to the low population at the spacing of 75×40 cm. However, the main reason determining the cobs' weight per plot was the number of populations per plot.

Leaf area, root volume, dry weight, leaf greenness, the weight of cob with husks, the weight of cobs without husks, and the weight of cobs per plot resulted in the highest mean in the NPK treatment of 500 kg/ha or 125% of the recommended dose compared to the NPK treatment of 400 kg/ha or 100% of the recommended dose and 300 kg/ha of NPK or 75% of the recommended dose. The higher the dose of NPK, the higher the response given by the corn plant. It was presumed that a dose of 500 kg/ha of NPK fertilizer was the appropriate dose for sweet corn on peatland, mainly in Rasau Jaya II, Kubu Raya Regency, West Kalimantan Province.

The dry weight of the plant was largely determined by the volume of roots, leaf area and greenness of the leaves. The cob weight per plot was determined mainly by the cobs' weight with husks and those without the husks. There was linearity between the growth and yield of corn. The dose of 500 kg/ha NPK fertilizer resulted in the best growth response and crop yields.

The best cob diameter in the treatment of plant spacing and NPK fertilizer was a spacing of 75×40 cm + 400 kg/ha of NPK fertilizer or 100% of the recommended dose and spacing of 75×25 cm + 500 kg/ha of NPK fertilizer or 125%

of the recommended dose. They differed from the diameter cobs at the plant spacing 80×20 cm + 300 kg/ha NPK fertilizer or 75% of the recommended dose. Meanwhile, the diameter of the cob in the other treatments was not significantly different. This was presumably the highest number of plant populations at a spacing of 80×20 cm, but the dose of fertilizer given was only 300 kg or 75% of the recommended dose.

CONCLUSION

The best spacing for sweet corn plant growth and yield is 75×25 cm and 80×20 cm. The best dose of NPK fertilizer is 500 kg/ha or 125% of the recommended dose. Plant spacing of 75×40 cm + NPK fertilizer 400 kg/ha or 100% of the recommended dose and spacing of 75×25 cm + NPK fertilizer 500 kg/ha or 125% of the recommended dose is the best treatment for the diameter of the sweet corn cob.

REFERENCES

Anschütz, U., Becker, D., & Shabala, S. (2014). Going beyond nutrition: Regulation of potassium homoeostasis as a common denominator of plant adaptive responses to environment. *Journal of Plant Physiology*, *171*(9), 670–687. https://doi.org/10.1016/j.jplph.2014.01.009

Ashley, M. K., Grant, M., & Grabov, A. (2006). Plant responses to potassium deficiencies: A role for potassium transport proteins. *Journal of Experimental Botany*, *57*(2), 425–436.https://doi.org/10.1093/jxb/erj034

Camporese, M., Ferraris, S., Putti, M., Salandin, P., & Teatini, P. (2006). Hydrological modeling in swelling/shrinking peat soils. *Water Resources Research*, *42*(6). https://doi.org/10.1029/2005WR004495

Elliott, D. E., Reuter, D. J., Reddy, G. D., & Abbott, R. J. (1997). Phosphorus nutrition of spring wheat (Triticum aestivum L.). 1. Effects of phosphorus supply on plant symptoms, yield, components of yield, and plant phosphorus uptake. *Australian Journal of Agricultural Research*, *48*(6), 855–868. https://doi.org/10.1071/a96159

Fitter, A. H., & Hay, R. K. M. (1991). *Fisiologi Lingkungan Tanaman*. Gadjah Mada University Press.

Gardner, F. P., Pearce, R. B., & Mitchell, R. L. (1991). *Fisiologi Tanaman Budidaya*. Universitas Indonesia Press.

Grant, C., Bittman, S., Montreal, M., Plenchette, C., & Morel, C. (2005). Soil and fertilizer phosphorus: Effects on plant P supply and mycorrhizal development. *Canadian Journal of Plant Science*, *85*(1),3–14. https://doi.org/10.4141/P03-182

Kechavarzi, C., Dawson, Q., & Leeds-Harrison, P. B. (2010). Physical properties of low-lying agricultural peat soils in England. *Geoderma*, *154*(3), 196–202. https://doi.org/10.1016/j.geoderma.2009.08.018

Kelemen, S. R., Afeworki, M., Gorbaty, M. L., Kwiatek, P. J., Sansone, M., Walters, C. C., & Cohen, A. D. (2006). Thermal Transformations of Nitrogen and Sulfur Forms in Peat Related to Coalification. *Energy & Fuels*, *20*(2), 635–652. https://doi.org/10.1021/ef050307p

Kementan. (2018). *Kementan Pastikan Produksi Jagung Nasional Surplus*. Kementerian Pertanian Republik Indonesia.https://www.pertanian.go.id/home/?show=news&act=view&id=3395#:~:text=Sementara%20dari%20sisi%20kebutuhan%2C%20berdasarkan,4%2C76%20juta%20ton%20PK.

Kuai, J., Sun, Y., Zuo, Q., Huang, H., Liao, Q., Wu, C., Lu, J., Wu, J., & Zhou, G. (2015). The yield of mechanically harvested rapeseed (Brassica napus L.) can be increased by optimum plant density and row spacing. *Scientific Reports*, *5*(1), 18835. https://doi.org/10.1038/srep18835

Leghari, S. J., Wahocho, N. A., Laghari, G. M., HafeezLaghari, A., Mustafa Bhabhan, G., Hussain Talpur, K., Bhutto, T. A., Wahocho, S. A., & Lashari, A. A. (2016). Role of nitrogen for plant growth and development: A review. *Advances in Environmental Biology*, *10*(9), 209–219.

Mahrus, A. (2020). *Intercropping System for Growth and Yield in Local Varieties of Madura* [Skripsi, Universitas Merdeka Surabaya]. http://agriscience.scientific-work.org/index.php/agriscience/issue/view/5

Panikkai, S., Nurmalina, R., Mulatsih, S., & Purwati, H. (2017). Analisis Ketersediaan Jagung Nasional Menuju Swasembada dengan Pendekatan Model Dinamik. *Informatika Pertanian*, *26*(1), 41–48. https://doi.org/10.21082/ip.v26n1.2017.p41-48.

Sangoi, L. (2001). Understanding Plant Density Effects on Maize Growth and Development: An Important Issue To Maximize Grain Yield. *Ciência Rural*, *31*(1), 159–168. https://doi.org/10.1590/S0103-84782001000100027.

Sitompul, S. M., & Guritno, B. (1995). *Analisa Pertumbuhan Tanaman*. Gadjah Mada University Press.

Wang, M., Zheng, Q., Shen, Q., & Guo, S. (2013). The Critical Role of Potassium in Plant Stress Response. *International Journal of Molecular Sciences*, *14*(4), 7370–7390. https://doi.org/10.3390/ijms14047370

Xiao, G., Li, T., Zhang, X., Yu, H., Huang, H., & Gupta, D. K. (2009). Uptake and accumulation of phosphorus by dominant plant species growing in a phosphorus mining area. *Journal of Hazardous Materials*, *171*(1), 542–550. https://doi.org/10.1016/j.jhazmat.2009.06.034

Zhang, D., Zhang, L., Liu, J., Han, S., Wang, Q., Evers, J., Liu, J., van der Werf, W., & Li, L. (2014). Plant density affects light interception and yield in cotton grown as companion crop in young jujube plantations. *Field Crops Research*, *169*, 132–139. https://doi.org/10.1016/j.fcr.2014.09.001