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Differences in Crop Growth Rate , Chlorophyll Content Index and Nitrate Reductase in Source N of Sweet Corn

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Abstract. A research to assess the interaction of nitrogen sources and doses of N in the growth and production as well as physiological effects of corn plants has been conducted in the Faculty of Animal and Agricultural Sciences, Diponegoro University, Indonesia. The research uses two sources of nitrogen namely NO3- (potassium nitrate) and NH4+ (ammonium sulfate), and doses of N (0, 50, 100 and 150 kg N/ha). The results showed that the dose of N fertilizer significantly effected on plant height, CCI, NR, CGR and weight of corn cobs. The interaction between the source of N and the dose of fertilizer N significantly effected on CCI, NR, and CGR, however, it had no significant effect on plant height and weight of corn cobs. The dose of N as much as 150 kg per ha resulted in plant height, CCI, NR, CGR and the highest cobs, respectively 82.33cm, 2.43, 84.3 umol, 18.87 g/day and 3538.2 g per plot.

Keywords: sweet corn, chlorophyll content index, NR, CGR, corncob

1. Introduction

Sweet corn (Zea mays L.) is a member of the Poaceae family. Corn is from Mexico [1]. Corn is the third major cereal crop after wheat and rice. Corn plants have an assortment of uses, namely as food, for industry of processed production and as animal feed. Corn has many types of cultivars and different plant ages have different tolerance to different environmental conditions. In production of plants, nitrogen can be in the form of NO_3-N and NH_4-N because the plants absorb N in the form of NO_3-N or NH_4-N [2]. The ability of N uptake by the plants vary considerably during the plant growth. On the ground with sufficient N, N plants accumulation is strongly associated with plant growth and accumulation of biomass [3].

Nitrogen is the main nutrient, it is a constituent component of amino acids, peptides and proteins, chlorophyll, nucleic acids and many cofactors and plant defense compounds. At the majority of higher plants that grow in good aeration soil, nitrate is a major source of inorganic nitrogen. Nitrates in the plant turn into nitrite, and ammonium, before assimilated into amino acids, in a highly complex series of reactions in cells and tissues [4]. Nitrogen (N) is a macro nutrients which is essential for the plant, but it is quite expensive to be fulfilled and may result either in unfavorable environmental conditions. An estimation of 50-70% of a given supply of N is lost and cannot be used by plants [5]. Nitrogen (N) is the most important limiting nutrient for plant growth and the availability of N, therefore, it simply

acts as a key factor to the healthy increase in agricultural production [6]. It was considered to be the most important factor since it plays several important roles in the metabolism and regulation in plants.

Nitrogen is easy to evaporate and leach in the soil. In relation to N uptake by plants, plants utilize nitrogen in the form of nitrite and ammonium. Nitrogen uptake by plant roots and its translocation is primarily in the form of nitrate ($NO_3^{-)}$ and ammonium (NH_4^+) and amino acids. Plants absorb nitrogen based on their nature and preferences. The forms of inorganic N, ammonium and nitrate, are both easily available to plants but they have different reactions in the soil. Different sources of nitrogen will affect the uptake by plants. KNO_3 is a provider of nitrogen fertilizers in the form NO_3^-, while AS (ammonium sulfate) is a provider of nitrogen in the form of NH_4^+. In addition to "the predilection" of plants ability to absorb nutrients N is affected by pH and the presence of other elements that are antagonistic or synergistic with nitrogen. The study aims to investigate the response of corn plants towards different types of nitrogen source. Based on that reason, specifically the targeted results through the course of this research was to study the interaction of nitrogen sources and doses of N in the growth and production as well as plant physiological effects of sweet corn.

2. Materials and Methods

The study was conducted in the laboratory of the Faculty of Animal and Agricultural Sciences, Diponegoro University, Indonesia during the dry season months of August to December 2014. The research location has Oxisol soil types with clay soil texture, soil pH of 6.7, a 0.12% total N content, total P of 0.10 %, 0.22% of K total and C content of 0.99%. The research of sweet corn (*Zea mays saccharata*) was performed using 24 experimental plot size 2 x 2 m2, with a spacing of 50 x 50 cm so that each plot had 16 plants. The research used 2 x 4 factorial design that is repeated 3 times. Factor I : a source of nitrogen (NO_3^- (potassium nitrate) and NH_4^+ (ammonium sulfate). Factor II : nitrogen fertilizers, ie 0, 50, 100 and 150 kg N/ha.

Each plant obtains fertilizer of N, P and K with the appropriate treatment dose of N, P fertilizers as much as 50 kg P_2O_5 per hectare and K as much as 50 kg KCl per hectare. Micro-nutrients are given in the form of liquid fertilizer of about 5 ml which are dissolved in one liter of water and sprayed onto plants at the age of one week after planting. The parameters of the experiment are the plants height, chlorophyll content index (CCI) which was performed on the fifth leaf from the tip of the plant, the activity of nitrate reductase (NR), crop growth rate and weight of cobs.

Corn plant height is measured from the ground to the highest end. Chlorophyll content index (CCI) is the ratio of chlorophyll a and b, measured using a CCI meter. Analysis of nitrate reductase activity is carried out in accordance to [7]. Corn cobs harvested are then weighed. Corn stover is the straw of corn that is crop yields of corn with the cobs taken. CGR parameters based on the dry matter = (W_2, dry matter harvest – W_1, seedling dry matter)/t_2, time of harvest- t1,time of planting [8].

From the observation of parameters analyzed variance and orthogonal polynomials. If there are differences continued with Duncan multiple range test according to [9]

3. Result and Discussion

3.1. Result

ANOVA results indicate that the N source significantly effect on plant height, CCI, NR, CGR and weight of corn cobs. Dose of fertilizer N significantly effect on plant height, CCI, NR, CGR and weight of corn cobs. Interaction between the source of N and N fertilizer dose significantly effect on CCI, NR, CGR but had no significant effect on plant height and weight of corn cobs.

Nitrogen source in the form of nitrate results in the corn plant height of 27.96% higher than the nitrogen source of ammonium form. CCI using the source of nitrogen as nitrate is 35.93% higher than ammonium. Nitrate reductase (NR) value with a source of nitrogen as nitrate is 8.26% higher than ammonium. Crop growth rate due to the use of nitrate form of nitrogen sources is 14.51% higher than the ammonium form. Crops of cobs due to the use of nitrate form of nitrogen sources are 14.27% higher than N sources in the form of ammonium(Table1).

Table 1. The effect of N dose and sources of nitrogen on plant height, CCI, NR, CGR and corn cobs yield.

Source	Plant height (cm)	CCI	NR μmol g^{-1} $FW.h^{-1}$.	CGR $g.day^{-1}$	Cob ($g.plot^{-1}$)
Nitrate					
0	54.33	1.08 def	40.85 f	9.76 de	1360.0
50	58.33	1.40 cd	67.27 d	11.03 d	1829.3
100	62.00	1.62 c	77.37 c	14.90 bc	2579.3
150	75.67	2.86 a	85.50 a	21.37 a	3843.7
Ammonium					
0	66.67	0.84 f	35,96 f	8.37 e	1360.0
50	79.33	0.98 ef	51,13 e	10.30 d	1611.7
100	85.33	1.30 cde	79,43 bc	13.77 c	2036.7
150	89.00	2.00 b	83,13 ab	16.37 b	3232.7
Nitrate	80.08 a	1.74 a	67.58 a	14.27 a	2403.08 a
Ammonium	62.58 b	1.28 b	62.42 b	12.20 b	2060.25 b
Nitrogen Dosage					
0	60.50 c	0.96 c	38.07 d	9.07 d	1360.0 d
50	68.83 b	1.19 c	59.20 c	10.67 c	1720.5 c
100	73.67 b	1.46 b	78.40 b	14.33 b	2308.0 b
150	82.33 a	2.43 a	84.32 a	18.87 a	3538.2 a

The doses of nitrogen increased the plant height of 13.6 to 36.08% due to the increasing amount of nitrogen dosage treatment used from 50-150 kg N per ha compared with no N (0 kg N per ha). CCI of corn increased along with the increasing of nitrogen doses of 50-150 kg N per ha which is in the amount of 24-66% compared with no nitrogen. The nitrate reductase activity decreased with the increasing of nitrogen doses given, namely 56% (50 kg N/ha) to 8% (150 kg N/ha), compared with no nitrogen. The crop growth rate of corn increased with the increasing of nitrogen doses of 50-150 kg N per ha, which is in the amount of 18-32% compared with no nitrogen. The weight of corn cobs per plot increased with the increasing of nitrogen doses of 50-150 kg N per ha, as much as 27- 53% compared with no nitrogen.

The amount of CCI, NR and CGR increased with the increasing dose of nitrogen fertilizer either in the source of nitrogen in ammonium or nitrate forms. The increase of N fertilizer dose of nitrate from 50-150 kg N per ha increased 30% to 77% of CCI amount. The increase of N fertilizer doses of ammonium form increased CCI by 17% (50 kg N per ha) and 54% (150 kg N per ha). N source in the form of nitrate with increasing doses of 50-150 kg N per ha lowered NR by 65% (50 kg N ha-1) and decreased by 11% at a dose of N as much as 150 kg N per ha, while ammonium increased from 42-131%. Although the corn plant height and weight of corncobs value go up, they did not statistically show a significant different.

3.2. Discussion

The physiological nature of plant is influenced by the interaction of nitrogen doses and forms of N sources, while the growth and weight of cobs do not show significant interaction between nitrogen doses and forms. Of the type of N source, nitrate gave a higher value on all parameters observed compared to ammonium. This is in line with the research of [4] showing that the majority of higher plants that grow on well-aerated soil used nitrate as a major source of inorganic nitrogen. N increased

dose caused an increase in all parameters, it is clear that N dose could be increased to get the cob's increasing production and better growth.

Nitrogen is a constituent of chlorophyll. Chlorophyll does not only affect photosynthesis, but also participates in the color of the fruit, which is an important index for fruit ripeness. During the development of the fruit, the color changes from green to yellow or red are associated with the reduction of chlorophyll and carotenoid accumulation. Chlorophyll content can be influenced by the biosynthesis of chlorophyll, interconversion and degradation of chlorophyll a / b. In addition, it was observed that the chlorophyll binding conditions also influence the degradation of chlorophyll. Therefore, chlorophyll metabolism consists of four main sections: the synthesis of chlorophyll, chlorophyll a / b interconversion, chlorophyll bond, and chlorophyll degradation [10]. Various levels of nitrogen are influenced by LAI, the amount of dry matter accumulation, and CGR, however, the plant height is not affected by different levels of nitrogen application [8]. The increasing doses of N fertilization improve the NR leaf (Table 1). N nutrient in the soil are taken by plants mainly in the form of nitrate ions (NO_3^-) and ammonium ion (NH_4^+), which of both forms, nitrate is at the most form [11]. The application of N fertilizer increases NR, it proves that most of the ammonium ions released by urea in the soil transform into nitrate ions. The increasing number of nitrate ions in the leaf tissue will further increase NR. This is in accordance with the opinion of [12] that the higher the content of substrate nitrate in the tissue, the more increased the NR rate. Crop production is the result of photosynthesis, respiration and translocation of assimilates to plant dry matter. The production increased is directly proportional to the increase of relative growth and the net result of photosynthesis. Such result is similar to the research of [13] which showed that the optimal supply of nitrogen is very important to the dry matter and other parts of the plant.

4. Conclusion

From the results of this study, it can be concluded that the sweet corn plant prefers nitrate compared to ammonium which is indicated by better plant height, CCI, NR, CGR, and cob weight than ammonium. The increasing doses of N fertilizer resulted in higher plants, CCI, NR, CGR, and cob weight, either in nitrogen source of nitrate or ammonium form.

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