Growth and Yield of Hybrid Corn under Different Fertilizer Applications

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***Abstract*—Conventional agriculture is heavily depended on the use of inorganic fertilizer that provides sufficient macro nutrients, with some draw back on the environment. On the other hand, organic agriculture that only use organic fertilizers is considered environmentally friendly but sometimes could not provide adequate nutrients for plants. The aim of this research was study the growth and yield of hybrid corn treated with different dose of Granular Organic Fertilizer (GOF) in comparison to inorganic fertilizers. The corns were planted in polybags arranged in Randomized Completely Block Design with four treatments, i.e. 10 tons/ha GOF, 20 tons/ha GOF, 30 tons/ha GOF, inorganic fertilizers (630 kg/ha ZA, 350 kg/ha Urea, 100 kg/ha SP36, 380 kg/ha Phonska). Each treatment consisted of 20 plants with 6 replications. The results showed that the height of plants treated with 20 tons/ha GOF or 30 tons/ha GOF was not significantly different from plants treated with inorganic fertilizers, but was significantly higher than those treated with 10 tons/ha GOF. The number of leaves did not significantly affected by different fertilizers application. Furthermore, plants treated with inorganic fertilizers significantly had higher chlorophyll content and produced higher yield than those treated with GOF at various doses. This revealed that application of GOF on corn at dose of up to 30 tons/ha was not sufficient to produce high yield. To increased yield, higher dose of GOF is needed or it can be supplemented by application of inorganic fertilizers.**

***Index Terms*—granular organic fertilizer, inorganic fertilizer, corn, growth, yield**

I. Introduction

Corn is one of important grains in the worlds. It is cultivated for food, feed and recently for renewable fuels in many countries. The world corn production is estimated to increase from 968,06 Million Metric Tons (MMT) in 2015/2016 to 1065,11 MMT in 2016/2017 and world consumption increase from 965,1 MMT in 2015/2016 to 1053,59 MMT (est.) in 2016/2017. In addition, the corn demand is projected to increase to 1062,3 MMT in 2017/2018, whereas the production is projected only 1033,66 MMT [1]. The United States of America is the highest producer of corn in the world with its production is estimated 384,778 MMT in 2016/2017. Indonesia is in the 12th position produced 10,200 MTT (est.) in 2016/2017 [2]. Corn is usually planted as a second crop after rice in Indonesia. Corn consumption in Indonesia as food and feed in 2016/2017 is estimated 3,8 MTT and 8,4 MTT, respectively [3]. The government of Indonesia has restricted the import of corn that implicated to boost the country production.

In general corn is cultivated conventionally with the intensive application of inorganic fertilizers. In Indonesia the recommended fertilizer dosage for corn are N: 65-95 kg/ha/season, P: 30-50 kg/ha/season, K: 10-30 kg/ha/season [4]. However, some time, farmers use fertilizer under or beyond recommended rates. There is a great concern that over use of inorganic fertilizers, continuously for long period unaccompanied by organic materials has adverse effect to the environment, including degradation of soil quality and pollution. Degraded soil characterized by compacted soil and reduced porosity, decreased soil fertility and content of essential micro nutrients [5]. In addition, soil treated with inorganic fertilizer alone significantly has lower populations of soil microbial biomass, such as bacteria, fungi and actinomycetes, as well as soil enzyme activities [6], [7]. Decreasing soil quality can, cause levelling off crop yield, although farmers use more fertilizer for their crop the yield remain the same or sometimes decrease.

In comparison, organic fertilizer poses many advantages including (1) provides a more balance macro and micro nutrients, (2) improves activities of soil microbes, (3) increases P supply by improves mycorrhizae colonization, (3) improves soil structure thus enhance growth of roots, (4) increases Soil Organic Materials [8]. The positive impact of organic fertilizer seen in the short term and long term, which increase soil fertility and crop yields. In the short term, organic fertilizer application can improve the biological and biochemical properties of the soil, so as to produce the similar yield of sweet corn as that treated with inorganic fertilizer [9]. A 32-year study in Sweden showed that the use of organic fertilizers would yield wheat and potatoes approximately the same as those using inorganic fertilizers. Increased yields on land given organic fertilizers were even higher than those given inorganic fertilizers. The quality of wheat and potatoes treated with organic fertilizers is better than those given inorganic fertilizers, in addition to the decrease in weight after storage is lower in wheat and potatoes given organic fertilizers than those given inorganic fertilizers [10]. Moreover, organic crops contained significantly more vitamin C, iron, magnesium, and phosphorus and significantly less nitrates than conventional crops [11].

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The nutrients content of organic fertilizer depend on the materials that are used as main substrate. Organic fertilizer made from cattle manure and broiler litter contains 1.5% N, 1.5% P2O5, 1.2% K2O, 1.1% Ca, 0.3% Mg and 3% N, 3% P2O5, 2% K2O, 1.8% Ca, 0.4% Mg, respectively [12]. Boiler ash as the residue of bagasse combustion produced in sugar production process can be added as organic materials, it contains 71% SiO2; 3% P2O5; 8.2% K2O; 3.4% CaO and some micronutrients (0.2% MnO; 1.9% Al2O3, 7.8% and 0.3% Fe2O3 MgO) [13].

As source of organic materials, boiler ash contains high percentage of silicate that improve plant resistance against biotic and abiotic stresses. Plants from the Gramineae family, including corn, are Silicate accumulators (Si). The absorbed silicate acid is stacked in the epidermal tissue of the plant thereby strengthening the stems and leaves [14]. Silicate can increase the efficiency of plant photosynthesis. The application of boiler ash with dose of 50 ton / ha can increase soil porosity, P, S and K, Fe, Mn, Zn and Cu availability as well as grain yield on calcareous soil [15].

However, constraints perceived by farmers with the use of organic fertilizers are it is to be given in large quantities because of low nutrient content, need more cost to transport and not practical. Farmers are less responsive in accepting the transformation of the idea of the benefits of solid organic fertilizers, not even believing that organic fertilizer is a fundamental component of soil fertility improvement as well as plant growth and yield. Research on the application of organic fertilizers to the growth and yield of various plants has been done. Nevertheless, research on the use of granular organic fertilizers enriched with boiler ash and neem leaves powder to increase yield on corn has never been done. Therefore, the aim of this research was to compare the growth and yield of hybrid corn treated with various dosage of granular organic fertilizers with inorganic fertilizer.

II. Materials and Methods

This experiment was conducted in The Experimental Field Station of Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" Yogyakarta, Indonesia. The experiment design was a Randomized Completely Block Design (RCBD) of four treatments with six replications, each treatment consisted of 20 polybags. The treatments were dose of granular organic fertilizer with control treatment according to conventional cultivation using recommended dose of inorganic fertilizers.

Granular organic fertilizer used for this experiment is specially formulated enriched with boiler ash and neem leaves powder. Granular organic fertilizer was supplied according to the treatments i.e., dose of 30 tons / ha (D1); dose of 20 ton / ha (D2); dose of 10 tons / ha (D3). For control, the plant was provided inorganic fertilizers as follows: at 15 dap (days after planting): 280 kg/ha ZA, 100 kg/ha SP36; at 35 dap: 200 kg/ ha Phonska; at 50 dap: 350 kg/ha urea, 180 kg/ha Phonska. Hybrid corns (Pioner variety) were planted in polybags (50 cm diameter; filled with 16 kg soil). Soil used for this experiment was obtained from location that has not been used for agricultural farming. The soil was sieved to remove the gravel. Granular organic fertilizer was placed into soil at a depth of about 10 cm two weeks before planting. Soil humidity was kept to field capacity by watering plants every day. Corn seeds were planted 2 pieces per polybag. One plant that grew unequally with others was removed from polybag after the plants were 2 wap (weeks after planting), leaving one plant per polybag.

Plant height, number of leaves and plant damage were measured every two weeks until eight weeks after planting (wap). Handheld Chlorophyll Meter (Konica Minolta SPAD-502Plus) was used to measure Chlorophyll content at 13 wap. The optical density of chlorophyll within two wavelength, blue (400-500 nm) and red (600-700nm) regions was recorded by the chlorophyll meter. The measurements showed the relative density of chlorophyll in the leaf [11]. Three leaves per plant were taken as sample to measure chlorophyll content. Yield parameters were cob fresh weight/polibag, economical weight (cob weight without sheath)/polibag that was measured at 13 wap.

The SPSS for Windows version 15 was used to analyze the data. Percentage data were transformed into Arcsin $\sqrt{x+1}$ before being analyzed to achieve normality. All data were analyzed using a one way ANOVA. All multiple comparison tests for means were performed using Duncan Multiple Range Tests.

III. Results and Discussion

Plant height and number of leaves can reflect the relative growth of plant. Nutrient status may affect the plant growth. This experiment showed that corn plant height at 2-6 wap was not significantly affected by the application of different dose of granular organic fertilizer (GOF) or inorganic fertilizer. Hybrid corns treated with inorganic fertilizer significantly have higher plant height than those treated with 10 ton/ha granular organic fertilizer, although the plant height was not significantly different from those treated with 20 ton/ha or 30 ton/ha granular organic fertilizer (Table I). This results showed that 10 ton/ha granular organic fertilizer did not provide sufficient nutrient for plant growth. Visual observation showed that the plant vigor was low and exhibited stunted growth.

Number of corn leaves at 2-8 wap did not affected significantly by application of different dose of granular organic fertilizer or inorganic fertilizer. However, chlorophyll content in plants treated with granular organic fertilizer significantly lower than those treated with inorganic fertilizer (Table II). Leaves are important parts of plant that facilitate photosynthetic. There is a positive correlation between chlorophyll content with nitrogen content [16], [17]. Nitrogen is macro nutrient that essential for proteins synthesis and is needed to develop chloroplasts and chlorophyll [18], [19]. The colour of the leaf reflect the chlorophyll content in the leaf. In this study, plants treated with inorganic fertilizer that supplied high nitrogen, their leaves were dark green, whereas plant treated with granular organic fertilizer,

their leaves were light green indicating that they lack of nitrogen.

Fresh cob weight with or without sheath represent yield of corn. The results showed that plant treated with inorganic fertilizer produced the highest fresh cob weight with or without sheath and plant treated with 10 tons/ha granular organic fertilizer produced the lowest fresh cob weight (Table III). This research indicate that the application of granular organic fertilizer on hybrid corn with dose up to 30 ton/ha was not sufficient to achieve high yield as those with recommended dose of inorganic fertilizer. Although organic fertilizer contains macro and micro nutrient, the amount did not provide adequate nutrient needed for plant growth and yield.

Inorganic provide plants with sufficient nitrogen, phosphate and kalium. Nitrogen is needed for protein synthesis and support the plant growth in general [19]. Phosphate is needed to generate energy, nucleic acid synthesis, carbohydrate metabolism and nitrogen fixation [20]. Kalium is needed to support the biochemical and physiological processes that influence plant growth and plant metabolism. In addition, adequate kalium will increase plant resistance against drought, salinity and pests attack [21]. Furthermore, kalium activate enzyme and support nutrient and water absorption from soil and distribute assimilates from leaf to other part of plant [22]. The photosynthetic rate is largely affected by the chlorophyll content. Plant with high content of chlorophyll as those treated with inorganic fertilizer will produce more assimilates, which subsequently will be accumulated to acquire yield. Therefore plant treated with inorganic fertilizer produced the highest yield.

TABLE I. CORN PLANT HEIGHT (CM) AT 2- 8 WAP (WEKS AFTER PLANTING) UNDER DIFFERENT FERTILIZER APPLICATION

Fertilizer dose	2 wap	4 wap	6 wap	8 wap
30 ton/ha	29,9 ±1,9 a	55,9 ±3,6 a	84,1 ±5,9 a	108,4 ±5,3 ab
20 ton/ha	27,3 ±1,5 a	61,2 ±5,8 a	83,3 ±5,2 a	109,33 ±5,3 ab
10 ton/ha	30,6 ±4,2 a	59,3 ±4,4 a	76,0 ±3,8 a	95,1 ±10,1 b
Inorganic fertilizer	27,4 ±1,2 a	51,1 ±3,1 a	81,7 ±1,5 a	123,1 ±4,9 a

Means in the same column followed by the same letters are not significantly different (P<0.05), according to Duncan's test (α: 5%).

TABLE II. NUMBER OF CORN LEAVES AT 2-8 WAP AND CHLOROPHYL CONTENT AT 13 MST WAP (WEKS AFTER PLANTING) UNDER DIFFERENT FERTILIZER APPLICATION

Fertilizer dose	2 wap	4 wap	6 wap	8 wap	Chlorophyl (SPAD value)
30 ton/ha	2,4 ±0,1 a	4,7 ±0,2 a	7,3 ±0,2 a	9,1 ±0,1 a	22,1 ±1,9 b
20 ton/ha	2,9 ±0,3 a	5,1 ±0,2 a	7,7 ±0,2 a	9,2 ±0,4 a	24,1 ±2,4 b
10 ton/ha	3,0 ±0,2 a	4,9 ±0,4 a	6,7 ±0,0 b	9,1 ±0,6 a	24,2 ±3,5 b
Inorganic fertilizer	2,9 ±0,1 a	4,8 ±0,3 a	7,3 ±0,2 a	9,8 ±0,4 a	44,5 ±2,7 a

Means in the same column followed by the same letters are not significantly different (P<0.05), according to Duncan's test (α: 5%). SPAD value: Index shown by Konica Minolta SPAD-502Plus that indicating the content of chlorophyl in the leaf.

TABLE III. CORN YIELD (G)/POLYBAG UNDER DIFFERENT FERTILIZER APPLICATION

Fertilizer dose	Fresh Cob with sheath	Fresh Cob without sheath
30 ton/ha	44,8 ±9,8 b	26,9 ±3,5 c
20 ton/ha	51,7 ±8,4 b	32,3 ±1,2 b
10 ton/ha	33,5 ±9,2 c	20,0 ±1,8 d
Inorganic fertilizer	124,3 ±7,7 a	48,8 ±4,1 a

Means in the same column followed by the same letters are not significantly different (P<0.05), according to Duncan's test (α: 5%)

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