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Effect of Inorganic Fertilizers and Stingless Bee Pollination on Increasing Productivity of Corn (*Zea mays* L.)

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ABSTRACT

Background: Increasing agricultural output can be encouraged by fertilizing, even the greater the fertilizer is given, the higher the yield will be obtained. On the other hand pollinator services to increase agricultural output is also quite large, but this potential has not yet been optimized. Corn plants are monoecious but they are also protandry so pollinator services are needed. This research aims to get optimization of increasing yield of corn by fertilizing and pollination with stingless bees.

Methods: The study was carried out at Korong Gadang sub-district, Kuranji District, Padang City at an altitude 20 m above sea level. The experiment comprised of 4 treatments laid out in randomized block design replicated thrice.

Result: The results of the study showed a positive influence of doses inorganic fertilization and stingless bee on com production. There was at an increase in the number of seeds per cob and cobs per plot due to fertilization than the pollination stingless bees. Increased seed production per plot due to fertilizer use ranged between 17.25 to 25.06% compared to organic manures. The pollination process could increase production in the range of 3,98 - 6.66% compared to wind pollination. Thus pollination with *Tetragonula laeviceps* could help seed yield per ha when accompanied by the application of inorganic fertilizers. The use of organic manures could not meet the nutrient requirement of the crop and hence production was low.

Key words: Fertilization, Optimization, Pollination, Production, Stingless bee.

INTRODUCTION

Currently, farmers just assume that fertilizer is the only input that contributes to improving agricultural output. Further they believe that bigger the fertilizer dose they provide bigher production they would earn. For example, in the 1970's, the farmers only requires 150 kg of urea per ha for paddy but now it reaches 300 kg urea per ha (Bustami *et al*., 2012). The role of fertilizer in increasing agricultural yields has been widely proven and felt by the farmers. The results of research in the United States show that various types of plants, such as corn, cotton, rice, barley and wheat production decreased between 16 percent to 41 percent when the plants were not given added urea or Nitrogen (Roberts,2009).

In the effort to increase the productivity of corn, appropriate cultivation technology is needed, especially in the provision of fertilizer. Corn yields can be increased by proper fertilization, both dosage, time and type of fertilizer given, namely N, P and K nutrients which are important nutrients for plant growth. The time, dose and method of fertilizer application affect the growth and yield of corn plants, so that nutrients are effectively absorbed by the roots of plants. The provision of N 1/3 part at planting, 1/3 part at 30 HST and 1/3 part at 45 HST is relatively better in terms of yield and efficiency of N uptake, compared to the whole giving at planting (Kasno and Tia, 2013).

Pollination is a mechanism of transfer of pollen from anther in male flowers to female flower stigma. Pollination by pollinators is an important ecosystem service as 35% of global food supply comes from plants that depend on animal pollination (Klein *et al.*, 2007) and 70% of all fruit and vegetable crops show an increase in the size, quantity, quality, or stability of the harvest when pollinated by bees or other animals (Ricketts *et al.* 2008; Nicholls and Altieri 2012).

Some researchers have shown that an increase in both the quality and quantity of agricultural products due to pollinators. In Kakamega, Kenya, there was an increase in yield ranging between 25% - 99% of various plants with the help of bees as pollinating insects (*pollinators)* (Kasina, 2007). The results of research onchili plants showed an increase in fruit yield per plant by 49.75% -66.46% and production per ha by 40.83% -54.26% pollinated by *Trigona* sp (Putra, *et al*., 2016).

Corn is a monoecious plant with male and female flowers observed in the same plant. Corn plants are protandry, wherein most varieties, male flowers appear (anthesis) 1-3 days before female flower hair appears (silking) (Malerbo-Souza *et al.,* 2008). Corn crop is mostly

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cross-pollinated, where most of the pollen comes from other plants. Cross-pollination always require pollinators that carry pollen from one flower to stigma of another flower.

On the basis of the above observations, an experiment was conducted to study the effect of inorganic fertilizers in combination with stingless bee pollination in increasing corn yield (*Zea mays* L.).

MATERIALS AND METHODS

This experiment was carried out at Korong Gadang Sub-District, Kuranji District, Padang City which is considered to be lowlands, which was conducted in April 2019 until October 2019.

Research Implementation

The experiment consisted of 4 treatments *viz*. P_O (Fertilizers inorganic and pollination by wind, P_1 (Organic fertilizers and pollination by *Tetragonula laeviceps,* P_2 (Inorganic fertilizers and pollination by *Tetragonula laeviceps,* (inorganic fertilizers and pollination by other pollinators laid out in randomized block design (RBD) replicated thrice. The sowing was done on raised bed of length 350 cm, width 50 cm and a height of 20 cm with at a spacing of 75 x 25 cm on a bed size of 4m x 4m. Single dose of 350 kg urea, 175 kg single super phosphate and 100 kg potassium chloride Ha^{-1} was applied at the time of sowing. Organic manures dosage of 20 tons ha^{-1} (equivalent to 230 kg Urea, 194 kg SP-36 and 136 kg KCl)

Observations were recorded on plant height, leaf length, leaf width, cob length, cob diameter, number of cobs, weight of cob, weight of 100 seeds and seed yield per plot.

The data recorded were analyzed using analysis of variance (ANOVA) techninque and when $F_{hit} > F_{tab}$ 5%, then Duncan Multiple Range Test (DMRT) was carried out to to check the statistical superiority of the treatments. Data analysis was performed using SPSS 16 statistical software.

RESULTS AND DISCUSSION

Plant height, leaf length and leaf width

The average plant height, leaf length and width of corn leaves with various fertilization and pollination treatments are presented in Table 1. The results showed plant height, leaf length and leaf width of the treatments P0, P1, P2 and P3 were not significantly different.

Fertilization treatment both with inorganic and organic showed no significant effect on the parameters of plant height, leaf length and width of corn leaves, this is because the same dose of fertilizer was given. Thus the response given by the plants will also be the same, although in the treatment of P1 using organic manures 20 tons ha^{-1} where the nutrient content is equivalent to 230 kg Urea, 194 kg SP-36 and 136 kg KCl (nutrient content of cow dung, N = 0.53%, P = 0.35% and K = 0.41%). The nutrient element that is needed by plants in the vegetative phase is the N element, where the N element is needed for the growth of roots, stems and leaves.

NPK fertilizer application significantly influences plant height and stem circumference. Besides affecting the height of fertilizing plants also affects the number of leaves and leaf width (Adediran and Banjoko, 2003). Nitrogen plays an important role in the growth process because nitrogen is an integral part of chlorophyll, protein and nucleic acids. Phosphate fertilizer is considered important for crop production. Potassium plays a role in plant biochemical functions such as activating various enzymes, increasing protein, carbohydrate and fat concentration.

Inorganic fertilizers have a strong influence on the growth, development and yield of plants. Plant height is an important growth character that is directly related to the productive potential of plants in terms of grains. Optimal plant height is claimed to be positively correlated with plant productivity (Saeed *et al*., 2001).

Cob length, Con diameter and amount of combs

The average length of cob, cob diameter and a lot of corn combs with various fertilizing and pollination treatments are presented in Table 2. The results showed the length of the cob and the many combs of the P_1 treatment were significantly different from the treatments of P_0, P_2 and P_3 and P_0 treatment, P_2 and P_3 differ markedly not each other. Treatment cob diameter P_0 no significant effect with treatment P_2 and P_3, but significantly different P_1 treatments. P_1 treatment is similar to the treatment of P_2.

Table 1: Average plant height, leaf length and width of corn leaves with various treatments.

Treatment	Plant Height (cm)	Corn Leaves Length (cm)	Corn Leaves Width (cm)
P_0	221,33	94.00	10,00
P_1	212,67	92.33	10,00
P_2	227,67	98.67	10,00
P_3	229,00	99.00	10,20

The same superscript in the column shows no significant difference (P> 0.05). P0 (Inorganic fertilizer and pollination by wind), P1 (Organic fertilizer and pollination by Trigona laeviceps, P2 (Inorganic fertilizer and pollination by Trigona laeviceps, P3 (Inorganic fertilizer and pollination by other pollinators.

Table 2: Average length of cob, diameter of cob and number of corn combs with various treatments.

Treatment	Cob Length (cm)	Cob Diameter (cm)	Number of Corn Combs (row)
P_0	16.23^a	5.35^a	15.78^a
P_1	$14,470^b$	5.08^b	$14,67^b$
P_2	16.38^a	$5,21^{ab}$	15.78^a
P_3	16.85^a	$5,31^a$	16.22^a

^{a,b,c,d}Different superscripts in the column show very significant differences (P <0.01). P_0 (Inorganic fertilizer and wind pollination), P_1 (Organic fertilizer and pollination by *Trigona laeviceps,* P_2 (Inorganic fertilizer and pollination by *Trigona laeviceps,* P_3 (Inorganic fertilizer and pollination by other pollinators).

Table 3: Average weight per cob, weight of 100 seeds and weight per variety of corn plots Treatment.

Treatmen、	Weight per Cob (g)	100 weight Seed Grain (g)	Weight per Plot (kg)
P_0	261.89[b]	33.30[c]	9,910[c]
P_1	223.35[c]	31.27[d]	8,690[d]
P_2	264.20[b]	34.73[b]	11,540[b]
P_3	279.33[a]	38.48[a]	12,090[a]

[a,b,c,d]Different superscripts in the column show very significant differences (P <0.01). P_0 (Inorganic fertilizer and wind pollination), P_1 (Organic fertilizer and pollination by *Trigona laeviceps,* P_2 (Inorganic fertilizer and pollination by *Trigona laeviceps,* P_3 (Inorganic fertilizer and pollination by other pollinators).

Significantly different in cob length, ear diameter and number of combs in treatment P_1 with treatments P_0, P_2 and P_3, this is due to the treatment P_1 fertilizer used is organic fertilizer, whereas in other treatments the fertilizer used is inorganic fertilizer. Nutrient of organic fertilizer, although complete both macro and micro, the percentage is very low. Hartatik and Widowati (2010), reported nutrient content of N, P and K, cow manure, respectively 1.53%, 0.67% and 0.70%. Besides that, its availability as plant nutrients in the soil is slowly available, especially P nutrients. The role of the P element in flower formation influences the formation and size of cob because the cob is the development of female flowers. Therefore the formation of cobs did not develop optimally. Kuswandi (2007) reports that to encourage the formation of flowers and fruit, it is necessary to have P. element. Thus, in corn plants, the formation of maximum cob is very necessary for balanced fertilization. Iskandar (2010) explains that the use of a balanced inorganic fertilizer can increase the growth and product of corn and can provide high levels of corncob production.

Increased production by inorganic fertilization treatment ranged from 17, 25-25.06% compared to organic fertilizers. In the treatment of P_1, although the pollution is assisted with *T. laeviceps* and the application of organic fertilizer, the lowest production, this is due to the length of the cob, the diameter of the cob and the smallest number of combs. Pollination on the corn crop 95% of the pollination process comes from the pollen of other plants. Therefore, with the help of the wind can help the pollination (Paliwal, 2000).

Weight per cob, Weight of 100 seeds and Product per plot

Average weight per cob, 100 seeds and product per plot with various fertilization and pollination treatments are presented in Table 3. The results showed that P_1 treatment showed weight per cob, the weight of 100 seeds and products per plot were lowest and were significantly different from other treatments. P_3 treatment (another pollinator) provides the highest results of the observation parameter weight per plot, the weight of 100 seeds and product per plot.

The production assisted by *T. laeviceps* and other pollinators can increase weight per cob, west 100 seeds and product per plot. This can be seen in the treatment P_2 and P_3 which are significantly different from the treatment P_0 (pollination with the help of wind). Increased production by *T. laeviceps* and other pollinator ranged from 3, 98 -6.66% compared to wind pollination.

Di-Giovanni *et al.*, (1 995) explained, because the size of corn pollen is large and heavy, the ability of the wind to fly pollen is not too far away. Therefore pollinator services are needed. However, because pollinator access to visit flowers is not very relevant (there is no nectar), pollinator assistance to help the pollination process does not work as it should.

Insects, such as bees, have been observed to collect pollen from corn tufts, but they do not play an important role in cross-pollination because there is no incentive to visit female flowers (Raynor *et al.*, 1972). Added by Silveira-Neto *et al*. (1976): Wiese, 2000). Only bees of *A. mellifera* species that constantly visit the male flowers of corn plants (86.11% - 100%).

CONCLUSION

Fertilization in corn is given mainly inorganic fertilizers, although it does not give effect to the phase of vegetative on plant height, length and width of leaves. Application of inorganic fertilizer in corn recorded an increase in cob length, cob diameter, number of cobs, weight of cob and increase in seed yield ranging 17.25 -25.06% as compared to organic fertilizer. The role of pollinators in pollination in corn is not very relevant. Increased corn crop production due to the help of *T. laeviceps* pollinator and other pollinators ranged from 3.98 -6.66% compared to wind pollination.

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