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Integrated pest control strategy (IPM) corncob borer (*Helicoverpa armigera* Hubner): Fertilization and weeding control

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ABSTRACT

Corn's multi-functionality as food, animal feed, and industrial raw material contributes to food security. Due to the infestation of the cob borer, maize yield frequently decreases. There have been reports of *Helicoverpa armigera* Hubner causing crop losses globally. The implementation of an integrated pest management (IPM) strategy employs an ecological IPM concept, one of which is the development of healthy plants employing fertilizer and weeding. This study was conducted to assess the impact of fertilizer and weeding on corn cob borer (*H. armigera* Hubner). The study technique employed was a factorial randomized block design (RAK) with two variables. The first component, fertilization, had three levels: P_0 (no fertilizer), P_1 (Papua Nutrient fertilizer), and P_2 (NPK fertilizer). The second aspect is weeding, which has three levels: G_0 (daily weeding), G_1 (weeding every 4 days), and G_2 (8 days interval weeding). The results indicated that the interaction between fertilization and weeding had no significant impact on any of the observational variables. The effect of NPK fertilization on the weight parameters of fresh corn cobs with and without cobs was considerable.

Keywords: Corn, *Helicoverpa armigera* Hubner, Integrated pest management, Fertilization, Weeding.
Article type: Research Article.

INTRODUCTION

In Indonesia, corn the second most important food crop commodity after the rice plays a strategic role in the national economy, due to its multi-purpose function as food, feed, and industrial raw materials, which also play a role in supporting food security. The area of maize planted around the world is higher than 100 million ha spread in 70 countries including 53 developing ones. The spread of corn plants is very wide, since they can adapt well to various environments, and grows well in the tropics up to 50° N and 50° South Latitude, from the lowlands to an altitude of 3,000 m above sea level (asl), with high, medium, and low rainfall, to a low of about 500 mm per year (Iriany *et al.* 2008). Corn productivity in Indonesia in 2014 was still very low at 4.96 tons ha^{-1} when compared to corn-producing countries in the world such as the USA, which averaged 9.77 tons ha^{-1}, or China 5.55 tons ha^{-1} (Pertanian 2015). Based on data from the Department of Food Crops, Horticulture and Plantation in West Papua Province (2018), corn production in Manokwari in 2015 reached 2,253 tons. The harvested area was 1,301 ha with the productivity of 1,732 tons ha^{-1}. In 2016 corn production reached 1,921 tons, the harvested area was 1,093 ha with productivity of 1,758 tons ha^{-1}. Based on these data, maize production in Manokwari decreased by 332 tons $year^{-1}$. Meanwhile, in minimizing and handling greenhouse gas emissions, the highest weight was found in

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the amount of fuel used in Fresh Fruit Bunch (FFB) shipments of 54.07% (Rosyidah *et al.* 2022). There are also some reports about fertilizers, productivity and pests in maize around the world (Shevchenko *et al.* 2021; Amraei 2022). Many variables, including physical elements (climate, soil type, and land) and biological factors (variety, pests, diseases, and weeds), as well as socioeconomic issues, contributed to the reduction in corn yield (Surtikanti 2011). Significant losses were incurred as a result of the decline in maize yield due to pests and illnesses (Lihawa 2013). The corn cob borer (*Helicoverpa armigera* Hubner) is one of the pests that causes the most significant damage to maize crops worldwide. According to Syamsuddin (2008), the signs of cob borer caterpillar attacks begin with the formation of flower buds, blossoms, and young fruit; the caterpillars penetrate the young fruit; the corn cob hair is cut off; the cob tip has burrs, and the caterpillar consumes corn kernels. The economic barrier for cob-boring caterpillars in maize, according to Sarwono *et al.* (2003), is two caterpillars per stem. The extension is an active procedure requiring contact between the extension worker and the individual to establish a behavior change process (Sulandjari *et al.* 2022). In Asia, Europe, Africa, and Australia, *H. armigera* incurs annual losses of more than USD 2 billion. *H. armigera* is polyphagous and is capable of feeding on corn, cotton, beans, sorghum, sunflower, soybean, and peanut (Tay *et al.* 2013).

During every planting season in Central Sulawesi, this insect affects the field of maize producers with an attacking intensity ranging from 15 to 69.3% in 2001(Nurkhasanah 2008). A total of 10% of the yield was lost owing to the *H. armigera* assault (Pabbage *et al.* 2007). The yield reduction caused by the cob borer in Gorontalo was 51.92% on the Bisi-2 variety and 53.44% on the Motorokiki type (Karim 2013). In East Java, the average attack rate of the maize cob borer was 21.54% on the K2C3 line and 7.04% on the Bisma line (Sarwono *et al.* 2003). In the United States, losses due to the *H. armigera* attacks on sweet corn reached 50% (Kelly & Rick 2004). There are members of the community who are relatively able to meet their financing needs, but a few of the community have not met their needs (Sungkawaningrum *et al.* 2022).

Integrated pest control (IPM) is a control strategy that is considered the most appropriate and effective in suppressing the growth of insect pests (Priyatno *et al.* 2011). The *H. armigera* control techniques that are in line with the IPM concept can be carried out with technology which affects the diversity of the existing ecosystem, so that it also has an impact on the incidence of pest attacks. The concept of IPM according to Kasumbogo (2006) consists of (i) healthy plant cultivation; (ii) preservation of natural enemies; (iii) weekly observations; and (iv) farmers becoming IPM experts. Similarly, in America and Africa, according to Gallagher *et al.* (2012), it has several principles, including: (i) maintaining soil and plant health; (ii) preserving natural enemies; (iii) regularly observing soil, water, plants, pests, and natural enemies; and (iv) make farmers strive to become IPM experts. Healthy plant conditions in corn can be done with an IPM strategy approach, called controlling farming, among others, by regular weeding and environmentally friendly or organic fertilizers according to soil and plant nutrient needs. IPM strategy requires several control components that are compatible and can be applied in an integrated manner, in addition to the ability of farmers to apply them. In addition, the control components used in integrated pest control (IPM) should always be developed to increase their effectiveness and ease of application by farmers. This study aims to determine the effect of proper fertilization and weeding on the corn cob borer (*H. armigera* Hubner).

MATERIALS AND METHODS

The study was conducted on the experimental field of Manggoapi Manokwari, Indonesia which is located at an altitude of 110 m above sea level. It was conducted for three months, from September to December 2018. The materials used in the Bisi-2 hybrid corn seed research were a tape measure, raffia rope, hoes and shovels, members for watering plants, cameras for documentation, writing instruments, caliper, rulers, and analytical scales.

The study method used was a factorial randomized block design (RAK) consisting of two factors, the first was fertilization and the second, weeding. The fertilization factor consisted of 3 levels, including: P_0 (without fertilizer), P_1 (Papua Nutrient fertilizer), and P_2 (NPK fertilizer). The weeding factor also consists of 3 levels, including: G_0 (weeding every day), G_1 (4 days interval weeding), and G_2 (8 days interval weeding). Each combination treatment was repeated three times to obtain 27 experimental units.

The land area for maize cultivation was 23 m × 10 m, then a plot was made with a size of 2 m × 2 m, the distance between plots in rows was 25 cm, and the distance between replications was 50 cm. Spacing in plots of 50 cm × 50 cm, with a total of 16 plants per plot and a total of 432 plants. The sampling pattern was carried out using a diagonal system with 5 points, so that the number of sample plants in 5 plots, and consequently the total number

of samples was 135. There were 2 types of fertilizers used, including Papua Nutrient organic fertilizer, and NPK. Mutiara inorganic fertilizer was given in plots before planting according to the fertilizer treatment plot. Seeds were planted with a depth of ± 10 cm and 3 seeds were inserted in each hole. After the seeds grow 2MST, 2 plants/holes were spaced apart.

Plant maintenance was carried out from planting seeds to harvesting. The combination of weeding and fertilization treatments is presented in the following table:

Table 1. Combination of weeding and fertilization treatments.

	G0	**G1**	**G2**
P0	P_0 G_0	P_0 G_1	P_0 G_2
P1	P_1 G_0	P_1 G_1	P_1 G_2
P2	P_2 G_0	P_2 G_1	P_2 G_2

Parameters observed after harvesting were: larval population, attack intensity, and production components, namely the weight of fresh corn with the weight of fresh corn without husks. Observations were made by counting the number of larvae in each predetermined sample plant. Observations were made only once, namely at harvest time. The formula used to calculate the intensity of the corncob borer (*H. armigera* Hubner) in absolute terms, according to Nurkhasanah 2(008) was:

$$P = \frac{n}{N} \times 100\%$$

where: P = Percentage of cob damage (%), n = Number of damaged corncobs (fruit), and N = number of corn cobs observed (fruit). The criteria for attack intensity (Directorate General of Food Crops, 2018) are as follows:

Table 2. Criteria for pest attack intensity.

Category	**Attack rate on plants**
Light	≤25%
Medium	>25%≤50%
Heavy	>50%≤85%
Puso	>85%

The data were analyzed statistically using analysis of variance (ANOVA) and further testing with BNJ at the 5% test level.

RESULTS AND DISCUSSION

Based on the results of the analysis of variance, there was no interaction between fertilization and weeding on all parameters observed. It means that the factors of fertilization and weeding have an individual effect.

Larvae Population

Based on Table 3, the results of the study on the population of corncob borer larvae which were mostly shown in P_0G_2 (treatment without fertilizer and weeding at 8-day intervals)) were 6,459 individuals.

Attack Intensity

Based on Table 4, the highest intensity of the attack of the corncob borer (*H. armigera Hubner*) on corn plants value was found in the P_0G_2 treatment (without weeding and fertilizing with NPK; 13.506%) with a mild attack category.

Table 3. The average population of pod borer (*Helicoverpa armigera Hubner*) larvae.

Treatment	Larvae Population Mean (tail)
P_0G_0	4,367
P_0G_1	2,235
P_0G_2	6,459
P_1G_0	2,235
P_1G_1	2,235
P_1G_2	2,235
P_2G_0	2,235
P_2G_1	2,235
P_2G_2	2,235

Table 4. Average attack of corn cob borer (*Helicoverpa armigera* Hubner).

Treatment	Average attack intensity of corn cob borer (%)	Attack category
P_0G_0	9,601	Light
P_0G_1	4,053	Light
P_0G_2	13,506	Light
P_1G_0	4,053	Light
P_1G_1	4,053	Light
P_1G_2	4,053	Light
P_2G_0	4,053	Light
P_2G_1	4,053	Light
P_2G_2	4,053	Light

The weight of fresh corn with and without husk

Table 5. The average weight of corn cobs with and without husks on maize plants with fertilization treatment.

Treatment	Weight of fresh corn cobs with husk (g)	Weight of fresh corn cobs without cobs (g)
P_0	284.258[b]	189.51[b]
P_1	231.27[a]	153.838[a]
P_2	364.56[c]	228.916[c]
BNJ 0 .0 5	24.366	15.84444

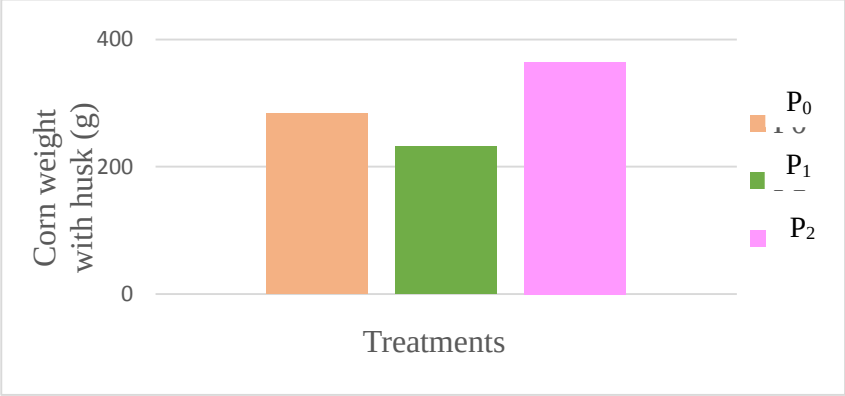

Fig. 1. Corn weight with husk (g) on corn plants treated with fertilization.

According to Table 5, the results after the analysis of variance showed that the fertilization treatment had a significant effect on the weight of fresh corn cobs with husks and on fresh corn cobs without husks. The treatment P_2 (NPK Mutiara fertilizer) exhibited a high values in the weight of fresh corn cobs with husk (364.56 g) and without husk (228.19 g). There was no interaction between the treatment combinations in this study, presumably

since the land used in the study provided all the nutrients needed for the maize. This indicates that the soil and plant conditions are healthy, under the concept of integrated pest control. According to Kasumbogo (2006) and Gallagher *et al.* (2012), the concept of integrated pest control (IPM) includes creating healthy plant cultivation, and maintaining soil and plant health. In addition, because the drilling process is carried out using generator power, it causes air pollution that can interfere with the respiratory system (respiratory inorganics; Rosyidah *et al.* 2022).

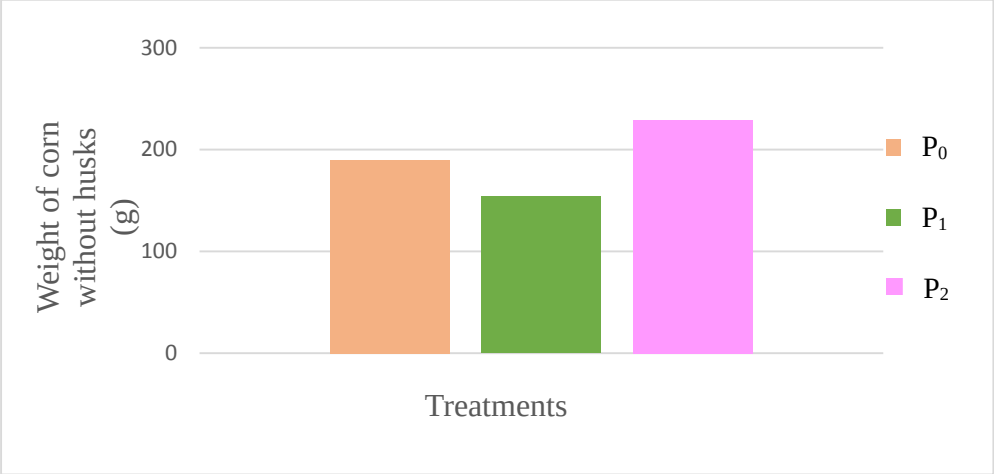

Fig. 2. Weight of corn without husk (g) on corn plants treated with fertilization.

Referring to Tables 3-4, the population of corn cob borer larvae that attack corn plants varies from 2,235 to 6,459 individuals with a mild attack intensity of 4,053 to 13, 506. According to Syamsuddin (2008), this caterpillar damages corn plants by causing visible damage symptoms on the hair and corn kernels that are still soft on the affected part of the cob. The population of corn cob borer larvae under observation was still within the economic threshold, as suggested by Sarwono *et al.* (2003), so that, the economic threshold for cob-boring caterpillars in maize is 2 caterpillars per stem. The number of population of *H. armigera* Hubner larvae and low attack intensity were suspected during the study in unfavorable climatic conditions such as high rainfall (125.7-287.1 mm), humidity 80-83%, and low temperature (27 ºC); suspected of experiencing diapause or often called facultative pupal diapause. Pupae diapause can last several months or even higher than one year. If environmental conditions are favorable, the pupal phase varies from six days at 35 ºC to 30 days at 15 ºC (Pabbage *et al.* 2007). In addition, the number of larvae that attack corn cobs is rarely more than one, since the larvae are cannibals (Kalshoven 1950). Likewise, the intensity of pest attacks is low, since during sampling, high rainfall is thought to allow insects to fall to the ground or die from excessive rainwater. According to Wardani (2017), rain can directly affect the population of insect pests if it rains a lot of insect pests die, especially affecting the growth and activity of insects. Table 3 depicts that the population of corncob borer larvae was mostly found in the treatment without fertilizer and weeding time at 8-day intervals. The weeds that grow a lot in the study area include grass class weeds (*Cynodon dactylon* L.), puzzle weeds (*Cyperus rotundus* L.), broadleaf weeds (*Ageratum conyzoides* L.), and spiny spinach (*Amaranthus* sp.) which function growth and development of cob borer imago as an alternative host, since *H. armigera* Hubner is a polyphagous species that feeds on more than 60 plant species or with a broad spectrum, in addition to agricultural plant species as well as weed species (Cunningham *et al.* 1999). The presence of weeds in the plantation will affect the plant in absorbing nutrients for the formation of cobs, since the photosynthate and energy formed (ATP) are low so the translocation of photosynthate into the cobs decreases (Dinata *et al.* 2017). Suveltri & Syam (2014) pointed out that the presence of weeds in maize plantations often reduces the yield and quality of seeds, depending on the type of weed, density, duration of the competition, and allelopathic compounds released. The ability of high weed competition will suppress plants in absorbing nutrients and water, thus affecting the length of the cob of the plant. Therefore, it is necessary to control weeds physically and mechanically (pulled by hand and tools). In line with the opinion of Fachrawati (2003), that manual weeding treatment can control weeds faster, so there is no competitiveness between weeds and plants in obtaining water, nutrients, growing space, and light, hence plant growth becomes more optimal. In addition, supported by (Tooli 2015) statement, proper and efficient weeding time, as well as proper soil management can inhibit weed growth,

so that there is no competition for nutrients, water, and sunlight. The results of observations of plant production parameters for the weight of corn cobs with and without husks had a significant effect, especially on the P2 (pearl NPK) treatment, with the weight of corn with husks of 364.56 g and weights without husks of 228.916 g. The application of fertilizers can improve the physical and chemical properties of the soil and determine the nutrient requirements in the metabolic and physiological processes of plants with different portions. Lack or excess of nutrients causes problems in plant growth (Adiningsih 1988). The addition of NPK fertilizer can give good results on corn cobs. This is in line with the opinion of *Kriswantoro et al.* 2016) who stated that NPK fertilizers, especially P, are used by plants when forming cobs, activating cob filling, and accelerating seed ripening. The adequacy of nutrients needed by plants will affect the photosynthate produced. Photosynthate contained in the leaves will be transferred to the stem during seed filling and will significantly form corn cobs (Falah 2009). Nugroho *et al.* (1999), pointed out that the increase in cob weight in sweet corn plants was in line with the increase in the efficiency of the photosynthetic process and the rate of translocation of photosynthate to the cob. If the photosynthesis process runs optimally, the photosynthate results will be translocated to the organs that need them for the corn cob formation. Giving organic fertilizer alone is not enough and it is necessary to add a little inorganic fertilizer so that fertilization is balanced (Indriati 2009). Provision of environmentally friendly organic fertilizer (Papua Nutrient fertilizer), on the weight of the cob both with husk (231.27 g) and without it (153.838 g), although in this study it was not as good as the yield on NPK fertilizer. This Papua Nutrient organic fertilizer is made from several ingredients including livestock manure, compost, peat, household waste, marine waste, and Krandalit Phosphate Sedimentary Soil (TEFK) which is then fermented into good fertilizer for plants (Musaad *et al.* 2018). Syam'un & Ala (2010), suggest that adding organic fertilizer can improve soil chemical properties, especially by increasing soil organic matter and soil cation exchange capacity, so that the plant growth environment improves and the availability of nutrients can increase, while liming can increase soil pH it affects the activities of microorganisms in the soil. An integrated pest control strategy (IPM) is a compatible integration of all effective and efficient techniques or pest control methods based on ecological and economic principles without neglecting the socio-cultural side. Baliadi (2008) pointed out that there are four approaches to IPM strategies in the community, including: (i) Utilization of natural control processes by reducing actions that can harm or kill the development of natural enemies (predators, parasitoids, insect pathogens); (ii) Ecosystem management through farming aims to make the plant environment unsuitable for life and the logging or growth of pests and to encourage the formation of natural enemies; (iii) physical and mechanical control aimed at reducing pest populations, disrupting normal biological activities of pests, and changing the physical environment to be less suitable for pest life and development; and (iv) selective using insecticides to control pest populations at the level of balance. Insecticide selectivity is based on physiological, ecological, and mode of application. Sharma (2008) stated that the application of environmentally friendly, effective, and economical pest control methods has stimulated new interest in integrated pest control (IPM) methods. The merits of many traditional farming practices have been confirmed by studying why farmers tend to prefer these control methods.

CONCLUSION

The results showed that there was no interaction effect of fertilization and weeding time between systems on all observed parameters. Fertilization with inorganic fertilizer (NPK) gave a significant effect on the weight of the cobs with- and without- husk.

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