Weed Management Practices on Maize Grown on Field with One Season of Residue of Manure and Green Organic Composts

Marulak Simarmata[1*)], Hery Gusmara[2)], and Herianto Barus[1)]

[1)] Department of Agroecotechnology, Faculty of Agriculture, the University of Bengkulu
[2)] Department of Soil Science, Faculty of Agriculture, the University of Bengkulu
Jl. W. R. Supratman Kandang Limun Bengkulu, Indonesia 38371
[*)] Corresponding author Phone: +6281316095384; E-mail: marulak_simarmata@yahoo.com

ABSTRACT

The research was aimed to study effectiveness of weed management practices using herbicide mixture of atrazine and mesotrione and hand weeding on maize grown in field with one season of organic compost residues. The research was conducted in Bengkulu, Indonesia, from November 2014 until February 2015. Research was arranged in split plot design. Residue of organic compost was a main plot which consists of residue of manure compost, residue of empty fruit bunches (EFB) of oil palm compost, and non-residual field. Weed management practices was a sub-plot which consists of pre- and post-emergence application of herbicide mixtures at 1.0 kg a.i. ha^{-1}, hand weeding, and untreated plot. Twelve treatment combinations were replicated three times. Results showed significant interactions between weed management practices and residue of organic compost on plant height, leaf area, yield, dry weight of 100 grains, and total weed biomass. The best weed management practice on maize field with organic compost residues is the use of herbicide mixtures applied preemergence, which increased maize yield by 52 percent. Interaction of the trials also suppressed weeds significantly, which was observed in the reduction of total weed biomass, where the strongest suppression was observed on post-emergence trials of herbicide mixture of atrazine and mesotrione in the non-residual plot.

Key words: atrazine, mesotrione, organic compost, weed management practices.

INTRODUCTION

Maize is one of the widely planted crops in the world. In Indonesia, it is the second rank of commodity crops after rice. Maize production in Indonesia in 2014 reached 19.03 million tons with a planting area of 3.873 million ha, or a yield average of 4.9 tons per ha (CBS, 2014). Efforts to increase yields of maize continue to be done through improvement of farming techniques and the expansion of planting areas. Decrease in arable land due to land conversion causes the expansion of planting area to be dependent on marginal land. Marginal land is low in potential because of physical, chemical, or biological limitations which does not support crop production (Gunadi, 2002). Availability of marginal land is very widespread in Indonesia and it is a great potential if it can be utilized for growing crops such as corn.

Technology of land preparation continues to be developed for growing plants in marginal land. An alternative approach to solve the problem is the addition of organic materials which can increase biological activities that leads to an improvement of soil fertility (Troeh *et al*., 2005; Brown and Cotton, 2011). One of the green organic materials is waste from the fruit bunches of oil palm or also known as empty fruit bunches (EFB) (Darnoko *et al*., 1993; Wardani, 2012). The empty bunches from oil palm fruits have the potential to be used in agriculture after going through composting process (Wardani, 2012). Like other green organic materials, EFB can also improve soil nutrients, thereby reducing fertilizer costs (Wardani, 2012). Chemical content of EFB are 42.8, 2.9, 0.8, 0.22, and 0.3% of C, K_2O, N, P_2O_5 and MgO, respectively and 10, 23, and 51 ppm of micro-elements of B, Cu, and Zn, respectively. A ton of fruit bunches of oilpalm contains 23 % of EFB, and a ton of EFB contains nutrients equivalent to 3, 0.6, 12, and 2 kg of Urea, TSP, KCl, and kieserite, respectively (Darnoko *et al.*, 1993).

Organic materials applied to the soil will undergo the decomposition process. Some researches found that residues of organic compost still showed positive influences to crops for several years (Fronning *et al*., 2008; Jackson *et al*., 2013). However, residue of organic compost may also stimulate early growth of weeds, increasing herbicide persistence in the soil because it is adsorbed by the organic compost, and also might accelerate the degradation of herbicides as a result of an increase in soil microorganisms (Hager and Sprague, 2003; Efthimiadou *et al*., 2012) .

Weeds are undesirable plants because the presence of weeds in cropping area will reduce yields. Crop yield loss due to weeds may reach up to 82 percent (Monaco *et al*., 2002). Therefore, weed control is a necessity to be done at an appropriate time to prevent the negative influences of weed competition to the plant (Monaco *et al.*, 2012). Hand weeding is an effective method for controlling annual weeds in a small area. However, for a wide area and for controlling perennial weeds, chemical control using herbicides is more effective and efficient (Monaco *et al*., 2002).

Atrazine, a widely applied herbicide on corn field in the United States was found in 1952. Atrazine (*2-chloro-4-ethylamino-6-isopropilamino-1,3,5-triazine*), included in *triazine* family, inhibits photosynthesis during the photolysis reaction (Muller , 2008). The problem of herbicide resistant weeds may be arising after intensive use of atrazine for a long period of time (Schooler *et al*., 2008; Williams II *et al*., 2010). One approach to prevent herbicide resistant weeds is by mixing two types of herbicides that have different mechanisms such as mixing atrazine and mesotrione (Woodyyard *et al*., 2009). Mesotrione {*2-[4-(methylsulfonyl)-2-nitrobenzonyl] cyclohexane-1,3-dione*}, a relatively new herbicide in *triketone* family, is effective to control weed species that are resistant to atrazine (James *et al.*, 2006). Mesotrione inhibit a carotene pigment in plant tissue; the symptoms are losing green color on leaves, bleaching, and death (James *et al.*, 2006; Schooler *et al*., 2008). Herbicide mixture of atrazine and mesotrione is sold as a herbicide package in the ratio of 500 and 50 g l^{-1}, respectively (James *et al.*, 2006; Woodyard *et al*., 2009). This mixture is broadly used as a selective herbicide for corn, wheat, sorghum, and sugarcane which can be applied preemergence or postemergence (Woodyard *et al.*, 2009).

The objectives of this reseach was to study the effectiveness of weed management practices using conventional and chemical weed control methods on corn which were grown in the field with one season of residue of manure and green organic composts.

MATERIALS AND METHODS

This research was conducted in the field in the campus of Bengkulu University, at the altitute of 10 meters above the sea level, with soil type of Ultisol, and done during November 2014 until February 2015. The field was in the second season after treated with manure and EFB of oil palm composts. Sweet corn was grown in the first season followed by three months fallow before land cultivating for this experiment. Trials investigated were similar to the previous season. Two experimental factors were conducted in split plot design arranged in blocks. The main plot consisted of residues of organic compost including residue of cow manure (10 ton ha-1), residue of EFB of oil palm compost (20 tons ha-1), and without residue as a control. The subplots were weed management practices which consisted of herbicide mixture of atrazine and mesotrione applied during preemergence, postemergence, hand-weeding at 14 and 28 days after planting (DAP), and unweeded as a control. Twelve treatment combinations were repeated three times. The size of experimental treatment plot was 3.0 m x 1.6 m and distance between the main plots was 0.5 m and between blocks was 1.0 m. The dose of herbicide mixture was 1.0 kg a.i. ha^{-1} and preemergence trials sprayed herbicide solution on soil surface one day prior to planting while postemergence trials sprayed herbicide solution directly on crops and weed vegetation at 14 DAP. Herbicide was delivered by a backpack sprayer in 400 L ha^{-1} solution at the pressure of 15 psi.

Weed vegetation in the plots were analyzed before land preparation. Land was prepared conventionally through manual ploughing at the depth of 20 cm without any changes in experimental plots as previous experiment. Two corn seeds var. NK-22 were planted in the planting hole with a depth of 3 cm and 5 pcs of Carbofuran granules were added into each hole to prevent insects from the seeds. Planting distance was 75 cm x 20 cm. Thinning was done two weeks after planting by leaving one healthy plant per hole.

Plants were fertilized in furrow with 10 cm distance from the row in a depth of 8 cm. The basic fertilizers consisted of 150, 100, and 100 kg ha^{-1} of urea, SP-36, and KCl, respectively. Urea was given twice, two third was given at planting time and the remaining one third was given 4 weeks after planting. Plants were watered daily if there was no rain. Preventive insect and pest controls were carried out by using insecticide Decis 25 EC and Dithane M-45 at recommended dose. Corn was harvested after 95% of the leaves color turned yellow or when the seeds dried.

Data were observed on weed vegetation, growth and yield of maize, and dry weight of total weed biomass. Weed analysis were conducted before land preparation and after harvesting corn. Variables observed in weeds analysis were weed density, frequency, and dominance. Relative density, relative frequency, and relative dominance of weeds were used to calculate summed dominance ratio (SDR) (Tjitrosoedirdjo *et al.*, 1984). Variables of growth and yield of maize observed included crop injury due to herbicide application, plant height, leaf area (lenght x wide x 0.75), flowering time, cob diameter, cob length, dry weight of 100 grains, and dry yield. Crop injuries were observed based on discoloration of leaf with a rating scale from 0 to 100 percent, where the score is 0 if there is no injury on crops and 100 if crops were completely killed (Burrill *et al*., 1976).

Data of growth, yield of maize, and total weed biomass were subjected to analysis of variance (ANAVA) using CoStat 6.4 software and means of observations were separated by least significant differences (LSD) test at 5% level.

RESULTS AND DISCUSSION

Overall, the maize germinated well and grew normal, but a week after herbicide application, slight injuries (ranging from 10 to 20 percent) were evolved on crops in trials of pre- and post -emergence of herbicides mixtures of atrazine and mesotrione. Maize growth recovered at three weeks after herbicide aplication. The average rainfall during the research was 382 mm month^{-1} and these were sufficient for the needs of the maize. Weed populations counted at the beginning of experiments were 17 species, consisting of 11 species of broadleaves and 6 species of grasses. However, at the end of the study weed populations declined to 12 species, consisting of 7 species of broadleaves and 5 species of grasses. No pests and diseases manifested during the period of study.

Results from data analysis indicated an interaction between methods of weed control with residue of organic compost to plant height, leaf area, dry yield, dry weight of 100 grains, and total weed biomass. The main plot of residual compost only influenced greenness level of leaves, while other variables such as flowering time, cob diameter, and cob length were not affected by experimental trials.

LSD tests (P <0.05) on plant height and leaf area at the age of 42 DAP were presented in Table 1 and 2. In the main plot O-0, it appears that the rank of crops from the highest to the shortest were observed in the subplot of T-1, T-3, T-0, and T-2; while in the main plot of O-1 were in the subplot of T-1, T-2, T-0, and T-3. In the main plot O-2, plant height was not different significantly among the weed control trials.

Table 1. Interaction of weed management practices and residue of organic compost to plant height (cm) at 42 days after planting (DAP).

Main-Plot	Sub-Plot			
	T-0	T-1	T-2	T-3
O-0	106.73 B b	116.93 B a	93.51 C c	112.04 B a
O-1	137.16 A b	167.35 A a	148.72 A b	130.10 A c
O-2	120.50 B a	112.48 B a	118.76 B a	123.01 AB a

Remarks: O-0=Non-residue, O-1=Residue of manure compost, O-2=Residue of empty fruit bunches compost, T-0=Untreated, T-1=Pre-mergence of (atrazine+mesotrione), T-2=Post-mergence of (atrazine+ mesotrione), T-3=Hand-weeding; Numbers followed by the same lowercase and uppercase letters are not significantly different by LSD test (P<0.05) within a row and a column, respectively.

Table 2. Interaction of weed management practices and residue of organic compost to leaf area (cm^2) at 42 days after planting (DAP).

Main-Plot	Sub-Plot			
	T-0	T-1	T-2	T-3
O-0	319.95 C b	154.54 C d	412.13 B a	242.77 C c
O-1	612.20 A c	714.12 A a	578.68 A d	665.91 A b
O-2	426.27 B a	424.95 B a	455.88 B a	446.33 B a

Remarks: Similar to Table 1.

The highest plant among the main plots was found on the plot of O-1 (Table 1). Similar evidents were observed in the variable of leaf area, where in the main plot O-2 the leaf areas were not significanly different among the weed control treatments. In the main plot O-0, the widest leaf area was observed in the treatment of T-2; in the main plot O-1, the widest leaf was observed on T-1 (Table 2). Among the main plot, the widest area of leaves was observed in the plot of O-1 followed by O-2 and O-0. The greenness level of leaf was only affected by the residue of organic compost in the soil. The highest of greenness level was observed in the plot of O-1 and this was significantly different with the main plot O-0 and O-2 (Table 3).

Table 3. Effect of organic compost residue to greennes level of leaves.

Main Plot	Level of Geenness
O-0	34.10 B
O-1	40.00 A
O-2	36.76 B

Remarks: Similar to Table 1.

The residue of organic compost after one growing season gave better growth of plant height and leaf area observed on each subplot of weed management practices where residue of manure compost (O-1) was better than residual EFB compost (O-2). The reason was because organic compost in the field was continuing in decomposition process (Jackson *et al*., 2013). A slower decomposition were giving advantages to extensively improve the physical, chemical, and biological properties of the soil to provide better growth for many growing seasons (Brown and Cotton, 2011; Efthimiadou *et al.*, 2012). This evident had been reported in some researches, where the residue of manure compost can still improve growth and yield of crops up to several growing seasons (Jackson *et al*., 2013; Louisa and Taguiling, 2013). Weed control practices using herbicide by preemergence application can improve plant growth which was observed from the improvement of plant height and leaf area. Overall, maize growth is better if weed management practices are applied. To reach the optimum growth, maize needed to be free from weeds competition during one third of early growth stage (Monaco, *et al.*, 2002).

Yield and dry weight of 100 grains of maize were affected by interactions of experimental trials (Table 4 and 5). The average yield increased significantly with all weed control practices and in all main plots. The highest yield in the mainplot O-0 and O-1 were observed at subplot T-1; while in the main plot O-2, the highest yield was observed at subplot T-2. Comparing the main plots, the residue of manure compost (O-1) delivered the highest improvement of maize yield followed by residue of EFB compost (O-2) and non-residual plot (O-0). Overall, the highest yield was observed in the interaction of subplot T-1 and mainplot O-1 which reached 877.91 gram m^{-2}. Compared to unweeding subplot and non residue of organic compost (T-0 and O-0) which yield was 516.83 g m^{-2}, the percentage of the yield increase was {(877.91-516.83) : (877.91 + 516.83) / 2} x 100% = 52%. The improvement of maize yields were also associated with dry weight of 100 grains of seeds (Table 5). In the main plot of O-1, dry weight of 100 grains increased significantly in all subplots of T-1, T-2 and T-3 compared to T-0.

Table 4. Interaction of weed management practices and residue of organic compost to yield (kg m^{-2}).

Main-Plot	Sub-Plot			
	T-0	T-1	T-2	T-3
O-0	516.83 B c	834.91 AB a	748.53 B b	822.31 A a
O-1	743.49 A c	877.91 A a	831.02 A b	801.02 A b
O-2	694.60 B c	747.04 B b	809.09 AB a	806.42 A a

Remarks: Similar to Table 1.

Table 5. Interaction of weed management practices and residue of organic compost to 100 dry grains (g).

Main-Plot	Sub-Plot			
	T-0	T-1	T-2	T-3
O-0	23,87 B bc	22,13 B c	27,50 A a	27,10 A a
O-1	23,40 B c	31,30 A a	28,97 A ab	26,40 A b
O-2	28,13 A a	26,10 B b	28,87 A a	25,03 A b

Remarks: Similar to Table 1.

The decrease or loss of maize yield due to unweeding (T-0) in the main plot O-0 can be calculated by substraction of the highest yield on subplots T-1 minus the yield on the subplots T-0, and results was divided by the yield on T-1, and then multiplied by 100 percent. Calculation showed that yield loss due to weed in the main plot of O-0 reached up to 38 percent. By the same ways, yield loss due to unweeding in the main plot O-1 and O-2 were up to 15 and 14 percent, respectively.

Variables of total weed biomass might be one factor that influenced the growth and yield of maize. Management of weed controls of T-1, T-2 and T-3 were very effective in suppressing weeds in all of the main plots (Table 6). The lowest weed biomass was observed at T-2 in the main plot O-0 and O-1, while in the main plot O-2, the lowest weed biomass was in the treatment of T-3. Between the main plots, weed biomass were higher on the O-1 and O-2, especially on unweeded subplot (T-0). Data of weed biomass indicated that the more suppression on weed biomass the higher the yield was produced. The suppresion on weed biomass harvested at the end of the study indicated the effectiveness of weed management practices. Herbicide mixture of atrazine and mesotrione applied pre- or post-emergence was very effective in suppressing weeds since the early stage of plant growth (Woodyard *et al*., 2009). Residues of manure and EFB compost after one season not only improve the crops but also can promote weed emergences, which was observed in unweeding plot. The main reason is bacause the availability of nutrients and improvement of physical and biological properties of the soil due to residues of organic composts (Efthimiadou *et al*., 2012; Jackson *et al*., 2013). Appropriate weed management practices to overcome the emergence weeds in crop field with organic compost residues are nessecity since early stage of crop growth in order to prevent weed competition (Hager and Sprague. 2003).

Table 6. Interaction of weed management practices and residue of organic compost to weed biomass (kg m^{-2}).

Main- Plot	Sub-Plot			
	T-0	T-1	T-2	T-3
O-0	108,80 B a	48,00 B c	42,26 B d	76,73 A b
O-1	118,46 A a	54,20 A b	44,33 B c	46,40 B c
O-2	116,00 A a	50,60 AB c	59,40 A b	48,26 B c

Remarks: Similar to Table 1.

CONCLUSION

The best weed management practice on maize grown in soil with residue of organic composts is using a herbicide mixture of atrazine and mesotrione applied either pre- or post-emergence. Yield of maize increased 52 percent from a combination of preemergence application of herbicide mixture with residue of manure compost. Yield lost on maize due to uncontrolled weeds in trials of non-residual, residue of manure, and residue of EFB composts can reach up to 38, 15, and 14 percent, respectively. A mixture package of herbicide atrazine and mesotrione is effective to control weeds on maize which was indicated in the declined of total weed biomass harvested in field.

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