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Effect of organic fertilizer and weed control methods on weeds species and growth of local waxy maize from Wawonii Island, southeast Sulawesi, Indonesia

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This research was conducted in the Field Laboratory of Agriculture Faculty Halu Oleo University. This research was aimed to study the effect of organic fertilizer and weed method to weed species and growth of local maize from Wawonii Island. This research is compiled using a completely randomized block design (CRBD) with factorial pattern and each treatment was repeated three times. The first factor are: organic fertilizer (A) with two levels i.e.: cow manure as 6 kg plot^{-1} (A_1), bokashi as 6 kg plot^{-1} (A_2) and second factor are weed control method (B) which comprises three levels i.e.: mulch from grasses weed (B_1),weeding at 14 days after planting (B_2), weeding at 28 days after planting (B_3). The variables observed for results were: weeds species, weed dry matter, plant height, number of plant leaves, and leaves area. The result of research showed that interactions between bokashi fertilizer and weed control method using mulch has significant effect on the average of plant height, the average number of plant leaves and the average leaf area of the plant. Weed control methods using mulch independently can suppress weed growth. Bokashi fertilizer and cow manure independently has no significant effect on the growth of maize.

Keywords: local maize, mulch, organic fertilizer, weeds

INTRODUCTION

Maize is the second most important cereal crop in Indonesia after rice, especially for society in several islands in Southeast Sulawesi as Buton, Muna and Wawonii. Word Data Atlas (2015), that's in 2015 the maize harvested area for Southeast Sulawesi was 23.945 ha. Though Southeast Sulawesi maize harvested area fluctuated substantially in recent years. One cause of the fluctuation of maize production in Southeast Sulawesi is the use of local varieties with relatively low yields (Teguh et al., 2012), dry land conditions and relatively low rainfall (Jatoi et al., 2014), pest and disease attack (Surtikanti, 2011) and weed competition (Halim, 2009).

The presence of weeds in the maize plant area is very influential on low yields. This happens because weeds have a high competing ability in obtaining water, nutrients, sunlight, CO_2, and growing places (Rao, 2000). The overall loss of yields caused by weeds outweighs the loss of outcomes caused by pest and disease attacks. Nevertheless, the loss of weeds results is difficult to estimate because their effects can not be immediately observed (Fadhly dan Fahdiana, 2005).

The maize crop yield loss due to weed competition ranges 16% - 62% (Bangun and Syam, 1988), 40% - 50% (Michael et al.,1999), 75% (Dalley et al., 2000), 90% - 95% (Violic, 2000; Harrison et al., 2001), 20% - 80% (Bilman, 2001), 35% - 40% (Nedim et al., 2004) and 25% -

50% (Hartzler and Pringnitz, 2005). The variation of crop loss is one of them is determined by the critical period of the plant with weeds competition (Kevin et al., 2007). The critical period of the plant starts to occur at the age of 20-45 days after planting (Moenandir, 1993), since the plant grows to a period of one-quarter or one-third of the plant's age (Ferrero et al.,1996; Hartzler and Pringnitz, 2005), and at age 2 - 8 weeks after planting (Utomo et al., 2004). The maize is grown in monoculture with low input can not produce optimum yields due to intensive competition with weeds (Clay and Aquilar, 1998). Therefore, weeds that grow in the maize fields if left uncontrolled, then the weeds will have the potential to compete with plants.

The weed control methods on maize done by farmers with technical culture, physical, mechanical, and chemical by using herbicide. The weed controlled by technical, physical, and mechanical culture was accidentally started by farmers during the land preparation (Bond and Grundy, 2001). Using of herbicides was done at the time of land clearing, before planting or after the plant grows (Fadhly and Fahdiana, 2005; William, 2008). The cultural control, in principle is a way of control by utilizing the environment to suppress the development of population of plant pest organisms (Sukman and Yakup, 2002). One of the weed control method is cultural control with using the mulch. The mulch will affect the light that will reach the soil surface and cause weed-sprout weeds as well as various types of dead adult weeds in addition to maintaining soil humidity mulch will affect soil temperature (Alif, 2015). The size of the effect caused by the mulching will depend also on the level of thickness and the mulch material used (Ali, 2014). In addition, weed control can also be done by weeding before the plant reaches a critical period.

To know the success of weed control methods and their effect on the growth of maize plants, it needs to be combined with the use of organic fertilizer. In general, the advantages of using organic fertilizers are: increase the content of organic matter in soil, improve soil structure, increasing water holding capacity, increase soil biological life activity, increase soil of cation exchange capacity, reduce phosphate fixation by Al and Fe on acid soils and increase nutrient availability in soil (Hasibuan, 2006). The result of research Halim et al., (2016), that's treatment of bokashi fertilizer with 22.5 kg plot^{-1} provide better real effect on plant height, cob diameter, number of row seed and shoot root ratio.

MATERIALS AND METHODS

Study Area and Experimental Setup

This research was conducted at Field Laboratory of Agriculture Faculty of Halu Oleo University, Kendari Southeast Sulawesi Indonesia. The plot of research done after soil processing, then made a plot with 4 m x 3 m in size, a drainage channel 0.5 m in size. The maize seeding is done by using manual pit (2 seeds/planting holes), spacing of 30 cm x 75 cm. The organic fertilizer analyzed before application and plantings as supporting data.

The treatment was using the completely randomized block design (CRBD) with factorial pattern consisting of 2 factors. The first factor is organic fertilizer (P) consist of cow manure as 6 kg plot^{-1} (P1), bokashi fertilizer as 6 kg plot^{-1} (P2) and second factor is weeding control method (G) i.e.: using mulch from grasses weed (G1), weeding at 14 days after planting (DAP) (G2), weeding at 21 DAP (G3). There are 6 combinations of treatment and each treatment was repeated 3 times, so there were 18 plots.

Observation Variable

The variable was observed in this study are:

1-Weed species were observed prior to cultivation of land and ages 28 DAP.

2-Weight dry matter of weed calculated based on the weight of weed sample observed.

3-Plant height measured from the base of the stem to the end of the leaves at the age of 14, 28 and 42 DAP.

4-The number leaves of plant was calculated from the lowest leaves to the top leaves that are perfectly open at ages 14, 28 and 42 DAP.

5-Area of leaf (cm^2), measured the length and width of the leaf.

Data Analysis

The data of plant growth observation was analyzed using the variety of variance according to the design used. If the variance shows the real effect will be continued with Duncan Multiple Range Test (DMRT) at 95% confidence level.

RESULTSAND DISCUSSION

Composition of Bokashi and Organic Fertilizer

Table 1, shows the nutrient content of cow manure is lower than bokashi fertilizer. However, both types of organic fertilizers are in accordance with Indonesian National Standard for use as organic fertilizer (Balai Penelitian Tanah, 2009).

Weed Species

The results of observations of weeds before

Tillage were found to be 12 species of weeds with 9 species from broad leaves and 3 species of grasses. While at the age of 28 DAP found as 13 species with 7 species from broad leaves, 4 species from grasses and 2 species from sedges.

Table 2 shows that there are 4 weed species found before soil tilage and at 28 DAP i.e.: *B. alata*, *H. corymbosa* (Rubiaceae), *A. conyzoides* (Asteraceae) and *E.indica* (Poaceae). This is according to a statement Afriantiet et al. (2015), that the family Poaceae, Rubiaceae and Asteraceae found many in dry land and have high growing power. The weed species were not found before tillage, but grown at 28 DAP i.e.: *F. miliacea, C. rutidosperma, D. ciliaris, P. conjugatum, C. mucunoides* and *C. rotundus*. The species of weeds are thought to be carried in cow dung. The results of research Halim et al., (2015) showed that some species of weed have potency as forage i.e. *D. ciliaris*and *P. conjugatum*. In addition, the emergence of new weeds due to the effect of soil processing, so that weed seeds stored in the soil or soil weed seed bank appear on the soil surface and grow rapidly.

Table 2 shows that there are 4 weed species found before soil tilage and at 28 DAP i.e.: *B. alata*, *H. corymbosa* (Rubiaceae), *A. conyzoides* (Asteraceae) and *E.indica* (Poaceae).

Table 1; Composition of bokashi and organic fertilizer

Kinds of Fertilizer	Composition				
	C-Organic (%)	P_2O_5 (mg 100 g^{-1})	K_2O (mg 100 g^{-1})	N-Total (%)	pH
Bokashi*	10.99	15.72	11.66	3.14	7.54
Cow Manure*	9.45	8.38	41.33	2.02	7.91
	9.80-32**	10-20**	0.20**	0.40**	6.8-7.4**

Notes:* = Result of Laboratory analysis in this study, ** =the quality of criteria of organic fertilizers was standard by Indonesian national standard (SNI 19-7030-2004)

Table 2; The weed species before tillage and at 28 DAP

No.	Weed species before tillage		
	Weeds species	**Family**	**Status**
1.	*Borreria alata* (Aubl.). DC.	*Rubiaceae*	Broadleaves
2.	*Hedyotis corymbosa* (L.) Lamk	*Rubiaceae*	Broadleaves
3.	*Ageratum conyzoides* L.	*Asteraceae*	Broadleaves
4.	*Euphorbia hirta* L.	*Euphorbiaceae*	Broadleaves
5.	*Phyllanthus urinaria* L.	*Euphorbiaceae*	Broadleaves
6.	*Mimosa pudica* L.	*Leguminaceae*	Broadleaves
7.	*Melastoma malabathricum* (L.) Smith	*Melastomataceae*	Broadleaves
8.	*Solanum melongena* L.	*Solanaceae*	Broadleaves
9.	*Lantana camara* L.	*Verbenaceae*	Broadleaves
10.	*Eleusine indica* (L.) Grant	*Poaceae*	Grasses
11.	*Imperata cylindrica* (L.) Beauv	*Poaceae*	Grasses
12.	*Themede arguens* (L*)* Hack	*Poaceae*	Grasses
No.	***Weeds species at 28 DAP***		
	Weeds species	***Family***	**Status**
1.	*Borreria alata* (Aubl.)DC	*Rubiaceae*	Broadleaves
2.	*Hedyotis corymbosa* (L.) Lamk	*Rubiaceae*	Broadleaves
3.	*Ageratum conyzoides* L.	*Asteraceae*	Broadleaves
4.	*Solanum melongena* L.	*Solanaceae*	Broadleaves
5.	*Cleome rutidosperma* DC.	*Capparidaceae*	Broadleaves
6.	*Crotalaria juncea* L.	*Fabaceae*	Broadleaves
7.	*Calopogonium mucunoides* Desv	*Fabaceae*	Broadleaves
8.	*Digitaria ciliaris* (Resz.) Koel.	*Poaceae*	Grasses
9.	*Eleusine indica* (L.) Grant	*Poaceae*	Grasses
10.	*Paspalum conjugatum* Berg.	*Poaceae*	Grasses
11.	*Axonopus compresus* (Sw.) Beauv	*Poaceae*	Grasses
12.	*Fimbristylis miliacea* (L.) Vahl	*Cyperaceae*	Sedges
13.	*Cyperus rotundus* L.	*Cyperaceae*	Sedges

This is according to a statement Afriantiet et al., (2015), that the family Poaceae, Rubiaceae and Asteraceae found many in dry land and have high growing power. The weed species were not found before tillage, but grown at 28 DAP i.e.: *F. miliacea, C. rutidosperma, D. ciliaris, P. conjugatum, C. mucunoides* and *C. rotundus*. The species of weeds are thought to be carried in cow dung. The results of research Halim et al., (2015) showed that some species of weed have potency as forage i.e. *D. ciliaris*and *P. conjugatum*. In addition, the emergence of new weeds due to the effect of soil processing, so that weed seeds stored in the soil or soil weed seed bank appear on the soil surface and grow rapidly.

Weight Dry Matter of Weed

Table 3 shows the most number of weeds occur in the treatment of cow manure + weeding once times (P2G2) with 12 weeds species and 24.55 g weight dry matter. While on the treatment of bokashi fertilizer + mulch (P1G1) and cow manure + mulch (P2G1) not found weeds that grow. According Syamsudin (2006), mulching spread over the soil surface can reduce the rate of weed growth and is effective compared to the use of pre-growth herbicide.

Table 3: Weed species and weight dry matter (g) at 28 DAP

No.	Weed species	weight dry matter of weed each treatments (g)					
		P1G1*	P1G2	P1G3	P2G1*	P2G2	P2G3
1.	*Ageratum conyzoides* L.	0.00	0.60	7.23	0.00	7.26	3.84
2.	*Akonopus compresus* (Sw.) Beauv	0.00	2.80	0.00	0.00	0.13	1.59
3.	*Borreria alata* (Aubl.). DC	0.00	9.65	4.73	0.00	2.66	4.54
4.	*Cyperus rotundus* L.	0.00	1.51	0.00	0.00	1.13	0.44
5.	*Digitaria ciliaris* (Resz.) Koel.	0.00	7.64	10.73	0.00	0.98	3.04
6.	*Eleusine indica* (L.) Grant.	0.00	2.47	0.11	0.00	2.43	0.00
7.	*Paspalum conjugatum* Berg.	0.00	0.79	9.64	0.00	3.41	3.89
8.	*Solanum melongena* L.	0.00	0.14	4.22	0.00	1.38	2.84
9.	*Cleomo rotidosperma* DC.	0.00	0.00	0.56	0.00	0.96	2.65
10.	*Fimbristylis miliacea* (L.) Vahl	0.00	0.00	0.45	0.00	2.18	0.00
11.	*Hedyotis corymbosa* (L.) Lamk	0.00	0.00	0.00	0.00	0.10	0.00
12.	*Calopogonium munuconoides* Desv	0.00	0.00	0.00	0.00	1.93	0.00
13.	*Crotalaria juncea* L.	0.00	0.00	0.00	0.00	0.00	0.09
	Total	**0.00**	**25.60**	**37.67**	**0.00**	**24.55**	**22.92**

Notes: *=mulch organic application

Table 4; Recapitulation of variance analysis of local maize on interaction of organic fertilizer and weed control method

Observation Variable	Observation Time (DAP)	Organic Fertilizer (P)	Weed Control Method (G)	Interaction P.G
Plant height	14	ns	*	ns
	28	ns	ns	ns
	42	ns	ns	ns
Leaves number	14	ns	*	*
	28	ns	ns	ns
	42	ns	ns	*
Index leaves area	14	ns	*	ns
	28	ns	ns	ns
	42	ns	**	*

Notes: ns = no significantly, * = significantly, ** = very significantly, DAP = day after planting

Components of Maize Growth

The result of variance analysis showed that the use of organic fertilizer had no significant effect on all observation variables. The weed control treatment had no significant effect on plant height and leaf number at age 28 and 42 DAP and leaf area at 28 DAP. While at the age of 14 and 42 DAP significantly affect the number of leaves and leaf area (Table 4).

The interaction between the organic fertilizer and weed control method had no significant effect on the height of the plant at all age of observation, the number of leaf age 28 DAP and the leaf area at 14 and 28 DAP, but significantly affected the number of leaves aged 14 and 42 DAP and leaf area at 42 DAP.

Plant Height and Leaves Number

The result of variance analysis showed that the use of organic fertilizer had no significant effect on plant height at age 14 and 42 DAP.

Table 5: Effect of weed control method on average of height plant and leaves number at 14 DAP

Treatment	Variable observation	
	Average of height plant (cm)	Average of leaves number
Mulch (G1)	53.11 a	4.83 a
Weeding at 14 DAP (G2)	47.82 ab	4.83 a
Weeding at 21 DAP (G3)	45.50 b	4.16 b
DMRT 95%	2= 7.00	2 = 4.49
	3= 7.30	3 = 4.70

Notes: the numbers followed by unequal letters in the same column differ significantly with Duncan Multiple Range Test (DMRT) at 95% confidence level.

Table 5 shows that the highest average of height obtained by mulch treatment (G1) as 53.11 cm is not significant with the weeding at 14 DAP (G2), but significantly different from with the weeding at 21 DAP (G3). The most average number of leaves on mulch (G1) as 4.83 sheet that is not significant with weeding at 28 DAP (G2) as 4.83 sheet, but significant with weeding at 21 DAP (G3) as 4.16 sheet. The weed control using mulch can provide a good temperature for the soil in which the crops grow. Sumarni et al., (2006); Mayun, (2007), reported that plant biomass such as rice straw and crop litter were potentially used as mulch. The use of mulch can reduce evaporation, as a source of organic matter and suppress weed growth so as to reduce the occurrence of competition between weeds and plants. With the reduced competition between weeds with plants, it can provide opportunities for corn crops to utilize the means of growing well, especially nutrients, water and sunlight. According Ali (2014), mulch serves to protect the soil from damaged by rain, can increase the absorption of water by the soil, reduce the volume and speed of surface flow, can maintain soil temperature and humidity and control weeds.

Table 6 shows that organic fertilizer (P2) and weed control methods (G1) have the highest average number of leaf plants at 14 DAP, whereas the treatment of organic fertilizer (P2) with weed control (G3) has an average number of plant leaves lowest. The organic fertilizer (P1) and weed control method (G2) had the highest leaf number at 42 DAP, whereas the treatment of organic fertilizer (P2) with weed control method (G3) showed the lowest number of leaves. This is in accordance with the statement Dukat (2007), that the presence of weeds in sufficient quantities and densities during the growth and development of plants can affect the growth of plants that affect the loss of crop yields.

Table 6: Effect of interaction between organic fertilizer and weed control method to leaves number at 14 and 42 DAP

Treatment	Average of leaves number		
	Mulch (G1)	Weeding at 14 DAP (G2)	Weeding at 28 DAP (G3)
Bokashi (P1)	4.60 a	4.67 a	4.60 a
	p	P	p
Cow manure (P2)	5.07 a	4.87 a	4.20 b
	p	P	p
DRMT 95%		2= 0.38	3= 0.40
Perlakuan	**Average of leaves number**		
	Mulch (G1)	**Weeding at 14 DAP (G2)**	**Weeding at 28 DAP (G3)**
Bokashi (P1)	10.8 a	11.13 a	10.00 a
	p	P	p
Cow manure (P2)	11.06 a	10.73 a	9.26 b
	p	P	q
DRMT 95%		2=1.12	3=1.16

Notes: the numbers followed by unequal letters in the same row (a, b) and column (q, p) differ significantly with Duncan Multiple Range Test (DMRT) at 95% confidence level.

Leaf Area (cm^2/Plant)

The result of variance analysis showed that the use of organic fertilizer had no significant effect on leaf area at age 14 and 42 DAP. The weed control significantly affected to leaf area at 14 and 42 DAP. The interaction between organic fertilizer and weed control had no significant effect on leaf area at 14 DAP, but had significant effect at 42

DAP.

Table 7; Effect of weed control method on average of leaf area (cm^2) at 14 and 42 DAP

Treatment	Average of leaves area (cm^2)	
	14 DAP	42 DAP
Mulch (G1)	269.38 a	3481.2 a
weeding at 14 DAP (G2)	251.24 ab	2911.6 b
weeding at 21 DAP (G3)	195.24 b	2784.6 b
	2 = 60.05	2 =434.2
DMRT 95%	3 = 62.58	3 = 452.4

Notes: the numbers followed by unequal letters in the same column differ significantly with Duncan Multiple Range Test (DMRT) at 95% confidence level.

Table 7 showed that the highest average of leaves area at 14 and 42 DAP was found in treatment of mulch (G1) and lowest in treatment of weeding at 21 DAP (G3). This is an indication that the fewer weeds that grow in the plant area, the negative impact on plant growth are lower. This is evidenced by the high dun at the G3 treatment compared to the leaf area in the treatment of G1 and G2.

Table 8; Effect of interaction between organic fertilizer and weed control method to average of leaf area at 42 DAP

Treatment	Mulch (G1)	Weeding at 14 DAP (G2)	Weeding at 42 DAP (G3)
Bokashi (P1)	3612.50 a	3234.41 b	2512.36c
	p	q	p
Cow manure (P2)	3321.26 a	2588.87 b	3056.77a
	p	q	p
DRMT 95%		2=362.75	3=374.35

Notes: the numbers followed by unequal letters in the same row (a, b) and column (q, p) differ significantly with Duncan Multiple Range Test (DMRT) at 95% confidence level.

Table 8 showed that the interaction between organic fertilizer and weed control method on the highest observation of maize leaves at 42 DAP was obtained at treatment of P1G1 and lowest in treatment of P1G3. The interaction of the use of organic fertilizer with weed control method had no significant effect on plant height, but significantly different to the number of leaf and plant leaf area at 14 DAP. The interaction of bokashi fertilizers and mulch effectively suppress weeds at the age of 42 DAP. It is happens because at the age of 14 DAP, the bokashi fertilizer has not decomposed completely and only decompose after age 42 DAP. The bokashi shape that still resembles litter causing the nutrient content in the bokashi fertilizer cannot be absorbed was directly by the roots of the plant at the beginning of plant growth. The bokashi fertilizer takes a relatively long time to decompose and the nut content can be used by plants.

CONCLUSION

Based on the above discussion, it can be concluded that: (1). The interaction between bokashi fertilizer and weed control method using mulch has significant effect on the average of plant height, the average number of plant leaves and the average leaf area of the plant, (2). The weed control methods using mulch independently can suppress weed growth and weeds do not grow, (3). The bokashi fertilizer and cow manure independently has no significant effect on the growth of corn crops.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Halim designed and performed the experiments and also wrote the manuscript. Makmur Jaya Arma was analyzed and interpreted the data. Fransiscus Suramas Rembon was reviewed the manuscript. Resman was collected and tabulated the data from field research. All authors read and approved the final version.

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