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Research Article

The effect of soil tillage system and weeding time on the growth of weed and yield of soybean (G*lycine max* (L.) Merril)

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Abstract: The growth and yield of soybeans can decrease due to competition from weeds. Various efforts have been made to control the growth of weeds such as land preparation and weeding periods. An experiment to study the effect of soil tillage systems and weeding time on the growth of weeds and soybean crop yield (*Glycine max* (L.) Merril) has been done in Wringinsongo Village, Tumpang Sub-District, Malang Regency from February to May 2017. The split-plot design with three replicates was used with the soil tillage system as the main plot consisting of three levels, T0: no tillage, T_1: minimum tillage, and T_2: conventional tillage, and weeding time as the sub plot consisting of 4 levels, P_0: no weeding, P_1: weeding 1 time, P_2: weeding two times and P_3: weeding three times. The results showed that the dominant weed species before treatment were *Amaranthus spinosus* (Spiny amaranth), *Cynodon dactylon* (Bermuda grass), *Cyperus rotundus* (Purple nutsedge), *Ageratum conyzoides* (Billygoat weed), and *Portulaca oleracea* (Common purslane). After treatment, the dominant weed species were *Cyperus rotundus* (Purple nutsedge), *Amaranthus spinosus* (Spiny amaranth), *Ageratum conyzoides* (Billygoat weed), *Physalis peruviana* (Cape gooseberry), and *Eclipta alba* (False daisy). There was no significant difference of the dry weight of weeds in conventional tillage followed by weeding 3 times at 15, 30 and 45 days after planting, and minimum tillage and no tillage. For the yield of soybeans, conventional tillage followed by weeding 3 times at 15, 30 and 45 days after planting were not significant with that of minimum tillage. The yield of soybeans was lower than that of with no tillage and no weeding.

***Keywords**: soybeans, tillage, weeding*

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Introduction

Soybean (*Glycine max* (L.) Merril) is in general the most popular source of protein for Indonesian society (Pusat Data dan Sistem Informasi Pertanian, 2016), that has a relatively high nutritional value compared to other crops, especially in regard to protein, fat, vitamins, and other minerals (Sutoto et al., 2001). The average soybean requirement per year is 2.2 million tons, and as much as 67.99% must be imported from abroad. This is due to domestic soybean production not being able to meet the demand of consumers (Pusat Data dan Sistem Informasi Pertanian, 2016). Various efforts have been made to increase the production of soybean crops such as weed control and land preparation. Akter et al. (2016) state that weeds are a serious problem for soybean plants and cause significant losses in yield and reductions in quality. Rijn and Soerjani (1975) state that yield of crops can be reduced due to damage of the crops by insects, fungi, bacteria, or viruses, or because of competition with weeds. Weeds can reduce crop yields because they compete in the growth media for nutrients, water, light, CO_2; complicate harvest activity; and increase production costs (Moenandir, 2010). Adisarwanto (2014) reported that the yield of

soybeans decreases from 20-80% due to weeds. Weed control is an effort to suppress weed growth and can be done mechanically, technically, biologically, and chemically (Sutoto et al., 2001). Another important factor in efforts to increase production of soybean crops is land preparation. Land preparation is an effort to prepare the land condition to produce a good soil structure clean from weeds.

Development of land preparation with no tillage is now often referred to as "conservation tillage". Phillips and Phillips (1984) state that some advantages of no tillage are easy planting, erosion control, reduced evaporation, increased land use, and reduced fuel and labor requirements. Tillage is done to prepare a growth medium that can provide an appropriate environment for germination and plant growth (Sasmita and Arifin, 2005). Hakim et al. (1986) state that tillage aims to prepare a nursery, control weeds, and improve soil conditions for root penetration. According to Utomo (2012), for preparation of land with no tillage, land is left undisturbed except for small holes for seed placement, and weeds are controlled with herbicides. For minimum tillage, weed control is usually sufficiently done manually or by spraying herbicides. For intensive tillage, the soil is ploughed several times using either traditional tools such as hoes or with plows.

The aim of this experiment was to study the effect of tillage systems and weeding time on the growth of weeds and yield of soybeans.

Materials and Methods

The experiment was conducted in Wringinsongo Village, Tumpang Sub-District, Malang Regency, at an altitude of about ± 597 m above sea level, with an average temperature of 20 - 29 °C during February - April 2017. The split plot design with three replicates was used with soil tillage system as the main plot consisting of three levels of T_0: no tillage, T_1: minimum tillage, and T_2: conventional tillage, and weeding time as the sub plot consisting of four levels of P_0: no weeding, P_1: weeding one time, P_2: weeding two times and P_3: weeding three times. The experimental field measured 2.4 m x 1.8 m, the distance between the plot was 50 cm, and the distance between replication was 85 cm. Soil tillage according to the treatment was no tillage, minimum tillage, and conventional tillage. Soil tillage was done one week before planting. In the no tillage plots, the land was sprayed using Isopropylamine glyphosate 486 g / L herbicide with a dose of 6 L / ha to kill weeds that grew, then the dead weeds were left and used to cover the soil surface. In the minimum tillage plots, the soil tillage was done once by digging the soil approximately 2-3 cm deep, which aims to remove the growing weeds. In the plot with conventional tillage, the soil tillage was done two times by digging the soil approximately 2-3 cm deep which aimed to remove the growing weeds and to loosen the soil. After soil tillage, Grobogan variety soybeans were planted over a distance of 30 cm x 20 cm and 5 cm deep, by planting two seeds per hole and covering the hole with soil. Fertilization utilized urea at 50 kg/ ha, SP36 at 75 kg/ha, and KCl at 100 kg / ha. All doses of SP36 and KCl were given at the beginning of planting, whereas for urea fertilizer 1/3 of the dose was given at the beginning of planting and 2/3 of the dose was given at 21 days after planting. Fertilization was done by distributing evenly around the plants on each plot. Maintenance of soybean crops was done in accordance with the recommendations. Treatment of weed control was done mechanically by weeding using a hoe in experimental plots adjusted with treatments of no weeding, weeding one time at 15 days after planting (DAP), weeding two times at 15 and 30 DAP, and weeding three times at 15, 30, and 45 DAP. Observations of soybean crops including leaf area and dry weight of plants were carried out at 55 and 65 DAP and plant yield was observed at harvest time. The total dry weight of weeds was observed at 55 and 65 DAP. Weed vegetation analysis was done to determine Summed Dominance Ratio/SDR (Wirjahardja and Pancho, 1975; Tjitrosoedirjo et al., 1984). Parameters for SDR were calculated by the following formulas:

a. Density is the actual number of species per sample plot.

$$\text{Absolute Density (AD)} = \frac{\text{Number of species}}{\text{Number of plots}}$$

$$\text{Relative Density (RD)} = \frac{\text{AD of the species}}{\text{Total AD for all species}} \times 100\%$$

b. Frequency is an expression of the ratio of the sample plot in which a species occurs.

$$\text{Absolute Frequency (AF)} = \frac{\text{Number of plots in which a species occurs}}{\text{Total number of plots sampled}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{AF for a species}}{\text{Total AF for all species}} \times 100\%$$

c. Dominance is used to refer of an area covered by, basal area of, or biomass of species.

$$\text{Absolute Dominance (AD)} = \frac{\text{The sum of basal area of the species}}{\text{The area of the plot sample}}$$

$$\text{Basal Area} = \left(\frac{\text{d1 x d2}}{4} \right)^2 \text{x } \pi$$

Basal area d1 and d2 are vertical to the projection of plant for the canopy of species

$$\text{Relative Dominance (RD)} = \frac{\text{AD for a species}}{\text{Total AD for all species}} \times 100\%$$

d. Importance Value (IV)
Importance Value (IV) = RD + RF + RD

e. Summed Dominance Ratio (SDR)
Summed Dominance Ratio (SDR) = (RD + RF + RD) /3

Data obtained were then tested subjected to analysis of variance (F test) with a 5% level to find out significant interactions or significant effects among treatments. This was followed by the LSD test with a 5% level to find out differences among treatments.

Results and Discussion

Observation of weeds

Types and SDR values of weeds before treatment and after treatment of soil tillage and weeding times

The types and SDR values of weeds before treatment and after treatment of soil tillage and weeding times are shown in Table 1. Table 1 shows that there were 20 species of weeds. The dominant weed species before treatment were *Amaranthus spinosus* (Spiny amaranth), *Cynodon dactylon* (Bermuda grass), *Cyperus rotundus* (Purple nutsedge), *Ageratum conyzoides* (Billygoat weed), *Portulaca oleracea* (Common purslane) with the SDR values being 20.33%, 17.06%, 10.45%, 7.85%, and 4.78% respectively. After treatment the dominant weed species were *Cyperus rotundus* (Purple nutsedge), *Amaranthus spinosus* (Spiny amaranth), *Ageratum conyzoides* (Billygoat weed), *Physalis peruviana* (Cape gooseberry), and *Eclipta alba* (False Daisy) with the SDR values being 17.42%, 13.31%, 12.06%, 11.81%, and 8.31 % respectively. The result showed that there was a change in the composition and SDR of weeds before and after soil treatment and weeding time. Fitriana et al. (2013) state that changes in weed composition are affected by cultivation methods such as soil cultivation, fertilization, weed control and weed characteristics. Prasetyo et al. (2014) reported that there was a shift in the dominance of weeds after the treatment of tillage systems and mulching.

Dry weight of weeds

The result showed that there was a significant interaction between soil tillage and weeding time on the total dry weight of weeds as observed at 55 and 65 days after planting. The average of total dry weight of plants due to interaction between soil tillage and weeding time can be seen in Table 2. Observations made at 55 days after planting showed that conventional tillage, minimum tillage, and no tillage followed by weeding three times did not significantly different from conventional tillage and minimum tillage followed by weeding two times, but significantly different with another treatment.

At observations of 65 days after planting, conventional tillage, minimum tillage, and no tillage followed by weeding three times resulted in lower total dry weights of weeds compared with conventional tillage, minimum tillage, and no tillage as well as weeding 1 time, 2 times and no weeding. Dry weight of weeds was significantly higher in conventional tillage, minimum tillage, and no tillage if weeding was not done compared with weeding one time, two times or three times. Antralina (2012) stated that different weeding periods would affect the growth of weeds. Weed dry weight increased if weeding was delayed.

Table 1. Types and SDR values of weeds before treatment and after treatment of soil tillage and weeding times

No	Name of Weed Species	Common Name	SDR (%) Before Treatment	Average of SDR (%) After Treatment
1	*Amaranthus spinosus*	Spiny amaranth	20.33	13.31
2	*Cynodon dactylon*	Bermuda grass	17.06	6.29
3	*Cyperus rotundus*	Purple nutsedge	10.45	17.42
4	*Ageratum conyzoides*	Billygoat weed	7.85	12.06
5	*Portulaca oleracea*	Common purslane	4.78	5.96
6	*Mimosa pudica*	Sensitive plant	4.23	0.75
7	*Eupatorium triplinerve*	Ayapan	3.77	1.27
8	*Eleusine indica*	Goose grass	3.76	1.27
9	*Euphorbia hirta*	Hairy spurge	3.72	1.43
10	*Axonopus compressus*	Carpetgrass	3.36	3.68
11	*Isotoma longiflora*	Star flower	3.35	0.00
12	*Eclipta alba*	False daisy	2.94	8.31
13	*Wedelia trilobata*	Yellow creeping daisy	2.92	0.64
14	*Paspalum conjugatum*	Buffalo grass	2.84	3.12
15	*Emilia sonchifolia*	Cupid's shaving brush	2.71	4.71
16	*Digitaria ciliaris*	Southern crabgrass	2.13	3.56
17	*Acmella paniculata*	Panicled spot flower	2.11	1.54
18	*Phyllantus niruri*	Gale-of-the-wind	1.7	1.67
19	*Bidens pilosa*	Hairy beggar-tick	0.00	1.19
20	*Physalis peruviana*	Cape gooseberry	0.00	11.81
	Total SDR (%)		**100 %**	**100 %**
	Total Weeds		**18**	**20**

Table 2. Averages of total dry weight of weeds due to interactions of tillage systems and weeding times

DAP	Treatment	Observed Average Total Weight of Weeds (g/250cm^2)			
		No Weeding	Weeding One Time	Weeding Two Times	Weeding Three Times
55	No Tillage	327.53 g	127.03 d	37.80 b	25.47 a
	Minimum Tillage	296.57 f	118.33 d	28.47 ab	19.17 a
	Conventional Tillage	241.33 e	101.77 c	22.63 a	13.43 a
	LSD 5%		11.97		
65	No Tillage	346.83 g	142.90 d	60.13 b	27.20 a
	Minimum Tillage	312.90 f	125.30 cd	54.40 b	24.10 a
	Conventional Tillage	263.93 e	118.90 c	42.67 b	20.63 a
	LSD 5%		21.59		

Notes: Numbers followed by the same letter are not significantly different based on the 5% LSD test. DAP = Days After Planting.

Growth observation of soybean

Leaf area

The result of variance analysis showed that there was no interaction between tillage system and weeding time on leaf area. Tillage system significantly affected plant leaf area as observed at 55 days after planting. The weeding time had a significant effect on leaf area at 55 and 65 days after planting (Table 3). At the observation of 55 days after planting, conventional tillage showed significantly higher leaf areas by 14.38% and 16.94% compared with minimum tillage and no tillage, respectively. Based on the effect of weeding treatment at 55 days after planting, weeding three times significantly gave a higher leaf area by 31.18%, 54.64%, and 111.71% compared with weeding two times, weeding one time, and no weeding, respectively. At the observation of 65 days after planting, weeding three times significantly gave a higher leaf area by 18.98%, 58.84%, and 87.29% compared with

weeding two times, weeding one time, and no weeding, respectively. Silva et al. (2010) state that the leaf area index is an important factor that determines dry matter accumulation. Prasetyo et al. (2014) showed that leaf area with conventional tillage treatment did not show significant differences with minimum tillage but was significantly different with no tillage.

Table 3. Average of leaf area due to tillage system and weeding times

Treatment	Observed Average Leaf Area (cm^2)	
	55 DAP	65 DAP
Tillage System		
No Tillage	482.36 a	557.38
Minimum Tillage	493.16 a	528.10
Conventional Tillage	564.08 b	634.82
LSD 5%	61.18	NS
CV %	10.52	13.47
Weeding Time		
No Weeding	336.63 a	407.71 a
Weeding One Time	460.97 b	480.73 b
Weeding Two Times	543.53 c	641.72 c
Weeding Three Times	712.67d	763.58 d
LSD 5%	70.50	60.70
CV%	13.88	10.69

Notes: Numbers followed by the same letter show no significant differences based on the 5% LSD test; DAP = Days After Planting. CV= Coefficient of variance. NS = Not significant

Dry weight of plants

The result of variance analysis showed that there was no interaction between tillage system and weeding time on the dry weight of plants. Tillage system significantly affected the dry weight of plants as observed at 65 days after planting, while weeding time had a significant effect on the dry weight of plants at 55 and 65 days after planting (Table 4). From the observation at 65 days after planting, conventional tillage gave a dry weight of 1.56% and 3.22% more than minimum tillage and no tillage, respectively. The results of research conducted by Riyati et al. (2005) also showed no significant difference between conventional tillage and minimum tillage as well as no tillage on the dry weight of sweet corn plants. For the effect of weeding treatment as observed at 55 days after planting, weeding three times did not significant differences to weeding two times on the dry weight of plants but was significantly higher by 23.94% and 47.72% for weeding one time and no weeding. For the dry weight of plants as observed 65 days after planting, weeding three times also did not show significant differences to weeding two times but was significantly higher by 19.54% and 48.39% to weeding one time and no weeding.

Table 4. Average dry weight of plants due to treatment of tillage and weeding times

Treatment	Average Dry Weight of Plants (g)	
	55 DAP	65 DAP
Tillage System		
No Tillage	20.19	23.25 a
Minimum Tillage	20.15	23.63 a
Conventional Tillage	21.94	24.00 b
LSD 5%	NS	0.49
CV %	17.14	1.82
Weeding Time		
No Weeding	16.47 a	18.39 a
Weeding One Time	19.63 ab	22.83 b
Weeding Two Times	22.62 bc	25.99 c
Weeding Three Times	24.33 c	27.29 c
LSD 5%	3.85	1.32
CV %	18.70	5.66

Notes: Numbers followed by the same letter show no significant differences based on 5% LSD test; DAP = Days After Planting. CV= Coefficient of variance. NS = Not significant

Observation of soybean yields

Yields

The result of variance analysis showed that there was interaction between tillage systems with weeding times on soybean crop yield per hectare. The average value of crop yield per hectare due to interaction of tillage system and weeding times can be seen in Table 5. For crop yield per hectare, conventional tillage followed by weeding three times was not significantly different with minimum tillage followed by weeding three times but was significantly different with another treatment. Yufi and Harjoso (2012) stated that weeding has a good effect in improving yields and yield components. Weed control with weeding will reduce the population of weeds that compete with plants in getting water, light, air, and nutrients. Prasetyo et al. (2014) indicated that the tillage system had a significant effect on soybean

crop yields. Conventional tillage treatment did not show significant differences with minimum tillage but showed significantly higher yields than no tillage. Results of a study conducted by Raintung (2010) showed that soil tillage twice at one week and two weeks before planting gave higher number of pods than minimum tillage and tillage once at one week before planting. Ohorella (2011) reported that soil tillage three times significantly increased the growth and yield of soybean crops compared to soil tillage two times and one time.

Table 5. Average yield of soybean crops due to the interaction of tillage system and weeding times

Parameters	Treatment	No Weeding	Weeding OneTime	Weeding Two Times	Weeding Three Times
Per hectares (t/ha)	No Tillage	0.93 a	2.02e	2.21 f	2.55 h
	Minimum Tillage	1.02 b	2.03 e	2.39 g	2.60 hi
	Conventional Tillage	1.14 c	1.90d	2.40 g	2.65 i
LSD 5%			0.07		

Notes: Numbers followed by the same letter are not significantly different based on the 5% LSD test.

Conclusions

Differences of soil tillage systems and weeding times affected type and dominance of weed that grew in soybeans crop. The dominant weed species before soil tillage were *Amaranthus spinosus* (Spiny amaranth), *Cynodon dactylon* (Bermuda grass), *Cyperus rotundus* (Purple nutsedge), *Ageratum conyzoides* (Billygoat weed), and *Portulaca oleracea* (Common purslane). After soil tillage and weeding time treatments, the dominant weed species were *Cyperus rotundus* (Purple nutsedge), *Amaranthus spinosus* (Spiny amaranth), *Ageratum conyzoides* (Billygoat weed), *Physalis peruviana* (Cape gooseberry), and *Eclipta alba* (False Daisy). The growth and yield of soybean significantly increased in the conventional tillage, minimum tillage and no tillage, followed by weed control. The yield of soybeans in conventional tillage followed by weeding three times at 15, 30, and 45 days after planting did not significantly differ with minimum tillage, but significantly differed with no tillage. The yield of soybeans was lower than with no tillage and no weeding.

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