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Weed control technology to increase growth and yield of mungbean (*Vigna radiata* L.) in soils types

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Abstract. Mungbean is a plant that is cultivated by most of the people of Indonesia at the time before the dry season in the former paddy fields. The presence of weeds in crops that are not controlled by farmers caused the low yield of mungbean obtained by farmers. This study aims to determine the weed control technology to increase the growth and yield of mungbean in soil types. This experiment is a factorial experiment arranged in a completely randomized design (CRD) and repeated three times. The first factor is the weed control technology consisting of three kinds: weedy, hand weeding, and tool weeding. The second factor is the type of soil that consists of four types: coastal sand, latosol, volcanic, and regosol. The results showed that weed control at the age of 20 days after planting (DAP) could increase the growth and yield of mungbean in soil types, except in volcanic soils. Weed control with the hand weeding in coastal sand can give a higher production than tool weeding. Weed control technology with the hand and tool weeding way gives the results of mungbean relatively similar to latosol and regosol soils.

Keywords: weed control, mungbean, yield, soil types

2 Introduction

Mungbean (*Vigna radiata* L.) is one of the legume crop commodities that is widely eaten by the people of Indonesia. According to Arsyadmunir [1] the mungbean plant has a business opportunity in the field of agribusiness because it can be processed into various forms such as porridge, cakes, and even can be made into vegetables.

Rice harvest area in Indonesia in 2018 is 10.90 million ha. Extents of paddy fields in Indonesia during the dry season from May to September range from 759.67-1,633.22 thousand ha [2]. Part of the degraded paddy land can be used for the cultivation of mung bean plants. Mungbean has advantages such as early maturing, and more drought-tolerant. Mungbean plants can grow optimally in the dry season with rainfall 50-200 mm/month. This plant does not need high rain.

Mungbean plants have a high potential to be developed in Indonesia. This plant has advantages in terms of agronomy and economics, which is resistant to drought and pests and diseases. It can be harvested at the age of 55-60 days and be planted on various soil types, and secure cultivation method. The low yield of mungbean is caused by weeds that grow in around the plant. The competition weeds and mungbean



plants decrease in return. Weed control around mungbean plants needs to be done. Weed control of mechanically adjusted to the soil types used.

Mungbean occupies the last position in the year cropping pattern. Early maturity, simultaneous cooking, and high yields are essential, especially in areas with limited labor. Vima 2 variety (MMC strain 342d-Kp-3-4) is a single crossbreed between Merpati variety and V.C. 6307A. The Vima 2 variety has old black pods, shiny green seed color, 6.37 g/100 seed size, 56 HST harvest age, yield potential of 2.44 tons/ha, and an average yield of 1.80 tons/ha. Plants ripen in unison, and tolerant of thrips pests in the generative phase because the flowers do not fall out easily and successfully form pods [3]

The superior varieties of mungbean are developed, namely Vima 1 - 5. For Vima, the odd number (1, 3, and 5) of the dull seed color, while the Vima even number (2 and 4), the seeds are slippery. Productivity is quite high up to 2 tons/ha, while, on average, it reaches 1.5 tons/ha. The advantage of the Vima variety of mungbean is that they are short-lived under 56 days and can be harvested at the same time so that farmers can save on harvest costs [4]. Planting time in paddy fields is done in the dry season after harvesting rice, while in the drylands, it is done at the beginning of the rainy season [5].

Weeding can prevent yield losses of up to 56% compared to the condition of the weed. The critical period of mungbean plants (*Vigna radiata* L. Wilczek) against weeds is in the age range of 14-21 days after sowing (DAS). Weeds species that were identified after planting mungbean are *Dactyloctenium aegyptium*, *Fimbristylis puberula*, *Eragrostis tenella*, *Paspalum conjugatum*, *Digitaria ischaemum*, *Cyperus iria*, and *Euleusine indica* [6]. Weeding done (14 and 28 DAS) and (21 and 35 DAS) produced dried seed drying 1.10 tons/ha and 1.14 tons/ha higher than without weeding (0.98 tons/ha). Weeds are plants that are not desired by plants because they will compete in the struggle for nutrients [7]. Dry weight per plant (12.38 g) was highest from three-stage weeding and the lowest from no weeding treatment. The highest number of pods (22.03) per plant, the most extended pod (5.95 cm), the highest number of seeds (17.07) per pod and the highest seed yield (1.38 tons/ha) was obtained from three-stage weeding (emergence-flowering and flowering-pod setting and pod setting-maturity) in mungbean [8]. The highest grain yield (1029.4 kg/ha) was recorded in hand weeded (15 + 30 DAS) plots and gave maximum net benefits [9].

All the mechanical and herbicidal weed control treatments gave a marked reduction in dry matter of weeds and produced significantly more seed yield as compared to unweeded. Though two hand hoeings at 25 and 40 DAS produced the highest seeds [10]. It is weeding by a tool weeding to anticipate increased evaporation, soil erosion, and the emergence of dormant weed seeds, especially on steep slopes or sandy soils. According to Ilham [11], weed removal regularly can suppress weed growth. On land that is not too broad can provide effective and efficient results. This control technique has the advantage that the results are quickly visible, easy to implement, avoid the effects of environmental pollution and soil erosion. The weakness of weed removal is that it requires relatively a lot of labor and long. Weed control is carried out by Sama's farmers by 73% by removing weeds. Weed control manually by hand is one of the techniques that are often applied by farmers in crop cultivation.

Weed control methods in weeding with weeding can reduce grass weeds, broadleaf, and puzzles successively by 33, 64, and 47% compared to controls (weeded). Weed weeds cause dormant weed seeds in the soil to rise, then grow into new plants and will grow and compete with the main crop [12]. Some soil types that can be used for the cultivation of mungbean plants include coastal sand, volcanic, latosol, and regosol soils. Coastal land was including sandy land and regosol land. According to Ilham [11], This coastal sand land can be utilized to develop the agricultural sector. One of the coastal sand fields that has been developed for the farming cultivation is the Samas coastal sand area.

Mungbean seed yield increased when the duration of the weed infestation period decreased. Yield components such as the number of pods per plant didn't show a significant difference, while the number of seeds per pod and 100 seed weight showed a significant difference. The critical weeding period for mungbean was 10-20 and 30-40 DAS [13]. Narrowing row spacing in mungbean could lead to reduced weed growth and seed production and increased crop yield [14]. The results indicated mungbean yield increased by 82.68% by weed control, highlighting the importance of weed interference in reducing mungbean yield and the necessity of weed control to achieve higher yields [15].

Coastal sand is dominated by sand with a content of more than 70%, low porosity, or less than 40%. Most pore spaces are large so that the air is good, conductivity is fast, but the ability to store water and

nutrients is low. In terms of chemistry, sand soil contains enough phosphorus (P) and potassium (K) elements that are not ready to be absorbed by plants. Still, sand fields lack nitrogen (N), so to improve soil conditions like this, it is necessary to fertilize [16]. Macronutrient content in sandy soil is generally low and very low, except for P-total and P-available, while micronutrients are sufficient except boron [17].

The lands that are around the Merapi volcano are soil derived from volcanic ash. Volcanic ash is an erupted volcanic material released by volcanoes in the form of dust, gravel, and hot rocks. Volcanic ash contains elements that are beneficial to plants. The nutrient content is dominated by silica by 54%. The elements sulfur (S) and chloride are elements needed by plants. There is no problem for farmers to replant agricultural lands by carrying out more profound cultivation by mixing with native land [18]. Volcanic soil is soil that originated from the results of volcanic eruptions. Three types of material released are solid, liquid, and gas. Solid material in the form of sand, volcanic ash and dust, and dissolved material are in the form of lava. Volcanic soil is formed from lava, tuff, and volcanic ash. Lava is loose volcanic material and is composed of fragments of rock, mineral grains, and volcanic glass.

Latosol soil (inceptisol) is a soil that has several characteristics, including having a rather thick soil solum of 1.3-5 m. The land is red, brown, to yellowish. The texture of the land in general, is clay and crumb structure with a loose consistency. Soil pH ranges from 4.5 to 6.5, from acidic to slightly acidic. Organic matter around 3-9%. Medium to high nutrient content. The more red the soil is, the fewer nutrients are contained. The land has a reasonably fast to slow infiltration, and the land water is quite good.

The physical properties of latosol soil are in rainfed paddy fields. Irrigated paddy fields are characterized by the highest content weights in the tread layer in the third layer (1.34 and 1.24 g/cm³), permeability is slow and rather slow (0.40 and 1, 02 cm/hour), with lower porosity (38.01 and 42.15%) than the one layer horizon mixture (52.22%). In mixed gardens at the one-layer horizon, it showed the lowest content weight (1.18 g/cm³), with moderate permeability (4.17 cm/hour). Soil chemical properties in rainfed paddy fields, irrigated land, and mixed gardens are classified as fertile with pH on the horizon in the processing layer of 6.33 - 6.89 (slightly sour-neutral), Al did not measured (very low), and CEC 24 - 36 cmol (+)/kg (medium-high) [19].

Regosol soil texture consists of the sand fraction (82.62%), dust (13.16%), and clay fraction (4.22%), so it belongs to the clay sand texture class. The presence of coarse soil texture causes moderate porosity values (58.92% by volume). The soil is dominated by fast drainage pore (33.0% volume), water pore is not available (8.2% volume), water pore is open (8.0% volume), and slow drainage pore (5.5% volume). The soil is dominated by macropores so that some water is easily leached after the addition of water stops [20]. Regosol soil is soil derived from volcanic material, coarse-textured mixed with sand, thick solum, and has a low fertility rate. Coarse-grained soil as a result of precipitation. Regosol soil type is suitable for planting crops such as rice, sugar cane, crops, tobacco, and vegetables. Regosol land is classified as an entisol soil type.

In this research, the Vima-2 variety of mungbean is used. This variety is a superior commodity with high yields, early maturity, and flour dew resistance. The method of controlling weeds mechanically is done to find out the magnitude of the increase in the production of mungbean plants that are cultivated on different types of soil. The results of the study can be used as guidelines in the cultivation of mungbean plants so that self-sufficiency in mungbean can be achieved.

2. Materials and Methods

2.1. Study area

The study was carried out from February to June 2020. The experiment was conducted at the greenhouse, Faculty of Agriculture, Universitas PGRI Yogyakarta, Ngestiharjo Village, Kasihan District, Bantul Regency, Special Territory of Yogyakarta. The height of the study area is 118 m above sea levels, and the position of the southern latitude is 7 ° 33 ' - 8 ° 12 ' and east 110 ° 00 110 - 110 ° 50 '.

2.2. Experimental design

This experiment is a pot experiment arranged in a completely randomized design (CRD) factorial 3 x 4 and repeated three times. The first factor is weed control consists of three types, namely weedy, hand weeding, and tool weeding. The second factor is the type of soil that consists of four types of soil, namely soil: coastal sand, latosol, volcanic, and regosol. Then, in this research was required $3 \times 4 \times 3 = 36$ wooden pots.

2.3. Research procedures

The soil that is needed is beach sand, latosol, volcanic, and regosol in the top-soil layer from a depth of 0-20 cm as a planting medium. The land was taken from four locations, namely: coastal sand (Congot), volcanic (Pakem), latosol (Nanggulan), and regosol (Kasih). Mungbean seeds of Vima 2 has high productivity. Black silver plastic mulch is used for the ground so that water and soil do not come out of the box. A ruler is used to measure plant height. That measured from the root of the neck to the shoots at the end of the stem. The oven is used Binder FED 53-UL Forced Convection Drying Oven to dry the safe box of the mungbean and weeds and mungbean seeds. DS-880 model digital scales for weighting the dry weights of plants, weeds, and mungbean seeds. Manual Scales Excellent Balance type ACS-A-30 kg for weighting the soil as a medium for growing mungbean.

Mungbean seeds are planted in soil media in pots made of wood with a size of 50 cm (width) x 80 cm (length) x 30 cm (height). The soil media used is a former rice plant. Wooden pots are placed on a concrete table inside a greenhouse building. Planting distance used 25 cm (distance between rows) x 27.5 cm (distance in row). Planting is done as much as two seeds per planting hole. Two days before planting, the planting media was watered. The next irrigation is done at 15 DAP. After that, the water is given once every three days. Mungbean plants are known as drought-tolerant plants.

Fertilization through the soil is done at the age of 15 DAP using NPK fertilizer at a dose of 5 g/planting hole. Weeding is carried out according to treatment during growth, while pest and disease control is carried out by the principle of IPM (integrated pest control).

2.4. Observation of variable

Observation of plants includes components of growth and yield. Parts of plant growth observed included, namely, leaf chlorophyll, stover dry weight, leaves dry weight, and leaf area index. The yield component was done only with the dry weight of seeds per hectare.

2.5. Statistical analysis

The observations data were analyzed with analysis of variance (ANOVA) at 5% significant level [21]. To find out the differences between treatment was using Duncan's multiple range test (DMRT) at 5% significant levels.

3. Results and discussions

3.1. Weed species

The observations showed there were differences in the types of weeds that grow in each type of soil. The SDR and types of weeds that grow around the planted pulverized to each kind of soil, namely beach sand, latosol, volcanic, and regosol, can be seen in Table 1. Based on Table 1 shows that there are differences in the number of weeds in each type of soil, namely: in coastal sandy soil (10 species), latosol (7 species), volcanic (13 species), and regosol (9 species).

Based on Table 3.1 shows that the number of weeds is higher in volcanic soils, then decreases in soils in coastal sand, regosols, and lowest in latosol. The less of weeds in latosol is caused by the dominance of one of the weed species. Plants that can't survive will die. However, this is different from what happens in volcanic soil. Weeds that grow more types in number because the dominance of weed species does not occur so that all species that have the opportunity to grow together. Four weeds species were found in four soil types, namely: *Acalypta indica* L., *Cleome rutidosperma* DC., *Echinochloa colonum* (L.) Link, dan *Eleusine indica* (L.) Gaertn. The four species of weeds have broad growth adaptations and are easy to grow in a variety of different types of soil.

There are differences in the types of dominant weeds that grow between soil types. In coastal sand (sandy soil) is dominated by one weed species, *Echinochloa colonum* (L.) Link (SDR 58.94%), but in

latosol (clay soil) by three weeds species, namely *Acalypta indica* L. (SDR 21,94%), *Cleome ruidosperma* D.C. (SDR 20,42%), and *Echinochloa colonum* (L.) Link (SDR 28,57%). Two types of weeds are dominant in volcanic soils (volcanic eruptions), namely *Cyperus iria* L. (SDR 22,28%) and *Echinochloa colonum* (L.) Link (SDR 22,89%). One type of weed is dominant in regosol (sandy loam) soils, i.e., *Cleome ruidosperma* D.C. (SDR 64,92%). According to Sumekar et al. [22], stated that the ratio of total dominance (SDR) is useful to describe the relationship of the dominance of one type of weed with other types of weeds in a community. The types of weeds that have the highest SDR value are the dominant weeds.

Table 1. SDR of weed species in weeded crops in different soil types (0,4 m²).

No.	Weed species	Soil types			
		Coastal sand	Latosol	Volcanic	Regosol
1	<i>Acalypta indica</i> L.	4.26	21.94	16.93	5.42
2	<i>Ageratum conyzoides</i> L.	2.25	-	2.84	-
3	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	-	-	4.90	-
4	<i>Alternanthera sesillis</i> (L.) DC.	-	-	-	2.48
5	<i>Blumea lacera</i> (Burm.f) DC.	4.87	3.43	-	-
6	<i>Cleome ruidosperma</i> DC.	9.81	20.42	6.49	64.92
7	<i>Cyperus iria</i> L.	-	3.18	22.29	2.41
8	<i>Croton hirtus</i> L'Herit.	-	-	3.78	-
9	<i>Echinochloa colonum</i> (L.) Link	58.94	28.57	22.89	3.63
10	<i>Echinochloa polystachyion</i> H.B.K	2.11	15.98	1.96	5.84
11	<i>Eleusine indica</i> (L.) Gaertn	-	6.49	3.92	9.63
12	<i>Euphorbia hirta</i> L.	1.92	-	-	-
13	<i>Euphorbia geniculata</i> Orteq.	-	-	-	2.62
14	<i>Ipome triloba</i> L.	1.98	-	6.74	-
15	<i>Ludwigia peruviana</i> (L.) H.Hara	-	-	2.03	-
16	<i>Ludwigia ascendens</i> (L.) H.Hara	-	-	2.05	-
17	<i>Phyllanthus debilis</i> Klein ex Willd.	9.72	-	3.19	3.04
18	<i>Phyllanthus urinaria</i> L.	4.15	-	-	-
Total		100.00	100.00	100.00	100.00

9.2. Weed dry weight

There was a significant interaction between weed weeding method and soil type to the weed dry weight. The results of the differences between treatment combinations based on the DMRT test at 5% significant levels on the dry weight of weed can be seen in Table 2.

Based on Table 2 shows that the weeding both by extraction and weeding can reduce the growth of weeds in the mungbean plants. It seems that weeding causes a slight increase in weed growth because weed seed banks in the soil will be raised to the surface and germinate into new weeds. The highest weed dry weight occurred in the treatment of weeded in latosol soil, then decreased in coastal sand, regosol, and lowest in volcanic soil. According to Mahendra *et al.* [23] said that weeding is effective in reducing the dry weight of weed compared to without weeding (weeded).

High weed dry weights as an indicator that latosol soil has better soil fertility than coastal sand, volcanic, and regosol soils. Latosol soil can hold water high so that soil moisture levels are well maintained. The lowest weed growth occurs in volcanic soils. It is an illustration that volcanic soil contains weed seed bank is less than different soil types because the land is less fertile. Weed growth in the previous season did not produce many seeds stored in the soil.

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Table 2. Effect of mechanical weed control and soil types on weed dry weights (g/0.4 m²).

Soil types	Weed control			Average
	Weedy	Hand weeding	Tool weeding	
Coastal sand	82.55 b	8.18 e	13.09 e	34.61
Latosol	95.78 a	18.15 de	28.86 cd	47.60
Volcanic	43.20 c	15.24 e	16.78 e	25.07
Regosol	76.84 b	11.24 e	17.19 e	35.09
Average	74.59	13.20	18.98	(+)

Remarks: The average treatment combination followed by the same letters in both rows and columns shows no significant difference based on the DMRT at 5% significance levels, and (+) = Significant interaction occurs.

3.3. Leaf chlorophyll

The interaction between weed weeding methods and soil types did not significantly affect the greenness of the leaves. Weed weeding methods and soil types significantly affect the greenness of the leaves. The results of the differences between treatments based on the DMRT at 5% significant levels on the leaf chlorophyll can be seen in Table 3.

Table 3 shows that the weeded plants have lower leafy greenness than weeding. There is no difference in leaf greening in the weeding method either through extraction or soil weeding. The presence of competition between weeds and mungbean plants causes a decrease in the greenness of the leaves in the mungbean plants. Weed growth that is fast and strong will be a struggle for nutrients, groundwater, CO₂, and growing space that results in plants unable to compete for these natural resources with a response to a decrease in green leaf mungbean plants.

Green differences occur in mungbean plants that grow on various soil types. The highest greenery occurs in coastal sandy soils, then decreases in regosol, volcanic, and lowest in latosol soils. The lower greening of plant leaves in latosol soil due to the growth of certain weeds is dominant in the environment of mungbean plantations, especially in the weed plants. According to Pratama & Laily [24] stated that a combination of pigments in plants produces this green color, sometimes chlorophyll a is more dominant so that the color tends to be light green, sometimes more dominant carotenoids. Hence, the color tends to turn yellow. A combination of plant pigments produced the green spectrum, specifically chlorophyll a and b.

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Table 3. The effect of mechanical weed control and soil types on leaf chlorophyll (unit).

Soil types	Weed control			Average
	Weedy	Hand weeding	Tool weeding	
Coastal sand	37.87	37.85	40.87	38.86 p
Latosol	25.48	38.70	33.13	32.44 r
Volcanic	34.58	35.27	34.73	34.86 qr
Regosol	34.28	38.67	37.13	36.69 pq
Average	33.05 b	37.62 a	36.47 a	(-)

Remarks: The average treatment followed by the same letters in rows or columns shows no significant difference based on the DMRT at 5% real levels, and (-) = no significant interaction occurs.

4.4. Stover dry weight

There was a significant interaction between weed control and soil types on stover dry weight. The results of the test differences between the treatment combinations of weed control and soil types based on the DMRT at 5% significance levels on stover dry weight can be seen in Table 4.

Based on Table 4 showed that the highest stover dry weight of mungbean plants occurs in the treatment of hand weeding in coastal sandy soil, and hand and tool weeding in latosol soils, and the lowest occurs in weeded latosol soils. Mungbean plants grow better planted on beach sandy soils

accompanied by weeding so they can form higher dry matter. Plants can appropriately utilize the availability of nutrients in the coastal sandy soil. The presence of weeding causes dry stover dry weight to decrease in coastal sandy soils. Competition between plants and weeds in latosol soils results in lower production of dry matter. Latosol soil can store high water in the land, so it has the potential to support weed growth. Strong weed growth will suppress the growth of mungbean plants, which results in lower dry weight growth.

Weeding is a way of controlling weeds and also loosening the top surface of the soil around where plants grow by using small hoes, gloves, or similar tools. This method of control can break the roots of plants if done close to plant roots and also causes dormant weed seeds to rise to the ground to grow.

Table 4. Effect of mechanical weed control and soil types on stover dry weight (g/clump).

Soil types	Weed control			Average
	Weedy	Hand weeding	Tool weeding	
Coastal sand	17.23 bcd	24.90 a	22.05 abc	21.39
Latosol	12.45 d	24.36 a	25.28 a	20.70
Volcanic	18.58 abcd	15.82 cd	23.41 ab	19.27
Regosol	23.72 ab	23.79 ab	19.83 abc	22.45
Average	18.00	22.22	22.64	(+)

Remarks: The average treatment combination followed by the same letters in both rows and columns shows no significant difference based on the DMRT at 5% significance levels, and (+) = Significant interaction occurs.

4.5. Leaf dry weight

There was a real interaction between weed control and soil types on the dry weight of leaf. The results of the difference test between the treatment combinations of weed weeding methods and soil types based on the DMRT test at a 5% significance level on the dry weight of leaf can be seen in Table 5.

The highest leaf dry weight occurs in a combination of weed extraction treatment in coastal sandy soil, and the lowest occurs in plants with weeding with hand weeding in volcanic soil. Coastal sand has excellent potential for the cultivation of mungbean plants. The soil nutrient content is limited, but can still support the growth of higher leaf dry weight. The soil has proper soil aeration, and compact soil structure causes more flexible and more extended root growth. Roots can utilize available nutrients without competition. Weeds are removed. It's just that the need for water is very high or wasteful for top watering because of the high level of evaporation of water from the ground surface. The dry weight of the leaves that occur in coastal sandy soil with weed removal is contrary to that which occurs in volcanic soils with weed removal. This soil has a rough soil structure and low soil fertility so that the root growth does not grow optimally because the length will be shorter and does not reach a sizeable rooting area, which consequently cannot support the maximum leaf growth.

The amount of water loss in the sand soil causes the bean plant to wilt during the day, which interferes with the process of photosynthesis during the daytime. Hand and tool weeding in latosol and regosol soils produced the same results. In both soil types, one of the most effective and efficient ways to control weeds can be chosen. According to soil water content with 100% field capacity gives the best leaf dry weight on mungbean plants.

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Table 5. Effect of mechanical weed control and soil types on the dry weight of leaf (g/clump).

Soil types	Weed control			Average
	Weedy	Hand weeding	Tool weeding	
Coastal sand	5.89 bcd	7.58 a	5.91 bcd	6.46
Latosol	4.85 cd	6.71 ab	6.93 ab	6.16
Volcanic	5.92 bcd	4.28 d	5.91 bcd	5.37
Regosol	5.42 bcd	6.53 ab	5.95 bc	5.97
Average	5.52	6.27	6.17	(+)

Remarks: The average treatment combination followed by the same letters in both rows and columns shows no significant difference based on DMRT at 5% significance levels, and (+) = Significant interaction occurs.

9.6. Leaf area index

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There was a significant interaction between weed weeding method and soil type on the leaf area index. The results of the test differences between the treatment combinations of weed weeding methods and soil types based on the DMRT at a 5% significance level on the leaf area index can be seen in Table 6.

Table 6. Effect of mechanical weed control and soil types on leaf area index (LAI) per clump.

Soil types	Weed control			Average
	Weedy	Hand weeding	Tool weeding	
Coastal sand	4.39 bc	5.15 a	4.28 bcd	4.60
Latosol	3.80 cd	4.78 ab	3.81 cd	4.13
Volcanic	3.70 cd	3.13 d	3.22 d	3.35
Regosol	4.19 bcd	3.30 d	3.51 cd	3.67
Average	4.02	4.09	3.71	(+)

Remarks: The average treatment combination followed by the same letters in both rows and columns shows no significant difference based on DMRT at 5% significance levels, and (+) = Significant interaction occurs.

The combination of hand weeding treatment in coastal sandy soil (Table 6) causes a higher leaf area index. Coastal sand can support a top leaf area index because horticultural crops are better suited to growing on soil that has proper soil aeration. The lowest leaf area index occurs in volcanic soils, which are followed by tool weeding. Low soil fertility causes a little leaf area index even though there is no competition with weeds.

Leaf area index is the ratio of leaf surface area to the area of land occupied or overshadowed by the plant canopy: the high and low leaf area index associated with a dry weight of leaf formed in plant organs. The higher the leaf area index, to a certain extent, will determine the ability of light absorption by plant leaves. The more light is captured. The photosynthesis process will run well and produce more carbohydrates. Carbohydrates produced will be used for plant tissue growth and replenishment of mungbean seeds. LAI was reflecting the amount of light interception by plants. The stem also intercepts light, but photosynthesis is more effective in the leaves. The leaf area index increases with increasing light intensity to the maximum extent the plant catches the sunlight.

4.7. Seeds dry weight per hectare

There was a significant interaction between weed control and soil types dry seed weight per hectare. The results of the differences between the combinations of weed control treatments and soil types based on the DMRT test at a 5% significance level of the seeds dry weight per hectare can be seen in Table 7. The highest seeds dry weight of mungbean per hectare (Table 7) occurred in the combination of weed extraction treatment in coastal sandy soils, but not significantly different between hand or tool weeding on latosol, and regosol soil. The seeds dry weight decreases in a weeded plant in coastal sand, latosol, and regosol soils. The lowest dry seed yield per hectare occurs in latosol soils. A different thing occurs in volcanic soils. Tool weeding gives the same dry seed yields as a planted weed. Removal of weeds in

coastal sand, latosol, volcanic, and regosol soil can increase the yield of mungbean by 55.7; 127.1; 1.5; and 28.7%, while weeding was 8.9; 128.8; 12.5; and 35.1% compared to weeded plants. According to Mahendra et al. [23], state that tool weeding can increase the pod weight compared to without weeding (weedy).

The presence of weeds in coastal sand, latosol, or regosol is closely related to the dry weight of seeds per hectare. The higher weed density decreased in the dry weight of seeds per hectare. The yield reduction is very significant in latosol soils compared to coastal sand, volcanic, or regosol sandy soils. The highest dry weight of seeds was obtained from weed control by removing weeds from coastal sand. Weed control methods by tool weeding the land on coastal sandy soils cause the dry weight of seeds per hectare to decrease. Soil flooding causes pores on the surface of the sand to open up as a result of the process of evaporation of water from the ground surface.

Weed control on volcanic soil does not affect at all on both the weed crop and tool weeding of the dry weight of mungbean seeds per hectare. Seen in this type of soil weed growth is not as high as that occurs in coastal sand, latosol, or regosol soils. Volcanic soil is composed dominated by cashier sands in small amounts compared to other soil types. Carrying capacity of the land against the growth of weeds and mungbean plants is very low because of the low nutrient content that is owned.

Table 7. Effect of mechanical weed control and soil types on seeds dry weight (tons/ha).

Soil types	Weed control			Average
	Weedy	Hand weeding	Tool weeding	
Coastal sand	1.61 cd	2.51 a	1.75 b	1.96
Latosol	1.00 d	2.28 ab	2.29 a	1.86
Volcanic	1.39 cd	1.41 cd	1.56 cd	1.45
Regosol	1.75 bc	2.25 a	2.36 a	2.12
Average	1.44	2.11	1.99	(+)

Remarks: The average treatment combination followed by the same letters in both rows and columns shows no significant difference based on the DMRT at 5% significance levels, and (+) = Significant interaction occurs.

4. Conclusions

Based on the results of the analysis and discussion above, it can be concluded that the presence of weeds in various soil types causes a decrease the growth and yield of mungbean plants, except on volcanic soils. Weed control by hand weeding in coastal sand gives higher yields than tool weeding. Mungbean yields increased in coastal sand, latosol, volcanic, and regosol soils by hand weeding, respectively 55.7; 127.1; 1.5; and 28.7%, and the tool weeding by 8.9; 128.8; 12.5; and 35.1% compared to the weedy plant. The high yield of mungbean should be done on coastal sandy soil during the rainy season because the water needs are extensive due to evaporation.

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