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CRITICAL PERIOD OF SHALLOTS (*Allium ascalonicum* L.) VARIETY SUMBU MARAPI DUE TO COMPETITION WITH WEEDS ON GROWTH AND YIELD

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Abstract

Shallots are a leading horticultural commodity in high demand in Indonesia. Efforts to increase shallot production include the use of superior varieties and improvements in cultivation techniques. The Sumbu Merapi variety is one of the prominent local varieties of West Sumatra. External factors influencing reduced onion production include Plant Pests and Diseases (PPD), one of which is weeds. The presence of weeds has a significant impact on the yield and quality of shallots. This study aimed to determine the critical growth period of the Sumbu Merapi shallot variety when competing with weeds, affecting growth and yield. The study was conducted from April to July 2024 at the Experimental Garden and Seed Technology Laboratory of the Faculty of Agriculture, University of Andalas. A Randomized Block Design (RBD) was applied with six weed-free periods as treatments: 0–20, 20–40, 20–60, 0–40, 40–60 days after planting (DAP), and weed-free until harvest, with three replications. Data were analyzed using analysis of variance (ANOVA) at a 5% significance level, and significant differences were further tested using the Least Significant Difference (LSD) test. Results revealed that the critical period for weed competition in the Sumbu Marapi shallot variety occurred between 20 and 40 DAP, indicating the importance of maintaining weed-free conditions during this phase to optimize growth and yield.

Keywords: horticultural, period, competition, weeds, yield

1. Introduction

Shallot (Allium ascalonicum L.) is one of Indonesia's leading horticultural commodities with promising prospects. It serves as an essential food ingredient, a source of income for farmers, and a contributor to the country's foreign exchange. In addition to being a popular kitchen spice due to its distinctive aroma, shallots also offer various health benefits because they contain enzymes, anti-inflammatory compounds, antibacterial agents, and antioxidants. According to data from the Directorate of Nutrition at the Ministry of Health, every 100 grams of fresh shallot bulbs contain 39 calories, 1.5 grams of protein, 0.3 grams of fat, 0.2 grams of carbohydrates, 36 mg of calcium, 40 mg of phosphorus, 0.8 mg of iron, 603 mg of vitamin B, 2 mg of vitamin C, and 88 grams of water, with an edible portion (EP) of 90%.

The demand for shallots in Indonesia is very high. According to data from Statistics Indonesia (BPS) (2024), national shallot production in 2021 reached 2.01 million tons, but decreased to 1.98 million tons in both 2022 and 2023. Meanwhile, data from the National Food Agency (2023) indicate that shallot consumption reached 2.86 kg per capita per year, a 5.3% decrease compared to the previous year. Yusral (2017) stated that demand for shallots would continue to rise alongside population growth and economic development.

Indonesia is one of the world's largest producers of shallots. National production is dominated by six central provinces, including West Sumatra. In 2023, West Sumatra contributed 233,917 tons of shallots from a total harvest area of 14,033 hectares (BPS, 2023), or about 12% of total national production. This shows there is still an opportunity to increase production in the region.

Various efforts have been made to increase shallot productivity, including the use of superior varieties and improved cultivation techniques. One of the exceptional local varieties from West Sumatra is Sumbu Marapi. This variety has a relatively short harvest period, approximately 60 days for consumption and 70 days for seeds. Additionally, the bulbs are medium-sized, with attractive colors, and they grow in tiers. The Sumbu Marapi variety is also recognized for its high productivity, yielding up to 15.75 tons per hectare.

Shallot production can also be increased by managing plant pests and diseases (PPD), including weeds. Weeds are the primary competitors of plants in competing for resources such as water, nutrients, light, air, and growing space. Umiyati and Widayat (2017) noted that the presence of Pests, including weeds, is one of the leading causes of reduced horticultural crop production. Competition with weeds can lead to reduced crop yield and quality, depending on the type, density, duration of competition, and allelopathic compounds produced by weeds (Kastanja, 2015; Violic, 2000).

Weed control is typically achieved through weeding, especially during the early stages of plant growth. Weeds that grow earlier can cause significant losses. If left uncontrolled, weeds can reduce onion yields by up to 38.26% due to direct competition and serving as alternative hosts for pests and plant diseases (Buthia et al., as cited in Sebayang & Ulya, 2022). Some common weed species found in onion fields include Amaranthus spinosus, Portulaca oleracea, Cynodon dactylon, Cyperus rotundus, Imperata cylindrica, Echinochloa colona, Panicum repens, and Eleusine indica (Moenandir, 2010).

The presence of weeds is critical during the early stages of plant growth. The critical weed-free period is when plants are susceptible to weed competition, and if they are not freed from weeds at that time, plant growth and yield will be disrupted. Conversely, if plants are free from weeds during the critical period, growth can proceed optimally even if weeds appear later.

Previous research has shown that weeding throughout the entire growth phase yields results equivalent to weeding only during the critical period (Fadhillah et al., 2018). Murthy, Fathima, and Vidya (2009) reported that the critical competition period between shallot plants and weeds occurs between 20 and 55 days after planting (DAP). Abdillah et al. (2016) noted that shallots are susceptible to weeds at 20–40 DAP, while Gumelar and Saputra (2021) stated that the critical period is between 28–42 DAP.

Based on this background, this study aims to determine the critical period of competition between Sumbu Marapi onion plants and weeds in terms of plant growth and yield.

2. Materials and Methods

This study was conducted from April to July 2024 at the Experimental Farm of the Faculty of Agriculture, Andalas University, Padang, located at an altitude of approximately 250 meters above sea level. The materials used consisted of shallot bulbs of the Sumbu Marapi variety, cow manure, fertilizer (urea, TSP, KCl, ZA), dolomite, pesticides (propineb 70%), an adhesive agent (Alkyl Polyglycoside 60%), and water. The equipment included a shovel, measuring tape, ruler, knapsack sprayer, knife, raffia rope, label paper, brown paper, measuring cup, wooden stakes, a Belgian auger, plastic, a tractor, standard pole, a digital scale, calipers, an oven, a digital camera, and other standard stationery.

This study employed a one-factor Randomized Block Design (RBD) with treatment based on different weed-free periods. The treatment levels were as follows: weed-free from 0–20 days after planting (DAP), 20–40 DAP, 20–60 DAP, 0–40 DAP, 40–60 DAP, and weed-free until harvest. Each treatment was

replicated three times, resulting in a total of 18 experimental units. Each plot consisted of 49 plants, from which seven were randomly selected as observation samples.

The research procedure included a series of stages, starting from weed vegetation analysis before soil preparation, soil analysis, land preparation and cultivation, liming and basal fertilization, installation of labels and standard stakes, seedling preparation, planting, application of weeding treatments according to the level, plant maintenance, and harvesting and drying of tubers. Weed vegetation analysis was conducted before soil preparation using the quadrat method. Ten observation plots, each measuring 40 × 40 cm, were randomly created using raffia rope tied to wooden stakes with a diameter of approximately 4 cm, which were driven into the soil. Weeds within the plots were carefully removed, identified by type, and their numbers recorded. The collected weeds were placed in newspaper envelopes with small holes for steam ventilation, then dried in an oven at 80°C for 24 hours and weighed using digital scales.

Weed removal is carried out according to the treatment level. For example, in the weed-free treatment from 20–40 DAP, weeds are allowed to grow from planting until 19 DAP, then pulled out and analyzed for type and quantity. Next, during the 20–40 DAP period, the plots were routinely cleared of weeds, and after the 40th day, the weeds were again allowed to grow until 60 DAP, then pulled out and observed again. Other treatments used a similar principle according to the specified time. Weeding around the field was also carried out to prevent the spread of plant pests. In practice, weeding was carried out carefully, especially in areas near the plant roots, because shallot roots are shallow and easily damaged by mechanical disturbance.

This study consisted of observations of weeds and shallot plants. Weed observations included identifying the dominant weed species and weighing their dry weight. Observations of shallot plants included plant height, number of leaves, bulb diameter, number of bulbs per clump, fresh and dry weight of bulbs per clump, and fresh and dry weight of bulbs per plot, which were then extrapolated to the dry weight of bulbs per hectare.

The data obtained were analyzed using analysis of variance (ANOVA) at a significance level of 5%. If the analysis results showed significant differences, the study was continued with the Least Significant Difference (LSD) test at the same significance level

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3. Results and Discussion

Weed Observation

Weed Dominance Calculation

Vegetation analysis of weeds conducted before soil preparation revealed nine broadleaf weed species, six grass weed species, and three sedge weed species. Broadleaf weeds include Asystasia gangetica, Mimosa pudica, Richardia scabra L., Spermacoce alata, Moehringia trinervia L., Ageratum conyzoides, Agratis etolonifera, Emilia sonchifolia, and Ocimum tenusflorum. Grasses include Digitaria sanguinalis L., Juncus effusus L., Eulisine indica L., Brachiaria mutica, Imperata cylindrica, and Setaria barbata. Sedges include Cyperus rotundus, Cyperus aromaticus, and Cyperus compressus.

The most dominant weeds before soil preparation were grass weeds. This type of weed dominated the study area and was frequently found in every plot. The grass weed species with the highest dominance level is Digitaria sanguinalis L. Grass weeds belonging to the Poaceae family have jointed stems, some of which grow upright and others creep along the ground. Their stems are hollow, their leaves are lanceolate-linear, their growth points are hidden, and they have fibrous roots (Sarangi, 2021).

Poaceae belongs to the class Liliopsida and is commonly found in tropical and subtropical regions. This adaptable weed enables it to survive in a range of conditions, including humid, dry, and waterlogged environments. Most grass weeds reproduce through generative organs, such as seeds, and vegetative organs, including stolons or rhizomes, thereby falling into the category of annual weeds. However, a small portion of grass weeds only have reproductive organs in the form of seeds, and are therefore classified as annual weeds.

Weed vegetation analysis on each treatment showed 17 broadleaf weed species, three grass weed species, and one sedge weed species. Broadleaf weeds include Asystasia gangetica, Mimosa pudica, Richardia scabra L., Spermacoce alata, Ageratum conyzoides, Emilia sonchifolia, Ipomoea nil, Cleome rutidospermae, Oxalis barrelieri, Melochia corchorifolia L., Stachytarpheta indica, Phyllanthus niruri, Arisarum vulgare, Oldenlandia corymbosa L., Synedrella nodiflora, Euphorbia maculata, and Ludwigia octovalvis. Weeds classified as grasses include Brachiaria mutica, Imperata cylindrica, and Setaria barbata. Weeds classified as sedges include Cyperus rotundus.

Of the 21 types of weeds present, the dominant weed in each treatment was the broadleaf weed Richardia scabra L. Broadleaf weeds are a type of weed characterized by growing upright, being either herbaceous or woody, with visible growth points, and belonging to the dicotyledonous group with taproots. Most broadleaf weeds reproduce solely through generative organs in the form of seeds, thus classifying them as annual weeds. However, some weeds also possess additional reproductive organs in the form of vegetative organs, which enable them to become perennial weeds. These weeds' seeds and vegetative organs are often found in the soil from the previous season. They are brought to the surface during soil preparation, germinating when they receive sufficient

water and sunlight (Putra et al., 2018). In addition, broadleaf weeds have a taproot system that makes them more robust than grass and sedge weeds, allowing broadleaf weeds to dominate the land (Jumatang et al., 2020).

The Summed Dominance Ratio (SDR) of weeds before soil preparation shows that the SDR value of Digitaria sanguinalis L. is higher than that of other weed species. This occurs because the higher the SDR value of a weed species, the greater its competitive ability against other species. This aligns with Sutriyono et al., as cited in Harahap (2022), who stated that the higher the SDR value of a species, the greater its ability to dominate biotic and abiotic factors in its environment. The weed SDR values are presented in Table 1.

Table 1. Weed SDR values on experimental land before cultivation and during the weed-free period

NO.	Name of Weeds	SDR (%) value of weeds before soil cultivation	Weed SDR value during weed-free period (%)				
			(0-20 DAP)	(20-40 DAP)	(20-60 DAP)	(0-40 DAP)	(40-60 DAP)
1.	*Digitaria sanguinalis* L	26,65	11,00	9,99	10,07	10,76	10,45
2.	*Cyperus rotundus*	5,57	7,21	12,76	12,87	9,23	11,17
3.	*Cyperus aromaticus*	1,65	-	-	-	-	-
4.	*Asystasia gangetica*	1,80	-	-	-	-	2,18
5.	*Mimosa pudica*	2.07	4,75	3,97	4,03	7,62	4,78
6.	*Richardia scabra* L.	9,05	15,94	20,78	20,94	16,27	18,58
7.	*Juncus effusus* L.	1,64	-	-	-	-	-
8.	*Spermacoce alata*	4,69	3,09	-	1,90	1,14	-
9.	*Moehringia trinervia* L.	6,12	-	-	-	-	-
10.	*Eulisine indica* L.	3,32	-	-	-	-	-
11.	*Cyperus compressus*	1,56	-	-	-	-	-
12.	*Ageratum conyzoides*	3,93	8,92	8,87	8,96	8,49	9,16
13.	*Agratis etolonifera*	2,18	-	-	-	-	-
14.	*Imperata cylindrica*	17,43	-	1.03	1,05	-	2,42
15.	*Emilia sonchifolia*	2,75	1,39	2,80	2,85	0,97	2,72
16.	*Setaria barbata*	6,90	12,27	-	3,46	2,46	12,67
17.	*Ocimum tenusflorum*	1,60	-	-	-	-	-
18.	*Ipomea nill*	-	4,34	3,51	3,56	3,49	3,28
19.	*Brachiaria mutica*	1,08	5,74	8,25	8,33	6,81	7,81
20.	*Cleome rutidospermae*	-	7,27	4,71	4,77	7,08	4,61
21.	*Oxalis barrelieri*	-	4,40	-	1,03	3,61	-
22.	*Melochia corchorifolia* L.	-	1,29	-	-	1,40	2,10
23.	*Stachytarpheta indica*	-	1,09	-	-	-	-
24.	*Phyllanthus niruri*	-	7,79	-	7,86	14,02	3,36
25.	*Arisarum vulgare*	-	0,97	3,22	3,27	2,42	1,20
25.	*Oldenlandia corymbosa* L.	-	2,54	1,90	1,93	2,88	2,58
26.	*Synedrella nodiflora*	-	-	1,82	1,84	0	-
27.	*Euphorbia maculata*	-	-	-	1,27	1,35	-
28.	*Ludwigia octovalvis*	-	-	-	-	-	0,93

Weed identification observations during several weed-free periods showed changes in weed composition. Changes in weed species composition will always occur with each weed control treatment, especially if the weed control treatment alters the ecological balance (weed growth) (Sukman & Yakup, 1995). Weed observations conducted during several weed-free periods identified 21 weed species.

The weed Richardia scabra L. showed the highest SDR value compared to other weed SDR values. This negatively impacts the growth and yield of shallot plants. The presence of weeds with high SDR values causes shallot plants to receive insufficient light. This can lead to etiolation, characterized by faster plant growth, susceptibility to lodging due to thin and weak stems, and inadequate leaf development.

Changes in weed composition are caused by soil cultivation, as stated by Sembodo (2011), who states that weeds can adapt well to environments disturbed by humans. Weeding frequency also influences shifts in weed species (Setyowati et al., 2005), and changes in weed dominance can be influenced by soil conditions, climate, and seed dormancy levels. Weeds thrive in suitable soil, and the emerging weed species are

likely derived from a seedbank influenced by soil cultivation and environmental conditions after cultivation, as stated by Setyowati et al. (2005).

Weed Dry Weight

Weed dry weight is an accurate measure for predicting the nutrients absorbed by weeds. Based on the results of the variance analysis, it can be seen that the weed-free period has a significant effect on weed dry weight. The analysis results are presented in Table 2 below:

Table 2. Dry Weight of Weeds in Shallot Crops Due to Competition with Weeds

Weed-Free Period (DAP	Weight of Dry Weeds (g)	
0-20	16,11	a
20-40	1,21	b
20-60	3,07	b
0-40	1,95	b
40-60	22,25	a
Weed-free until harvest	0,00	b
KK = 29,95%		

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT post hoc test at the 5% significance level. (Data transformed using log x+1) HST = days after planting.

In Table 2, the weed-free period treatments of 0-20 DAP and 40-60 DAP show different effects compared to other treatments. During these periods, environmental conditions such as light, water, and nutrients are more favorable for weeds to grow faster and larger, resulting in a higher dry weight. In the weed-free period treatment from 0-20 DAP, it can be confirmed that weed growth rates increase, leading to faster weed coverage in the weed-planted area. Although weeds are absent in the early growth phase, once allowed to regrow until harvest, weeds have sufficient time to develop and grow large.

This is what causes the dry weight of weeds to be higher, as indicated by a high SDR value, because weeds have more time to grow and compete for light, water, and nutrients. The high dry weight of weeds during this period indicates that weeds can grow and develop rapidly once allowed to regrow after the initial weed-free period. High weed density is offset by an increase in weed dry weight as the weeds' growth time increases (Latifa et al., 2015). This situation will reduce the dry weight of shallot bulbs, as shown in Table 7.

During the weed-free period of 20–40 DAP, weeds were controlled during growth, where competition with weeds affected onion yields. When weeds were controlled during this period, onion plants could grow without significant disruption during the onion growth phase. After this period, although weeds regrew, the onion plants were already strong enough to compete with the regrowing weeds, so the dry weight of weeds remained lower. This period also shows results that are not significantly different from those of the weed-free period until harvest (as shown in Table 10). Weeds that grow afterward do not have the opportunity to grow rapidly because the onion plants are already more dominant.

Reducing weed presence during the critical period is crucial for maintaining the quantity and quality of onion harvest yields. Moenandir (2010) states that one-third of the crop's lifespan is sensitive to weed competition, which can lead to significant yield reductions. Research shows that weed-free treatment 20–40 days after planting (DAP) is nearly equivalent to weed-free treatment until harvest, indicating that maintaining onion plants weed-free during this period can yield different production levels from weed-free treatment until harvest. His research also shows that the critical period for shallots occurs between 28 and 42 days after planting. During the early stages of growth, plants are highly susceptible to competition. Diverse and competitive weeds can severely hinder crop growth if not managed properly.

Plant Height

Based on the results of the variance analysis, it can be seen that the weed-free period had no significant effect on plant height, as shown in Table 3.

Table 3. Height of shallot plants at several weed-free periods at 42 days after planting

Weed-Free Period (DAP)	Plant Height (cm)
0-20	31,98
20-40	34,76
20-60	34,55
0-40	32,48
40-60	34,73
Weed-free until harvest	37,62
KK = 9,89%	

Note: Figures in the same column are not significantly different according to the F-test at the 5%

Table 3 shows that the height growth of shallots has the same effect on all weed-free periods. This indicates that the weeding period has no significant impact on the height growth of shallots. This allows weeding during the shallot growth period to produce the same response because the need for growing space, light, water, and nutrients is met, so there is no competition between plants and weeds.

The adaptability and ability of the Sumbu Marapi onion variety to dominate the planting space are relatively fast. This characteristic allows plant height growth to remain optimal even as weed populations increase. According to Wahyudin et al. (2017), the main crop will grow tall if it can quickly dominate sunlight, preventing weeds from competing with the main crop. Another study using the same plant genus showed that weed control over multiple periods had no significant effect on plant height growth onion (Kusmiadi et al., 2015).

The average plant height across all weed-free periods showed consistency because the same variety, Sumbu Marapi, was used. However, the height of shallot plants exceeded the Sumbu Marapi variety criteria, which range from 25.46 to 29.38 cm. Differences in plant height are influenced by the intensity of light received by the plants and are related to plant hormones, specifically auxin. Pantilu et al. (2012) state that plants growing under shade receive lower light intensity, so auxin hormones are not damaged. The growth rate of shallot plant height at 14–42 days after sowing (DAS) due to weed competition can be seen in Figure 1.

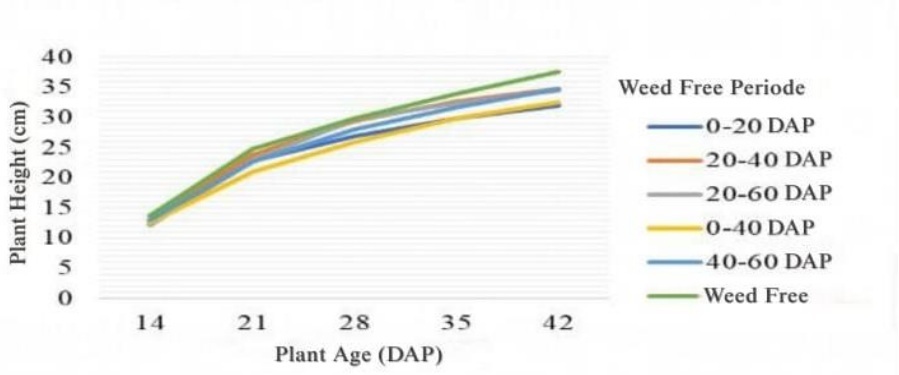


Figure 1: Growth rate graph of onion plants aged 14–42 days after planting

Based on Figure 1, it can be seen that the growth rate of onion plants due to competition with weeds in all treatments increased weekly. During the weed-free period from 0 to 40 HST, the plant height from 14 to 28 HST showed the lowest value compared to other weed-free treatment periods. Conversely, from 35 to 42 HST, the plant height decreased, followed by a decrease from 0 to 20 HST. During the weed-free period until harvest, plant height increased by approximately 1 cm per week. This is because shallot plants do not face competition from weeds, so during the growth period, the shallot's needs for growing space, light, water, and nutrients are well met.

The height of shallot plants reflects the distinct characteristics or genetics of each variety. Bari et al. (in Kartinaty et al., 2019) added that environmental factors can influence the appearance of a variety. Several genetic and environmental factors are closely related and cannot be separated. If ecological factors support plant growth, the plant will appear optimistic.

Number of Leaves

Based on the results of the variance analysis, it can be seen that the weed-free period had no significant effect on the number of leaves, as shown in Table 4.

Table 4. Number of shallot leaves at several weed-free periods at 42 days after planting.

Weed-Free Period (DAP)	Number of leaves (pieces)
0-20	23,34
20-40	24,09
20-60	21,48
0-40	21,62
40-60	21,24
Weed-free until harvest	24,81
KK = 16,86%	

Note: Figures in the same column that differ are insignificant according to the 5% significance level of the F-test. DAP = days after planting

The weed-free period did not significantly affect the average number of leaves. This is because the ability of shallot plants to absorb nutrients and water from the soil may be more influenced by the root system than by the number of leaves. If the shallot root system is strong and can absorb nutrients efficiently, the plants can survive better in the face of competition from weeds, even though the number of leaves does not change significantly. If the plants can overcome weed competition during the early phase and then adapt to denser weed conditions in the subsequent phase, the number of leaves can remain consistent despite some weed-free periods. The process of leaf formation in shallot plants requires sufficient nutrients; if the nutrients in the soil are adequate, this can stimulate the growth of new leaves (Siregar, 2017).

Based on Table 4, the Sumbu Marapi onion variety showed optimal leaf growth during weed-free periods, with an average leaf count ranging from 21.48 cm to 24.81 cm. However, this leaf count was lower than the variety description criteria, which range from 28.00 to 44.85 leaves. This indicates that leaves, as a vegetative part, are less affected by resource competition, such as light or water. Shallot plants have a specific adaptive ability to maintain leaf number despite competition with weeds. Also, leaves grow earlier in the plant's life cycle and are more tolerant of weed pressure. The growth graph of the number of onion leaves at 14–42 days after planting due to weed competition can be seen in Figure 2.

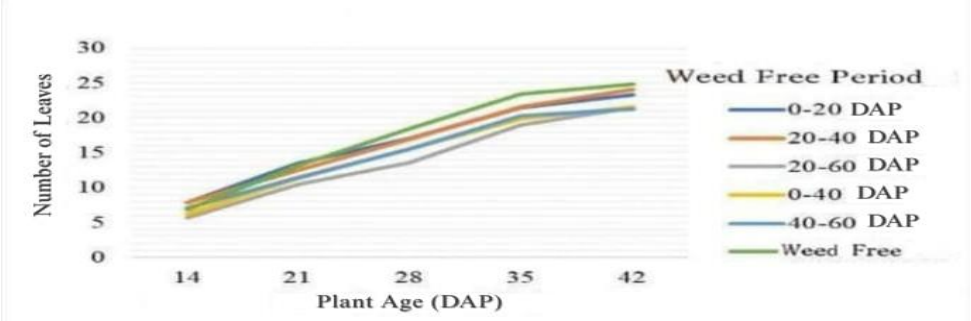


Figure 2. Graph showing the growth rate of leaves aged 14-42 days after planting in shallot plants.

Figure 2 shows that the growth rate of shallot leaves due to competition with weeds in several periods experienced a relatively similar increase each week. During the weed-free period from 20 to 60 HST at the age of 21 to 28 HST, there was a decrease in the number of leaves due to damage caused by pests. The weed-free period and the weed-free period from 20 to 40 HST showed the highest number of leaves compared to other treatments. Although the weekly increase in leaf number was not significant, the graph shows that during the weed-free periods of 20–60 HST and 40–60 HST, weeds absorbed nutrients, growing space, water, and light more quickly than shallot plants, thereby inhibiting leaf formation and potentially affecting shallot bulb development.

Bulb Diameter

Based on the results of the analysis of variance, it can be seen that the weed-free period has a significant effect on the bulb diameter of shallots, as shown in Table 5.

Table 5. Diameter of shallot bulbs at several weed-free periods

Weed-Free Period (DAP)	Tuber Diameter (cm)
0-20	2,94 bc
20-40	3,37 ab
20-60	2,72 c
0-40	2,63 c
40-60	2,70 c
Weed-free until harvest	3,62 a
KK = 11,42%	

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT post hoc test at the 5% significance level. DAP = days after planting

Table 5 shows that the weed-free period until harvest yields different results than other periods, but the results are similar to the 20-40 HST weed-free period. The 0-20 HST weed-free treatment is not significantly different from the 20-60 HST, 0-40 HST, and 40-60 HST treatments. When plants have sufficient resources, more energy is used to enlarge the bulbs rather than increase the number of bulbs, as plants prioritize bulb quality and size for energy and nutrient storage. Conversely, plants tend to produce more small bulbs if resources are limited. Nurjannah (2003) explains that water stress, temperature, light, or nutrient deficiency can disrupt the relationship between resources and yield.

Furthermore, the weed-free period until harvest provides optimal conditions for shallot growth; however, if weeds are effectively controlled during the 20–40 HST weed-free period, the plants have already obtained sufficient resources during the growth phase without competition from weeds. Therefore, even though weeds may regrow after 40 HST, their impact on bulb diameter is insignificant because the critical phase has passed, and the shallot plants are already strong enough to withstand such competition.

Onion bulbs have high economic value, and the bulb filling process is influenced by several factors, such as nighttime temperature, irrigation, mineral nutrition, and competition with weeds (Pangestuti et al., 2022). Weeding can increase bulb size by almost double compared to without weeding, so it is essential to maintain the quality of shallot crop yields.

Number of Bulbs per Clump

Based on the results of the variance analysis, it can be seen that the weed-free period has a significant effect on the number of bulbs per clump of shallots, as shown in Table 6.

Table 6. Number of shallot bulbs in several weed-free periods

Weed-Free Period (DAP)	Number of tubers (fruits)
0-20	4,81 bc
20-40	5,19 ab
20-60	4,72 bc
0-40	4,76 bc
40-60	4,43 c
Weed-free until harvest	5,76 a
KK = 6,88%	

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT post hoc test at the 5% significance level. DAP = days after planting

Table 6 shows that the weed-free period until harvest has a different effect on other treatments, but has the same effect as the 20-40 HST weed-free period treatment. This is because this period is a critical time for shallots. During this period, shallots are in an intensive vegetative growth phase, during which leaf formation and early bulb formation occur. Additionally, during this period, weeds are believed to no longer significantly impact bulb formation because shallots can grow without competition, allowing for optimal development, including bulb formation and increased bulb count. Abdillah et al. (2016) reported that weeds allowed to grow for an extended period can reduce the number of shallot bulbs.

The Sumbu Marapi variety used in this study should produce 11.15–21.85 bulbs per clump. However, the research showed that the number of bulbs produced was lower than the variety description because weeds compete with shallots for water, nutrients, light, and growing space. If weeds are not controlled, onion plants do not get enough resources to develop optimally, decreasing the number of bulbs produced. Although onion plants inhibited by weeds can still produce bulbs, the quality of the bulbs will be

different compared to plants that grow free of weeds (Alipour et al., 2022).

Fresh Weight of Tubers per Clump

Based on the results of the variance analysis, it can be seen that the weed-free period has a significant effect on the fresh weight of tubers per clump of shallots, as shown in Table 7.

Table 7. Fresh weight of bulbs per clump of shallot plants in several weed-free periods

Weed-Free Period (DAP)	Fresh weight (g)
0-20	33,57 bc
20-40	47,19 ab
20-60	45,24 ab
0-40	46,28 ab
40-60	27,90 c
Weed-free until harvest	54,43 a
KK = 18,15%	

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT post hoc test at the 5% significance level. DAP = days after planting.

In Table 7, the weed-free period until harvest shows a different effect compared to the weed-free periods of 0-20 HST and 40-60 HST, but has the same effect as the periods of 20-40 HST, 20-60 HST, and 0-40 HST. This is due to the ability of shallot plants to adapt to competition with weeds if weeds are controlled during the critical period. When weed control is effective during the crucial period, shallot plants can adapt and maximize their growth during the remaining time. The weed-free period from 20 to 40 HST shows no significant difference in results because weeds are controlled during bulb growth. After this period, although weeds regrow, onion plants are strong enough to compete, resulting in a lower dry weight of weeds.

The average fresh weight of bulbs per onion clump ranged from 27.90 to 54.43 grams per clump. The average fresh weight of bulbs per clump across various weed-free periods did not meet the criteria for the Sumbu Marapi variety, which is 150.15–194.85 grams (Appendix 2). It is suspected that different weed control timings can result in different yields. Weed control timing can reduce weed growth, thereby decreasing competition between shallot plants and weeds for growing space, water, light, and nutrients. This aligns with Indriyani's opinion in Loleh et al. (2018), where plants relatively free from weeds experience lower competition for light, water, and growing space, enabling higher yields.

Dry Weight of Tubers per Clump

Based on the results of the variance analysis, it is evident that the weed-free period has a significant impact on the dry weight of tubers per clump of shallot plants, as shown in Table 8.

Table 8. Dry weight of tubers per clump of shallot plants in several weed-free periods

Weed-Free Period (DAP)	Dry weight (g)
0-20	30,63 bc
20-40	42,69 ab
20-60	41,18 ab
0-40	41,69 ab
40-60	25,20 c
Weed-free until harvest	57,88 a
KK = 18,20%	

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT post hoc test at the 5% significance level. HST = days after planting.

Table 8 shows that the weed-free period until harvest has a different effect compared to the weed-free periods of 0-20 HST and 40-60 HST, but is not significantly different from the other weed-free periods. This causes the appearance of shallot plants to seem unaffected by biotic stress due to the presence of weeds. However, upon further examination, the plants experience disruptions in the assimilation process due to weeds. According to Korav et al. (2018), the presence of weeds in the planting area can reduce the dry weight of cultivated plants. This dry weight reflects the accumulation of assimilates obtained by the plants during their growth period (Wang et al., 2021).

During the weed-free periods of 0-20 HST and 40-60 HST, the dry weight was low, likely due to the weed control conducted during those periods, which would have faced intense competition from weeds during their growth. This competition can reduce the dry weight of shallot plants because the plants do not receive sufficient resources to grow optimally. Meanwhile, the weed-free period from 20 to 40 HST yielded the best dry weight of plants after the weed-free period until harvest compared to the weed-free periods from 20 to 60 HST and 0 to 40 HST because the plants began to grow faster and stronger, enabling them to better compete with weeds for resources. As a

result, weed growth is inhibited during this period, resulting in lower dry weight of weeds.

Suneth et al. (2020) state that bulb weight loss is related to the timing and criteria for harvesting shallots, which should be done when 90% of the leaves have turned yellow and the bulb neck has softened. At this stage, photosynthesis decreases, and the photosynthetic product plays a role in bulb filling. According to the description of the Sumbu Marapi variety, the fresh bulb weight loss is approximately 30%. However, in treatments competing with weeds, fresh bulb weight loss does not reach 30% because, by the time of harvest at 70 HST, the field is already dry, leading to respiration that reduces the water content of the shallot bulbs.

Fresh Weight of Tubers per Plot

Based on the results of the variance analysis, it is evident that the weed-free period has a significant impact on the fresh weight of tubers per plot of shallot plants, as shown in Table 9.

Table 9. Fresh weight of tubers per plot of shallot plants in several weed-free periods

Weed-Free Period (DAP)	Fresh weight of tubers (kg)
0-20	0,7896 bc
20-40	1,1270 ab
20-60	1,0266 ab
0-40	1,1233 ab
40-60	0,6130 c
Weed-free until harvest	1,2066 a
KK = 21,98%	

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT post hoc test at the 5% significance level. DAP = days after planting.

Dry tuber production per experimental unit shows differences in the ability of plants to absorb nutrients during growth. As shown in Table 9, the weed-free period until harvest has a different effect compared to the weed-free periods of 0-20 HST and 40-60 HST, but it does not differ significantly from the other weed-free periods. The weed-free period from 20 to 40 HST is believed to be sufficiently effective for achieving optimal growth, resulting in fresh weight yields of shallot plants that are not significantly different from those of the weed-free period until harvest. In other words, the weed-free period from 20 to 40 HST is sufficiently effective for reducing the negative impact of weeds and achieving optimal crop yields.

Generally, the fresh weight of onion plants tends to decrease as the dry weight of weeds increases due to increased competition for resources (nutrients, light, and water). The dry weight of weeds during the weed-free period of 20–40 HST is relatively low compared to other periods. This indicates that weeds are effectively controlled during this period. This means that competition between weeds and onion plants for resources such as water, light, and soil nutrients is minimal. These conditions support optimal onion growth without significant interference from weeds.

Jamilah (2013) states that if food reserves are available in the soil, weeds will not affect mature plants, thus preventing competition with weeds. Eleni (2013) adds that plant growth and yield will increase if nutrients are well available. Competition between weeds and plants for nutrients and sunlight can cause a decline in appearance in specific parts or the entire plant (Sitepu et al., 2013).

Dry Weight of Tubers per Plot and per Hectare

Based on the analysis of variance results, it is evident that the weed-free period significantly affects the dry weight of tubers per plot and hectare of shallot plants, as shown in Table 10.

Table 10 shows that the dry weight of bulbs per plot and hectare during the weed-free period, from harvest to the end of the experiment, had a different effect compared to the weed-free periods of 0-20 HST and 40-60 HST, but had the same effect as the other periods. The dry weight of bulbs per plot and hectare during the weed-free period, from harvest to the end of the season, yielded the highest results compared to other periods, followed by the weed-free period of 20-40 HST. This is likely because the weed-free period until harvest was free of weeds, so the onion plants did not compete with weeds for space, water, light, and nutrients.

Table 10. Dry weight of bulbs per plot and hectare of shallot crops in several weed-free periods

Weed-Free Period (DAP)	Dry Weight of Tubers per Plot (kg)	Dry Weight of Tubers per Hectare (tons)
0-20	0,6981 Bc	4,85 bc
20-40	1,0000 ab	7,05 ab
20-60	0,9325 ab	6,48 ab
0-40	0,9849 ab	6,84 ab
40-60	0,5374 C	3,73 c
Weed-free until harvest	1,0946 a	7,60 a
KK = 22,69%		

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT post hoc test at the 5% significance level. DAP = Days After Planting.

During the weed-free period of 20-40 days after sowing, the dry weight of shallots was higher than after the weed-free period until harvest. This is likely because the dry weight of weeds during this period was lower due to weeding during the critical phase of shallot growth, so that the dry weight of shallots tended to increase. This statement aligns with the findings of Kusmiadi et al. (2015), who stated that weed-free plants exhibit better growth than those growing alongside weeds.

The onion bulb yield, as described in the production per hectare of 29.74 tons per hectare, is lower than the average dry weight obtained from this study. The low onion yield is attributed to the difference in environmental conditions between the midland area, where the Sumbu Merapi variety is typically grown, and the lowland area where this experiment was conducted. Although the Sumbu Merapi variety of shallot can still grow in lowland areas, its yield does not meet the variety description due to the shallot plant's adaptation to different environmental conditions.

The environment can influence variations in plant characteristics, and continuous changes in conditions often result in reduced productivity or even plant death. Rolenzah (2013) states that shallots have poor competitive ability against weeds, due to slow growth, short plant height, non-branching structure, small leaf size, and shallow root system. A large number of weeds during the growth phase can reduce crop yield.

4. Conclusions

The results demonstrated that the critical period of weed competition for the Sumbu Marapi shallot variety occurs between 20 and 40 days after planting (DAP). Weed growth during this interval exerts the most significant adverse effect on plant growth and yield compared with other growth stages. Hence, maintaining weed-free conditions between 20 and 40 DAP is crucial for preventing yield losses and achieving optimal crop performance.

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