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Determination of Critical Periods of Soybean cv. Dema 2 Against Weeds in The Dry Season

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Abstract. Though labor-intensive and expensive, weeding is the safest method of controlling weeds. So, to effectively and timely pull weeds, one must be aware of the critical period during which soybean plants are protected from weeds. This study aimed to determine the impact of weeding time on soybean development and production as well as weeds' critical period. From September to December 2023, the studies were conducted in Mekarjaya Village, Gantar District, and Indramayu Regency. Randomized Complete Block Design (RCBD) was the method used for the investigation. Nine levels of weeding time were examined, including weeds-free, weeding at three weeks after planting (WAP), weeding at four WAP, weeding at five WAP, weeding at six WAP, weeding at seven WAP, and weeding at eight WAP. B9 = not weeded included in the treatment set. A triplicate of each treatment was conducted. According to the results, the timing of the weeding treatment significantly impacted the soybean yield components but not the growth component. As a result of weed competition, the soybean cultivar Dena 2 saw a yield loss of 8.87% to 27% during the crucial period, which was observed to occur at 0-9 WAP.

Keywords: Critical Period, Soybean, Weeding

INTRODUCTION

Soybeans are a crucial crop for providing the necessary protein for communities to have better nutrition. Soy products, including tempeh, tofu, soy sauce, soy milk, and tacos, are processed foods made from soybeans. Soybeans are also processed to create soy flour, which is then used as a raw ingredient to make milk, cakes, and other baked goods (Ministry of Agriculture, 2022; Rohmah & Saputro, 2016).

The presence of weeds in agricultural land regions is one element that can lower production. The type and dominance of weeds that grow among plants vary greatly. According to Umami et al. (2020), weed species with a high degree of dominance can be highly harmful to crops. Most of the time, farmers pull weeds. This process is costly and labor-intensive, yet it is environmentally safe. Herbicides are another method, but they risk polluting the environment and preventing soybean plants from growing properly.

Although they do not always compete with plants over their lives, weeds can significantly impact a plant's ability to thrive during certain times. (Ketut Ngawit & Fauzi, 2021). This is a significant era. Compared to leaving weeds until the plant's generative phase, Korav et al. (2018) research demonstrates that weeding during the vegetative phase significantly boosts plant growth and yield. The outcomes of additional studies demonstrate that the treatment during the weedy and weed-free periods also significantly affects the dry weight of the plants, the number of seeds, the weight of 100 seeds, and the weight of seeds per plot (Yulia et al., 2019).

When weeds need to be controlled to prevent losses in crop yield, this is the critical period for weeds (Abdullah et al., 2016). When determining when to control weeds to prevent growth hindrance and lower soybean crop yields, understanding the vital period soybeans need to withstand weeds is essential. This method increases efficiency in weeding, reducing labor expenditures and expenses.

LITERATURE

According to Puspita et al. (2017), there is intense competition between cultivated plants and weeds when weeds are present among the plants under cultivation. Regarding physiological traits, weeds are preferable since they can swiftly adapt to their surroundings and have solid capacities for germination and pollination. According to Oksari (2014), weeds in the agricultural area disrupt plant life. Additionally, according to Duwadi et al. (2021), weeds are significant rivals of plants for nutrients, light, space, and water. There is rivalry starting at the start of planting and ending shortly before harvest (Padang et al., 2017). As to Gawaksa et al. (2016), certain weeds can create substances known as allelopathic, which can hinder the growth of neighboring plants. According to Christia et al. (2016), weeds pose a threat to major crops and serve as a haven for pests and plant illnesses that can lower crop yield.

There are considerable differences in the types and dominance of weeds that grow amid the plants. According to Umami et al. (2020), weed species with a high degree of dominance can be highly harmful to crops. Nutrients, light, soil processing, plant cultivation techniques, plant density or spacing, and plant age are some of the many variables that affect weed diversity (Tustiyani et al., 2019). The number of specific weeds involved in the competition and the weeds' life cycle are directly correlated with the quantity of food crop output lost due to interference. Plant height and dry weight in soybeans can be decreased by weeds (Christia et al., 2016); yields can even be decreased by up to 50% (Puspita et al., 2017).

When weeds are effectively controlled, cultivated plants can access more growing space, light, and nutrients, leading to increased photosynthate production, plant growth, and yield (Kilkoda, 2017). The timing of weed control is crucial, as longer weed seasons can result in soybean plants having less dry weight (Yulia et al., 2019). Gulotom et al. (2017) found that dry soybean seed weights are lower in areas where soybean plants compete with weeds from the beginning of soybean planting, compared to areas where weeds sprout after the plants emerge for a while.

After planting, the Grobogan and Argomulyo cultivars of soybean plants have a critical time of 0–6 weeks (Puspita et al., 2017). Research conducted by Yulia et al. (2019) revealed that four weeks after planting (WAP), weeds started to drastically lower yields in soybean planting areas. Weeds will drastically lower crop production if they are present during the crucial time. Therefore, the critical period can be determined based on how the weed-free time affects crop production

METHOD

The experiment's operational altitude was thirty meters above sea level in Indramayu Regency's Mekarjaya Village, Gantar District. The research period was from September 2023 through December 2023.

The approach was experimental, utilizing a randomized whole-block design. Vegetable weed weeding time (B) was the treatment under test; there were nine treatment levels in total: B1 = no weeds, B2 = weeding at three weeks after planting (WAP), B3 = weeding at age 4 WAP, B4 = weeding at 5 WAP, B5 = weeding at 6 WAP, B6 = weeding at 7 WAP, B7 = weeding at 8 WAP, B8 = weeding at 9 WAP, and B9 = not weeding.

Planting spacing is 20 cm by 30 cm, and the plot size is 2 m × 2 m. Soil tillage occurs twice: a full 14 days before planting and seven days before planting. During the second tillage, manure is used as a primary fertilizer at a rate of five tons per hectare. NPK Mutiara fertilizer is another ingredient utilized. It is used twice at planting time and once at three WAP, at a dose of 325 kg ha-1.

All of the weeds in the experimental plot were physically pulled out. Except in treatments without weeds, weeding is done weekly and is determined by the treatment. Weed observations were made in two quadrants of each experimental plot. The quadrant is arbitrary in placement and measures 50 cm by 50 cm.

The following parameters were noted: plant height, stem diameter, number of leaves, leaf area index, relative growth rate, shoot-to-root ratio, root length, flowering age, number of pods per plant, one hundred seeds, and grain weight per plot. Observations were made on the weed diversity index, dominance, and density. The formula is used to calculate the density and relative density of weeds.

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$$\text{Density} = \frac{\text{the number of individuals of a type of weed}}{\text{Observation Area Size}}$$

$$\text{Relative Density} = \frac{\text{Density of a type of weed}}{\text{Density of all type of weed}} \times 100\%$$

Dominance and relative dominance of weeds are calculated using the formula:

$$\text{Dominance} = \frac{\text{dry weight of a type of weed}}{\text{Observatioon Area Size}}$$

$$\text{Relative Dominance} = \frac{\text{Dominance of a type}}{\text{Dominance all type}} \times 100\%$$

The weed diversity index is calculated using the formula:

$$H' = \sum p_i \,\text{Ln}\, p_i, \text{ where } p_i = n_i/N$$

Note :
H' = Diversity Index
ni = Number of individuals of type i
N = Number of individuals of all species

The data obtained were analyzed using analysis of variance and Scott Knott cluster test at the 5% level.

DISCUSSION

Expanding Factors

Excluding leaf area index (LAI) at 6 WAP, relative growth rate (RGR) at 5–6 WAP, and shoot root ratio (SRR) at 6 WAP, the statistical analysis findings indicated that weeding time had no significant impact on growth indicators (Table 1). Up to five WAP soybean plants can still compete with weeds, as evidenced by the lack of treatment-related changes. However, the soybean plants' relative growth rate declined after weeding at 6 WAP. The rate at which plant biomass increases in a given area at each stage of plant age is determined using a computation known as relative growth rate, or RGR. Widyaswari et al. (2017) have observed that the RGR value indicates the treatment response that yields the most plant growth.

Table 1. Effect of weeding time on growth variables at 6 WAP

Treatment	Plant Height (cm)	Stem Diameter (mm)	Number of Trifoliate	LAI	RGR ($g.g^{-1}.day^{-1}$)	SRR	Root Length (cm)
B1	51.93 a	5.53 a	20.73 a	1.15 a	0.10 b	16.68 e	29.50 a
B2	48.70 a	5.53 a	19.40 a	1.11 a	0.08 b	16.78 e	27.83 a
B3	46.73 a	5.30 a	18.33 a	0.90 a	0.08 b	16.53 e	26.33 a
B4	45.97 a	5.20 a	18.47 a	0.93 a	0.08 b	15.45 e	25.67 a
B5	46.30 a	5.22 a	17.80 a	0.85 a	0.07 b	12.28 d	23.00 a
B6	44.47 a	5.03 a	17.87 a	0.90 a	0.06 a	09.60 c	24.33 a
B7	44.87 a	5.10 a	17.27 a	0.87 a	0.05 a	06.64 b	22.17 a
B8	41.97 a	4.77 a	17.33 a	0.90 a	0.03 a	05.30 b	24.00 a
B9	42.90 a	5.00 a	17.07 a	0.77 a	0.04 a	03.55 a	19.50 a

Note: numbers followed by the same letter in the same column are not significantly different according to the Scott Knott Cluster Test at an error level of 5%.
LAI = leaf area index; PGR = plant growth rate; SRR = shoot-root ratio

The slower the weeding time, the lower the shoot root ratio (SRR). In Table 1, it can be seen that the decrease in SRR began to occur in the weeding time treatment of 6 WAP (B5). A lower SRR indicates that the upper part of the plant has a smaller proportion compared to the roots (Irwan et al., 2017). In the weed-free treatment, soybean growth was in optimal conditions as indicated by the large shoot root ratio value. This is because the biomass produced is high and growth is more focused towards the shoots.

Component of Yield and Yield Variables

The statistical analysis show that weeding time treatment has a significant effect on all components of soybean yield and yield (Table 2). In Table 2 it can be seen that the later the weeding is done, the faster the flowering period, the smaller the seed size, and the lower the yield of pods and seeds.

Table 2. Effect of weeding time on yield and yield component variables

Treatment	Flowering Age (day)	Number of pod per plant	Weight of 100 seed (g)	Seed weight per plant (g)	Seed Weight per plot (g)
B1	37.39 d	39.89 d	14.50 c	15.60 b	492.29 b
B2	36.25 d	39.53 d	13.19 b	15.20 b	486.02 b
B3	35.31 c	39.41 d	13.03 b	14.91 b	485.25 b
B4	35.13 c	39.19 c	12.95 b	14.79 b	485.63 b
B5	34.29 b	38.86 c	12.61 b	14.03 b	483.79 b
B6	33.53 b	38.66 c	12.57 b	14.53 b	485.44 b
B7	33.32 b	38.10 b	12.43 b	13.31 a	483.28 b
B8	32.83 b	38.02 b	11.36 a	12.87 a	465.31 a
B9	31.49 a	37.32 a	11.24 a	12.23 a	448.61 a

Note: numbers followed by the same letter in the same column are not significantly different according to the Scott Knott Cluster Test at an error level of 5%.

Our study on the impact of weeding on soybean plant growth and yield has revealed significant findings. Weeds, by providing competition to soybean plants, influence the timing of flowering. The more pressure weeds exert, the quicker soybean plants blossom. Conversely, regular weeding eliminates weeds as rivals, allowing soybeans to flower at the ideal age (Ramadani et al., 2021).

After 35 days of planting, or 5 WAP, the Dena 2 cultivar blossoms. The findings of this study suggest that the weeds will flower more quickly the longer they are left in the soybean planting area. On the other hand, Table 2 suggests that the yield and seed size would drop the more extended the weeds remain in the plot. Pod Filling is Affected by the Flowering Age (Handayani & Hidayat, 2016). A plant with a quick blooming age has an advantage over a slow flowering age because it has more time to maximize pod filling, resulting in more robust pods. Nevertheless, in this investigation, the treatment without weeds (B1) produced the most significant number of pods (39.89 pods plant-1) despite having a later flowering age of 37.39 days.

According to Jamsijah et al. (2018), environmental factors that exist from seed filling to the flowering period will significantly impact soybean plant yields. The number of flowers that develop into fruit and the photosynthetic process during the vegetative phase of a soybean plant also impact the number of pods on the plant, in addition to environmental considerations. According to Umaine and Holil (2016), the number of pods that form on soybean plants during vegetative growth is determined by the rate of photosynthesis and the availability of assimilation products. The generative growth of the plant will be less than ideal if weeds grow in denser and denser regions planted with soybeans, as per Widyatama et al. (2012).

Relative yields between the weeding and no weeding treatments were much more significant. 15.56 g plant-1 of dry seed was planted in the weed-free treatment (B9), compared to 12.23 g plant-1 in the weed-free treatment (B1). Plant yield might be decreased by 27% when weeds are present. Dry seed weight per plot in the weed-free treatment (B1) was 492.29 g plot-1, or 1.12 tons ha-1; in contrast, the weed-free treatment (B9) yielded 448.61 g plot-1, or 1.23 tons ha-1, according to dry seed weight calculations. Weeds can lower yields by 8.87% when compared to other conditions. Eight weeks after planting, the weeding treatment started to experience a decline in output, according to the data (B7). This indicates that you can wait until eight weeks after planting to weed during the dry season. The yield of soybean plants will decrease if weeds are removed beginning nine weeks after sowing.

According to Lailiyah et al. (2014), competition between weeds and soybean plants disrupts the pace of photosynthesis, resulting in a drop in the amount of carbohydrates generated. As the results of photosynthate are stored in the seeds, there is a close relationship between the rise in soybean seed weight and photosynthate production. According to Padang et al. (2017), weeds that arise at the start of plant growth have a more significant impact on soybean yields than weeds that emerge later in the growth stage but at the same time.

Weed Density

The density of weeds is the number of weeds per observation area. The relative density of weeds is the proportion of the density of one type of weed in the density of all types of weeds. The results showed that the highest total density was obtained at weeding age 7 WAP (B6), namely 391 individuals m^{-2}, while the lowest density was obtained at weeding 3 WAP (B2), namely 180 individuals m^{-2} (Table 3).

Table 3. Weed Density

No	Species	Weed Group	Weed Density (individual m^{-2}) at:						
			B2	B3	B4	B5	B6	B7	B8
1	*Axonopus compressus*	Broadleaf	6	24	24	14	12	-	16
2	*Caperonia palustris*	Broadleaf	32	6	12	10	6	6	10
3	*Malachra alceifolia*	Broadleaf	-	-	-	2	-	12	-
4	*Momordica charantia*	Broadleaf	14	8	8	6	-	4	2
5	*Thladiantha dubia*	Broadleaf	-	-	-	-	-	6	2
6	*Digitaria sanguinalis*	Broadleaf	-	8	12	-	-	-	-
7	*Drymaria cordata*	Broadleaf	-	-	-	-	-	-	4
8	*Mimosa pudica*	Broadleaf	3	3	4	1	1	-	1
9	*Calopogonium sp*	Broadleaf	22	36	4	-	6	-	2
10	*Centrosema pubescens*	Broadleaf	-	-	-	-	-	-	4
11	*Cynodon dactylon*	Grasses	32	12	14	18	2	52	18
12	*Eleusin indica*	Grasses	14	2	2		2	4	6
13	*Cyperus rotundus*	Sedges	54	174	104	256	361	282	134
	Total Density		180	276	188	308	391	366	200

The most common types of weeds found in the experimental field were from the broad-leaf group. The results of this research are in line with the results of Kilkoda (2017). The weeds *Caperonia palustris*, *Cynodon dactylon*, and *Cyperus rotundus* were the types of weeds found in all experimental plots, with the highest density obtained by the weed *Cyperus rotundus*. The weeds *Drymaria cordata* and *Centrosema pubescens* were only found in the weeding treatment at 9 WAP with a low density, namely 4 individuals m^{-2}.

Table 4. Relative Density of Weeds

No	Species	Weed Group	Weed Relative Density (%) at:						
			B2	B3	B4	B5	B6	B7	B8
1	*Axonopus compressus*	Broadleaf	3.33	8.70	12.77	4.55	3.07	-	8
2	*Caperonia palustris*	Broadleaf	17.78	2.17	6.38	3.25	1.53	1.64	5
3	*Malachra alceifolia*	Broadleaf	-	-	-	0.65	-	3.28	-
4	*Momordica charantia*	Broadleaf	7.78	2.90	4.26	1.95	-	1.09	1
5	*Thladiantha dubia*	Broadleaf	-	-	-	-	-	1.64	1
6	*Digitaria sanguinalis*	Broadleaf	-	2.90	6.38	-	-	-	-
7	*Drymaria cordata*	Broadleaf	-	-	-	-	-	-	2
8	*Mimosa pudica*	Broadleaf	3.33	2.17	4.26	0.65	0.51	-	1
9	*Calopogonium sp*	Broadleaf	12.22	13.04	2.13	-	1.53	-	1
10	*Centrosema pubescens*	Broadleaf	-	-	-	-	-	-	2
11	*Cynodon dactylon*	Grasses	17.78	4.35	7.45	5.84	0.51	14.21	9
12	*Eleusin indica*	Grasses	7.78	0.72	1.06	-	0.51	1.09	3
13	*Cyperus rotundus*	Sedges	30	63.04	55.32	83.12	92.33	77.05	67

The density value is a description of the number of species at the research location, so that the density of a species indicates the number of species involved in a certain area (Umar, 2017). Density is a factor that influences tree growth, if density is high then competition for nutrients and sunlight is greater (Nizar et al., 2016).

Weed Dominance

Dominance describes the area of cover or part of the land controlled by plants. The dominance value of a plant type is obtained by looking at the percentage of area covered or controlled by the plant type (Oktaviani et al., 2017). The dominance of a plant species can be seen from the number of species, diameter size and dominant growth (Umar, 2017). Weed dominance describes the ability of weeds to compete with other plants. Factors responsible for high levels of weed competition include their density levels and growth patterns (Pranesti et al., 2014). The high dominance of weeds shows the ability of weeds to compete with cultivated plants. The results of research on peanuts show that the higher the dry weight of weeds will reduce plant yields (Korav, Ram, Ray, Krishnappa, et al., 2018).

Table 5. Weed Dominance

No	Species	Weed Group	Weed Dominance (g m^{-2}) at:						
			B2	B3	B4	B5	B6	B7	B8
1	*Axonopus compressus*	Broadleaf	0.10	1.04	1.04	1.02	0.13	-	1.03
2	*Caperonia palustris*	Broadleaf	0.90	1.17	2.52	3.75	1.62	0.50	1.36
3	*Malachra alceifolia*	Broadleaf	-	-	-	0.21	-	0.79	-
4	*Momordica charantia*	Broadleaf	0.52	0.77	0.90	1.41	-	0.50	0.68
5	*Thladiantha dubia*	Broadleaf	-	-	-	-	-	0.33	0.19
6	*Digitaria sanguinalis*	Broadleaf	-	1.01	2.15	-	-	-	-
7	*Drymaria cordata*	Broadleaf	-	-	-	-	-	-	0.77
8	*Mimosa pudica*	Broadleaf	0.16	0.12	0.14	0.10	0.03	-	0.46
9	*Calopogonium sp*	Broadleaf	0.34	0.38	0.73	-	0.18	-	0.41
10	*Centrosema pubescens*	Broadleaf	-	-	-	-	-	-	0.49
11	*Cynodon dactylon*	Grasses	3.72	4.04	1.76	5.14	0.49	2.01	5.88
12	*Eleusin indica*	Grasses	0.38	0.66	0.66	-	0.10	0.46	1.80
13	*Cyperus rotundus*	Sedges	0.70	7.45	3.27	10.52	11.24	6.05	28.34
	Total Dominance		180	6.82	16.63	13.16	22.14	13.79	10.64

The findings demonstrated that Cyperus rotundus was the most prevalent weed in every experimental plot, with the most extraordinary dominance of 11.24 g m-2 being attained in the 7 WAP (B6) weeding condition (Table 5). This is also the case in agreement with the density, which was 361 individuals m-2 in the 7 WAP (B6) weeding treatment (Table 3). Kilkoda (2017) states that Cyperus sp. weed may proliferate, reproduce through tubers, and yield many seeds. It can also thrive in unfavorable surroundings.

As per Table 6, the most dominant weeds are Cyperus rotundus and Cynodon dactylon, based on the findings of relative dominance estimates. Overshadowing Cyperus rotundus in the weeding treatment at 3 WAP (B2) was Cynodon dactylon. The opposite occurred, nevertheless, with the subsequent treatment.

Weed Diversity Index

Based on the results of observations, the highest diversity index was obtained by treatment B6, namely weeding at 7 WAP and the lowest was in B7, weeding at 8 WAP (Table 7). A community is said to have high species diversity if the community is composed of many species, and conversely a community can be said to have low species diversity if the community is composed of few species (Ismaini et al. 2015).

Table 7. Weed Diversity Index

No	Species	Weed Group	Weed Diversity Index at:						
			B2	B3	B4	B5	B6	B7	B8
1	*Axonopus compressus*	Broadleaf	0.14	0.21	-	0.26	0.11	0.11	0.2
2	*Caperonia palustris*	Broadleaf	0.11	0.08	0.07	0.18	0.31	0.06	0.15
3	*Malachra alceifolia*	Broadleaf	0.03	0.04	0.11	-	-	-	0.11
4	*Momordica charantia*	Broadleaf	0.08	0.1	0.05	0.13	-	-	0.05
5	*Thladiantha dubia*	Broadleaf	-	-	0.07	-	-	-	0.05
6	*Digitaria sanguinalis*	Broadleaf	-	0.1	-	0.18	-	-	-
7	*Drymaria cordata*	Broadleaf	-	-	-	-	-	-	0.08
8	*Mimosa pudica*	Broadleaf	0.03	0.08	-	0.13	0.11	0.03	0.05
9	*Calopogonium sp*	Broadleaf	-	0.27	-	0.08	0.26	0.06	0.05
10	*Centrosema pubescens*	Broadleaf	-	-	-	-	-	-	0.08
11	*Cynodon dactylon*	Grasses	0.17	0.14	0.28	0.19	0.31	0.03	0.22
12	*Eleusin indica*	Grasses	-	0.04	0.05	0.05		0.03	
13	*Cyperus rotundus*	Sedges	0.15	0.29	0.2	0.33	0.36	0.07	0.27
	Total Weed Diversity Index		0.71	1.35	0.83	1.53	1.46	0.39	1.31

A community is said to have high species diversity if the community is composed by many types, whereas a community is said to have low species diversity if the community is composed by few types and if only a few are dominant (Indriyanto 2015). High diversity index can increase competition between weeds but can reduce dominance and density values (Fajarwati, Hadisusanto, and Hartono 2020; Maknun 2017), but that is not always the case because a high diversity index indicates that there are many different types of weeds in an area.

CONCLUSION

Weeding time did not have a significant effect on the plant growth components but had a significant effect on the yield components and yield of the soybean cultivar Dena-2. Delaying weeding until 8 WAP in the dry season will not reduce yields, but postponing weeding further will significantly reduce yields. This shows that the critical period for soybean plants against weeds in the dry season is 8 WAP. The highest weed density, dominance and diversity were obtained at 7 WAP weeding, with the most dominant weed types being *Cyperus rotundus* and *Cynodon dactylon*.

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