Characteristics of soybean yield influenced by the application of herbicides oxyfluorfen and pendimethalin

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Abstract. Type and dose of herbicides are important factors affecting weed control efficacy on soybean crop. This research was conducted to discover the effective doses of oxyfluorfen and pendimethalin to control weeds, starting from May to August 2019 in Meunasah Manyang Village, Krueng Barona Jaya District, Aceh Besar Regency, Aceh, using Randomized Completely Block Design (RCBD) Factorial. The first factor was type of herbicide: oxyfluorfen and pendimethalin, and the second factor was doses of herbicide: 0, 0.5, 1, 1.5 and 2 kg ai ha⁻¹. The results showed that type of herbicide affected the weed dry weight, number of seeds per plant and number of pods per plant. Oxyfluorfen reduced weed dry weight but it increased the number of seeds per plant and number of pods per plant. The application of different doses also affected weed dry weight, number of pods per plant and weight of 100 seeds, where dose 1.5 kg ai ha⁻¹ lowered weed dry weight but it also improved the weight of 100 seeds. There was an interaction between type and dose of herbicide on the number of pods per plant. It showed that the application of 1.5 kg ai ha⁻¹ oxyfluorfen increased the number of pods per plant.

1. Introduction

The presence of weeds during vegetative phase until harvest has led to a decrease in soybean yield. Rao [1] stated that the yield loss can be attributed by the lack of water, nutrition, and sunlight due to competition and also the influence of allelopathy. The research of Hasanuddin and G Erida [2] found that weeds caused 54% yield loss of soybean. Weed control is an important practice to reduce the yield loss. However, this practice needs to be carried out efficiently with considering the cheaper cost, lesser employee and shorter time of application. The application of synthetic herbicides is the best answer to those considerations mentioned above [3, 4]. Regarding to research done by Zimdahl [5], the use of herbicides can suppress the growth and development of weeds, also to inhibit the growth of...
weeds developed from seeds. Oxyfluorfen and pendimethalin are pre-emergence herbicides, which commonly used to control weeds in soybean crop.

Oxyfluorfen is a selective and pre-emergence herbicide, which has been used to effectively control broadleaves and grasses weeds in soybean crop [6]. The application of oxyfluorfen can increase the yield of soybean [7]. Finding of Qasem [8] showed that the use of oxyfluorfen 0.6 kg ai ha\(^{-1}\) has reduced the weed growth and increased the crop yield. Pendimethalin is also a selective and pre-emergence herbicide from dinitroaniline class used to control broadleaves and grasses weeds. This pre-emergence herbicide is applied on the soil surface [9], [10] said that this herbicide interfere mitosis activity by disrupting the production of microtubular protein. The application of pendimethalin 0.9-2.0 kg ai ha\(^{-1}\) has controlled annual and perennial weeds [11]. Buttar et al., [12] also revealed that the use of pendimethalin 0.8 kg ai ha\(^{-1}\) disrupted the growth of broadleaves and grasses weeds.

2. Materials and methods
2.1 Place and duration
This research was carried out in Meunasah Manyang Village, Krueng Barona Jaya District, Aceh Besar Regency, Aceh and at Weed Management Laboratory, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, from May to August 2019.

2.2 Tools and materials
Tools used in this research were handtractor, knapsack hand sprayer 15 L, syringe 5 ml, oven, analytical balance and grain moisture meter. Materials used in this research were soybean seeds variety Devon 1, urea, SP\(_{36}\), KCl, rooting promoter Rhizogen, herbicides oxyfluorfen and pendimethalin, insecticides carbofuran and deltamethrin.

2.3 Data analysis
This research used Randomized Complete Block Design (RCBD) Factorial with 2 (two) factors: 2 (two) different herbicides, \(J_1 = \text{oxyfluorfen}\) and \(J_2 = \text{pendimethalin}\), with 5 (five) various doses such as \(D_0 = \text{control (0 kg ai ha}^{-1}\)), \(D_1 = 0.5 \text{ kg ai ha}^{-1}\), \(D_2 = 1 \text{ kg ai ha}^{-1}\), \(D_3 = 1.5 \text{ kg ai ha}^{-1}\) and \(D_4 = 2 \text{ kg ai ha}^{-1}\). These experiments had 3 replications. Data collected were statistically analyzed using Analysis of Variance (ANOVA) where significant differences in existed means were compared using Duncan’s Multiple Range Test (DMRT) at 0.05 probability level.

2.4 Research methods
The land was tilled twice by using hand tractor. Independent 30 plots with size 2.5 m x 2.5 m were made with space 30 cm for each experimental unit and 50 cm for each replication. Before being planted, the seeds must be soaked into water for 15 minutes and then were coated with Rhizogen. Independent 4 selected seeds were infested into each planting hole along with carbofuran application. The space for planting the seeds was 30 cm x 30 cm. The practice of thinning plants (into 2 plants only for each hole) were done 10 days after planting to allow them plenty of growing room in order to receive all the proper growth requirements (moisture, nutrients, light, etc.) without having to compete with other seedlings.

Fertilizers used were SP-36, Urea and KCl in mixture (doses of urea 50 kg ha\(^{-1}\), SP\(_{36}\) 60 kg ha\(^{-1}\) and KCl 70 kg ha\(^{-1}\)). Fertilization applied in stages. The mixture has been given twice, half was applied during planting, while the next half is applied 30 days after planting (DAP). The fertilizers were placed using ring method. Oxyfluorfen and pendimethalin were applied after planting using knapsack hand sprayer 15 L. Water 300 L ha\(^{-1}\) was applied to dilute the herbicides.

2.5 Variables observed
2.5.1 Weed dry weight. The observation was done 35 days after planting by taking the samples and then were dried using oven for 48 hours at 80°C to reach constant weight.
2.5.2 Number of seeds per plant. This activity was done also after harvest, by calculating the seeds resulted from sampled plant in the sampled plot.

2.5.3 Weight of 100 seeds. The observation was made also after harvest by weighing the seeds. The seeds weighed was only the seeds with moisture content 14% after being dried for 3 days.

2.5.4 Number of pods per plant. It has done after harvest, by calculating pods from sampled plants obtained from sampled plots.

2.5.5 Dry seed yield. This applied by weighing seeds that have been dried for 2-3 days to reach moisture content 14%, obtained from plots 180 cm x 60 cm.

3. Results and discussions

3.1 Weed dry weight

The results of the analysis of variance showed that the type and dose of herbicides affected the dry weight of the weeds (Table 1). The application of oxyfluorfen gave better result at reducing weed dry weight compared to pendimethalin. This finding showed that there were special characteristics from chemical aspects that can affect the growth of weeds, which is shown in the reduction of weed dry weight. It was explained by Vencill et al. [13] that oxyfluorfen has possessed rapid activity in controlling weeds, by disrupting photosynthesis mechanism and destructing cell membranes and all organs of the weeds, resulting in chlorosis and the weeds appear to burn, which ultimately causes weeds to die. From the results, there was a significant difference in the dry weight of the weeds between treated weeds and control. This has revealed that at the lowest dose 0.5 kg ai ha⁻¹ has significantly reduced the weed dry weight. However, Permana et al.[14] confirmed that weeds can be controlled by oxyfluorfen at dose 1.5 kg ai ha⁻¹. This suppression caused by the herbicide has changed weed morphology, which led to absolute mortality of weeds, where this mortality has caused lower weed dry weight.

Table 1. Average number of dry weed weight, number of seeds per plant, weight of 100 seeds and dry seed yield of soybean crop treated with different type and dose of herbicide.

| Treatment                     | Weed dry weight (g) | Number of seeds per plant | Weight of 100 seeds (g) | Dry seed yield (g m⁻²) |
|-------------------------------|--------------------|---------------------------|------------------------|----------------------|
| Type of herbicide             |                    |                           |                        |                      |
| Oxyfluorfen                   | 15.79 a            | 50.60 b                   | 13.76                  | 152.01               |
| Pendimethalin                 | 21.03 b            | 43.45 a                   | 14.36                  | 131.76               |
| Dose of herbicide (kg ai ha⁻¹)|                    |                           |                        |                      |
| 0                             | 30.68 b            | 42.07                     | 12.35 a                | 132.95               |
| 0.5                           | 13.70 a            | 47.74                     | 13.85 ab               | 136.92               |
| 1.0                           | 15.17 a            | 46.44                     | 14.33 ab               | 134.61               |
| 1.5                           | 12.48 a            | 50.39                     | 15.41 b                | 155.00               |
| 2.0                           | 15.02 a            | 48.50                     | 14.35 ab               | 149.93               |

Mean values in the same columns followed by the same letters do not differ significantly as determined by Duncan’s Multiple Range Test (α = 0.05)

3.2 Number of seeds per plant

The results of analysis of variance exhibited that the application of oxyfluorfen possessed the best result in controlling weeds, resulted in significant result to the number of seeds per plant (Table 1). Permana et al. [14] stated that the application of oxyfluorfen can kill the germinated seeds, that those seeds would never have chance to grow and develop themselves. The results also described that the
application of different herbicides exhibited non-significant difference to number of seeds per plant. It has shown that the doses given have controlled the weeds but it did not affect the number of seeds. The application of both herbicides with similar doses, 1.5 kg ai ha\(^{-1}\) slightly increased the number of seeds per plant. This result confirmed that this dose has effectively controlled the weeds, which has given the plants chance to grow and develop better without having to compete with undesired plants, resulted in higher number of seeds.

3.3 Weight of 100 seeds
The results illustrated that the application of different herbicides was also non-significant to the weight of 100 seeds even though it has controlled the weeds, except the dose 1.5 kg ai ha\(^{-1}\) (Table 1). These results have proved that higher doses attributed to effective weed control which it will affect the seed weight. Pasaribu et al. [15] explained that the application of higher doses of herbicides would rapidly kill weeds due to higher active compound contains in it compared to lower doses. This mortality gave positive contribution to the plants in absorbing nutrients, water, and sunlight, causing the plants to grow better and develop well, resulted in higher weight of weeds. This finding is in line with the research of Rahmawasiah [16] who investigated that an increase in seed weight contributed by perfect absorption of complete nutrients provided in the soil.

3.4 Number of pods per plant
The results also illustrated that there was an interaction between type and dose of herbicide to the number of pods per plant. The application of oxyfluorfen 1.5 kg ai ha\(^{-1}\) has increased the pod number per plant by reducing the weed dry weight (Table 2). This lower weight indicated that there was no competition between the crops and weeds, where this condition was good for the crop to have well development in order to have higher number of pods. Hasanuddin [17] informed that good development of the crop will boost the metabolism activity in the crops which facilitates photosynthate distribution to plant’s body including pods.

Table 2. Average number of pods due to interaction between type and dose of herbicide.

| Type of herbicide | Dose of herbicide (kg ai ha\(^{-1}\)) |
|-------------------|--------------------------------------|
|                   | 0     | 0.5    | 1     | 1.5    | 2     |
| Oxyfluorfen       | 22.26 aA | 32.22 aB | 28.09 aAB | 36.04 bB | 34.72 aB |
| Pendimethalin     | 30.85 bA | 30.70 aA | 31.65 aA | 28.19 aA | 28.54 aA |

Mean values in the same columns followed by the same letters (vertical lowercase and horizontal uppercase) do not differ significantly as determined by Duncan’s Multiple Range Test (α = 0.05)

3.5 Dry seed yield
The type and dose of herbicide independently had not significant on the dry seed yield of soybean (Table 1). The application of oxyfluorfen and pendimethalin effectively controlled the weeds, but it did not give better result to dry seed yield. Also, the application of herbicides at various doses have inhibited the growth of the weeds, but it also did not affect the dry seed yield. This growth inhibition indicated that the herbicides applied was absorbed by the soil, caused a disruption in photosynthesis activity, resulted in disruption of growth and development of the weeds. The highest dose (2 kg ai ha\(^{-1}\)) demonstrated lower dry seed yield compared to application of 1.5 kg ai ha\(^{-1}\) herbicides even though it showed insignificant results. The application of higher dose has caused higher percentage weed control. Growth inhibition can affect crop yield, resulted from disruption in photosynthesis process, which caused lower result of photosynthate. Hasanuddin [18] explained that if photosynthesis
is inhibited, lesser photosynthate will be formed that causes lower ATP produced and the translocation of photosynthate into the pods or seeds will be deteriorated.

4. Conclusions
Type of herbicide has affected the weed dry weight, number of seeds per plant and number of pods per plant. The application of oxyfluorfen has reduced the weed dry weight while at the same time it has increased the number of seeds per plant and number of pods per plant. Doses of herbicides also affect the weed dry weight, weight of 100 seeds, and number of pods per plant. The dose of 1.5 kg ai ha\(^{-1}\) can reduce the dry weight of weeds and increase the weight of 100 seeds. There was an interaction between the type and dose of herbicide on number of pods per plant. The application of oxyfluorfen 1.5 kg ai ha\(^{-1}\) increased the number of pods per plant.

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