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Weeds diversity and the production of shallot (*Allium ascalonicum* L.) due to the application of azolla fertilizers and oxyfluorfen

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Abstract. The study aimed to determine the growth and production responses of shallot plants to the application of azolla fertilizer and oxifluorfen herbicide. This research was conducted in Balubu Village, Belopa District, Luwu Regency, South Sulawesi (3°23'32" South latitude and 120°19'56" East longitude) from February to April 2019. The study site was located at an altitude of 20 meters above sea level with average monthly rainfall of 151-200 mm/month. The study was conducted as experimental research based on a Split Plot Design. Azolla fertilizer was set as the main plot consisted of three levels, namely control, 3, and 6 tons ha^{-1} and the oxyfluorfen concentration was set as the sub plots consisted of four levels, namely control, 2, 4, and 6 cc L^{-1}. Each treatment combination was repeated 3 times. The results show that the application of 6 ton per hectare of azolla fertilizer resulted in the highest average plant height at 42 days after planting (27.91 cm), bulb diameter (20.78 mm), bulbs fresh weight per plant (24.72 g), bulbs dry weight per plant (19.73 g), bulbs fresh wet per plot (1112.25 g), bulbs dry weight per plot (888 g), and production per hectare of 8.88 ton ha^{-1}. Oxifluorfen treatment with a concentration of 6 cc L^{-1} effectively controlled the dominant weeds of onion plants such as *Synedrella nodiflora*, *Mimosa pudica*, and *Stachytarpheta jamaicensis* with the lowest average number of individual weed per plot of 6.00 weeds.

1. Introduction

Shallot is a horticultural commodity that has many benefits and high economic value. This vegetable commodity is included in the spice group which functions as a food seasoning and traditional medicine. Demand for shallots continues to increase from year to year in line with the increase in population and diversification of various types of food. The national consumption of shallots in 2018 was recorded at 672,812 tons, then in 2019 it increased to reach 684,028 tons, resulted in increases average demand by 1.73% per year [1]. The increasing demand for shallots should be balanced with an increase in onion production. Data from the Indonesian Central Statistics Bureau in 2018 reveal that harvest area in 2015 was 122,126 ha and in 2016 increased by 22.5% to 149,635 ha [2]. The increase in shallot harvest area was accompanied by a large increase in production but a decreased level of productivity. National shallot production in 2015 that was 1,229,189 tons with a productivity of 10.06 tons per ha while in 2016 production was 1,446,869 tons with a productivity of 9.67 tons per ha. The latest data in 2017, national shallot production is 1,470,155 tons with productivity of 9.69 tons per ha [2]. This shows that an increase

in onion production is in line with the increase in national harvest area, but the productivity did not show a significant increase.

The decrease in shallots productivity has caused an uneven distribution of shallots throughout the year and it is aggravated by the suboptimal arrangement of the production system of the dry season (off-season) and the production system of the rainy season (in-season). Hence, resulting in fluctuations in the price of this commodity in the domestic market. As a result, the shallot trade deficit tends to increase from year to year [3].

One of the efforts to optimize the growth of the shallots plants is by conducting good practices in cultivation techniques such as fertilizing, both in the form of organic and inorganic fertilizers. Organic fertilizers are fertilizers with basic ingredients taken from nature with the amount and type of nutrients contained naturally. Organic fertilizer is thought to be one of the most important ingredients in the efforts to improve soil fertility. Even though the nutrient content in organic fertilizers quantitatively are inferior to inorganic fertilizers, but the use of organic fertilizers continuously in long term will make soil quality better than inorganic fertilizers use. According to Suwahyono [4], organic fertilizer is the best solution to restore soil conditions and efforts to restore soil fertility.

Among organic fertilizers, one of the famous in use is the fertilizer made from aquatic *Azolla pinnata* plants. Application of azolla into the soil can affect the physical, chemical and biological properties of the soil, physically improving soil structure, chemically enrich the soil with nutrients, especially N, and biologically, among others, it can increase the activity of soil microorganisms [5]. Azolla has N, P, and K content of 3.91%, 0.30%, and 0.65%, respectively, C/N of 6 and 39.9 organic matter [6]. According to Nurhasanah et al. [7] the use of azolla as organic fertilizer can increase total N in the soil by about 0.43-0.59%. Aksan research [8] shows that the treatment of *Azolla pinnata* 120 kg per hectare produces the root length and fresh weight of most mustard plants.

In addition to the use of organic fertilizers, production of shallots also should consider the interspecies competition such as weeds. One of the main factors that cause yield loss and reduce the productivity of onion plants is weeds [9]. Loss of onion yields due to weeds reaches 40-80% [10]. Lack of weed control can lead to increased loss of marketable onions. Shallots cannot compete against weeds because of their slow growth, short plant height, unbranched plant structure, small leaf area and shallow root system [11]. Weed control methods on shallots are usually done manually. Weed control manually requires a lot of labor, expensive and inefficient. Therefore, controlling weeds using herbicides is a more efficient alternative choice [12].

One herbicide that can be used to control weeds in onion crop cultivation is an herbicide with an active ingredient of oxifluorfen. Oxifluorfen herbicide is a herbicide that can inhibit the growth of new weed seeds or weeds that are absorbed through the leaves to inhibit the enzyme ACCase (Acetyl Coa Carboxylase) thereby inhibiting lipid synthesis [13]. According to Umiyati [14], the oxygluorphene herbicide 240 g L^{-1} with a concentration of 3.3 mL L^{-1} resulted in higher average of shallot bulbs wet weight which is high at 24.15 kg / plot. Therefore, it is necessary to conduct a research to study the effect of azolla fertilizer on the growth and production of shallots combined with the use of oxyfluorfen herbicide in controlling the weeds in the shallots crop cultivation.

Methodology

This research was conducted in Balubu Village, Belopa District, Luwu Regency, South Sulawesi (3°23'32" South Latitude and 120°19'56" East Longitude) from February to April 2019. The study site was located at an altitude of 20 meters above sea level with average monthly rainfall of 151-200 mm/month.

2.1. Experimental design

This research was conducted in the form of experiment based on Split Plot Design. Azolla fertilizer was set the main plot, while the oxyfluorfen set as the sub plots. Two levels of Azolla fertilizer were used consisted of 3 and 6 ton ha^{-1}, while three levels of concentration were used for the application of the oxyfluorfen herbicide, namely 2, 4, and 6 cc L^{-1}. In addition, control treatment was set for each factor.

Therefore, there were 12 treatment combinations repeated three times resulted in total of 36 experimental plots.

2.2. Land preparation

Study site was prepared by clearing the area from weeds and then the soil was ploughed and hoed about 30 cm deep. The beds or plots were 1 x 1 m in size, 30 cm in height, 30 cm in width between the beds, and 50 cm in width between replications.

2.3. Azolla fertilizer application

The material for Azolla fertilizer used in this study was dry azolla. The application of the fertilizer was conducted by previously weighing the dose used (0.3 kg and 0.6 kg per plot) then applying it to the experimental plot accordingly. Application was carried out five days before planting.

2.4. Oxifluorfen herbicide application

The herbicide used in this study was the Oxyfluorfen 240 g L^{-1}. The application of the Oxifluorfen was conducted by spraying the herbicide solution on the trial plot at 3 days before planting with concentration according to the treatment.

2.5. Planting

The shallot seeds used are Super Philip variety. Prior to planting, bulbs were cut 1/3 part from the top to enhance uniformly seedling growth. Planting was conducted by making a planting hole with planting stick with 10 x 20 cm planting distance then sowing one seed bulbs per planting hole until the edges of the cutting were level with the soil.

2.6. Observation parameters and data analysis

The observational parameters used in this study were the characteristics of the types of weeds that exist in plantations and the growth and production parameters of the shallot plants. Data were analysed using a two-way analysis of variance (ANOVA) for split plot designs. A further test was conducted if there is significant effect of the treatment using the Least Significance Difference (LSD) test at the 5% level. Analysis of weed vegetation was performed using the Summed Dominance Ratio (SDR) technique at 5 weeks after planting. According to Kastanja [15], the SDR value was calculated using the formula:

$$Relative\ density\ (RDn) = \frac{Absolute\ density\ of\ a\ species}{Absolute\ density\ of\ all\ species} \times 100\%$$

$$Relative\ frequency\ (RF) = \frac{Absolute\ frequency\ of\ a\ species}{Fbsolute\ frequency\ of\ all\ species} \times 100\%$$

$$Relative\ dominance\ (RDm) = \frac{Absolute\ dominance\ of\ a\ species}{Absolute\ dominance\ of\ all\ species} \times 100\%$$

$$Summed\ Dominance\ Ratio\ (SDR) = \frac{RDn + RF + RDm}{3} \times 100\%$$

3. Results

3.1. Weeds composition

The results of variance show that azolla doses did not have a significantly effect on the number of weed individuals, while the concentration of oxifluorfen significantly affected the parameter and there were interactions between the two factors. Effect of different doses of azolla fertilizer and concentration of oxyfluorfen on the number of individual weeds are presented in table 1. Table 1 shows that the higher

the concentration of oxifluorfen used, the number of individual weeds decreases. The lowest average number of weed individuals was found in the azolla control treatment (0 ton ha^{-1} azolla fertilizer) applied with 6 cc L^{-1} oxifluorfen herbicide ie. 6.00 individuals. While the highest average number of weed individuals was found in the plot applied with 3 tons ha^{-1} azolla and no herbicide application (40.67 individuals).

Table 1. Average number of individual weeds on shallot plots at different doses of azolla fertilizer and concentration of oxyfluorfen.

Azolla dose (ton ha^{-1})	Oxyfluorfen concentration (cc L^{-1})				Average
	0	2	4	6	
0	34.67^{bc}_{r}	14.67^{a}_{pq}	17.33^{a}_{q}	6.00^{a}_{p}	18.17
3	40.67^{c}_{q}	12.67^{a}_{p}	8.33^{a}_{p}	6.67^{a}_{p}	17.08
6	23.33^{a}_{q}	13.33^{a}_{pq}	9.33^{a}_{p}	8.00^{a}_{p}	16.25
Average	32.89	13.56	11.67	6.89	

Number followed by the same letter in the row (ab) and in the column (pq) means that it is not significantly different in the LSD test α = 0.05.

Analysis of the weeds composition on the experimental plots shows that there were 9 species of weeds that grow on the shallots plots. The results of the analysis along with the SDR value of each weed are shown in table 2. Table 2 shows that there were 9 species of weeds found in the shallot plots with a total of 584 individuals. The species with the highest number of individuals is *Synedrella nodiflora* with a SDR value of 55.75% while the species with the lowest number of individuals is *Cyperus esculentus* with an SDR value of 1.11%.

Table 2. Weed composition and the Summed Dominance Ratio (SDR) of each weed species on the shallot plots.

No.	Weed name	Indonesian	*Summed Dominance Ratio* (%)
1	*Synedrella nodiflora*	*Jotang Kuda*	55.75
2	*Stachytarpheta jamaicensis*	*Pecut Kuda*	9.89
3	*Spermacoce remota*	*Rumput Kancing*	4.95
4	*Cleome rutidospermae*	*Maman Ungu*	1.98
5	*Phyllanthus niruri*	*Meniran*	9.11
6	*Mimosa pudica*	*Putri Malu*	12.74
7	*Ipomoea triloba*	*Kangkung Hutan*	3.27
8	*Axonopus compressus*	*Rumput Gajah Mini*	1.19
9	*Cyperus esculentus*	*Rumput Teki*	1.11

3.2. Effect of azolla fertilizer and oxyfluorfen on the growth and production of shallots

Analysis of variance show that application of azolla fertilizer on shallot significantly increased the plant height, fresh and dry weight of the bulbs and bullbs diameter parameters (table 3). However, no significant effect on leaves number and number of bulbs per plant.

Tabel 3. Average values of growth and production parameters of shallots on different azolla fertilizer dosages.

Azolla dose (ton ha^{-1})	Plant height at 42 DAP (cm)	Number of leaves at 42 DAP (leaves)	Number of bulbs per plant (bulbs)	Fresh weight of bulbs per plant (g)	Dry weight of bulbs per plant (g)	Bulb diameter (mm)
0	27.14 *a*	20.5	5.63	17.13 *a*	11.95 *a*	17.29 *a*
3	27.82 *ab*	20.9	5.69	20.10 *ab*	15.02 *ab*	18.64 *ab*
6	27.91 *b*	20.3	5.39	24.72 *b*	19.73 *b*	20.78 *b*

Number followed by the same letter in the row (ab) and in the column (pq) means that it is not significantly different in the LSD test α = 0.05. DAP = Days After Planting.

Table 4 shows that the highest average production of shallot per hectare was resulted from the azolla fertilizer treatment with a dose of 6 tons ha^{-1} (8.88 tons ha^{-1}). While the lowest average production per hectare was found in the control treatment of azolla (0 tons ha^{-1}) which was 5.38 tons ha^{-1}.

Table 4. Productivity of shallots on different dosages of Azolla fertilizers

Azolla dose (ton ha^{-1})	Bulbs fresh weight (FW) per plot (g)	Bulbs dry weight (DW) per plot (g)*	Production per hectare (ton / ha)
0	771.0 a	537.75 a	5.38 a
3	904.5 ab	675.75 ab	6.76 ab
6	1,112.2 b	888.00 b	8.88 b

*Air dried for 10 days. Number followed by the same letter in the row (ab) and in the column (pq) means that it is not significantly different in the LSD test α = 0.05.

4. Discussion

The results show that there was an interaction between the treatment of azolla dose and the concentration of oxifluorfen on the number of weed individuals per plot with the lowest average number of weeds per plot of 6 individual weeds found in plots applied with the highest concentration of oxyfluorfen herbicide. The application of the oxifluorfen herbicide had a major influence on the growth and development of weed seeds. According to Zimdahl [16], the application of oxyfluorphous herbicides caused weeds to experience chlorosis and retarded growth without affecting the growth of the main crop in this case the shallots. The oxifluorfen 240 g L^{-1} is a broad-spectrum, selective and systemic herbicide. This active ingredient is able to be absorbed mainly through leaves and shoot germination. Oxifluorfen herbicides are translocated to all parts of the plant, so that the vegetative part experiences a disturbance in cell division and eventually the growth of weeds becomes depressed and their weight is low. The oxifluorfen herbicide is known can control all weeds of both broad-leaf and weed grasses by inhibiting the ACCase enzyme so that it can inhibit lipid synthesis which causes the weeds to experience chlorosis [17].

Azolla and oxifluorfen herbicides each have an influence on weeds that grow on the shallot plots. Use of azolla fertilizer on the plots can function as fertilizer and improving soil fertility in addition to its benefit as organic mulch. Therefore, shallots could grow well and the space as a place for growing weeds were smaller or narrower in turn will supressed weed growth due to azolla which partially covers the land surface.

The recent study results show that adding the azolla fertilizer in various doses had an influence on plant growth and production. The response of the shallot only can be seen at the later stage of the growth, the height of the shallot plants treated with azolla did not grow optimally at the beginning because the azolla applied was dry azolla, and therefore the fertilizer had not been completely decomposed. The dry Azolla has a rough texture and is unable to store water. Dahliana [18] explained that the azolla decomposition process reached a maximum limit of 35 days. At that time, azolla has undergone a further process and the process of mineralization or release of nutrients has been going on perfectly. This means that azola physically can fertilize the soil, can chemically provide nutrients, and can biologically activate soil microorganisms.

Azolla application with a dose of 6 tons ha^{-1} also had a significant effect on the diameter of the bulbs produced. Addition of the azolla to the shallot plots brought benefit such as additional substances that function actively in the metabolic process. The addition of the substances derived from azolla such as N, P, K, Ca, Mg, Mn, protein, carbohydrates, and fat even in small amounts, but are needed by plants. Process of growing bulbs closely related to the supply of carbohydrates, so that during the growth of the bulbs there will be an enlargement and division of cells, carbohydrate supply is so great as energy and the rest will be piled up in the form of food reserves namely on the bulbs [19].

Plant production parameters shows the best results at the treatment of 6 tons ha^{-1} dry azolla. This shows that administration of azolla at this dose can increase the productivity of shallots. This is because azolla has been able to supply nutrients absorbed by plants, especially the elements N, P and K. According to Isnaini [20], nitrogen is an important constituent of amino acids and essential elements for cell division, cell enlargement and plant growth. Nitrogen is needed in large quantities at each plant growth, especially at the vegetative growth stage such as increasing tuber weights.

5. Conclusions

Based on the research results that have been described, it can be concluded as follows:

- The treatment of azollas and oxifluorfen herbicides provides interactions for the number of individual weeds per plot.
- Azolla with a dose of 6 tons ha^{-1} shows that the highest average plant height at 42 DAP (27.91 cm), bulbs diameter of 20.78 mm, fresh wet (FW) of bulbs per plant of 24.72 g, dry weight (DW) of bulbs per plant of 19.73 g, FW of bulbs per plot of 1,112.25 g, DW of bulbs per plot of 888.0 g, and production per hectare of shallots (8.88 tons ha^{-1}).
- 240 g L-1 oxifluorfen herbicide with a concentration of 6 cc L^{-1} is effective in controlling dominant weeds of shallot plants such as *Synedrella nodiflora, Mimosa pudica* and *Stachytarpheta jamaicensis* with the lowest average number of individuals per plot of 6 individual weeds.

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