Fitness of Paraquat Resistant and Susceptible Biotypes Population of Goosegrass (*Eleusine indica* (L.) Gaertn.)

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Abstract. A biotype of Paraquat resistant goosegrass (*Eleusine indica* (L.) Gaertn.) has evolved in an oil palm plantation in North Sumatera after being treated with Paraquat herbicide in a long period of time. This study aims to investigate the fitness of Paraquat resistant biotype when growing with susceptible biotype in the absence of herbicide. Seeds of Paraquat resistant biotype of *Eleusine indica* were collected from an oil palm plantation in Deli Serdang and had been proven to have resistant of Paraquat herbicide whereas the susceptible population from a field near campus of Universitas Sumatera Utara which never been exposed to Paraquat herbicide. Both biotypes were planted with proportions of 100 R: 0 S, 75 R: 25 S, 50 R: 50 S, 25 R: 75 S, and 0 R: 100 S with four replications. The result showed that Paraquat resistant biotypes had stronger fitness that the susceptible biotypes.

1. Introduction

Goosegrass (*Eleusine indica* (L.) Gaertn.) is a member of the Poaceae (grass) family of plants and is a major weed in most cash crops, found in most areas of the world. Goosegrass can produce approximately 50,000 seed with high viability potential and it is a diploid summer annual [5]. In the tropics areas, Goosegrass is considered an annual plant. Goosegrass produces seeds followed by vegetative growth throughout the year. Goosegrass seeds can germinate and grow at alternating temperatures between 20 and 40 °C in almost any soil type. Seeds do not show dormancy when its come directly from their elder plants (without human help) and its reportedly viable up to 5 years. These characteristics allow seeds of Goosegrass to germinate consistently throughout the growing seasons [2].

The use of various herbicide has been synthesized and used to reduce weed infestation and is known as an effective, reliable, and cheap method of weed control. Excessive use of certain herbicides in the same area on the same weed species has increased the ability of weeds to be resistant to herbicides so that weed biotypes are susceptible to becoming herbicide-resistant weed biotypes. Goosegrass developed herbicide resistance to Paraquat in Southern Orchids and Glyphosate-resistant goosegrass was also confirmed in fruit and vegetable farming in China. Several reports covered the seriousness of the herbicide resistance of goosegrass in China because farmers frequently overused herbicides with intense applications and higher dosage rates. The herbicide resistance of goosegrass makes it more difficult for farmers to control the growth and development of goosegrass weeds [9].

The resistance of herbicide is an large global problem observed in 250 weed species for 23 of the 26 known herbicide sites of action (SoA). The over use of herbicides over many generations targeting a few specific SoA in weeds has led to the evolution of weed populations surviving increasing doses
of herbicides. Evolution is a continuous process of natural selection in plants that allows weed populations to eventually overcome most selection pressures that humans apply as eradication strategies in a long period of time. In the meantime, using herbicides with SoA may be able to control weeds that are resistant to herbicide, but surely some populations will develop resistance. The strength and speed at which herbicide resistance can develop de novo or spread from different area populations in adjacent areas is an important factor in the herbicide resistance mechanism. Non-target site resistance (NTSR) implies defending plants from herbicides being used continuously by reusing existing stress and defense enzyme pathways. Therefore, herbicide resistance management can depend not only on chemical solutions but also incorporate evolutionary biological knowledge when dealing with resistant weeds in non-target site resistance [1].

Traditionally, fitness is the number of viable and fertile offspring and produces more production which contributes to the next generation. This implies that fitness can only be measured by assessing the quantity and quality seeds that the plant can produce individually [7]. However, the growth and health of individual Goosegrass produces different numbers of seeds. This based on the theory of resource allocation, namely the limited amount of energy to be allocated to vegetative versus generative growth resulting from individual metabolism and any additional energy allocated to the health quality of plants used by plants if they live in sub optimal environment so that it will have a negative impact on their reproductive ability [10].

Fitness can be evaluated by measuring the growth and health of an individual. In agricultural weeds, fitness is defined as the survival and success of reproduction in cropping land conditions which are directly related to competition. Therefore, evaluation of traits related to competitiveness such as vegetative growth characteristics and the time needed to reach a certain growth stage can show differences in fitness of plants that are continuously applied herbicide [6].

2. Methodology

2.1. Source of Seeds

The resistant biotype of E. indica seeds were taken from stored seeds from the Adolina Plantation PTPN IV Perbaungan and susceptible biotype weeds were taken directly from an area near campus Universitas Sumatera Utara which had never been sprayed with herbicide. This research was carried out in a farm field in Medan Sunggal sub-district, Medan.

2.2. Breaking Seed Dormancy

Breaking E. indica seed dormancy is soaked in potassium nitrate (KNO3) at a concentration of 0.1% for 30 minutes [4]. The purpose of this immersion is to break the secondary dormancy of E. indica seeds.

2.3. Germination and Transplanting

Media sprouts using topsoil land. Then the topsoil land is sterilized from the seed bank with a temperature of 100 °C for ± 3 h. After that the soil is removed from the oven and aerated before being put into a sprout tub with a size of 33 cm x 24 cm. During 3-4 days weed seeds have been germinated, the germination media is sprayed with water every afternoon. After the seedlings have 2-3 leaves, the seeds are transferred to the land with a plot size of 1 meter by 1 meter and has 100 plants in one square meter and has four blocks. Then the seedlings are maintained and watering is done in the morning and evening.

2.4. Weed Harvesting and Results Observation

The plants were harvested 11 weeks after transplanting. The parameters for the observations are number of panicles each clump, number of seeds each panicle, and dry weight of plants m⁻².

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\text{Number of panicles each clump} = \frac{\text{Number of seeds each panicle}}{\text{Panicle height}} \times \text{number of panicle each clump}
\]
3. Result and Discussion
3.1. Number of Panicles Each Clump

Based on Table 1, it can be seen that the planting proportion of 100 R : 0 S has a higher number of panicles each clump than other proportions, namely 31.98. From the results it can be seen that the Paraquat resistant biotype gene has a superior metabolism even though it is grown in a competitive manner so that it produces a superior number of panicles than other compositions even though planted in groups. This is because the resistance mutations establish diverse defence mechanisms that protect plants from herbicide damage in different ways. The structural changes significantly reduce herbicide binding into the target enzyme, and thus confer resistance at the whole plant level [8].

| Planting Compositions | Number of Panicles Each Clump |
|-----------------------|--------------------------------|
| R : S                 |                                |
| 100 % : 0 %           | 31.98 b (± 4.12) : -           |
| 75 % : 25 %           | 23.35 a (± 2.73) : 20.20 a (± 3.31) |
| 50 % : 50 %           | 15.28 a (± 1.52) : 20.90 a (± 2.30) |
| 25 % : 75 %           | 15.20 a (± 1.12) : 17.13 a (± 1.38) |
| 0 % : 100 %           | - : 17.95 a (± 1.25)           |

Figure 1. Number of panicles each clump of Paraquat resistant biotypes and susceptible biotypes of *E. indica* in the planting proportions

3.2. Number of Seeds Each Clump

Based on Table 2, it can be seen that the planting proportion of 100 R : 0 S has a higher number of seeds each clump than other proportions, namely 2348.95 seeds. The lowest yield was found in the planting proportions of 0 R : 100 S, which is 1326.78 seeds. The planting proportions of 75 R : 25 S, resistant biotypes had strong competitiveness compared to sensitive biotypes. This is because the result of resistant biotypes competitiveness in taking nutrients from photosynthetic material is higher in a high number of seeds each clump. This is because observations of fitness costs associated with resistance to herbicides in natural weed populations are scarce and mostly concern herbicides targeting photosynthesis [3].
Table 2. Number of seeds each clump of paraquat resistant biotypes and susceptible biotypes of *E. indica* in the planting proportions

| Planting Compositions | Number of seeds each clump |
|-----------------------|----------------------------|
| R : S                 | R : S                      |
| 100 % : 0 %           | 2348.95 b (± 334.38) : -   |
| 75 % : 25 %           | 1627.70 a (± 197.25) : 1172.23 a (± 174.38) |
| 50 % : 50 %           | 1040.70 a (± 106.89) : 1535.20 a (± 188.96) |
| 25 % : 75 %           | 1008.38 a (± 110.30) : 1534.83 a (± 97.33) |
| 0 % : 100 %           | - : 1326.78 a (± 109.32)   |

Figure 2. Number of seeds each clump of paraquat resistant biotypes and susceptible biotypes of *E. indica* in the planting proportions

### 3.3. Dry Weight

Table 3. Dry weight of Paraquat resistant biotypes and susceptible biotypes of *E. indica* in the planting proportions

| Planting Compositions | Dry Weight |
|-----------------------|------------|
| R : S                 | R : S      |
| 100 % : 0 %           | 3.38 b (± 0.54) : - |
| 75 % : 25 %           | 2.54 s (± 0.41) : 1.80 a (± 0.20) |
| 50 % : 50 %           | 1.47 a (± 0.14) : 2.41 a (± 0.36) |
| 25 % : 75 %           | 1.39 a (± 0.22) : 2.18 a (± 0.12) |
| 0 % : 100 %           | - : 2.27 a (± 0.22) |

Figure 3. Dry weight of Paraquat resistant biotypes and susceptible biotypes in the planting proportions of *E. indica* when grown under competitive conditions at various ratios with an overall density of 100 plants m$^2$
From the results obtained in response to dry weight with the planting proportions biotypes resistant and sensitive to herbicide Paraquat, it's known that resistant biotypes are superior in competing in obtaining nutrients compared to sensitive biotypes (Figure 3). In the compositions of planting 100 R: 0 S, the results of dry weight is 3.38 g and the planting proportions of 0 R: 100 S, the results of dry weight is 2.27 g.

4. Conclusion
Based on data, *E. indica* Paraquat resistant biotypes has a better fitness than the susceptible biotype. *E. indica* Paraquat resistant biotype can not be eliminated because its already have resistant genes and have genetic changes that make this biotype superior to biotypes that have not been exposed to Paraquat herbicide.

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