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Weed Vegetation Analysis and response to sunflower extracts in the uplands

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Abstract

Weeds are plants whose presence is unwanted by humans because of competition with cultivated plants for nutrients, sunlight, and growing space, producing allelochemicals that interfere with plant growth, reduce production and product quality, and increase farming costs. The continuous use of synthetic herbicides has adverse effects on the environment and health, so it is necessary to seek a weed control mechanism that is more efficient and environmentally friendly. One is utilizing secondary metabolites, namely sunflower plant allelochemicals, that can control weeds. This study aims to determine the response of weeds to the application of extracts of sunflower plant parts as bioherbicides. This research was conducted in three stages: raw material preparation, extraction, and application. The results obtained 17 weed species in the experimental field of Nagari Selayo Tanang Bukit Sileh from 7 families (Asteraceae, Poaceae, Lythraceae, Polygonaceae, Brassicaceae, Caryophyllaceae, and Mazaceae) and two weed classes (broadleaf weeds and grasses). The bioherbicide efficacy of sunflower extract (Helianthus annus L.) has not caused symptoms of toxicity in weeds.

Keywords: Weeds, composition, diversity, usefulness, ethnobotany

1. Introduction

Weeds are unique species that have evolved geographically and temporally due to their large seed production, aggressive reproduction, regeneration capacity, and high phenotypic plasticity. Weeds are undesirable in a given place and are a biological factor that interferes most with crop production. In addition, weeds shelter many plant pests that cause many plant diseases. Weeds reduce crop yields and are economically more harmful than bacteria, fungi, insects, or other plant pests (Haq *et a*l. 2023).

In crop cultivation systems, weeds compete with plants for nutrients, water, space, CO2, and light. In modern intensive agriculture, weed control is essential to protect crops and global agricultural productivity. FAO (2022) states that weeds cause 10% of annual crop yield loss worldwide.

Most weeds are considered extremely harmful, as they damage agriculture and negatively affect human health and the overall stability of the ecosystem. Weed control requires timely monitoring of their spread in the field and is easy and effective (Martinez *et al.* 2020; Enders *et al.*, 2018; Nie *et al.* 2020; Chung *et al.* 2020; Reaser *et al.* 2020).

However, excessive and inappropriate use of herbicides has several negative consequences, including increased production costs and resistant weeds and herbicide residues in food, soil, and water (Macias *et al.* 2003; Bhadoria, 2011). In addition, increasing consumer demand for organic products has encouraged more environmentally friendly efforts, such as using chemical compounds derived from plants.

consumer demand for organic products has encouraged more environmentally friendly efforts, such as using plant chemical compounds.

Allelochemicals, which are secondary metabolites, are found in almost all plant species in different concentrations in different parts of the plant, from roots to flowers and seeds, and affect plant growth and development directly or indirectly through the secretion of chemical compounds in the environment (Rice, 1984). Allelopathy can be used to protect crops from weeds in various ways, such as as a cover crop, as mulch, in crop rotation, as a natural bioherbicide, or as water extract (Sing *et al.* 2001; Alsaadawi *et al.* 2012; Rehman *et al.* 2019; Scepanovic *et al.* 2021).

Sunflower (Helianthus annuus L.) is highly allelopathic. Several factors, such as concentration, test species, and genotype, have demonstrated its phytotoxic properties on plants and weeds in the laboratory, greenhouse, and field (Alsaadawi *et al.* 2012; Khaliq *et al.* 2011; Kamal, 2011; Bogatek *et al.*, 2006; Silva *et al.* 2009; Dilipkumar *et al.* 2012). However, studies have yet to be conducted on the impact of plant parts, growth stages, and sunflower genotypes. This study aimed to evaluate the allelopathic potential of sunflower plant part extracts from different genotypes of agricultural weeds. The results of this study are expected to help further research evaluating bioherbicidal properties by determining the best sunflower parts and genotypes.

2. Materials and Methods

The research was conducted in Nagari Selayo Tanang Bukit Sileh, Lembang Jaya District, Solok Regency, West Sumatra Province, from July to December 2022. The materials and tools used were sunflower seeds Accession Ha1 and Ha15, soil, chicken manure, husk, and distilled water. The tools used were hoes, polybags measuring 40 x 40, paddles, digital scales, meters, blenders, ovens, measuring cups, erlenmeyer flasks, funnels, filter paper, hand sprayers, scissors, knives, buckets, filters, paper folders, markers, labels, stakes, machetes, raffia, cameras, stationery, and PictureThis software.

Preparation of raw materials

Planting media was prepared as a mixture of soil, chicken manure, and husk (3:1:1) and put into polybags. Sunflower seeds from accessions Ha1 and Ha15 were soaked in water for about 10 minutes, and the sunken seeds were planted three seeds per polybag. Seeds were

watered daily, weeded if weeds were, and integrated pest and disease control was carried out. Harvesting was done at 91 days after sowing. Plants were carefully uprooted and cleared of soil.

Extraction of Sunflower Plant Parts

Sunflower plants are cut and separated between leaves, stems, and roots. Furthermore, each part of the sunflower plants weighed as much as 1 kg each. The material was washed thoroughly with running water and then dried. Sunflower plant leaves were cut into small pieces using a knife and blended with a mixture of 1 liter of distilled water. The results of the blender were filtered, placed in a closed container, and stored in the refrigerator.

The stems and roots of sunflower plants were cut into pieces and pounded until smooth with a stone. The results of the pounding were then placed in a bucket, 1 liter of distilled water, and covered not too tightly. This material was stirred every day and left for one week. After one week, the material is filtered.

Sunflower plant extract application

18 plots of 0.5 x 0.5 meters were prepared. Each plant part and accession was repeated on three different plots. In addition to plots for sunflower plant application, plots were also prepared for weed vegetation sampling areas before application. The application was carried out twice in the morning when the weather was hot, and it was estimated that 2 hours after the application, it did not rain. 250 ml of sunflower plant extract was diluted with 250 ml of distilled water to be sprayed on three plots. The

application is to spray all weeds in the plot until they are wet. The second application was done one week after the first one and had the same volume.

Observations

Observations were made, namely weed identification, weed dominance, percentage of live and dead weed, and herbicide effectiveness.In addition, abundance, dominance, and similarity index were calculated with the following formula (Tjitrosoedirdjo *et al.* 1984):

$$\text{Density} = \frac{\text{absolute density of a weed species}}{\text{total absolute density of a weed species}} \times 100\%$$

$$\text{Frequency} = \frac{\text{absolute frequency of a weed species}}{\text{total absolute frequency of a weed species}} \times 100\%$$

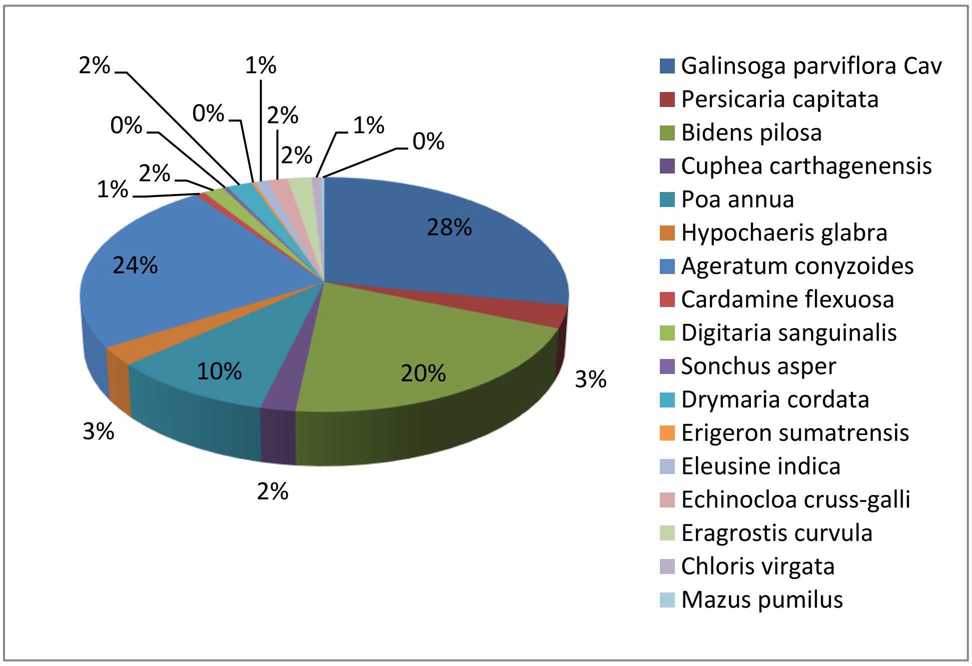
$$\text{Dominance} = \frac{\text{absolute dominance of a weed species}}{\text{total absolute dominance of a weed species}} \times 100\%$$

$$\text{SDR} = \frac{\text{Density} + \text{Frequency} + \text{Dominance}}{3}$$

3. Results and Discussion

Weed Identification

The results of weed vegetation analysis data collection on former agricultural land obtained a composition of 17 weed species spread across seven different families, namely the Asteraceae and Poaceae families, as many as six weed species each, the Lythraceae, Polygonaceae, Brassicaceae, Caryophyllaceae, and Mazaceae families each with one weed species. According to the class, there are as many as two groups, namely broadleaf weeds, and grasses, with 11 species of broadleaf weeds and six species of grass weeds. The identification results can be seen in Figure 1.



Description: Broadleaf, Grass***

Figure 1. Weed types from vegetation analysis

According to Miranda et al (2011), the identification results of local paddy rice weeds in Padang City obtained as many as 13 species, less when compared to the types of weeds obtained in Nagari Selayo Tanang Bukit Sileh, Lembang Jaya District, Solok Regency. Many factors affect the presence of weeds in an area, including cultivation systems, planting systems, irrigation systems, and weed control methods. Environmental conditions affect weed diversity (Perdana *et al.* 2013). Many variables affect weed diversity at each location, including light, nutrients, tillage, crop cultivation techniques, and plant spacing or density. Due to these influencing factors, weed distribution differs from place to place. Identifying weeds is the first step toward successful weed control. This also includes identifying the dominant weed species (Afiyah *et a*l. 2023).

In addition, the history of different land uses, in addition to affecting the environment, also affects the change and development of plants or succession (Mardiyanti *et al.* 2013). This statement is reinforced by Whitten (1996) in Wicaksono (2006), which states that the composition of plants and animals that inhabit the area will also change in succession. The speed, direction, and composition of succession are determined by the species that exist and reproduce rapidly after disturbance. Some species will later emerge and are most adaptable to the new environment, thus dominating the new environment.

Weed species in a place vary depending on climate and location. Weeds sometimes grow in different ways in different places. The crop produces many weeds due to tillage action and manure input (Syawal, 2009). According to Tantra and Santosa (2016), the hoeing process during tillage can cause weed seeds to be lifted to the soil surface. At any time, if environmental factors are favorable, weed seed deposits in the soil, also known as weed seed banks, can develop into individual weeds.

Broadleaf weeds were the dominant weeds in the experimental field. The broadleaf weed species with the highest level of dominance were Galinsoga parviflora Cav, Ageratum conyzoides, and Bidens pilosa. These three weed species are members of the Asteraceae family. According to Reader and Buck (2000), weeds from the Asteraceae family can reproduce through seeds, adapt to environments with little water and wet places, and resist shade.

Weed Dominance

Dominance is the ability of a weed to survive in a particular agroecosystem by competing with other weeds (Imaniasita *et al.* 2020). This condition is indicated by some weeds that are more numerous than some other weeds. Dominance is expressed regarding coverage of basal area biomass or volume. Dominance is seen based on the SDR value of a weed species. The Summed Dominance Ratio (SDR) value is calculated to determine the dominance level of a weed species. The structure of weeds on land in Nagari Selayo Tanang Bukit Sileh, Lembang Jaya District, Solok Regency, can be seen in Table 1.

Table 1. Structure, composition and SDR (Summed Dominance Ratio) of weeds

No	Gulma	Absolute Density	Absolute Frequency	Absolute Dominance	Density	Frequency	Dominance	SDR
1	*Bidens pilosa**	175	3	83,6	20,42	8,57	49,06	26,02
2	*Galinsoga parviflora* Cav*	241	3	35,1	28,12	8,57	20,60	19,10
3	*Ageratum conyzoides**	207	3	5	24,15	8,57	2,93	11,89
4	*Poa annua***	83	3	5,9	9,68	8,57	3,46	7,24
5	*Persicaria capitata**	27	3	6,3	3,15	8,57	3,70	5,14
6	*Cuphea carthagenensis**	18	3	4	2,10	8,57	2,35	4,34
7	*Hypochaeris glabra**	22	3	2	2,57	8,57	1,17	4,10
8	*Chloris virgate***	6	1	8,6	0,70	2,86	5,05	2,87
9	*Drymaria cordata**	16	2	1,7	1,87	5,71	1,00	2,86
10	*Echinocloa cruss-galli***	13	1	7,1	1,52	2,86	4,17	2,85
11	*Sonchus asper**	3	2	3,4	0,35	5,71	2,00	2,69
12	*Digitaria sanguinalis***	13	2	0,6	1,52	5,71	0,35	2,53
13	*Eleusine indica***	8	1	5,7	0,93	2,86	3,35	2,38
14	*Cardamine flexuosa**	6	2	0	0,70	5,71	0,00	2,14
15	*Eragrostis curvula***	15	1	1,1	1,75	2,86	0,65	1,75
16	*Erigeron sumatrensis**	2	1	0,3	0,23	2,86	0,18	1,09
17	*Mazus pumilus**	2	1	0	0,23	2,86	0,00	1,03
	Total	857	35	170,4	100	100	100	100

Description: Broadleaf, Grass***

Based on the calculation of the Summed Dominance Ratio (SDR) value, it was found that the weed species that had the highest SDR value were *Bidens pilosa* (26,02%), followed by *Galinsoga parviflora* Cav (19,10%) and *Ageratum conyzoides* (11,89%), followed by *Poa annua (*7,24%), *Persicaria capitata (*5,14%), *Cuphea carthagenensis (*4,34%), *Hypochaeris glabra (Hypochaeris glabra (*4,10%*), Chloris virgate (*2,87%), *Drymaria cordata (*2,86%), *Echinocloa cruss-galli (*2,85%), *Sonchus asper (*2,69%), *Digitaria sanguinalis (*2,53%), *Eleusine indica (*2,38%) dan *Cardamine flexuosa (*2,14%). Jenis gulma dengan nilai SDR terkecil adalah *Mazus pumilus* (1,03%), *Erigeron sumatrensis* (1,03%) and *Eragrostis curvula* (1,75%).

The high value of SDR in Bidens pilosa, Galinsoga parviflora Cav, and Ageratum conyzoides was accompanied by high density, frequency, and dominance values. The high values of density, frequency, and dominance indicate that the number of Bidens pilosa, Galinsoga parviflora Cav, and Ageratum conyzoides individuals found are many and found in all sample plots. The soil surface area covered by these species is more significant than other weed species.

These three weed species come from the same family and class: Astraceae and the broadleaf weed class. This type of weed is highly adaptable because it can survive in humid, dry, and waterlogged conditions. This weed has a taproot silvery system, is a compound flower type with flat and oval-shaped fruit, and is down to allow the widest distribution. The Asteraceae family is a perennial weed that is widely spread and is included in malignant weeds because its population is often more dominant than other wild plants in a field (Sukamto, 2007).

Bidens pilosa SDR value is higher than other weed species, and its presence is in all weed plots. Bidens pilosa has the highest population size and dry weight compared to other weed species. The greater the SDR value of a weed species, its ability to compete with other species increases. This study is in line with Sutriyono *et al* (2009), who states that the higher the SDR value of a species, the greater its ability to master biotic and abiotic factors in its environment.

Weed A. conyzoides is one type of weed from the Asteraceae family. A. conyzoides weed belongs to a group of annual plants that grow on agricultural land, rubber plantations, secondary crops, coffee, tobacco, cloves, and oil palm. It can be found up to 3,000 meters above sea level, with high light intensity and shade. Ageratum conyzoides has a light seed texture with many seeds, can be scattered with the help of wind, and is quite disturbing in plantations. This plant is highly competitive, so it quickly grows everywhere and is often a weed that harms farmers (Okunade, 2002).

Weed species with the smallest SDR values are Mazus pumilus, Erigeron sumatrensis, and Eragrostis curvula. These weed species come from different families: Mazaceae, Asteraceae, and Poaceae. The low SDR values of these three weed species align with the low values of relative density, relative frequency, and relative dominance. The number of individuals of these three weed species was not found in many sample plots, and the soil surface area covered by these species was less than other weeds.

It can be due to the small seed bank and the position of weed seeds in the soil that do not rise to the surface, dormant weed seeds, unfavorable environmental conditions, and the non-fulfillment of the weed's growing conditions. The dominance of one or more weed species can also cause certain weed species not to develop. According to Hendrival *et al.* (2014), the reproductive organs of some weed species are initially in the soil (seed bank) and are still dormant due to tillage, fertilization, and irrigation. However, without tillage support, weeds become dormant and do not develop and compete for nutrients, water, light, and growing space.

In general, SDR is determined by three factors, namely density, frequency, and dominance. A high density indicates its ability to reproduce. The higher the ability to reproduce, the more the weed species will be able to compete with the surrounding plants (Yuliana and Ami, 2020).

Percentage of Live Weeds, Dead Weeds, and Herbicide Efficacy

Allelopathy is one of the new, cheap, natural, and effective weed control methods. Many recent studies have shown that allelopathic extracts can control noxious weeds. Important allelopathic plants release glycosides, sorgoleones, alkaloids, phenolics, flavonoids, and terpenoid allelopathic compounds. Due to their highly allelopathic nature, these compounds actively reduce the growth of surrounding plant species and affect seed germination. Allelopathic plants and weeds can significantly reduce weed solids and biomass (Korejo *et al.* 2021).

The results of field tests using extracts of sunflower plant parts (Helianthus annus L.) at a concentration of 1000 molar showed the same results on the percentage of live and dead weeds, as shown in Table 2. The percentage of live weeds against bioherbicide applications from each part of the sunflower plant showed 100% live and no dead weeds, so the percentage of dead weeds was 0%. The efficacy of sunflower plant parts extracts showed poor results at (%) coverage of 69.9 - 65, except for the Ha15 stem part with (%) coverage of 29.9 - 0. It can occur because the low concentration of extracts of sunflower plant parts affects the content of bioactive compounds/allelochemicals and shortens environmental durability. It often uses various action modes, reducing the risk of herbicide resistance (Bailey, 2014).

Table 2. Percentage of Live Weeds, Dead Weeds, and Herbicide Effectiveness

Treatment	Live Weeds	Dead Weeds	Efficacy
Root Ha1	100%	0%	Ugly
Root Ha15	100%	0%	Ugly
Stem Ha1	100%	0%	Ugly
Stem Ha15	100%	0%	No effect
Leaf Ha1	100%	0%	Ugly
Leaf Ha15	100%	0%	Ugly

Figure 2. Weeds after application of sunflower extract (Helianthus annus L.)

However, visually, the application of the extract showed little effect on the leaves of Galinsoga parviflora Cav, which is classified as a broadleaf weed, as shown in Figure 2. It could be because allelochemicals interfere with photosynthesis, respiration, hormone balance, and water absorption so that they can affect the growth of surrounding vegetation. The type of allelochemical, bioactive compound/allelochemical content, concentration, plant growth stage, type of formulation, spray preparation, application method, soil type, target plant, and environmental factors (light, CO_2, temperature, humidity) are the main factors responsible for allelopathic interactions. (Hasan *et a*l. 2021)

Factors that may affect the allelopathic possibilities of plant species include plant part. The allelopathic potential of plant material extracted from fresh or dried plants varies depending on the method used. Allelopathic performance is affected by seasonal changes and the growth stage of the species. The results confirmed similar findings in a previous study: sunflower aqueous extract in 10% concentration delayed and reduced mustard and oilseed germination but increased seedling dry weight. Increasing concentrations of sunflower aqueous extracts increase the negative allelopathic potential, which is especially noticeable in seedling growth. Higher concentrations usually have a more significant negative impact; studies have sometimes found germination and growth inhibition of up to 100%.

Conversely, lower extract concentrations can result in seedling growth and biomass accumulation. These extracts can also serve as biostimulators to promote plant growth. The phenological stage of donor plants affects allelochemical diversity, concentration, and potency. Plant material at the vegetative stage was more allelopathic than at the fertilization stage in some studies (Ravlic *et al*. 2022)

4. Conclusions

The results obtained 17 weed species in the experimental field of Nagari Selayo Tanang Bukit Sileh from 7 families (Asteraceae, Poaceae, Lythraceae, Polygonaceae, Brassicaceae, Caryophyllaceae, and Mazaceae) and two weed classes (broadleaf weeds and grasses). The bioherbicide efficacy of sunflower extract (Helianthus annus L.) has not caused symptoms of toxicity in weeds. This is because the concentration used is still low.

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