Allelopathic Potential of Basil's Leaves Extracts on the Germination Characteristics of Several Vegetables

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Abstract. Some plants can prevent seed germination and other plants' growth by producing poisonous allelochemical ingredients. This research aimed to study the effect of basil leaves extracts on the germination characteristics of several vegetables. The experiment was conducted in factorial based on a completely random design with three replications. The experimental treatments were three types of vegetables (green mustard, green spinach, and water spinach) and five-level of basil leaf extracts (with concentrations 0, 25, 50, 75, and 100 percent). Results showed that there were significant differences between the concentrations of basil leaves extracts, vegetable types, and interaction between both of them for all studied traits ($P < 0.05$). There was no significant difference in the treatment of vegetable types in the germination rate and germination percentage parameters. The extract of basil leaves at 100 g / 200 ml of water (0.5 g/ml of water) had the effect of reducing germination rate and germination percentage of green mustard and water spinach. In the present study, increasing the concentration of basil extracts from zero to 100% in all three types of vegetables decreased significantly germination rate, germination percentage, radicle length, plumule length, and seed vigor index.

Keywords: Allelopathy · Basil · Seedling · Seed vigor · Vegetables

1 Introduction

Allelopathy is a mechanism that shows competition in which some plants produce biomolecular compounds (called allelochemicals) into the environment and have the potential to inhibit the growth of other plants around the allelopathic producers [1]. Allelochemical compounds in plants that are released into the environment can interfere with the growth of other types of plants that grow nearby, such as inhibiting plant growth, nutrient absorption, and germination, so it can act as a plant growth regulator by encouraging or inhibiting the growth of an organism. The release of an allelopathic compound process to the environment can be done through several methods which are leaves or stem leaching (deposition), evaporation (especially in semi-arid and arid states), root secretion, and tissue degradation by microorganisms [2] The allelopathic activity relevance in plants has been suggested for weed management because it allows the reduction expensive synthetic herbicides usage [3, 4].

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Species from the Labiatae family (Lamiaceae) are known to have the ability to secrete strong allelochemical compounds against other plant species [5]. One of the plant species from the Labiatae family is *Ocimum basilicum* L. (basil). The chemical content of phenols and terpenes as secondary metabolites in basil indicates that basil is an allelopathic plant, although phenolic compounds have been studied more because they are contained in most plants and are significantly involved in allelopathy interactions [6, 7]. According to [8] the effect of aqueous extracts from allelopathy plants on germination and growth can occur directly or indirectly, through mechanisms of inhibition of plant growth, and transformation of nutrients to their effect on germination. Basil was reported as a plant that has allelopathic potential for other plants [9]. Research on the effect of basil extract on corn and soybean seeds showed that the concentrate enhancement from basil extracts can decrease germination percentage, fresh weight, and radicle and plumule length in corn and soybean, but it raised shoot and root ratio for both of them [10]. However [6], it showed that a high concentrate of basil extract (20%) had a negative effect, namely reducing radicle and plumule length for corn, while the low concentration of basil extracts (5% and 10%) can trigger radicle and plumule elongation in corn. The study on the other plants showed that basil extracts can reduce the plumule growth in wheat, corn, chickpeas, lentils, mustard, barley, okra, and peas seed in the amount of 37% compared with the control [11].

Understanding the mechanism of the allelopathic relationship between aromatic plants and cultivated plants is necessary for the proper and effective management of agricultural ecosystems. Considering the economic importance of several vegetable crops, this research aimed to study the effect of basil's leaves extracts on the germination characteristics of several types of vegetables, particularly green mustard (*Brassica juncea* L.), green spinach (*Amaranthus tricolor* L.) and water spinach (*Ipomea reptans* Poir).

2 Materials and Methods

The present research aimed to study the effect of basil leaf extract on the germination characteristics and the growth of several types of vegetables. The experiment was carried out in factorial based on a completely random design with three replications in the Environmental Resources Laboratory, Universitas Brawijaya in September 2022. The treatments of the experiment included three types of vegetables (green mustard, green spinach, and water spinach) and five levels of aqueous extracts of basil's leaves (0, 25, 50, 75, and 100 percent).

2.1 Extraction of Plant Parts

Leaves from the basil plant were used to obtain basil's aqueous extracts. The leaves part was chosen because the maximum allelopathic inhibitory effect was obtained from basil extract from the leaves than the other organs [11]. Basil's leaves were obtained from a vegetable merchant in Kedungrejo Vegetable Market, Pakis, Malang District in September. The leaves and stems of the plants were separated, then the leaves were dried by using an oven at 105 °C. The leaves were dried until their weight was stable. Then, the dried leaves are crushed with a blender into a powder and stored in an airtight container until used. Furthermore, basil powder was added with 70% alcohol which functions to release chemical compounds contained in plant organs. After that, the basil powder was left at room temperature until the alcohol evaporated. To obtain 100% basil extract, it was needed 100 g of basil powder and added 200 mL of distilled water, then filtered by using a sieve and filter paper. In the next step, by adding distilled water to this strong extract, aqueous extracts with concentrations of zero (control), 25, 50, and 75% were prepared. Furthermore, aqueous extracts were stored in a fridge before they were applied [12].

2.2 Germination of Vegetables

Certified commercial seeds from tosakan variety green mustard (CV. East-West Seed), maestro variety green spinach (CV. East-West Seed), and laris variety water spinach (CV. Seed Inti), which contain 85% germination percentage and 99% purity were used in this study.

In the preparation stage, the seeds were sterilized with 1% (v/v) sodium hypochlorite solution (NaOCl), for 3 min while continuously stirring to reduce fungal infection. Next, the seeds were washed by using distilled water several times and were stored at room temperature until they were used. Seed testing was carried out using straw papers. The first sheet of straw paper was sprayed at the beginning with basil's aqueous extract. Then fifty seeds of each type of vegetable were placed on the straw paper and covered with another sheet of straw paper, furthermore, the paper was rolled up and stood up. Three replicates were repeated for each treatment. The rolled papers were placed at room temperature which is 25.4–26 °C and 71–79% humidity for 9 days. During germination, the rolled papers were opened, and extract solutions were sprayed according to concentrate treatments. The seeds were observed for their germination after 9 days germinate. At the end of the experiment (day 9), germination rate, germination percentage, root length, shoot length, and seed vigor were measured. The data were analyzed using Microsoft Excel and Honest Significant Difference Test (HSD) was used for ranking of means.

3 Results and Discussion

Analysis of variance (ANOVA) indicated that there were significant differences between basil extracts, types of vegetables, and interactions between the two treatments for all studied traits (Table 1). There were significant differences between the type of vegetables and interaction between the type of vegetables × basil's extracts in terms of the studied traits. There was no significance in the treatment of vegetable type on the parameters of germination rate and germination percentage.

3.1 Germination Rate

The results of laboratory experiments showed that water extract of basil leaves at a concentration of 100% decreased germination rate of the tested vegetable seeds more than the control, except for green spinach. The reduction in germination rate increased

Table 1. Analysis of variance (mean of squares) for some germination characteristics and growth of several vegetables.

Mean squares						
SOV	Df	Germination rate	Germination percent	Root length	Shoot length	Seed Vigor
Type of vegetables	2	0.85ns	0.85ns	26.18**	8.29**	47.71**
Basil's extracts	4	8.53**	8.53**	37.44**	39.30**	150.58**
Type of vegetables x basil extracts	8	1.16**	1.16**	1.90**	4.99 **	9.53**
Error	30	0.35	0.35	0.44	0.35	0.80
CV	44	13.39	13.39	23.23	18.54	16.94

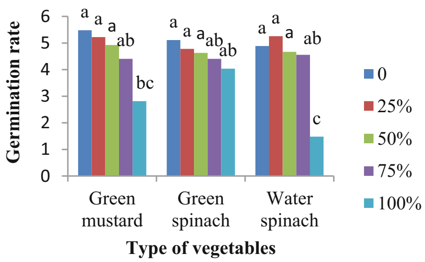

Fig. 1. Mean comparisons of basil extract with the type of vegetable treatments in terms of germination rate.

along with the increasing concentration of basil extracts in green mustard and water spinach. Figure 1 showed that the highest germination rates observed in green mustard were control, 25%, 50%, and 75% basil extracts. Water spinach showed that the highest germination rates observed were control, 25%, 50%, and 75% basil extracts. The lowest germination rates were observed in water spinach and green mustard which were given 100% basil extract with an average of 1.48 and 2.81. Water spinach seeds were more highly affected by the aqueous extract of basil's leaves than other types of vegetables.

Ns, **, and * are no Significant, Significant at 1 and 5% probability levels, respectively.

The germination delay is probably due to the release of some phenolic compounds from basil, which affects germination [13]. In green spinach, the application of basil extracts did not show a significant difference with an increase in extract concentrations compared to the control.

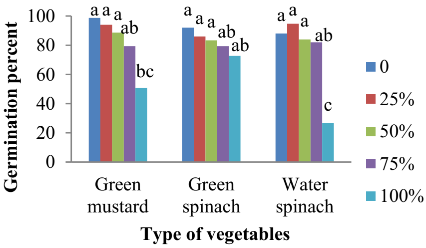

Fig. 2. Mean comparisons of basil extract with the type of vegetable treatments in terms of germination percent.

3.2 Germination Percentage

Figure 2 showed the average comparison of basil extracts to vegetable treatment, it showed that basil's control treatment to three types of vegetables (green mustard, green spinach, and water spinach) showed the highest germination percentages of 98.67, 92, and 94. 67 percent. The lowest germination percentages with an average of 26.67 and 50.67 percent were observed in water spinach and green mustard which were treated with 100% basil extract. This finding is following the observations made by [14] that evaluated the allelopathic effect of basil (*O. basilicum*) in plant germination as toxic. They found that the aqueous extract of the above-ground portion of sweet basil significantly reduced the seed germination proportion from poaceus plants compared to the control. The percentage reduction of seed germination was increased with water extract from the topsoil.

In this study, green spinach had a relatively high germination percentage compared to other vegetable seeds in the basil extracts treatment. It can be said that green spinach was not sensitive enough to basil's extracts which showed at 83% average germinate percentage.

3.3 Radicle Length

The highest radicle lengths (7.30 cm and 7.40 cm) were obtained from green mustard and water spinach with control treatments. The smallest radicle length was observed in green mustard and green spinach with 100% basil extract which was not significantly different from green mustard at 50% and 75% treatment; with green spinach at 25%, 50%, and 75% treatments. In green mustard and water spinach, giving basil extract concentrate starting from 25% significantly reduced radicle length compared to the control. In green spinach, the application of basil extracts at a concentration of 50% significantly reduced radicle length than the control (Fig. 3).

Radicle length showed more inhibition than plumule length. A possible explanation is that the allelochemical permeability to roots is greater than to stems [6, 15]. This result is also aligned with other studies which reported that lower allelochemical concentrations generally have less impact or stimulatory effects on plant growth, while negative effects increase with advanced concentrations [16].

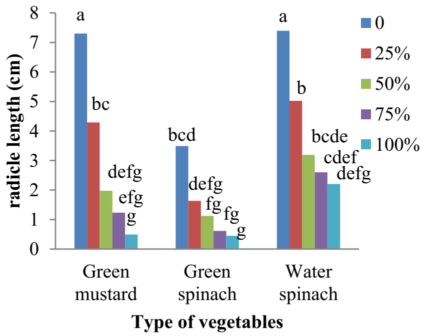

Fig. 3. Mean comparisons of basil extract with the type of vegetable treatments in terms of radicle length.

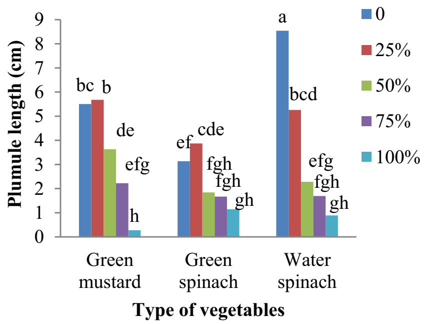

Fig. 4. Mean comparisons of basil extract with the type of vegetable treatments in terms of plumule length.

3.4 Plumule Length

The highest plumule length was found in the control of water spinach with an average of 8.54 cm, while the lowest was recorded in green mustard with 100 percent basil extract with an average of 0.27 cm which was not significantly different from green spinach in 50%, 75%, and 100% treatments; water spinach at 75% and 100% treatments (Fig. 4). In water spinach, by giving of basil's extracts at the concentration of 25% significantly reduced plumule length than control. In green mustard, giving basil extracts with concentrations starting from 50% significantly reduced plumule length compared to controls. In green spinach, the application of basil extract with concentrations starting from 100% significantly reduced plumule length more than the control. These results showed that stem growth is depending on nutrient content in initial growth seeds, and direct contact with basil extracts occurs higher in roots than stems [10].

3.5 Seed Vigor

The highest seed vigor was obtained from mustard green and water spinach with extract control, the lowest seed vigor was obtained from mustard green starting from 50% to

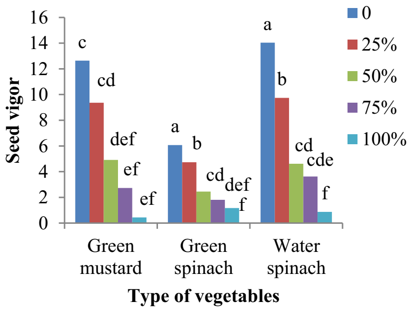

Fig. 5. Mean comparisons of basil extract with the type of vegetable treatments in terms of seed vigor.

100% basil extract concentrations, green spinach with 75% to 100% basil extract concentrate, and water spinach with 100 percent basil's extract concentrate. At a concentration of 25% basil extract, it significantly reduced the vigor index of green spinach and water spinach seeds than the control. While in green mustard seeds, the concentration of 50% basil extracts significantly reduced the seed vigor index compared to the control (Fig. 5).

4 Conclusion

The results showed that there were significant differences between the concentrations of basil extracts, the type of vegetables, and the interactions between the two studied traits ($P < 0.05$). There was no significant difference in the treatment of vegetable types in germination rate and germination percentage parameters. The extract of basil leaves at 100 g / 200 ml of water (0.5 g/ml of water) had the effect of reducing germination rate and germination percentage of green mustard and water spinach. In the present study, increasing the concentration of basil extracts from zero to 100% in all three types of vegetables decreased significantly germination rate, germination percentage, radicle length, plumule length, and seed vigor index. Basil's leaves extract with a high concentration (100%) had a negative effect, namely reducing the length of the radicle length and plumule length in green mustard by 93.25% and 94.97%, in green spinach by 87.11% and 63.51%, in water spinach by 70.17% and 89.58%, while at low concentrations (25%) basil extract was able to trigger plumula elongation in green mustard by 3.21% and in green spinach by 23.51%.

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