

WEED SUPPRESSION POTENTIAL OF *AILANTHUS*
ALTISSIMA COMPOST: EFFECTS ON GERMINATION
AND EMERGENCE

Ahmet Tansel Serim

Received on March 21, 2025

Presented by H. Najdenski, Member of BAS, on April 29, 2025

Abstract

The Tree of Heaven (*Ailanthus altissima* (Mill.) Swingle), originally from Southeast Asia, is considered an invasive alien plant in many countries. It produces a strong allelochemical called ailanthone, and this phytotoxic quassinoid inhibits the germination of seeds and/or suppresses the growth of other plants. This study aimed to determine the applicability of plant biomass of the *Ailanthus* as a raw material to prepare various compost types. The compost treatments were composed of the biomass of *A. altissima* alone, the biomass of *A. altissima*+chicken manure, and the biomass of *A. altissima*+cattle manure. Weed seeds in the mixtures were kept for 7, 14, 21, and 28 days in the composts during the summer and autumn seasons, and the effect of these durations on the viability of the weed seeds was determined by a 28-day petri experiment. The percentage of decayed weed seeds (DSP) placed in the compost increased over time. The decayed seed percentage for *Sorghum halepense* (L.) Pers. (Johnson grass) in summer-prepared compost was higher than that in autumn-prepared composts, whereas seasonal differences were insignificant for *Convolvulus arvensis* L. (Field bindweed). Additionally, increasing mulch thickness reduced weed emergence, indicating that a mulch layer of at least 5 cm is necessary for effective weed control.

Key words: *Ailanthus altissima*, compost, weed control, manure, germination, emergence

This study was supported by the Bilecik Seyh Edebali University Coordinatorship of Scientific Research Projects Commission. Project Number: 2021-01.BŞEÜ.06-01.

<https://doi.org/10.7546/CRABS.2025.05.17>

Introduction. Agricultural production aimed to feed humans and animals at the early stages, but industrial revolution followed by green revolution led to a paradigm shift in all agricultural production systems in the world called the agro-industrial model [1, 2]. Agriculture has become a major industrial branch to provide raw materials to other sectors [3]. Although many scholars indicated that this system was built on the knowledge of other modern industries, heavy input use such as pesticides and fertilizers, was the basis of the system [4]. Herbicides are pesticides that are commonly used to kill weeds in agricultural and non-agricultural areas because they may reduce the cost of crop production, and affect in a short while [5]. Although the advantages of herbicides are evident, public concern about their side impacts is increasing day by day [6]. Nevertheless, chemical weed control should have been a complementary part of integrated weed management. On the other hand, using allelopathic plants or their extract to control weeds in agricultural fields is an eco-friendly and cost-effective approach compared to herbicides [7].

Allelopathic plants can be used in various ways such as cover crop, compost material, plant extract, or herbicide + plant extract mixture [8]. The aims of all application techniques are the same; effective use of allelochemicals which are plant-derived chemicals that may effectively suppress the growth or proliferation of weeds. The extraction of allelopathic compounds is a time-consuming and expensive process to reach the extract even if it has a strong impact on the weeds. However, the use of allelopathic plants as a mulching material can be more reliable when the plant material can be easily reachable and in large amounts compared to other methods, and they may also prove a physical barrier for weeds [8, 9].

The Tree of Heaven is a perennial woody plant that can produce various allelochemicals including quassinoids, terpenoids, and alkaloids [10]. The widespread distribution and invasive nature of this plant in many regions around the world have been well documented, making it a problematic weed in these areas [11]. Numerous studies have reported that the allelochemicals released from the weed exhibit strong inhibitory effects on the germination and growth of a diverse range of plant species [12]. This feature of the tree makes it a potential candidate as a natural weed suppressor in agricultural systems instead of synthetic herbicides [13].

Crops or weeds can be a valuable source for preparing compost or mulch if they are obtained in sufficient quantity. Using some part of perennial weeds in fallow fields or invasive alien plants may be a new source to prepare compost/mulch materials. However, their seeds in compost/mulch are the biggest obstacle to using them safely. Field bindweed is considered one of the most difficult weeds to control due to its extensive root system and ability to spread [14]. Johnson grass is also a competitive and persistent perennial grass species that can outcompete crops [15]. Seeds of both have a thick seed coat that prevents germination of most seeds simultaneously and protects from unfavourable conditions. Using their veg-

etative biomass as compost material may not be practically possible because their robust seeds may incorporate into compost.

This study aims to determine the impact of various compost materials that were produced from the Tree of Heaven on seed germination of field bindweed and Johnson grass when they were used as mulch materials, and the emergence of various weeds.

Material and methods. Preparing crude compost material. The branches of the Tree of Heaven were cut and dried under shadow for 3–4 weeks. Dried branches were chopped by using a crumbler (3–5 cm) and were dried again for 4 weeks. The compost was prepared by wood clipping of the Tree of Heaven (WCTH), dried chicken or cow manure, urea, and water (50 kg + 12.5 kg + 0.25 kg + 2 l) on polypropylene sheet. The mixture was put in black PP bags and stored for 28 days. Compost mixtures were prepared in summer and autumn. Three compost mixtures were prepared using the above materials: WCTH+Urea+Water (T1: Control), WCTH+Urea+Water+Cow manure (T2), and WCTH+ Urea+Water+Chicken manure (T3).

Field bindweed (*Convolvulus arvensis* L.) and Johnson grass (*Sorghum halepensis* (L.) Pers.) seeds were collected from the fields of Agricultural Treatment and Research Centre (ATRC Asagikoy, Bilecik, Türkiye), dried in laboratory at ambient conditions and cleaned. Seed packets consisting of field bindweed and Johnson grass were prepared and put in stainless steel tea strainers. Each strainer contained 200 seeds, with equal numbers from both species. These strainers were placed immediately after in black compost bags filled with compost materials. One strainer was removed from the bags to test the germination rate each week.

The data logger was sealed using a thick stretch film layer, and placed into the bag to record temperature during composting. Maximum summer and autumn temperatures were 36.2 and 31.6 °C, whereas average temperatures were 26.7 and 21.4 °C during the composting period.

Laboratory experiment. A standard seed germination test protocol was conducted to determine the impact of compost mixture on seed germination. The seeds taken from the compost were disinfected by using sodium hypochlorite solution (1%) for 3 min and rinsed with distilled water for 3 min three times. Cleaned seeds were placed in Petri dishes including 3 Whatman filter paper (No 1) that were moistened using distilled water. Petri dishes were sealed by parafilm to reduce water loss and prevent contamination. They were placed in an incubator adjusted at 20 ± 1 °C and checked 3 times a week to determine the germination rate. Molded seeds were removed from the medium of each check using sterile forceps. The experiment was set up completely randomized block design with three replicates.

Climate chamber experiment. The soil that contains numerous seeds belonging to different genera was collected from ATRC, and was sieved through an 8 × 8 mm wide sieve to remove stones and debris. The soil was dried for one

week under shadow and stored until used in the experiments. The pots (20 cm high $\times$ 7 cm diameter) were filled up to one fourth with dried soil. Thereafter, rude compost materials were chopped into 0.5–1 cm long pieces and filled on the soil at 4 lengths, 2.5, 5, 7.5, and 10 cm in the pots. The pots were placed into cuvettes filled with 2 cm tap water, and these cuvettes were put in a climate chamber adjusted to $24 \pm 1^\circ\text{C}$ and at $20 \pm 1^\circ\text{C}$ (12 h Day-Night 12 h Night). The pots were checked 3 times a week, and the germinated seeds were counted and removed from the pots. The experiment was set up complete randomized block design with three replicates. Weed species that emerged in control pots were *Amaranthus retroflexus* L., *Portulaca oleracea* L., *Chenopodium album* L., *Cyperus rotuntus* L., *Echinochloa crus-galli* (L.) P. Beauv., *Seteria viridis* (L.) P. Beauv., *Sorghum halepense* (L.) Pers., *Convolvulus arvensis* L., *Conyza canadensis* (L.) Cronquist.

The data was subjected to analysis of variance using the R statistical program with package Agricolae [16, 17]. The means were separated from others using the Duncan multiple comparison test.

Results and discussion. The germinated seed percentage (GSP) of Johnson grass and field bindweed in non-treated control was 7.3 and 9.1%, respectively. GSP in all composts prepared in the summer season for both weeds was lower than untreated control (Table 1, 2), and no significant differences were found between composting seasons in terms of seed germination. This result aligns with previous studies, which indicate that the seeds of these weeds had strong seed coats to protect them from unfavourable environmental conditions and continued their dormancy [18, 19].

The decayed seed percentage (DSP) of Johnson grass was limited at the end of the first week, but more seeds decayed in the second week and the following

T a b l e 1

Impact of composting time, composting period (week), and compost type on the germination of Johnson grass seed (%)

Composting time	Week	Control		TH+Cow manure		TH+Chicken manure	
		Germinated	Decayed	Germinated	Decayed	Germinated	Decayed
Summer	1	0.67 c*	3.33 d	0.33 d	10.67 d	1.00 a	11.67 d
	2	3.67 b	11.33 c	1.33 c	27.00 c	1.00 a	27.33 c
	3	5.00 a	28.00 b	2.33 b	59.00 b	2.00 a	53.67 b
	4	6.00 a	46.67 a	4.00 a	93.67 a	2.67 a	91.33 a
Autumn	1	1.00 c	9.33 d	1.00 d	6.67 d	0.67 d	5.67 d
	2	1.33 c	15.67 c	2.00 c	17.33 c	2.00 c	19.67 c
	3	2.00 b	26.00 b	3.67 b	35.00 b	3.00 b	41.33 b
	4	3.33 a	40.67 a	4.33 a	50.67 a	4.33 a	67.00 a

*The letters in the same column represent statistical significance, while different letters indicate significant differences between the weeks in the same composting time ($P < 0.05$).

T a b l e 2

Impact of composting time, composting period, and compost type on the germination of field bindweed seed (%)

Composting time	Week	Control		TH+Cow manure		TH+Chicken manure	
		Germinated	Decayed	Germinated	Decayed	Germinated	Decayed
Summer	1	0.33 c*	2.33 d	–	6.33 d	0.33	10.67 cd
	2	1.33 b	7.67 c	0.33 b	27.00 c	1.33 ab	19.67 c
	3	3.00 a	18.33 b	1.33 a	40.33 b	1.67 a	38.33 b
	4	3.33 a	25.33 a	1.67 a	73.33 a	3.00 a	59.33 a
Autumn	1	0.67 d	4.33 d	1.00 c	9.33 d	0.33 d	11.00 d
	2	1.00 c	10.00 c	2.33 b	22.67 c	1.00 c	20.67 c
	3	2.00 b	21.67 b	3.33 ab	50.67 b	2.33 b	38.67 b
	4	3.67 a	36.67 a	4.67 a	77.67 a	3.33 a	55.00 a

*The letters in the same column represent statistical significance, while different letters indicate significant differences between the weeks in the same composting time ($P < 0.05$).

period. Manure-borne pathogens quickly contaminated weed seeds during the composting period. The mold penetrated the seeds and prevented germination even if all seeds were disinfected by sodium hypochlorite solution before the germination test. The decayed seed percentages exceeded 50% and 70% in T3 and T2 composts, respectively. No meaningful difference was found between germination seed numbers of Johnson grass placed in T2 and T3 composts prepared in summer and autumn at the end of the 4th week, but it was significant for T1 compost (Table 1).

DSP of field bindweed in all composts prepared in the summer season was statistically higher than in the autumn season except for T1 compost (Table 2). Although there was no meaningful difference between T2 and T3 composts prepared in the summer season regarding DSP, this difference was significant for the autumn-prepared composts 28 DAT. DSP of Johnson grass in all summer-season composts was higher than that of the field bindweed (Table 1, 2). Contrary to the summer season, T2 autumn-season compost caused less field bindweed decay than Johnson grass during autumn. WIESE et al. [20] showed that viability loss of field bindweed was only possible at high temperatures (83 °C) in compost for seven days whereas Johnson grass seeds were killed at 72 °C for 3 days similar to our results.

The seedling counts declined as mulch depth increased regardless of compost type (Table 3). Summer-season compost was more suppressive on the emergence of weeds than autumn-season compost when mulch depth was less than 5 cm. No significant difference was found between the suppressive impact of 7.5 cm and 10 cm mulch prepared in both seasons. Ten centimeters of mulch was the most effective in preventing weed emergence regardless of season or compost type. Previous studies indicated that increasing mulch depth negatively correlated with

weed counts similar to our findings [21].

T a b l e 3

Effect of composting time, mulch depth, and composting type on the emergence of weed seeds (%)

Composting time	Depth (cm)	Treatments	
		TH+Cow manure	TH+Chicken manure
Summer	2.5	53.34 a*	100.00 a
	5	35.00 b	61.67 b
	7.5	21.67 c	25.00 c
	10	23.34 c	13.34 d
Autumn	2.5	61.67 a	86.67 a
	5	45.00 b	48.34 b
	7.5	23.34 c	21.67 c
	10	11.67 d	16.67 d

*The letters in the same column represent statistical significance, while different letters indicate significant differences between the mulch depth in the same composting time ($P < 0.05$).

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Department of Plant Protection, Faculty of Agriculture and Natural Sciences,
 Bilecik Seyh Edebali University, Petiözü/Bilecik, 11110, Türkiye
 e-mail: ahmettansel.serim@bilecik.edu.tr