

EFFECTS OF HERBICIDAL TREATMENTS IN “FINOLA”
HEMP VARIETY (*CANNABIS SATIVA* L.)

Kübra Kale^{1✉}, Doğan Işık¹, Hasan Kale²,
Güngör Yılmaz³

Received on January 8, 2024

Presented by H. Najdenski, Member of BAS, on October 29, 2024

Abstract

Industrial hemp (*Cannabis sativa* L.) is a multi-purpose crop grown for its fibres, seeds and oil obtained from its seed. Finola hemp variety is a dioecious plant according to its flowering state, and its seeds have high protein and oil content and low THC content, making them preferred for use. This study was conducted to determine the effects of some herbicides on the Finola hemp variety. The trial was carried out in the trial area of Yozgat Bozok University in the form of pot and field studies. In the trial, the phytotoxic effects of herbicides on Finola variety hemp, plant height, technical stem length, stem diameter, biomass yield, dry stem yield, and fibre yield were examined. As a result of the experiment, the highest phytotoxicity was obtained from the application of bentazone (%75.52). The highest plant height (88.91 cm), technical stem length (660.25 cm), stem diameter (6.69 mm), biomass yield (1479.1 kg ha⁻¹), dry stem yield (378.6 kg ha⁻¹), and fibre yield (427.1 kg ha⁻¹) were obtained in the weed-free control plots. The lowest plant height was obtained from the weedy control (34.12 cm), the lowest technical stem length was from the bromoxynil application (20.85 cm), the lowest stem diameter was from the bromoxynil application (3.87 mm), the lowest biomass yield was from the bromoxynil application (352.0 kg ha⁻¹), the lowest dry stem yield (136.0 kg ha⁻¹), and the lowest fibre yield were obtained from bentazone application (129.0 kg ha⁻¹).

Key words: herbicide, industrial hemp, *Cannabis sativa* L., fibre yield, Finola

<https://doi.org/10.7546/CRABS.2024.11.18>

Introduction. Industrial hemp (*Cannabis sativa* L.) is a plant species belonging to the order Rosales, the family Cannabaceae and the genus Cannabis. The cannabis plant is an annual, herbaceous and dioecious plant [1]. Hemp is native to Central Asia and has spread to China, Manchuria, Japan, northern India, Turkey, Russia, Australia, Hungary, Italy, France, Belgium, Germany, Chile, and the United States. In these countries, hemp was cultivated for fibre production, in China and Manchuria for the extraction of oil from the seeds and fibres [2]. Hemp is a valuable plant for the fibres obtained from the stalks, the seeds and the oil extracted from the seeds [3].

Finola was first included in the official list of plant varieties in Finland in 2003 and is on the list of industrial hemp in the European Union [4]. The seeds of the hemp variety Finola have a high oil and protein content and are a dioecious plant according to their flowering time. Finola is a short and fast-maturing hemp variety that today has various potential uses in food and industry thanks to its secondary metabolites with different biological properties [5]. As the hemp variety Finola cannot compete well with other plants, weed control is necessary before planting. SANDLER and GIBSON [6] reported that studies on yield and quality losses caused by plant protection factors, especially weeds, in the production of Finola hemp variety are extremely limited, as in other countries of the world. This shows that it is important to increase studies on plant protection factors and especially weeds in hemp production. The aim of this experiment was to determine the herbicides and their doses that cause phytotoxicity in Finola hemp variety through pot and field trials, and to determine the effect of herbicides on plant height, technical stem length, stem diameter and the rate of change on fibre yield in hemp.

Materials and methods. Experimental site. This experiment to determine the effect of some herbicides on Finola variety hemp was conducted in a field of Yozgat Bozok University Agricultural Research and Application Centre in Yozgat province during the 2021 production seasons (Finola planting date: May 21, Finola harvest date: September 25). The meteorological information for the years during which the research took place is presented in Table 1. In the year 2021, when the trial was conducted, the total precipitation was determined to be 526.9 mm, with the lowest temperature recorded in April at 4.5 °C and the highest temperature in July at 37.4 °C. According to the soil analysis results, the soil texture is clayey with a slightly saline, moderately calcareous nature, neutral pH, high phosphorus content, and a moderate amount of organic matter.

In the pot and field experiment, 4 pre-emergence: 330 g/l pendimethalin (Tirinity EC), 480 g/l clomazone (Titan 48 EC), 720 g/l dimethenamid-P (Spectrum EC), 85% pyroxasulfone (Kelt Wg 85) and 4 post-emergence: 50 g/l Quizalofop-P-Ethyl (Quadrant EC), 480 g/l bentazone (Wuya SL), 75% halosulfuron methyl (INPUL 75 WG), 225 g/l bromoxynil (Elacure EC) were used as herbicides. 330 g/l pendimethalin 5000 ml ha⁻¹, 480 g/l clomazone 200 ml ha⁻¹, 720 g/l dimethenamid-P 800 ml ha⁻¹, 85% pyroxasulfone 150 g ha⁻¹, 50 g/l

T a b l e 1

Meteorological information for the year of the study

Month	Monthly average temperature (°C)	Monthly average humidity (%)	Monthly total precipitation (mm)
January	-1.5	71.8	81.8
February	1.4	63.9	25.8
March	1.6	71.4	138.7
April	9.3	59.8	52.2
May	15.5	48.9	18.5
June	16.1	63.1	67.4
July	21.2	51.1	27.1
August	21	51.8	5.8
September	14.6	62.7	38.0
October	9.9	60.1	1.8
November	6.6	73.0	65.4
December	2.0	71.1	4.4

Quizalofop-P-Ethyl 1000 ml ha⁻¹, 480 g/l bentazone 1500 ml ha⁻¹, 75% halosulfuron methyl 40 g ha⁻¹, 225 g/l bromoxynil 1500 ml ha⁻¹ were applied.

Pot experiments. The pot study was designed with four replicates. The mortar in the pots contained a mixture of arable soil, perlite and manure at a ratio of 1:1:1. Ten seeds per pot were sown with a volume of 5 l, a depth of 22 cm, and a diameter of 24 cm. The pot experiment lasted 90 days.

Field experiments. The experiments were conducted with three replicates according to the randomized block trial design in 2021. In the experimental blocks, 4 pre-emergence herbicide, 4 post-emergence herbicide, 1 hoe plot, 2 hoe plots, weedy control and weed-free control plots were established with and without weeds. In the experiment, the plots created as $1 \times 5 \text{ m} = 5 \text{ m}^2$ and the space between plots was 1 m. In the experiment, planting was done in a way that the distance between rows was 20 cm and the distance between plants was 4 cm. Planting of Finola hemp variety was done on 22 May 2021. Harvesting was performed on 22 September in 2021. In the experiment, 70 kg ha⁻¹ pure P and 40 kg ha⁻¹ pure N, which is half of the total nitrogen, were applied as base fertilization, and the remaining part of the nitrogen was applied during the stemming period of the plants. The trial was irrigated using the drip irrigation method.

Herbicide applications. In pot and field trials, pre-emergence herbicide applications were made on the same day after planting. Post-emergence herbicide application was carried out on 21 June 2021, 30 days after the Finola hemp variety was planted.

Herbicides were administered employing a Palmera SX-MD 18E portable sprayer. This portable sprayer was equipped with four 110° flat fan nozzles (11002) and

had a working width of 2 m. The spraying operation was carried out with a spray volume of 300 l ha⁻¹ under a constant pressure of 303.97 kPa.

Plant biometry. Plant height was determined by measuring the distance between the soil level and the top of 10 randomly selected plants from each plot. The technical length of the stem was determined by measuring the section from the hypocotyl to the intersection of the leaves in 10 randomly selected plants from each plot. The stem diameter of 10 randomly selected plants from each plot was determined using calipers at a point 15–20 cm above the soil surface. Ten randomly selected plants from each plot were weighed and the biomass yield was determined. After the leaves and side branches of the plants were cut off, the remaining part was dried and weighed, and the yield of dry stems was determined. After the harvested hemp stalks were separated from their branches, the pooling method was used to determine the fibre yield. The fibre yield was calculated by weighing the peeled and dried hemp stalks. In the evaluation of phytotoxicity, the visible damage was assessed on a scale from 0 to 100, with the plants killed by the herbicide being classified as 100 and the undamaged plants as 0 [7].

Statistical analysis. The phytotoxicity, yield, and yield components resulting from applications conducted to determine the effect of certain herbicides on the Finola hemp variety were statistically analyzed. The statistical analyses of the obtained data involved the formation of groups using the LSD multiple comparison test at a significance level of 0.05.

Results and discussion. The result of the pot experiment. In the pot experiment, the data obtained in the observations made on the 14th day after the application of pre-emergence herbicides to the Finola hemp variety were compared with the control group pot data and the effects of the herbicides on the hemp emergence rate were evaluated. Ten seeds were planted in each pot and 8 plants emerged in the control pot. In the research, the application with the highest emergence rate was pyroxasulfone (75%), while there was no statistical difference between this and the control group. The lowest emergence was achieved by the application of clomazone (40%), while the application of clomazone prevented emergence by 50%.

In the pot experiment, in Finola hemp variety the highest plant height was obtained from the control group (59.40 cm), while the lowest plant height was obtained from the bentazone application (32.54 cm). The highest stem diameter was obtained in the control group (3.30 mm), while the lowest stem diameter was obtained from bentazone application (1.99 mm). The highest root length was obtained from the application of pendimethalin (9.06 cm) in the control group, while the lowest root length was obtained from the application of pendimethalin (9.06 cm). In Finola hemp variety the highest phytotoxicity rate was detected in bentazone-treated plants with 80.25% (Table 2).

The result of the field experiment. In the field trial, as a result of herbicide application in Finola hemp variety, the highest plant height was obtained

T a b l e 2

Effect of herbicides on plant height (cm), stem diameter (mm), root length (cm) and phytotoxicity rate of Finola in pot trial

Treatment	Plant height (cm)	Stem diameter (mm)	Root length (cm)	Phytotoxicity (%)
Bentazone	32.54 d*	1.99 c	12.25 ab	80.25 b
Bromoxynil	33.39 d	2.04 c	10.10 bc	58.66 a
Clomazone	39.62 cd	2.11 bc	9.23 c	70.33 ab
Dimethenamid-P	44.52 bc	2.75 b	12.20 ab	0 c
Halosulfuron-methyl	48.00 b	2.80 ab	12.88 ab	0 c
Pendimethalin	44.33 b	3.20 a	9.06 c	0 c
Pyroxasulfone	52.92 ab	3.10 a	13.39 a	0 c
Quizalofop-p-ethyl	50.63 b	2.98 ab	12.56 ab	0 c
Control	59.40 a	3.30 a	14.32 a	0 c

*There is no difference according to the LSD test between the applications shown with the same letter in the columns ($p \leq 0.05$)

in the plots with weed-free control (88.91 cm), while the lowest plant height was obtained when bromoxynil (47.07 cm) and clomazone (47.95 cm) were applied (Table 3).

T a b l e 3

In the field trial, the effect of herbicides on plant height (cm), technical stem length (cm) and stem diameter (mm) in Finola hemp variety

Treatment	Plant height (cm)	Technical stem length (cm)	Stem diameter (mm)
Bentazone	57.30 d*	38.02 cd	4.46 ef
Bromoxynil	47.07 e	20.85 e	3.87 g
Clomazone	47.95 e	32.25 d	4.27 fg
Dimethenamid-P	72.19 c	37.19 cd	5.70 cd
Halosulfuron-methyl	57.22 d	34.57 cd	4.68 ef
Pendimethalin	81.99 b	59.60 a	6.45 ab
Pyroxasulfone	84.79 ab	39.81 c	5.91 bc
Quizalofop-p-ethyl	58.49 d	24.11 e	5.26 de
1 hand hoe	69.41 c	36.68 cd	5.68 cd
2 hand hoe	83.09 b	38.76 cd	6.58 a
Weed free control	88.91 a	60.25 a	6.69 a
Weedy control	34.12 f	33.43 d	3.95 g

*There is no difference according to the LSD test between the applications shown with the same letter in the columns ($p \leq 0.05$)

BYRD [8] reported that the highest hemp plant height was 49 cm in the control plot and was measured with pendimethalin (46 cm), dimethanamid-p (39 cm) and pyroxasulfone (21 cm), while the lowest plant height was measured with clomazone (8 cm) reported that it was achieved by application. METTLER [9] reported in his study that the lowest plant height was 100 cm in the weed control plot, the highest plant height was 121 cm in the plants treated with pendimethalin, and in the weed-free control plot it was measured at 113 cm, pyroxasulfone was 119 cm and bromoxynil was 99 cm.

In Finola hemp variety the highest technical stem length was obtained in the weed-free control plots (60.25 cm), and the lowest technical stem length was obtained when bromoxynil was applied (20.85 cm) (Table 3). AKSOY [10] indicated that the technical stem length of the hemp variety Finola, which had the shortest technical stem length of the 32 cm. YILMAZ et al. [11] reported that the technical stem length of the variety Finola was 56.23 cm.

In Finola hemp variety the highest stem diameter was obtained in the weed-free control plots (6.69 mm), while the lowest stem diameter was obtained when bromoxynil was applied (3.87 mm) (Table 3). KARA [12] and MERT [13] reported that the most suitable stem thickness for fibre yield in hemp plants should be between 5 and 20 mm. Based on this literature, it was found that the stems of Finola hemp variety treated with the herbicides bromoxynil, bentazon, clomazone and halosulfuron-methyl were outside the ideal values for stem thickness due to phytotoxicity.

According to the data obtained from the field trial, the highest biomass yield of the Finola hemp variety was observed in the weed-free control plots (1479.1 kg ha⁻¹) and the lowest biomass yield when bromoxynil was applied (352.0 kg ha⁻¹) (Table 4).

MAXWELL [14] reported that the application of bromoxynil and bentazone reduced the biomass yield by an average of 52% compared to the weed-free control and there is a correlation between phytotoxicity and biomass yield in hemp. In accordance with this literature, bromoxynil and bentazone applications cause high phytotoxicity, resulting in a lower biomass yield than the control. In Finola hemp variety the highest dry stem yield was obtained in the weed-free control plots (378.6 kg/ha⁻¹), while the lowest dry stem yield was obtained when bromoxynil was applied (136.0 kg ha⁻¹) (Table 4). Yilmaz et al. [11] reported that the dry yield of the Finola variety was given as 920 kg ha⁻¹.

In Finola hemp variety the highest fibre yield was obtained in the weed-free control plots (427.1 kg ha⁻¹), the lowest fibre yield when bentazone was applied (129.0 kg ha⁻¹). The highest phytotoxicity rate, 75.52%, was obtained in the plants treated with bentazone, but phytotoxicity was also observed in the plants treated with bromoxynil (58.44%) and clomazone (20.54%) (Table 4).

In this trial, weedy control and weed-free control were compared in terms of yield and yield components, and yield reductions due to weeds were reported.

T a b l e 4

In the field trial, the effect of herbicides on biomass yield, dry stem yield, fibre yield and phytotoxicity rate in Finola hemp variety

Treatment	Biomass yield (kg ha ⁻¹)	Dry stem yield (kg ha ⁻¹)	Fibre yield (kg ha ⁻¹)	Phytotoxicity (%)
Bentazone	691.6 cde*	199.6 bc	129.0 f	75.52 a
Bromoxynil	352.0 e	136.0 c	156.2 ef	58.44 ab
Clomazone	502.3 de	178.0 bc	198.7 de	20.54 c
Dimethenamid-P	854.6 cd	228.3 abc	307.4 bc	0 d
Halosulfuron-methyl	789.0 cd	264.3 abc	262.5 bc	0 d
Pendimethalin	1296.3 ab	28.6 abc	410.7 a	0 d
Pyroxasulfone	1402.6 a	276.6 abc	417.2 a	0 d
Quizalofop-p-ethyl	735.0 cd	227.0 abc	250.4 cd	0 d
1 hand hoe	969.0 bc	255.3 abc	315.7 b	0 d
2 hand hoe	1458.0 a	299.0 ab	399.4 a	0 d
Weed free control	1479.1 a	378.6 a	427.1 a	0 d
Weedy control	491.8 de	161.0 bc	191.3 def	0 d

*There is no difference according to the LSD test between the applications shown with the same letter in the columns ($p \leq 0.05$)

The originality of this trial is increased by the fact that data that will enable spraying with herbicides with the appropriate active ingredient at the appropriate time in order to reduce the need and dependency on labour for weed control in the cultivation of the Finola hemp variety, especially in the early period, increases the originality of this trial.

Conclusion. This research comprehensively evaluated the effects of different herbicides applied to the Finola plant on growth parameters and yield components. The highest phytotoxicity rate was observed with the application of bentazone, which negatively affected plant growth. In the weed-free control plots, the highest plant height, technical stem length, stem diameter, biomass yield, dry stem yield, and fibre yield were achieved. These results demonstrate the critical role of weed control and appropriate herbicide selection in optimizing Finola yield.

The findings also highlight that herbicides such as bentazone and bromoxynil can potentially harm the Finola hemp variety, underscoring the importance of selecting the right herbicide to achieve maximum yield. Overall, the higher yield achieved in weed-free areas indicates the necessity of integrated crop protection strategies and the careful use of herbicides in Finola cultivation.

REFERENCES

- [1] KOCA U., S. YILDIRIM (2020) Hemp and its use in health, Ankara University Faculty of Pharmacy Journal, **44**(1), 112–113.
- [2] DEWEY L. H. (1914) Hemp in USDA Yearbook of Agriculture, 283–346.
- [3] AYTAÇ S. (2018) The fact of industrial hemp and the situation in our country, Black Sea Agricultural Research Institute Directorate of Industrial Hemp Fact Panel, 2–3 May, 2018, Samsun.
- [4] HALL S., D. MIDMORE (2014) Effect of industrial hemp (*Cannabis sativa* L.) planting density on weed suppression, crop growth, physiological responses, and fibre yield in the subtropics, Renewable Bioresources, **2**(1), 1, <https://doi.org/10.7243/2052-6237-2-1>.
- [5] FIKE J. (2016) Industrial Hemp: Renewed opportunities for an ancient crop, Crit. Rev. Plant Sci., **35**(–6), 406–424, <https://doi.org/10.1080/07352689.2016.1257842>.
- [6] SANDLER L. N., K. A. GIBSON (2019) A call for weed research in industrial hemp (*Cannabis sativa* L.), Weed Research, **59**(4), 255–259.
- [7] TANSEL A., S. MADEN (2014) Effects of soil residues of sulfosulfuron and meso-sulfuron methyl+ iodosulfuron methyl sodium on sunflower varieties, Journal of Agricultural Sciences, **20**(1), 1–9.
- [8] BYRD J. (2019) Industrial hemp (*Cannabis sativa* L.) germination temperatures and herbicide tolerance screening, Virginia State University, MS Thesis, Petersburg, VA, 1–65.
- [9] METTLER J. E. (2021) Herbicide screening in industrial hemp (*Cannabis sativa* L.) Production, MS Thesis, North Dakota State University of Agriculture and Applied Sciences.
- [10] AKSOY D. (2021) Investigation of yield and some quality characteristics of foreign origin hemp varieties with the Narlisaray population in Samsun ecological conditions, Ondokuz Mayıs University Graduate Education Institute, Field Crops Department, MS Thesis, Samsun.
- [11] YILMAZ G., L. YAZICI, C. YILDIRIM et al. (2023) Performance of some European hemp (*Cannabis sativa* L.) varieties in terms of Yield Criteria, MAS Journal of Applied Sciences, **8**(1), 7–15, <https://doi.org/10.5281/zenodo.7603456>.
- [12] KARA K. (2013) Fiber Plants Cultivation and Breeding, Atatürk University Faculty of Agriculture Publications, No. 239, pp. 236, Erzurum.
- [13] MERT M. (2017) Fiber Plants. Updated 2nd Edition, Publication number: 1734, Science number: 130, ISBN: 978-605-320-641-5, Nobel Academic Publishing.
- [14] MAXWELL B. A. (2016) Effects of herbicides on industrial hemp (*Cannabis sativa*) phytotoxicity, biomass, and seed yield, Masters Theses & Specialist Projects, Paper 1742, <https://digitalcommons.wku.edu/theses/1742>.

¹Department of Plant Protection, Agricultural Faculty, Erciyes University,
38280 Kayseri, Turkey
e-mails: kubrakale766@gmail.com, dogani@erciyes.edu.tr

²*Department of Field Crops, Bogazliyan Vocational School, Yozgat Bozok University,
66100 Yozgat, Turkey*
e-mail: hasan.kale@bozok.edu.tr

³*Department of Field Crops, Agricultural Faculty, Yozgat Bozok University,
66100 Yozgat, Turkey*
e-mail: gungor.yilmaz@bozok.edu.tr