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Integration of Sunflower and Sorghum Water Extracts Applied Alone or in Combination With Reduced Doses of Chevalier for Weed Control in Wheat

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Abstract

Field trial was conducted with the aim of utilizing extract of allelopathic crop to reduce the use of synthetic herbicides in wheat fields. Sorghum extract at 12 L /ha, sunflower extract at 12 L /ha, combination of sorghum and sunflower extracts at 12 L /ha and chevalier at 25, 50 and 100% of recommended dose were applied alone or in combination with each other. Weed free and weedy check treatments were included for comparison. The experiment was conducted in a randomized complete block design with three replications. The results showed that the recommended dose of chevalier treatment recorded lowest means of weed density 15.7, 23.7, 25.3 and 27.9 weeds $m^{-2}$and weeds dry weight 13.4, 16.4, 23.3 and 29.2 g m^{-2} and gave highest percentage of weed control 71.4, 67.4, 64.3 and 63.0% after 60, 75, 95 and 115 days of planting respectively, without significant difference on the sorghum water extract + sunflower water extract at 12L/ha +50% of treatment. Also, the recommended dose of chevalier treatment had highest mean of number of spikes 368.6 spike m^{-2}, grain yield 5.75 ton ha^{-1}, biological yield 17.70 ton ha^{-1} and harvest index 32.55% without significant difference in the sorghum water + sunflower water extracts at 12L/ha +50% of treatment in the grain yield and biological yield also without significant difference on the sorghum water extract + sunflower water extract at 12 L/ha) +33% of recommended chevalier treatment in the grain yield and biological yield. We can conclude that the allelopathic effects of sorghum and sunflower extracts with chevalier herbicide at half dose gave positive results in weeds control while improving the grain yield of wheat without a significant difference with the spraying of the chevalier herbicide at full dose.These results were a clear indication that the presence of the extracts had a synergistic or cumulative additive role with the low doses of chevalier herbicide that contributed to raising its efficacy in weeds control.

Keywords: Allelopathy, Herbicide, Weed control, Chevalier herbicide

أستخدام المستخلصات المائية لزهرة الشمس والذرة البيضاء بمفردها أو مع جرع منخفضة من مبيد الشيفالير لمكافحة أدغال الحنطة

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الخلاصة

أجريت تجربة حقلية بهدف استخدام مستخلص المحصول الاليلوباثي لتقليل استخدام مبيدات الأدغال الكيميائية في حقول الحنطة. تم تطبيق مستخلص الذرة البيضاء بمعدل 12 لتر / هكتار ومستخلص زهرة الشمس بمعدل 12 لتر / هكتار ومزيج من الذرة البيضاء ومستخلص زهرة الشمس بمعدل 12 لتر / هكتار ومبيد الشيفالير بمعدل 25 و 50 و 100٪ من الجرعة الموصى بها بمفرده أو مع بعضهما البعض. تم تضمين معاملات خالية من الادغال للمقارنة. أجريت التجربة بتصميم القطاعات العشوائية الكاملة بثلاثة مكررات. اظهرت النتائج ان معاملة مبيد الشيفالير (كامل الجرعة الموصى بها) قد سجلت أقل معدل بكثافة الادغال بواقع 15.7, 23.7 , 25.3 و 27.9 أدغال / م^{2} و اقل معدل بالوزن الجاف للأدغال بواقع 13.4 , 16.4 , 23.3 و 29.2 غرام / م$^{-2}$ وأعطت أعلى معدل تثبيط نمو للادغال 71.4 , 67.4 , 64.3 و 63% بعد 60 , 75 , 95 و 115 يوم بعد الزراعة (بدون فروق معنوية عن معاملة المستخلصات للذرة البيضاء و زهرة الشمس مع نصف الجرعة الموصى بها من المبيد)، كما أعطت أعلى معدل بعدد السنابل ب 368.6 سنبلة / م^{2}، حبوب 5.75 طن / هـ ك$^{-1}$ ، حاصل بايولوجي 17.7 طن /هـ ك$^{-1}$ و دليل حصاد 32.55 % بدون أي فروق معنوية مع معاملتي استخدام المستخلصات مع ثلث ونصف الجرعة الموصى بها من المبيد في حاصل الحبوب والحاصل البايولوجي . نستنتج من ذلك ان التأثير الاليلوباثي للمستخلص المائي للذرة البيضاء وزهرة الشمس مع نصف جرعة من مبيد الشيفالير ساعدت في السيطرة على الادغال وحسنت من حاصل الحبوب لمحصول الحنطة بدون وجود فروق معنوية مع رش المبيد بجرعة كاملة . هذه النتائج أعطت مؤشر واضح أن وجود المستخلص النباتي زاد من فعالية المبيد في السيطرةعلى الادغال وبالتالي أنعكس على زيادة الحاصل .

1. Introduction

Allelopathy has become a clear scientific phenomenon in the present times, as it gives a convincing explanation for various changes in ecosystems, such as the dominance of some plant species in plant communities, determining the type of vegetation cover, environmental succession, seed constraints and preventing their decay. Allelopathy is known as the mechanism by which chemical compounds are first produced from different plant parts and then released to the environment in several ways such as leaching, volatilization and root exudation, as well as the decomposition of plant residues in soil by microorganisms [1]. Allelopathy is caused by plant metabolites produced by secondary metabolites such as phenolic compounds, alkaloids, coumarins, tannins, flavonoids, etc. It has been found that some allopathic compounds can be key compounds in the plant such as organic acids, alcohol and fatty acids [2]. In general, the release of allelopathic compounds settle in the soil or may be absorbed from plants grown which has direct effects on metabolic processes such as photosynthesis, respiration, protein biosynthesis, hormone biosynthesis cellular membrane synthesis,permeability and activity of some enzymes.

Wheat crop, one of the most important grain crops, is the most cultivated and productive because of its great importance in human food as well as being one of the most important source of carbohydrates and protein. Weeds cause serious yield reductions and lower the productivity of field crops worldwide. Chemical control is an efficient method to control weeds and herbicides account for two third of total pesticide usage in the world [3]. Nevertheless, continuous and indiscriminate use of synthetic herbicides has created hazardous effects related to environment with an alarming increase in herbicide-resistant weeds. Hence, it has become imperative to find out some natural practice or method to control the weeds. Allelopathy has been found to offer ecofriendly approaches that can be used for controlling weeds effectively with least environmental concerns. Application of allelopathic crop extracts and residues is among the promising practical strategies for this purpose. However, in most cases, allelopathic extracts or crop residues provide limited weed suppression. However, more often suppression

in weed growth is less than that achieved with labeled herbicide dose. Therefore, other methods that help increase the efficacy of allelopathic extracts or residues may be critical to enhance weed suppression while reducing our reliance on herbicides [4]. Substantial scope exists to reduce the herbicide rate when lower rates of herbicides are applied in combination with aqueous extracts or residues of different allelopathic crops without any yield penalty. The present work was conducted to test the combined effects of allelopathic water extracts with lower rates of chevalier herbicides on weed management in wheat crop.

2. Materials and Methods

A field trial was carried out during winter season of 2021-2022 at Field Crops Department - College of Agricultural Engineering Sciences - University of Baghdad / Jadiriyah in a clay loam soil to determine the best combination of plant extracts and weeds herbicide in weeds control accompanying with wheat and its effects on yield and its components. Randomized complete block design RCBD was used with three replicates and nine treatments included:

1. Sorghum water extract at 12 L ha^{-1}
2. Sunflower water extract at 12 L ha^{-1}
3. Sorghum water extract + Sunflower water extract at 12 L ha^{-1}
4. Sorghum water extract + Sunflower water extract at L2L/ha +25% of recommended Chevalier
5. Sorghum water extract + Sunflower water extract at 12 L/ha +33% of recommended Chevalier
6. Sorghum water extract + Sunflower water extract at 12L/ha +50%
7. Recommended dose of Chevalier
8. Weed free.
9. Weedy check

The plant extracts were prepared according to the method reported by Cheema et al., [5]. The experiment land was divided into 27 experimental units with the area of each experimental unit being 4 m^2 (2m x 2m) which contained 10 lines, 20 cm apart. The seeds of the wheat cv. Abu Ghraib 3 were sown at a seed rate of 120 kgs ha^{-1} on the 20 November 2021. Chemical fertilizers were added with an average 10 kgs tri-super phosphate ha^{-1} before sowing and 200 kgs urea ha^{-1} four equal parts [6]. Crop management was carried out as needed.Plants were harvested after the appearance of physiological maturity and the following traits were studied:

Weed measurements

Weeds density (weed m^{-2}) was calculated after 60, 75, 95 and 115 days of sowing by using square methods [7].Control percentage was calculated after 60, 75, 95 and 115 days of sowing by the following equation [8]:

$$\textbf{Weed control } \% = \frac{\textbf{No. of weeds in the Weedy check} - \textbf{No. of weeds in the control treatment}}{\textbf{No. of weeds in the Weedy check}} \times \mathbf{100}$$

Weeds dry weight (g m^{-2}) was calculated after 60, 75, 95 and 115 days of sowing by harvesting 1 m^2 from each experiment unit, and dried in the oven at 70ºC and weighed [9]. Inhibition (%) was calculated after 60, 75, 95 and 115 days of sowing by the following equation [10]:

$$\textbf{WeedInhibition } (\%) = \mathbf{100} - \frac{\mathbf{a}}{\mathbf{b}} \times \mathbf{100}$$

Where:

a = Weeds dry weight in the control treatment

b = Weeds dry weight in the weedy check

Wheat measurements
5. Number of spikes m^2
6. Number of grain $spikes^{-1}$
7. Weight of 1000 grains (g)
8. Grain yield (Ton ha^{-1}) was calculated by harvesting 1 m^2 of each experimental unit, the straw was isolated from the grains, weighed and then converted from gm m^{-2} to ton ha^{-1}.
9. Biological yield (Ton ha^{-1}) was calculated by harvesting 1 m^2 of each experimental unit, dried, weighed and converted from gm m^{-2} to ton ha^{-1}.
10. Harvest index (%) was calculated by the following equation [11]:

$$\textbf{Harvest index} = \frac{\textbf{Seed Yield}}{\textbf{Biological yield}} \times \textbf{100}$$

The data was analyzed statistically by using Genstat software and least significant difference (LSD) test at 0.05 probability level was used to compare the treatment means [12].

3. Results and Discussion

3.1 Weeds Identification

Table 1 indicates that the population of broad-leaved weeds was larger than the narrow leaved weeds. The dominant weeds were *Melilotus indicus* L., *Beta vulgaris* L., *Carthamus oxyacanthus* M. B, *Malva rolundifolia* L. and *Ammi majus* L. Whereas there were a few number of *Sonchus oleraceus* L., *Silybum marianum* (L.) Gaertn, *Plantago lanceolata* L., *Daucus carota* L., *Lactuca serriola* L. and *Polygonum aviculare* L.The narrow leafy weeds were *Phalaris minor* L., *Lolium rigidum* Gaud and *Avenafatua* L. The dominance of broad leaved weeds especially *Beta vulgaris* L., *Carthamus oxyacanthus* M. B. and *Malva rolundifolia* L. could be due to its competitiveness and sovereignty due to its vegetative and root growth which helped them to interrupt light and

absorb nutrients from the soil compared with narrow broad leaved weeds, in addition to ability of some of broad-leaved weeds to produce large numbers of seeds which survived in the soil for years compared with narrow leaved weeds [13]. Also, the absence of competition between both types of weeds may have led to the emergence of one type without another meaning that the lack or absence of narrow leafy weeds allowed or encouraged the emergence of wide leafy weeds due to the absence of competition between the two types [10].

Table 1: Weeds grown in wheat field during the growing season of 2021-2022

Scientific Name	Family

***Avenafatua* L.**	Poaceae	Annual weed, Narrow leaved weed
***Phalaris minor* L.**	Poaceae	Annual weed, Narrowleaved weed
***Lolium rigidum* Gaud**	Poaceae	Annual weed, Narrow leaved weed
***Malva rolundifolia* L.**	Malvaceae	Annual weed, wide leafy
***Daucus carota* L.**	Apiaceae	Annual weed, broad leaved weed
***Carthamus oxyacanthus* M.B.**	Astraceae	Annual weed, broad leaved weed
***Melilotus indicus* L.**	Fabaceae	Annual weed, wide leafy
***Chenopodium album* L.**	Chenopodiaceae	Annual weed, Broad leaved weed
***Sonchus oleraceus* L.**	Astraceae	Annual weed, Broad leaved weed
***Beta vulgaris* L.**	Chenopodiaceae	Annual weed, Broad leaved weed
***Silybum marianum* (L) Gaertn**	Campositeae	Annual weed, Broad leaved weed
***Plantago lanceolata* L.**	Plantaginaceae	Annual weed, Broad leaved weed
***Raphanus raphanistrum* L.**	Brasicaceae	Annual weed, Broad leaved weed
***Lactuca serriola* L.**	Astraceae	Annual weed, Broad leaved weed
***Cardaria draba*(L). Desv**	Brasicaceae	Annual weed, Broad leaved weed
***Polygonum aviculare* L.**	Polygonaceae	Annual weed, Broad leaved weed
***Ammi majus* L.**	Apiaceae	Annual weed, Broad leaved weed

3.2 Effects of Plant Extracts and Chevalier Herbicide on Weeds Density

The results in Table 2 indicate that the plant extracts, with or without chevalier herbicide, significantly reduced weeds density compared to weedy check treatment. The recommended dose of chevalier recorded the lowest weed density at all days after planting.

These results clearly indicated that the extracts of the test plants had a synergistic or additive effect with low doses of chevalier herbicide which contributed to raising their efficiency in weeds control. It is possible that the low dose of chevalier may have acted as predisposal agent for the allelopathic effects in controlling weeds [14, 15].

Table 2: Effects of sorghum and sunflower extracts alone and in combination with different rates of chevalier on weeds density in wheat at different days after planting (DAP).

Treatments	Weed Density (Weeds m^{-2})			
	60 DAP	75 DAP	95 DAP	115 DAP
Sorghum extract at 12 L/ha	40.3	47.3	54.4	57.0
Sunflower extract at 12 L/ha	37.0	45.3	52.2	54.7
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha	32.4	39.3	47.0	48.8
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 25 % of recommended dose of chevalier	30.7	37.0	43.7	46.3
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 33 % of recommended dose of chevalier	25.3	31.3	37.0	39.7
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 50 % of recommended dose of chevalier	18.4	23.7	29.8	31.0
Chevalier at full dose	15.7	20.5	25.3	27.9
Weed free	0.0	0.0	0.0	0.0
Weedy Check (control)	54.0	63.3	72.0	75.0
LSD ≤ 0.05	7.0	6.7	7.0	7.5

3.3 Effect of Plant Extracts and Chevalier Herbicide on Weeds Control Percentage

The results in Table 3 indicate that plant extracts, with or without chevalier herbicide, significantly inhibited the percentage of weeds control compared with weedy check treatment, but it was lower than weedy check. However, sorghum and sunflower extracts in combination with 50% of recommended dose of chevalier recorded weed control inhibition statistically similar to that achieved by full dose of chevalier. The inhibitory effects of allelopathic potential of plant extract in combination with different types of herbicides have been published and well documented [14, 16, 17].

Table 3: Effects of sorghum and sunflower extracts alone and in combination with different rates of chevalier on weeds density in wheat at different days after planting (DAP).

Treatments	Weed Dry Weight (g m^{-2})			
	60 DAP	75 DAP	95 DAP	115 DAP
Sorghum extract at 12 L/ha	47.2	59.2	73.3	88.7
Sunflower extract at 12 L/ha	45.3	56.0	69.2	84.0
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha	33.4	42.2	54.4	70.5
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 25 % of recommended dose of chevalier	29.6	37.9	51.2	65.0
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 33 % of recommended dose of chevalier	17.5	22.6	30.7	42.4
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 50 % of recommended dose of chevalier	14.3	18.2	22.5	37.5
Chevalier at full dose	13.4	16.4	23.3	29.2
Weed free	0.0	0.0	0.0	0.0
Weedy Check (control)	59.7	75.2	88.4	100.5
LSD ≤ 0.05	10.3	11.2	11.6	10.7

3.4 Effects of Plant Extracts and Chevalier Herbicide on Weeds Dry Weight

Table 4 indicates that the test doses of chevalier reduced dry weight of weeds and percent of weed inhibition, and the reduction increased with the increased dose rate. Sunflower and sorghum extracts considerably reduced dry weight of weeds and percent of weed inhibition at different DAP. The reduction increased when the plant extracts were combined with different rates of chevalier. However, the plant extracts applied with 50% of recommended dose of herbicide yielded reduction in dry weight of weeds and percent of weed inhibition statistically similar to that recorded by full dose of chevalier at DAP.

The results of this study agree with other investigators who found that sunflower and sorghum extracts significantly inhibited weed seed germination and growth but the inhibition was less that than the full dose of the tested herbicides and combination of allelopathic extracts with lower rates of herbicides that became more effective with the full dose of herbicides [18, 19, 20].

Table 4: Effects of plant extracts and chevalier herbicide on weeds control percentage (%)

Treatments	Weed Dry Weight (g m^{-2})

	60 DAP	75 DAP	95 DAP	115 DAP
Sorghum extract at 12 L/ha	47.2	59.2	73.3	88.7
Sunflower extract at 12 L/ha	45.3	56.0	69.2	84.0
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha	33.4	42.2	54.4	70.5
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 25 % of recommended dose of chevalier	29.6	37.9	51.2	65.0
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 33 % of recommended dose of chevalier	17.5	22.6	30.7	42.4
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 50 % of recommended dose of chevalier	14.3	18.2	22.5	37.5
Chevalier at full dose	13.4	16.4	23.3	29.2
Weed free	0.0	0.0	0.0	0.0
Weedy Check (control)	59.7	75.2	88.4	100.5
LSD ≤ 0.05	10.3	11.2	11.6	10.7

Treatments	Inhibition (%)			
	60 DAP	75 DAP	95 DAP	115 DAP
Sorghum extract at 12 L/ha	20.1	19.5	20.4	11.4
Sunflower extract at 12 L/ha	21.5	23.8	38.0	15.5
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha	44.5	44.0	38.7	30.0
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 25 % of recommended dose of chevalier	50.6	49.7	42.0	35.4
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 33 % of recommended dose of chevalier	71.1	70.4	65.6	57.9
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 50 % of recommended dose of chevalier	71.2	74.8	73.7	62.0
Chevalier at full dose	74.5	78.1	74.6	70.9
Weed free	100.0	100.0	100.0	100.0
Weedy Check (control)	0.0	0.0	0.0	0.0
LSD ≤ 0.05	18.1	15.3	20.1	9.8

3.5 Effect of Plant Extracts and Different Rates of Chevalier and Yield Components of Wheat

3.5.1 Number of Spikes m^{-2}

Table 5 indicates that the sorghum and sunflower extracts significantly enhanced number of spikes per square meter over weedy check. On the other hand, chevalier herbicide significantly increased number of spikes m^{-2} over weedy check treatment. The number of spikes further increased when plant extract in combination with test rates of herbicide was applied. It was interesting to find out that combination of plant extracts with 50% of recommended dose of chevalier yielded number of spikes statistically similar to that achieved by recommended dose of herbicide. The superiority of full dose of chevalier herbicide and combination of sunflower and sorghum extracts in combination with 5% of recommended dose of chevalier is due to the reduction of weeds density and population making the nutrients available for wheat crop to produce more fertile tillers and then increase the number of spike. These results agreed with Jordan *et al*. [21] who reported that the increase in the number of spikes is correlated with increasing the number of fertile tillers which depend on the decrease of competition between plants or the tillers themselves on the light and nutrients.

The number of grains per spikes and the weight of 1000 grains appeared to be not responsible for the increased yield of wheat since there were no significant differences among the treatments (Table 5).

Table 5: Effects of sorghum and sunflower extracts alone and in combination with different rates of chevalier yield components of wheat.

Treatments	Yield Components		
	Number of spikes / m^2	Number of grains per spike	Weight of 1000 grains (g)
Sorghum extract at 12 L/ha	250.5	52.2	24.2
Sunflower extract at 12 L/ha	252.8	53.4	25.1
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha	297.4	56.3	26.7
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 25 % of recommended dose of chevalier	315.7	60.6	26.2
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 33 % of recommended dose of chevalier	330.9	66.6	27.4
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 50 % of recommended dose of chevalier	346.6	70.1	30.7
Chevalier at full dose	368.6	72.4	34.2
Weed free	392.3	52.6	35.4
Weedy Check (control)	220.6	50.6	20.9
LSD ≤ 0.05	34.08	N.S	N.S

3.6 Grain Yield

The results in Table 6 show that the plant extracts significantly increased grain yield over weedy check treatment. Different rates of chevalier significantly increased yield over control with the highest yield recorded by full dose of chevalier. Sorghum and sunflower extracts in combination with 5% of recommended dose of chevalier gave yield of grains as full dose of chevalier. The increase in grain yield by this treatment was due to its greater reduction in weed growth and population which resulted in increasing growth of wheat plants and thereby grain yield. These results agree with some other researchers [10 ,22] who reported that the increase of the grain yield was in synchronization with increase number of spikes

3.7 Biological Yield

The results in Table 6 indicate that sorghum and sunflower extracts in combination with 50% of recommended dose of chevalier provided biological yield similar to recommended dose of herbicide. All other treatments improved biological yield compared to weedy check treatments. These results confirm that the plant extracts and low doses of chevalier herbicide had a synergistic or cumulative additive effect causing more weed control and provided more radiation and nutrients and thereby increasing the biological yield. Some authors have indicated that the biological yield represents the amount of dry matter accumulated in the plants as a result of photosynthesis associated with the availability of necessary growth factors such as light, water, nutrients beside less competition of weeds[23, 24].

3.8 Harvest Index

The harvest index expressed the plant's efficiency in converting photosynthesis products to grains and represented the ratio of the grain yield to the biological yield.It mainly depends on the system capacity constant (SCC) which is the basis for increasing the yield [24]. The results in Table 6 show that the chevalier herbicide significantly increased harvest index compared to weedy check treatment. The superiority of the spraying of chevalier herbicide at full dose could be due to its positive role on dry matter accumulation and transport from sources to sinks and then an increasing grain yield and biological yield.

Table 6: Effects of plant extracts and chevalier herbicide on yield and harvest index of wheat.

Treatments	Biological Yield (t/ha)	Harvest Index	Grain Yield (t/ha)
Sorghum extract at 12 L/ha	15.24	26.99	4.11
Sunflower extract at 12 L/ha	15.38	27.00	4.15
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha	15.81	26.70	4.22
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 25 % of recommended dose of chevalier	16.20	27.53	4.45
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 33 % of recommended dose of chevalier	16.61	28.39	4.72
Sorghum extract at 12 L/ha + Sunflower extract at 12 L/ha + 50 % of recommended dose of chevalier	17.45	30.93	5.53
Chevalier at full dose	17.70	32.55	5.75
Weed free	17.75	32.80	5.82
Weedy Check (control)	13.82	26.92	3.72
LSD ≤ 0.05	1.46	1.06	0.43

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