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# The potential role of sorghum and sunflower water extracts in enhancing the herbicidal potency of atrazine herbicide in controlling weeds in Zea maize

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**Abstract:** Allelopathy research has advanced remarkably during the two last decades due to the need to a substitute to alleviate application of synthetic herbicides. Response of maize and associated weeds to foliar application of sorghum or sunflower water extracts alone or in combination with reduced doses (0.50 and 0.75 L/fed., fed.=feddan=0.42 ha) of atrazine herbicide were studied in comparison with hand hoeing twice at 30 and 45 days after sowing (DAS) and the recommended field dose (labeled) of atrazine (1 L/fed). The study was carried out at a privet farm, Shalkan Province, Kalubia Governorate, Egypt over two summer seasons in 2013 and 2014. The experimental design was a randomized complete block design with four replications per treatment. Below-labeled doses of atrazine were combined with 100 L/fed. of each of allelopathic sorghum or sunflower water extract. Results showed that all weed control treatments significantly suppressed total dry weight of weeds. Whereas, these treatments increased total dry weight of maize at least 13% than un-weeded control. Allelopathic sorghum water extract sprayed alone or in combination with reduced doses of atrazine herbicide gave, to a large extent, similar results to applying the full dose of atrazine, either in reducing total dry weight of weeds or increasing total maize dry biomass. Maize grain yield was significantly increased by 32.18% and 34.16% with applying sorghum or sunflower extracts plus atrazine at 0.75 (L/fed), respectively versus 39.60% of applying the full dose of atrazine. Hand hoeing twice recorded the maximum weed suppression and subsequently the highest grain yield per fed. It could be concluded that the use of water extract of sorghum or sunflower can improve atrazine performance. They allowed for greatly enhanced weed control and significantly increased yield and yield-related components in maize.
**Keywords:** Maize – Allelopathy – Allelochemicals - Weed control - Sorghum extracts - Sunflower extracts.

## Introduction

Weeds are the most costly category of agricultural pests worldwide. Weeds reduce crop yields directly by competing for light, nutrients, moisture, space and carbon dioxide, and indirectly through releasing natural

bioactive substances into rhizosphere that inhibit crop growth[9,12,29]. The magnitude of losses resulting from weed infection in maize varies from 17 to 50%[1, 23, 29].

Weeds can be controlled chemically or mechanically. However, increased labour costs and expensive chemicals have hampered the use of some of these methods. In addition, continuous uses of herbicides resulting in health hazards and pollute both the soil and aerial environment. Some herbicides can adversely affect the nutritive value of certain crops [20].

The main objective of weed control treatments is to increase the yield per area with minimum expenditure. Nowadays, there is a strong emphasis on search for new methods for weed control that are safe, harmless and less expensive than traditionally used herbicides. Allelopathy has emerged recently as an important area in weed research. Allelopathy could lead to reduced labour costs and increased efficiency, without any harmful effects on the environment[33]. Allelopathic plants as sorghum, sunflower and oats have been found to contain a number of allelochemicals that in low doses act as hormones and in high doses act as herbicides[23, 25,35]. Allelopathic crop plants not only control weeds but also enhance crop growth and yield [5, 19, 21, 22.23, 31].

Like other pesticides, herbicides have health and environmental hazards. This has stimulated the search for natural eco-friendly alternatives, which are biodegradable and non-toxic to the surrounding media. Use of plant extracts for weed suppression and increase crop productivity has been reported by many authors [4, 10,14, 23, 34,]. The concept of using allelochemicals crop extracts for controlling weeds was first given by [27] They found that sorghum residues reduced normal weed population by 95%.

The present study was initiated to investigate the potential impact of water extract of sorghum or sunflower in increasing the herbicidal efficiency of atrazine herbicide in controlling weeds and increasing productivity in maize.

## Materials and Methods

The study was conducted during two successive seasons (2013 and 2014) at a private farm, Shalkan Province, Kalubia Governorate, Egypt. Soil at the experimental site was clay-loam with a pH of about 7.8 and organic matter 1.9%.

### Plant materials and extraction procedure

Mature sorghum and sunflower shoot without head were used in the experiment for obtaining water extract. The uprooted shoot plants were dried at room temperature for 15 days then cut into small pieces (0.2-0.3 cm). The ground materials (40 Kg) were soaked in distilled water (1:5) and left to stand over night (12 hrs) at room temperature (20-25 °C). The extracts were immediately used to avoid any possible microbial contamination. Prior to spraying volume of the spray (200 L/fed) calibrated by using tap water. Spraying was done by Knapsak hand sprayer.

### Cultivation methods

Maize (*Zea mays* cv. single-cross hybrid 10) seeds (10 Kg/fed.; fed.=feddan=4200 $m^2$) were sown on ridges 70 cm apart, in intra-row spacing of 20- 25 cm. Two - three seeds were placed manually per hill. The sowing date was the last week of May in both seasons. Sowing was done after ploughing, harrowing and fertilizing with calcium super phosphate (200 Kg/fed., 15.5% $P_2O_5$) and potassium sulfate (50 Kg/fed.,48% $K_2O$). Nitrogen fertilizers (120 Kg N/fed.) in the form of urea (46% N) were added later in two equal split doses before the first and second irrigation. To decrease interactions among closely immerged seedlings, seedlings were thinned to one per hill twenty one days after initial emergence. The plants were watered according to recommendations.

### Treatments

The plants were subjected to the following treatments: No weeding ($T_1$): plants received no treatment other than ordinary practices. Hand hoeing ($T_2$): plants were subjected to removing weeds (manually) twice at 30 and 45 days after sowing (DAS). Atrazine ($T_3$): plants were foliar-sprayed with atrazine herbicide) at

recommended field dose (1 L/fed). Sorghum extract ($T_4$): plants were foliar-sprayed with aqueous extract of sorghum (twice, 30 and 45 DAS) at a rate of 200 L/fed. T4 + 50% of the recommended dose of atrazine ($T_5$): plants were foliar-sprayed with aqueous extract of sorghum in combination with atrazine at (0.5 L/fed.) $T_4$ + 75% of the recommended dose of atrazine ($T_6$): plants were foliar-sprayed with aqueous extract of sorghum in combination with atrazine at (0.75 L./fed.) Sunflower extract ($T_7$): Plants were foliar-sprayed with aqueous extract of sunflower (twice, 30 and 45 DAS) at a rate of 200 L/fed. $T_7$ + 50% of the recommended dose of atrazine ($T_8$): plants were foliar-sprayed with aqueous extract of sunflower in combination with atrazine at (0.5 L/fed.) $T_7$ + 75% at the recommended dose of atrazine ($T_9$): plants were foliar-sprayed with aqueous extract of sunflower in combination with atrazine at (0.75 L./fed.). The treatments were arranged in a randomized complete block design with four replicates for each treatment. The size of each plot was 30 m² (5 m width x 6 m long) divided into 7 rows.

**Data recorded.**

**Weed sampling:** In both growing seasons, weeds were sampled at 65 DAS at one randomly selected spot (1 $m^2$) in each plot to measure total dry weight (g). Dry weight was estimated after drying at a constant temperature of 70 °C for 48 hrs.

**Crop sampling:** Maize samples of five plants were taken randomly from each plot (65 DAS) to determine dry weight/plant (g).

**Yield and its components:** After 120 days of sowing, random samples of ten guarded plants were taken from each plot and measured for plant height (cm), ear characters (i.e., length [cm], weight [g], rows number and grain weight [g]), grain index (100- kernel weight) and shelling percentage ([ear grain weight/cob weight] × 1000). Grain yields (ton/fed.) were determined by harvesting the whole plot area.

**Statistical analysis:**

The data collected were subjected to the statistical analysis by (25) program Since the trend was similar in both seasons, Bartlett's test was applied and the combined analysis of the two growing seasons as well as the different among the treatments was tested using Least Significant Differences at 5% level ($LSD_{5\%}$).

## Results and Discussion

### Weeds growth

Dominant weed species at the experimental site were *Portulaca oleracea* L., *Corchorus olitorius* L., *Cyperus rtundus* L., *Dactyloctenium aegyptium* L. and *Digitaria sanguinalis* L. All the treatments showed good influence in reducing total dry weight of weeds irrespective of their type or concentration (Table 1). The highest weed biomass suppression (84.74%) was achieved with hand hoeing twice treatment (30 and 45 DAS). Aqueous extract of sorghum recorded a growth reduction estimated at 70.52%, versus 50.84% for aqueous allelopathic sunflower water extract. Among all the foliar application treatments, the highest weed control was recorded with atrazine applied alone at the recommended dose (1 L/fed.), followed by the combined application of aqueous extract of sorghum plus atrazine at 0.5 L/fed. and 0.75 L./fed. The combined application of aqueous extract of sunflower plus atrazine herbicide at both concentrations showed lower efficiency (54.69% and 63.09% growth reduction, resp.) in comparison with the control. Good results were obtained with applying allelopathic sorghum or sunflower water extract alone. In this regard, our findings coincide with the results obtained by [2,11] in which they reported that the aqueous extracts of sorghum and sunflower either used alone or in combination are promising as weed killers. Similar results previously reported by [16,17].

Use of sorghum or sunflower water extracts along with lower doses of atrazine herbicide had overall more inhibitory effect on reducing total dry weight of associated weeds due to both allelopathic and herbicidal activities. The results of the research conducted in recent years have revealed that 1/3 or 1/5 dose of herbicides combined with sorghum extracts provide similar weed control to the labeled dose of herbicides in different field crops [3, 36] while working on wheat showed fair degree of success in reducing herbicide doses through mixing with allelopathic water extracts of sorghum and sunflower. We may suggest that use of sorghum or sunflower along with atrazine has a supportive role in enhancing the overall efficiency [7,13, 23].

**Maize growth**

All weed control treatments significantly increased maize growth (Table 1). Maximum increase in total dry weight of maize was recorded in plots sprayed with atrazine at 1 L/fed. A greater influence was noted with hand hoeing twice treatment, resulting in a total dry weight increment of 144% over the control. Sorghum water extract in combination with atrazine at 0.75 L/fed. gave the best results among all combinations. These results are in coincidence with those obtained by [18,15] in which using water extract of sorghum and sunflower markedly improved cotton and maize growth with reducing herbicide dose below the recommended dose [16,17,6]. The improvement in total dry biomass of maize plants is a natural result, where suppressing weeds growth leads to abundance in the primary factors of growth including light, nutrients, and moisture.

**Table 1. Combined effect of allelopathic sorghum or sunflower water extract with reduced doses of atrazine herbicide on total dry weight of maize and associated weeds at 65 DAS. (Combined data over two seasons).**

| Character / Treatment | | maize dry weight (g) | Increasing % of control | Weed dry weight (g $m^{-2}$) | Reduction % of control |
|---|---|---|---|---|---|
| **T1** | **Un-weeded** | 17.17 | -- | 153.22 | -- |
| **T2** | **Hand hoeing twice (30 & 45 DAS)** | 41.97 | 144.46 | 23.39 | 84.74 |
| **T3** | **Atrazine (1 L/fed.)** | 40.51 | 135.99 | 25.22 | 83.54 |
| **T4** | **Sorghum extracts (40 kg dried shoot/fed.)** | 25.48 | 48.45 | 45.17 | 70.52 |
| **T5** | **T4 + 50% recommended dose of atrazine** | 26.47 | 54.21 | 45.07 | 70.58 |
| **T6** | **T4 + 75% recommended dose of atrazine** | 35.34 | 105.85 | 42.22 | 72.44 |
| **T7** | **Sunflower extracts (40 kg dried shoot/fed.)** | 19.38 | 12.92 | 75.33 | 50.84 |
| **T8** | **T7 + 50% recommended dose of atrazine** | 21.89 | 27.52 | 69.42 | 54.69 |
| **T9** | **T7 + 75% recommended dose of atrazine** | 23.70 | 38.06 | 56.55 | 63.09 |
| **F significant** | | ** | | ** | |
| **LSD at 5% level** | | **2.55** | | **3.81** | |

**Maize yield and its components:**

**Plant height at harvest (cm):**

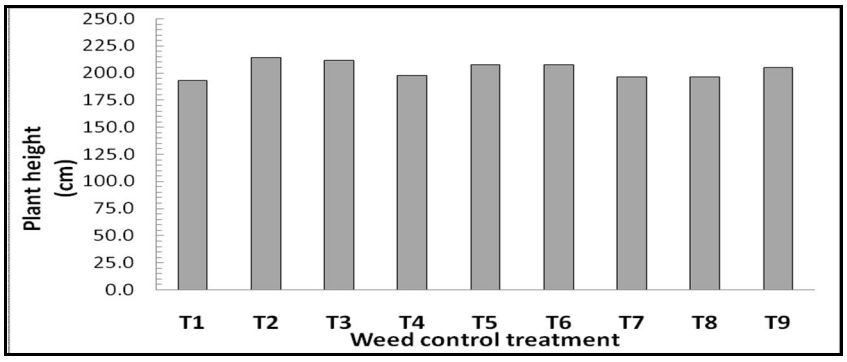


**Fig. 1. Combined effect of allelopathic sorghum or sunflower water extract with reduced doses of atrazine herbicide on plant height of maize at harvest stage 120 DAS. (Combined data over two seasons). $LSD_{5\%}$ =9.42.**

**Table 2. Combined effect of allelopathic sorghum or sunflower water extract with reduced doses of atrazine herbicide on ear traits of maize at harvest stage (120 DAS). (Combined data over two seasons).**

| Character | | Ear parameters | | | | |
|---|---|---|---|---|---|---|
| Treatment | | Length (cm) | Weight (g) | Row number | Grain weight (g) | Shilling % |
| T1 | Un-weeded | 14.92 | 128.00 | 9.83 | 90.79 | 70.93 |
| T2 | Hand hoeing twice (30 & 45 DAS) | 19.00 | 182.42 | 13.58 | 154.33 | 84.60 |
| T3 | Atrazine1.0 L/fed. | 18.58 | 170.04 | 12.25 | 142.76 | 83.96 |
| T4 | Sorghum extracts (40 kg dried shoot/fed.) | 16.67 | 168.83 | 12.25 | 131.25 | 77.74 |
| T5 | T4 + 50% recommended dose of atrazine | 17.58 | 173.83 | 12.00 | 140.88 | 81.04 |
| T6 | T4 + 75% recommended dose of atrazine | 18.67 | 170.38 | 12.46 | 140.71 | 82.59 |
| T7 | Sunflower extracts (40 kg dried shoot/fed.) | 17.00 | 151.25 | 11.42 | 118.12 | 78.10 |
| T8 | T7 + 50% recommended dose of atrazine | 17.17 | 161.54 | 11.75 | 127.60 | 78.99 |
| T9 | T7 + 75% recommended dose of atrazine | 15.50 | 159.08 | 12.00 | 128.21 | 80.59 |
| F significant | | | | | | |
| LSD at 5% level | | **1.36** | **4.38** | **0.91** | **3.41** | **5.61** |

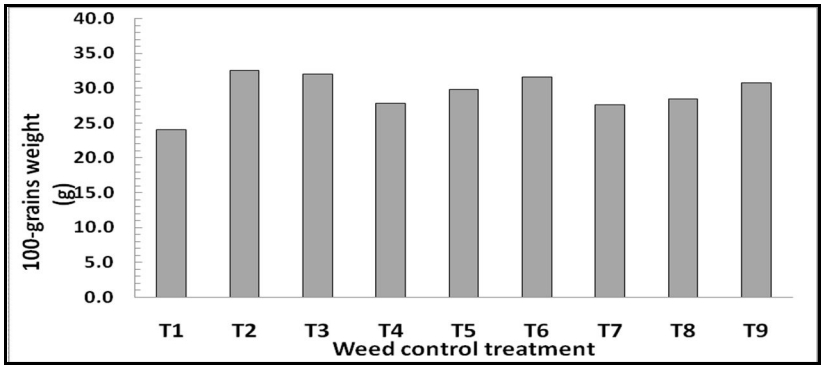


**Fig. 2. Combined effect of allelopathic sorghum or sunflower water extract with reduced doses of atrazine herbicide on 100-grains weight of maize at harvest stage (120 DAS). (Combined data over two seasons). $LSD_{5\%}$ =1.00.**

**Maize yield (ton $fed^{-1}$):**

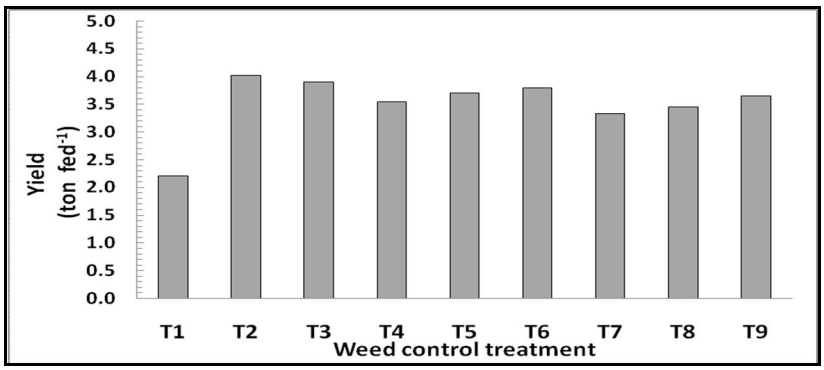


**Fig. 3. Combined effect of allelopathic sorghum or sunflower water extract with reduced doses of atrazine herbicide on maize yield (ton/fed.) at harvest stage (120 DAS). (Combined data over two seasons). $LSD_{5\%}$ =0.09.**

The results in Table (2) and Figures (1,2 and 3) showed that all treatments significantly enhanced yield and yield-related traits over the control. A significant yield gap was observed between hand hoeing treatment and different other treatments. Grain yield in plots treated with hand hoeing twice recorded 82.72% increase over the control. However, atrazine alone at 1 L/fed. (the label dose) increased grain yield by 72.72%. Among the various combinations, sorghum water extract plus atrazine at both concentrations (0.5 and 0.75 L/fed.) recorded the largest grain weight on ears and subsequently yield per fed. Similar results were reported by [8] who found that integration of herbicides and sunflower residue resulted in similar yield advantage as was noted with 100% herbicide dose. [14] described that atrazine at rates less than 1.5 kg a.i./ha e.g., 500 and 750 g a.i. ha provided very significant increases in maize grain yield over weedy check (>52%) when applied in tank mixture with sorghum and sunflower water extracts each at 10 L/ha. [24] demonstrated a similar trend with using half and 1/3 dose of atrazine plus sorghum, sunflower, brassica, sunflower or mulberry water extracts in increasing maize yield and quality traits.

The study concluded that, efficacy of atrazine to control weeds and increase maize yield can be enhanced by integrating it with allelopathic sorghum or sunflower water extract. Reduction in herbicide dosages through using allelopathic plant extracts can lead to less environmental pollution and lower production costs.

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