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# INTEGRATED WEED MANAGEMENT IN WHEAT CROPS BY APPLYING SORGHUM AQUEOUS EXTRACT AND REDUCED HERBICIDE DOSE

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## Abstract

Aqueous extract of Allelopathic crops have the potential to control weeds successfully, particularly when integrated with reduced herbicide doses. A field experiment was conducted to evaluate the effect of allelopathic water extract of sorghum shoot part combined with reduced doses of Tarxos 045 EC. (Clodinafop-propargyl 2.5 % + Pinoxaden 2.5 %) herbicide for control wild barley, wild oat and canary grass that cultivated in bread and durum wheat. Sorghum aqueous extract @ 200 g. $L^{-1}$ (100%) and Traxos herbicide @ label dose (1 L. $ha^{-1}$) were applied alone and combined with each other as (sorghum aqueous extract 50% + Traxos 50% of label dose) and (sorghum aqueous extract 25% + Traxos 75% of label dose), the both weed free and weedy check plots were included as controls for wheat crops and weeds. The experiment laid out in randomized complete block design. Results showed that the combination of allelopathic potential of sorghum aqueous extracts with reduced doses of herbicide had suppression effects on weeds variously which canary grass cultivated in durum wheat was the most sensitive weeds and recorded minimum grain yield and biological yield (0.68 g/ plant, 2.29 g/ plant) respectively. Combination of 25% sorghum aqueous extract with reduced dose of herbicide by 75% significantly inhibited weeds that statistically similar to application of herbicide alone which it recorded (1.75 g/ plant, 3.05 g/plant, 4.81 g/ plant, 34.74 %, 89.22 cm, 13.03 $cm^2$) for grain yield, straw yield, biological yield, harvest index, plant height and flag leaf area. This study concluded that sorghum aqueous extract could be used with reduced dose of Traxos (045 EC.) herbicide to control three grassy weeds wild barley, wild oat, canary grass in bread and durum wheat economically and eco-friendly under field condition.

***Keywords***: Water extract, Allelopathy, weed control, lower dose, herbicide.

## Introduction

Ecological risks, weed resistance development and hygienic threats owing unwise use of synthetic herbicides have forced scientist to working intensively to develop substitute weed management methods. Thus, water extract of allelopathic plants with reduced doses of herbicide has been used as an attractive choice. Wheat ranks in the first position due to its high productivity and importance among cereals, but high weed infestation and other factors are the most important limitations of wheat production (Akbar *et al.*, 2011). In deserts, the survival of plants is subjected to the adaptation of particular characters (Ghulam *et al.*, 2020). Weed defined as an unwanted growing plant, that is not only compete with crops for environmental resources such as space, water, air, nutrients and light, but frequently decline regular plant growth through releasing allelochemicals into the soil (Khaliq *et al.*, 2010). Herbicides are very influential in eliminating weeds however there are obvious problems such as ecological risks and human health in herbicide use. Herbicides offer significant increase in crop yielding through adequate weed control (Santos, 2009). But inaccurate and non-judicious use of herbicide could cause crop impairment, health threats, water, and soil contamination and oftentimes, selected weeds are not suppressed due to low rates that employed by farmers (Farooq *et al.*, 2011). However, excessive dose and improper use of herbicide lead to develop tolerance of weeds toward herbicides as it was known this phenomena weed herbicide resistance (Kruidhof *et al.*, 2008; Walker *et al.*, 2013). Such negative effects related with the utilization of chemical herbicides have caused to encouraged attempts to find some other replacement methods that not only have the prospective for successful weed suppression but that must be ecologically sustainable with few health issues.

Allelopathy is a term that expresses a natural occurrence of a plant liberated chemical inhibitors that inhibits the plant growth in vicinity (Krmanj and Kawa, 2020). Allelopathy is any direct or indirect beneficial or harmful effects of one plant on another plant by the production of allelochemicals that release into the environment (Saman and Kawa, 2020). Allelopathy is thought to be an alternative to chemical weed management under current conditions, wherein allelopathic plants are defined that release allelochemicals (secondary metabolites) by different plant parts and species have the negative influential to suppress the growth of plants in vicinity via decomposition, volatilization or leaching (Putnam and Duke, 1974; Stamp, 2003; Cheema *et al.*, 2004). Weed growth can be inhibited through inhibition of photosynthesis, decreasing chlorophyll content, inhibition of enzyme activity, free radical production and cell membrane disruption (Ghanizadeh *et al.*, 2014). Allelopathic potential that were approached previously for weed management showed good effects (Khan *et al.*, 2012; Khaliq *et al.*, 2012) but the amount of controlled weeds was not adequate as they inhibited by herbicides. Tank mixed of allelopathic crop aqueous extract with herbicides reduced dose could be the effective technique to improve the efficacy of weed control and decrease the reliance on chemical herbicides, its dose and hence the cost of weed control (Hong *et al.*, 2004). Application of the integration aqueous extracts with herbicides work synergistically that lead to decrease herbicide dose. For example, lower doses (70% of label dose) of herbicides such as mesosulfuron + idosulfuron (Atlantis 3.6 WG), mesosulfuron + idosulfuron (Atlantis 12 EC), metribuzin + fenoxaprop (Bullet 38 SC), bensulfuron + isoproturon (Cleaner 70 WP) and metribuzin (Sencor 70 WP), when tank mixed with allelopathic water extracts of crops (sorghum, sunflower) at 18 l.ha$^{-1}$ have been showed great inhibition of weed in wheat (Razzaq *et al.*, 2010). Allelopathic potential of (*Sorghum bicolor* L. Moench) may be due to the presence of phenolic compounds such as (vanillic, syringic, ferulic, p-hydroxybenzoic, p-coumaric and gallic acids in the residues quantity of them vary with cultivars, and they responsible of weed growth inhibition of weeds (Alsaadawi and Dayan, 2009). Although lots of information about the allelopathic potential of sorghum is available, but information regarding allelopathic potential of sorghum tank mixed with Taraxos 045 EC had never been reported. Therefore, the present study was designed to evaluate the possible impacts of integrated allelopathic potential of aqueous extract of (*Sorghum bicolr* L. Moench ) shoot plant part tank mixed with reduced doses of Taraxos 045 EC. Clodinafop-propargyl (2.5 %) + Pinoxaden (2.5 %) on the growth and yield of (*Hordeum spontaneum*), wild oat (*Avena fatua*) and canary grass (*Phalaris minor*) [the most problematic weeds in wheat fields], bread and durum wheat growth, yield and yield components.

## Materials and Methods

The field experiment was conducted at Grdarasha research farm/ College of Agricultural Engineering Science/ Salahaddin University Lat. 36.4° N, Long. 44.1° E elevation 390 m above sea level under semi guaranteed Iraqi rain zone during winter season 2016-2017. Three crop seeds sorghum (*Sorghum bicolor* L. Moench) Var. Enqaz, bread wheat (*Triticum aestivum* L.) Var. Aras, durum wheat (*Triticum durum* L.) Var. Hawler and three grassy weed seeds wild barley (*Hordeum spontaneum*), wild oat (*Avena fatua*) and canary grass (*Phalaris minor*) were received from Erbil Research Center. Sorghum seeds (*Sorghum bicolor* L. Moench) var. Enqaz were sown Grdarasha research farm. Plant herbages (stem and leaf) at maturity stage chopped into 2-3 cm pieces and then dried under shade until dryness after that they were grind into powder. Aqueous extracts of sorghum's shoot part prepared by mixing the powder in distilled water with the ratio of (20gm: 100 ml) considered as stock solution (100% concentration) by the procedure of (Cheema and Khaliq, 2000). Bread and durum wheat were cultivated at (100 kg. ha$^{-1}$) also 24 seeds of each three grassy weeds were planted between crop lines then thinned to 12 seedlings arranged in three lines at post-emergence stage (Z 12-13). The experiment laid out in randomized complete block design with three replications, plot size was 2 m x 2m and distance between the lines of wheat were 20 cm. Two factors were used in the study first, plant types that include bread wheat, durum wheat, (wild barley, wild oat, canary grass) cultivated in bread wheat and (wild barley, wild oat, canary grass) that cultivated in durum wheat, second, weed control treatments that involve weed free (zero weed), weedy check, water, herbicide Traxos 045 EC. (Clodinafop-propargyl 2.5 % + Pinoxaden 2.5 %) @ 1 L. ha$^{-1}$ (label dose), sorghum aqueous extract 200 g. L$^{-1}$ (100%), (Traxos 50% of label dose + sorghum aqueous extract 50%) and (Traxos 75% of label dose + sorghum aqueous extract 25%). All the plant aqueous extract and its combination with herbicide were sprayed as a pots emergence 64 days after sowing or when the wheat at (2-3) real leaves and even nodes or Zadox (12-13) stage, for weed species at (3-4) leaves appearance or Zadox (13-14) stage. Knapsack 16 L pressure with T-jet nozzle was used, the spray volume (320 L. ha$^{-1}$) was determined after calibration using ordinary water. The recorded data in this study were seed yield ton. (ha$^{-1}$). Straw yield ton. (ha$^{-1}$). Biological yield (ton. ha$^{-1}$). Harvest index (%). weed index (%) which estimated according to the following equation reported by (Mishra and Misra, 1997). Plant height (cm). Flag leaf area (cm$^2$) for wheat, while for weeds were seed yield g/plant. Straw yield (g/ plant). Biological yield (g/ plant). Harvest index (%). Plant height (cm). Fag leaf area (cm$^2$) for weed species that calculated according (Hunt, 1982). Statistical analysis was conducted by using statistical computer software SPSS version 20 Tukey test ($P \leq 0.05$) was used to determine the significance difference between means value. The presented data were expressed mean and ± standard error.

Weed Index (%) = grain yield of weed free – grain yield of treated plot/ grain yield of weed free.

Flag leaf area (cm$^2$) = leaf length × leaf width × index factor (0.905).

Abbreviations: g = gram, cm = centimeter and ha = hectare.

## Results and Discussion

### The combination effects of sorghum aqueous extract and reduced dose of Traxos herbicide on wheat species

All studied parameters of wheat species except (biological yield, harvest index and weed index) were significantly affected by integration of sorghum aqueous extract with Traxos herbicide (Table 1).

**Table 1:** The combination effect of sorghum aqueous extract and reduced herbicide dose on growth, yield and yield components of wheat species.

| Wheat species | Grain yield ton. ha$^{-1}$ | Straw yield ton. ha$^{-1}$ | Biological yield ton. ha$^{-1}$ | Harvest index % | Plant height cm | Flag leaf area cm$^2$ | Weed index % |
|---|---|---|---|---|---|---|---|
| Bread wheat | 3.21 b ±0.07 | 7.13 b ±0.29 | 10.34 a ±0.38 | 31.28 a ±0.69 | 95.36 a ±1.25 | 40.34 b ±0.67 | 11.57 a ±1.56 |
| Durum wheat | 3.41 a ±0.11 | 7.86 a ±0.23 | 11.26 a ±0.33 | 30.25 a ±0.64 | 92.05 b ±0.86 | 42.50 a ±0.75 | 12.09 a ±2.44 |

Means not sharing the same letters differ significantly at 5% probability level.

Maximum values of grain yield, straw yield and flag leaf area (3.41 ton. ha$^{-1}$, 7.86 ton. ha$^{-1}$, 42.50 cm$^2$) respectively were found in durum wheat but the highest plant height (95.36 cm) was recorded in bread wheat. Plant species have various sensitivity toward allelopathic potential due to genetic variation properties of plant species (Ali, 2016). Allelopathic potential of sorghum as a bio herbicide and tank mixing with chemical herbicide were used to suppression weeds in different crops such as rice, maize and cotton (Cheema *et al.*, 2002; Cheema *et al.*, 2005; Afzal *et al.*, 2014). In addition, the results (Table 2) showed that all treatments had significant effects on growth, yield and yield components of wheat. The highest records of grain yield and harvest index (3.75 ton. $ha^{-1}$, 33.88%) respectively were recorded in weed free while, the maximum measures of straw yield, biological yield and flag leaf area (9.14 ton. $ha^{-1}$, 12.75 ton. $ha^{-1}$, 44.38 $cm^2$) respectively were measured in spraying herbicide at label dose (100%) but weedy check produced the maximum plant height (98.57 cm) however, water treatment scored the highest weed index percentage (26.03%). Whereas, the lowest values for grain yield and harvest index (2.77 ton. $ha^{-1}$, 27.69%) were obtained with plots that sprayed with water only, but the minimum levels of straw yield biological yield and flag leaf area (6.12 ton. $ha^{-1}$, 9.17 ton. $ha^{-1}$, 38.15 $cm^2$) respectively were observed with weedy check treatment however, spraying herbicide at label dose produced the lowest plant height (88.63 cm) also weed free treatment resulted the minor value for weed index (0.00%). Yield and yield component of crops may be enhanced or not affect by allelopathic water extract of sorghum and sunflower alone or in combination with herbicide (Khan *et al*., 2012). These result are agreement with the findings reported by (Jamil *et al*., 2009; Hussain *et al*., 2014; Al- Obaidi and Alsaadawi, 2015). The grain yield of rice was significantly affected by application the combination of sorghum, sunflower and rice with herbicide to control weeds in rice (Rehman *et al*., 2010). Furthermore, all interaction between wheat species and treatments had significant effects on all studied parameters except biological yield, plant height and flag leaf area (Table 3).

**Table 2:** The effect of weed control treatments on growth, yield and yield component of wheat species.

| Weed control treatments | Grain yield ton. $ha^{-1}$ | Straw yield ton. $ha^{-1}$ | Biological yield ton. $ha^{-1}$ | Harvest index % | Plant height cm | Flag leaf area $cm^2$ | Weed index % |
|---|---|---|---|---|---|---|---|
| Weed free | 3.75 a ±0.12 | 7.39 bc ±0.37 | 11.11 ab ±0.67 | 33.88 a ±0.85 | 89.87 bc ±2.34 | 43.64 ab ±1.11 | 0.00 e ±0.00 |
| Weedy check | 3.05 bc ±0.13 | 6.12 c ±0.44 | 9.17 b ±0.53 | 33.30 ab ±0.64 | 98.57 a ±1.48 | 38.15 b ±1.24 | 18.69 b ±1.67 |
| Water | 2.77 c ±0.12 | 7.28 bc ±0.38 | 10.05 ab ±0.51 | 27.69 e ±1.32 | 96.30 ab ±1.80 | 39.52 ab ±1.03 | 26.03 a ±3.37 |
| S.A.E. (100%) | 3.31 abc ±0.14 | 7.20 bc ±0.23 | 10.51 ab ±0.52 | 31.48 abc ±0.76 | 95.20 abc ±1.57 | 42.30 ab ±1.25 | 11.86 bc ±1.99 |
| S.A.E. (50%) + H. @ (50% label dose) | 3.24 abc ±0.15 | 7.64 abc ±0.34 | 10.87 ab ±0.55 | 29.80 cde ±0.59 | 95.10 abc ±1.43 | 40.50 ab ±1.56 | 13.75 bc ±1.52 |
| S.A.E. (25%) + H. @ (75% label dose) | 3.43 ab ±0.12 | 7.71 ab ±0.40 | 11.14 ab ±0.66 | 30.83 bcd ±0.73 | 92.27 abc ±1.63 | 41.46 ab ±0.92 | 8.61 cd ±1.68 |
| H. @ label dose (100%) | 3.61 ab ±0.14 | 9.14 a ±0.59 | 12.75 a ±0.65 | 28.40 de ±1.39 | 88.63 c ±1.64 | 44.38 a ±1.13 | 3.87 de ±1.23 |

Means not sharing the same letters differ significantly at 5% probability level. A.E.A. sorghum aqueous extract, H. herbicide.

**Table 3:** The interaction effect between wheat species and weed control treatments on growth, yield and yield components of wheat species.

| Wheat species X Weed control treatments | | Grain yield ton. $ha^{-1}$ | Straw yield ton. $ha^{-1}$ | Biological yield ton. $ha^{-1}$ | Harvest index % | Plant height cm | Flag leaf area $cm^2$ | Weed index % |
|---|---|---|---|---|---|---|---|---|
| Bread wheat | Weed free | 3.63 ab ±0.25 | 6.66 bc ±0.09 | 10.28 a ±0.73 | 35.27 a ±0.68 | 90.00 a ±3.70 | 42.24 a ±1.63 | 0.00 e ±0.00 |
| | Weedy check | 2.99 abc ±0.11 | 5.73 c ±0.57 | 8.72 a ±0.91 | 34.30 a ±0.51 | 100.60 a ±1.97 | 37.95 a ±1.72 | 17.48 bc ±1.91 |
| | Water | 2.90 bc ±0.13 | 6.62 bc ±0.48 | 9.52 a ±0.40 | 30.51 abc ±0.12 | 99.27 a ±2.66 | 38.22 a ±0.65 | 19.88 b ±2.16 |
| | S.A.E. (100%) | 3.15 abc ±0.24 | 6.96 bc ±0.36 | 10.12 a ±0.84 | 31.17 ab ±1.05 | 97.93 a ±1.92 | 41.72 a ±2.65 | 13.05 bcd ±3.69 |
| | S.A.E. (50%) + H. @ (50% label dose) | 3.14 abc ±0.14 | 7.13 bc ±0.27 | 10.27 a ±0.54 | 30.58 abc ±0.99 | 97.87 a ±1.46 | 38.86 a ±1.15 | 13.34 bcd ±2.33 |
| | S.A.E. (25%) + H. @ (75% label dose) | 3.23 abc ±0.01 | 7.09 bc ±0.50 | 10.31 a ±1.08 | 31.28 ab ±1.43 | 93.07 a ±2.21 | 40.62 a ±1.43 | 11.02 b-e ±2.40 |
| | H. @ label dose (100%) | 3.40 abc ±0.20 | 9.75 a ±0.47 | 13.15 a ±1.00 | 25.86 cd ±0.78 | 88.80 a ±2.81 | 42.73 a ±1.88 | 6.21 cde ±1.37 |
| Durum wheat | Weed free | 3.88 a ±0.03 | 8.11 abc ±0.39 | 11.93 a ±1.02 | 32.49 ab ±1.12 | 89.73 a ±3.70 | 45.03 a ±1.27 | 0.00 e ±0.00 |
| | Weedy check | 3.11 abc ±0.26 | 6.51 bc ±0.71 | 9.62 a ±0.63 | 32.29 ab ±0.89 | 96.53 a ±1.71 | 38.35 a ±2.17 | 19.90 b ±2.98 |
| | Water | 2.63 c ±0.19 | 7.94 abc ±0.26 | 10.57 a ±0.94 | 24.87 d ±0.83 | 93.33 a ±0.55 | 40.81 a ±1.78 | 32.18 a ±3.78 |
| | S.A.E. (100%) | 3.46 abc ±0.12 | 7.43 abc ±0.29 | 10.89 a ±0.70 | 31.78 ab ±1.30 | 92.47 a ±1.07 | 42.88 a ±0.61 | 10.67 b-e ±2.17 |
| | S.A.E. (50%) + H.. @ (50% label dose) | 3.33 abc ±0.28 | 8.14 abc ±0.49 | 11.47 a ±0.91 | 29.02 bcd ±0.43 | 92.33 a ±0.66 | 42.14 a ±2.86 | 14.15 bc ±2.45 |
| | S.A.E. (25%) + H. @ (75% label dose) | 3.64 ab ±0.17 | 8.33 ab ±0.40 | 11.97 a ±0.55 | 30.38 abc ±0.64 | 91.47 a ±2.79 | 42.30 a ±1.21 | 6.19 cde ±1.60 |
| | H. @ label dose (100%) | 3.82 ab ±0.14 | 8.52 ab ±1.08 | 12.34 a ±0.97 | 30.94 ab ±1.62 | 88.47 a ±2.34 | 46.03 a ±0.33 | 1.53 de ±0.43 |

Means not sharing the same letters differ significantly at 5% probability level. A.E.A. sorghum aqueous extract, H. herbicide.

**The combination effects of sorghum aqueous extract and reduced dose of Traxos herbicide on weed species**

All calculated traits of weed species were significantly influenced by combination of sorghum aqueous extract with Traxos herbicide (Table 4). Whereas the most sensitive weed species among other weed species was canary grass that cultivated in durum wheat. Consequently, minimum values of grain yield, straw yield, biological yield, harvest index, plant height and flag leaf area (0.68 g/ plant, 1.60 g/ plant, 2.29 g/ plant, 30.92 %, 61.02 cm, 5.55 $cm^2$) respectively were recorded at canary grass in durum wheat. While, the most tolerant weed species was wild barley that planted in durum wheat. Weed activity must be decreased by allelopathic aqueous extracts by influencing on several physiological process involving mitotic inhibition, nutrient uptake inhibition, photosynthetic inhibition, reactive oxygen species production and impacts on membrane permeability (Ali and Aziz, 2002). Taraxos 045 EC. (Clodinafop-propargyl + Pinoxaden) is a mixture of carboxylic acid derivative and phenylpyrazoline herbicides possessing acetyl CoA carboxylase (ACCase) inhibition mode of action. Sorghum water extract had inhibitory effects on various weed species such as purple nutsedge, (*Chenopodium album* L.), (*Medicago polymorpha* L.), (*Anagalis arvensis* L.), (*Fumaria indica* L.), (*Convolvulus arvense* L.) and (*Melilotus parviflora* L.) due to the presence of an appropriate number of phenolic acids like vanillic, syringic, ferulic, p-hydroxybenzoic, p-coumaric, trans-cinnamic and gallic acids (Mahmood *et al*., 2013, Won *et al*., 2013).

**Table 4:** The combination effect of sorghum aqueous extract and reduced herbicide dose on growth, yield and yield components of weed species.

| Weed species | Grain yield g/ plant | Straw yield g/ plant | Biological yield g/ plant | Harvest index % | Plant height cm | Flag leaf area $cm^2$ |
|---|---|---|---|---|---|---|
| Wild barley in bread wheat | 3.47 b ±0.15 | 4.86 bc ±0.23 | 8.32 b ±0.31 | 41.81 a ±1.36 | 120.55 a ±1.66 | 10.00 b ±0.78 |
| Wild barley in durum wheat | 4.52 a ±0.18 | 6.10 a ±0.24 | 10.62 a ±0.41 | 42.59 a ±0.45 | 122.61 a ±1.60 | 10.16 b ±0.51 |
| Wild oat in bread wheat | 2.54 c ±0.39 | 5.54 ab ±0.62 | 8.08 b ±0.99 | 28.48 b ±2.07 | 91.30 b ±0.91 | 28.74 a ±1.50 |
| Wild oat in durum wheat | 2.27 c ±0.33 | 4.23 c ±0.58 | 6.49 c ±0.89 | 34.52 b ±1.49 | 84.97 c ±1.14 | 28.59 a ±1.80 |
| Canary grass in bread wheat | 0.76 d ±0.16 | 1.68 d ±0.23 | 2.43 d ±0.35 | 31.40 b ±2.67 | 73.18 d ±1.19 | 9.15 b ±0.76 |
| Canary grass in durum wheat | 0.68 d ±0.07 | 1.60 d ±0.26 | 2.29 d ±0.32 | 30.92 b ±1.67 | 61.02 e ±1.49 | 5.55 c ±0.59 |

Means not sharing the same letters differ significantly at 5% probability level.

**Table 5:** The effect of weed control treatments on growth, yield and yield component of weed species.

| Weed control treatments | Grain yield g/ plant | Straw yield g/ plant | Biological yield g/ plant | Harvest index % | Plant height cm | Flag leaf area $cm^2$ |
|---|---|---|---|---|---|---|
| Weedy check | 3.31 a ±0.42 | 5.61 a ±0.63 | 8.92 a ±1.02 | 36.20 a ±2.79 | 97.27 a ±5.49 | 20.41 a ±2.93 |
| Water | 2.92 ab ±0.38 | 5.33 a ±0.57 | 8.24 a ±0.90 | 33.70 a ±1.93 | 95.88 ab ±5.45 | 17.61 ab ±2.87 |
| S.A.E. (100%) | 2.24 cd ±0.37 | 3.51 bc ±0.48 | 5.74 bc ±0.85 | 37.12 a ±1.06 | 90.39 c ±5.68 | 14.17 c ±2.22 |
| S.A.E. (50%) + H. @ (50% label dose) | 2.57 bc ±0.38 | 4.23 b ±0.46 | 6.80 b ±0.82 | 35.13 a ±1.65 | 92.12 bc ±5.51 | 15.99 bc ±2.69 |
| S.A.E. (25%) + H. @ (75% label dose) | 1.75 de ±0.36 | 3.05 cd ±0.48 | 4.81 cd ±0.80 | 34.74 a ±2.15 | 89.22 c ±5.93 | 13.03 cd ±2.10 |
| H. @ label dose (100%) | 1.44 e ±0.37 | 2.28 d ±0.40 | 3.72 d ±0.75 | 32.85 a ±2.85 | 88.74 c ±5.75 | 10.98 d ±1.60 |

Means not sharing the same letters differ significantly at 5% probability level. S.A.E. = sorghum aqueous extract, H. = herbicide.

The results (Table 5) illustrates that the grain yield and other weed parameters except harvest index significantly were reduced in all the weed control treatments as compared to weedy check (control). Although the lowest value for weed grain yield (1.44 g/ plant) was counted in (H. @ label dose 100 %) treatment but that was statistically similar to S.A.E. (25%) + H. @ (75% label dose) treatment. As well as biological yield of weeds significantly decreased from (8.92 g/ plant) in weedy check to (3.72 g/ plant) in the H. @ label dose (100%), also that lowest value was statistically same as in S.A.E. (25%) + H. @ (75% label dose). Present study revealed reduction of weed dry weight by combined aqueous extract of allelopathic plant with lower doses of herbicide due to synergistic effect of herbicide when, tank mixed with water extract of allelopathic crop, potentiality of sorghum aqueous extract was developed by mixing it with lesser doses of herbicide. The results are in agreement with those of Elahi *et al.* (2011) who showed similar reduce of weed biomass with sorghum + sunflower aqueous extract integrated with low doses of herbicides. Furthermore, dry weight of weeds were decreased effectively by combination of sorghum and sunflower with lower rates of herbicides (Lahmod and Alsaadawi, 2014). The maximum values of straw yield, plant height and flag leaf area (5.61 g/ plant, 97.27 cm, 20.41 $cm^2$)

were found in weed check (control treatment), while the H. @ label dose (100%) produced minimum records (2.28 g/ plant, 88.74 cm, 10.98 $cm^2$) respectively for straw yield, plant height and flag leaf area.

**Table 6:** The interaction effect between wheat species and weed control treatments on growth, yield and yield components of weed species.

| Weed species X Weed control treatments | | Grain yield g/ plant | Straw yield g/ plant | Biological yield g/ plant | Harvest index % | Plant height cm | Flag leaf area $cm^2$ |
|---|---|---|---|---|---|---|---|
| Wild barley in bread wheat | Weedy check | 3.68 abc (±0.32) | 5.40 b-g (±0.14) | 9.08 a-f (±0.42) | 40.55 ab (±1.95) | 128.13 a (±0.37) | 13.07 ghi (±2.98) |
| | Water | 3.60 abc (±0.34) | 5.28 b-h (±0.57) | 8.88 a-g (±0.91) | 40.55 ab (±0.50) | 126.60 a (±1.31) | 11.11 ghi (±2.01) |
| | S.A.E. (100%) | 3.40 a-d (±0.38) | 4.99 b-h (±0.74) | 8.38 b-h (±1.04) | 40.53 ab (±2.78) | 117.73 a (±3.24) | 9.66 hi (±1.95) |
| | S.A.E. (50%) + H. @ (50% label dose) | 3.53 a-d (±0.56) | 5.08 b-h (±0.67) | 8.61 b-g (±1.16) | 40.99 ab (±2.31) | 117.87 a (±3.04) | 9.87 ghi (±1.28) |
| | S.A.E. (25%) + H. @ (75% label dose) | 3.35 a-e (±0.60) | 4.71 c-i (±0.65) | 8.05 b-i (±0.09) | 41.59 ab (±7.73) | 116.50 a (±6.75) | 8.31 i (±1.50) |
| | H. @ label dose (100%) | 3.23 a-f (±0.07) | 3.70 d-k (±0.21) | 6.93 c-j (±0.17) | 46.65 a (±1.71) | 116.47 a (±1.22) | 7.97 i (±1.15) |
| Wild barley in durum wheat | Weedy check | 5.27 a (±0.22) | 6.91 a-d (±0.52) | 12.18 ab (±0.64) | 43.29 ab (±1.55) | 123.67 a (±1.74) | 12.23 ghi (±2.19) |
| | Water | 4.77 ab (±0.15) | 6.81 a-e (±0.27) | 11.58 abc (±0.42) | 41.21 ab (±0.19) | 123.10 a (±4.01) | 10.67 ghi (±1.71) |
| | S.A.E. (100%) | 4.51 ab (±0.66) | 6.01 a-e (±0.83) | 10.51 a-e (±1.48) | 42.90 ab (±1.21) | 122.33 a (±3.89) | 9.78 ghi (±0.70) |
| | S.A.E. (50%) + H. @ (50% label dose) | 4.58 ab (±0.50) | 6.16 a-e (±0.59) | 10.75 a-d (±1.06) | 42.65 ab (±1.08) | 123.00 a (±6.01) | 10.06 ghi (±0.85) |
| | S.A.E. (25%) + H. @ (75% label dose) | 4.08 abc (±0.33) | 5.82 a-e (±0.52) | 9.90 a-e (±0.83) | 41.25 ab (±0.90) | 122.33 a (±5.88) | 9.34 hi (±0.77) |
| | H. @ label dose (100%) | 3.89 abc (±0.33) | 4.89 c-i (±0.24) | 8.78 a-g (±0.57) | 44.27 ab (±1.01) | 121.20 a (±4.84) | 8.88 hi (±0.30) |
| Wild oat in bread wheat | Weedy check | 4.63 ab (±0.59) | 8.90 a (±1.25) | 13.52 a (±1.84) | 34.24 abc (±0.28) | 94.20 b (±2.62) | 34.88 ab (±1.92) |
| | Water | 3.89 abc (±0.19) | 8.11 ab (±0.50) | 12.00 ab (±0.69) | 32.39 abc (±0.30) | 93.63 b (±1.97) | 33.30 abc (±0.60) |
| | S.A.E. (100%) | 2.10 c-i (±0.52) | 4.06 c-j (±0.57) | 6.17 d-k (±1.09) | 34.12 abc (±1.83) | 90.21 bc (±1.17) | 27.20 b-e (±2.12) |
| | S.A.E. (50%) + H. @ (50% label dose) | 3.20 a-g (±0.43) | 5.85 a-e (±0.75) | 9.05 a-f (±1.17) | 35.38 abc (±0.68) | 92.11 b (±3.45) | 31.62 abc (±4.69) |
| | S.A.E. (25%) + H. @ (75% label dose) | 1.00 hi (±0.00) | 3.75 d-k (±0.52) | 4.76 f-m (±0.52) | 21.11 bc (±1.95) | 89.27 bc (±1.77) | 25.27 b-e (±2.12) |
| | H. @ label dose (100%) | 0.40 i (±0.06) | 2.55 g-k (±0.52) | 2.96 j-m (±0.46) | 13.67 c (±3.22) | 88.35 bc (±0.61) | 20.16 d-g (±1.59) |
| Wild oat in durum wheat | Weedy check | 3.73 abc (±0.58) | 7.04 abc (±1.58) | 10.78 a-d (±2.16) | 34.64 abc (±1.16) | 92.40 b (±0.76) | 38.74 a (±2.58) |
| | Water | 3.32 a-e (±0.94) | 6.74 a-e (±0.07) | 10.05 a-e (±0.87) | 33.00 abc (±5.52) | 87.20 bcd(±3.10) | 33.95 abc (±4.12) |
| | S.A.E. (100%) | 2.22 c-i (±0.52) | 3.65 e-k (±0.52) | 5.86 e-l (±1.04) | 37.82 ab (±1.65) | 82.78 b-f (±1.21) | 25.66 b-e (±2.21) |
| | S.A.E. (50%) + H. @ (50% label dose) | 2.72 b-h (±0.52) | 4.44 c-i (±0.52) | 7.15 c-j (±1.04) | 37.99 ab (±1.39) | 84.68 b-e(±2.37) | 30.01 a-d (±2.08) |
| | S.A.E. (25%) + H. @ (75% label dose) | 1.12 f-i (±0.06) | 2.34 g-k (±0.52) | 3.45 i-m (±0.46) | 32.36 abc (±4.87) | 81.84 b-f (±1.33) | 24.06 c-f (±2.09) |
| | H. @ label dose (100%) | 0.52 i (±0.06) | 1.14 ijk (±0.23) | 1.65 klm (±0.17) | 31.31 abc (±5.74) | 80.92 b-f (±1.39) | 19.12 e-h (±1.58) |
| Canary grass in bread wheat | Weedy check | 1.40 d-i (±0.94) | 2.89 f-k (±0.32) | 4.29 g-m (±1.26) | 32.60 abc (±1.63) | 78.39 b-g(±2.87) | 13.85 f-i (±1.43) |
| | Water | 1.02 ghi (±0.09) | 2.59 g-k (±0.76) | 3.60 i-m (±0.79) | 28.15 abc (±4.59) | 77.94 b-g(±2.29) | 10.37 ghi (±1.67) |
| | S.A.E. (100%) | 0.61 hi (±0.06) | 1.22 ijk (±0.06) | 1.82 klm (±0.12) | 33.19 abc (±1.20) | 70.68 d-i (±0.69) | 8.10 i (±1.21) |
| | S.A.E. (50%) + H. @ (50% label dose) | 0.72 hi (±0.06) | 1.73 ijk (±0.09) | 2.44 j-m (±0.15) | 29.27 abc (±1.12) | 73.58 c-h(±2.54) | 9.24 hi (±0.74) |
| | S.A.E. (25%) + H. @ (75% label dose) | 0.50 i (±0.06) | 0.91 ijk (±0.06) | 1.40 lm (±0.12) | 35.29 abc (±1.41) | 69.74 e-i (±1.96) | 7.15 i (±1.24) |
| | H. @ label dose (100%) | 0.32 i (±0.06) | 0.74 k (±0.06) | 1.05 m (±0.12) | 29.92 abc (±2.72) | 68.75 e-i (±1.96) | 6.20 i (±1.62) |
| Canary grass in durum wheat | Weedy check | 1.17 e-i (±0.10) | 2.50 g-k (±0.47) | 3.67 h-m (±0.52) | 31.92 abc (±5.04) | 66.83 f-i (±5.75) | 9.72 ghi (±0.65) |
| | Water | 0.90 hi (±0.10) | 2.46 g-k (±1.12) | 3.36 i-m (±1.22) | 26.88 abc (±6.83) | 66.80 f-i (±3.37) | 6.25 i (±1.32) |
| | S.A.E. (100%) | 0.58 hi (±0.06) | 1.11 ijk (±0.06) | 1.69 klm (±0.12) | 34.18 abc (±1.22) | 58.60 hi (±1.85) | 4.61 i (±0.58) |
| | S.A.E. (50%) + H. @ (50% label dose) | 0.69 hi (±0.04) | 2.12 h-k (±0.44) | 2.81 j-m (±0.47) | 24.47 abc (±2.36) | 61.50 ghi(±1.76) | 5.17 i (±1.08) |
| | S.A.E. (25%) + H. @ (75% label dose) | 0.47 i (±0.06) | 0.80 k (±0.06) | 1.27 lm (±0.12) | 36.82 abc (±1.42) | 55.66 i (±1.08) | 4.05 i (±1.00) |
| | H. @ label dose (100%) | 0.29 i (±0.06) | 0.63 k (±0.06) | 0.92 m (±0.12) | 31.27 abc (±3.00) | 56.74 hi (±1.27) | 3.52 i (±0.58) |

Means not sharing the same letters differ significantly at 5% probability level. S.A.E. = sorghum aqueous extract, H. = herbicide.

The interaction effects of weed species and weed control treatments had significant impact on all studied parameters (Table 6).

## Conclusion

Sorghum aqueous extract decreased weed dynamics. Water extracts sorghum's shoot part have reduced herbicide dose of (Traxos 045 EC.) up to 25% that produced similar results to applied herbicide alone in suppressing wild barley, wild oat and canary grass in bread and durum wheat filed. Hence, this combination can be use in controlling weeds in wheat economically and eco-friendly by reducing reliance on synthetic herbicide.


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