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# Comparison of Sorghum Extracts Chemical and Hand Weeding Management in Wheat (*Triticum aestivum* L.) Crop

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**Abstract:** An experiment was designed to investigate the feasibility of using extract of sorghum as a natural weed control approach in comparison with hand weeding and herbicides for wheat crop. The experiment was conducted at Agricultural University Research Farm of NWFP Agricultural University, Peshawar during 1999-2000. Ten treatments were studied in the experiment including check, hand wedding, herbicides Assert and Diazon and 20, 30 and 40 kg sorghum extract ha$^{-1}$ applied once and twice. Mature sorghum herbage was used for preparing water extract in 1: 20 ratio i.e. 1 kg sorghum herbage soaked in 20 L of water. Sorghum extracts of 20, 30 and 40 kg ha$^{-1}$ were applied twice, 55 days after sowing and 85 days after sowing. Hand weeding was carried out as required while no weed control was done in check plots. All the weeding control treatments significantly affected seed filling duration, weeds weight, weeds number and grain yield. Sorghum extract also reduced weeds number and weeds weight. Plots sprayed with Diazon herbicides application resulted maximum mean tiller growth rate (0.05 g day$^{-1}$). Diazon reduced weds mass and weeds number. Sorghum extract at the rate of 30 kg ha$^{-1}$ twice increased fresh (13.25 g) and dry (6.28 g) and grain yield (4318 kg ha$^{-1}$) as compared to check plots.

**Key words:** Weeds control methods, sorghum extract, wheat

## INTRODUCTION

Pakistan is one of the top ten wheat-producing countries and wheat is an indispensable food article for the people of Pakistan. Due to high demand for wheat, major emphasis has to be but on increasing yield unit$^{-1}$ area, which can be achieved when an appropriate production technology is adopted. One of components of improved production technology is appropriate weed control because weeds are of serious concern under higher fertility levels that is needed for obtaining higher yield of wheat. Weeds reduce crop yield not only by competing with crop plants for light, nutrients and carbon dioxide[1] but also by affecting plant roots by resulting secondary substances into rhizosphere of the crop[2]. The magnitude of losses in yield due to presence of weeds and the extent of damage to wheat crop by weeds varies greatly from one year to year depending upon the degree of weed infestation, soil and climatic conditions, cultural practices like seed rate, methods of sowing, date of sowing etc. wheat yield losses due to weeds in Pakistan were estimated to be in the range of 17 to 25%[3]. Considering minimum loss in yield (17%). Monetary loss could as high as 5.00 billion rupees per annum[4]. Weeds can be controlled by physical and mechanical; methods. Increased labor cost, limited energy resource and expensive chemical have hampered the use of some of these methods. In addition continuous uses of pesticides result in health hazards and pollute both the soil and aerial environment as well as lead to resistance in crop enemies. The safety of any pesticides is uncertain[5]. Some herbicides can adversely affect the nutritive value of certain crops[6]. The primary objective of weed control treatment is to increase the yield unit$^{-1}$ area with minimum expenditure. Now a day there is much emphasis on search for new methods of weed control that are safe, harmless and less expensive and uses farm-produced material. Allelopathy has emerged as an important area of weed research and has been accepted very recently as important ecological phenomena. Allelopathic plants for example sorghum, sunflower and oats, contain a number of allelochemicals in low quality act as hormones and in high amount as herbicides. Allelopathic crop plants not only control weeds but also enhance crop growth and yield. The economic importance of wheat crop, heavy weed infestation in wheat search for innovative less expensive method for weeds control, the evidence of Allelopathic compounds in sorghum and their subsequent effects on other plants inspired the idea for conducting this field study to explore the feasibility of using sorghum

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water extract as natural herbicides to control weeds in wheat crop and to study its effects on growth and yield of wheat in comparison with hand weeding and herbicides. Wheat (*Triticum aestivum* L.) is the most widely grown cereal grain crop in the world, except in the rice eating regions of Asia. Wheat products are the principal cereal foods of an over helming majority of the world's inhabitants. Wheat has great adaptability to a wide variety of soil and climatic conditions. But, the important wheat growing areas of the world are located in temperate zones. Wheat is occupying important positions in the economy of Pakistan. A better progress has been made in increasing the per acre yield of wheat in the country during the last few years. But, still Pakistan has a low yield as compared to advanced wheat growing countries. The reasons for low yield are many, but one of the most serious but less noticeable causes of the low yield is the presence of weeds. The main reason is causing of lower input cost by the farmers. However, for increasing per acre yield of wheat, use of high yielding varieties and improved cultural practices are two main dominant factors. Frisen and Kanwar[7] suggested that the crop yield could not be increased without integrated weed management system. Now-a-days weeds are generally controlled by chemical methods that are costly and hazardous for health and cause environmental pollution problem. Due to awareness developed in farming community about the risks involved in herbicide usage, new methods of weed control are being evaluated which are safer and harmless for health and environment. Use of sorgaab (sorghum water extract) for weed suppression and increase in crop yield has been reported in field studies by Cheema and Khaliq[8]. The concept of using allelochemicals crop extracts for controlling weeds was 1st given by Putnam and Duke (1974). They found that sorghum residues reduced normal weed population by 95%. About the frequency of spray different reports have been given as Cheema *et al.*[9] and Kaliar[10] reported that two sprays of Sorgaab were economical, while, Ahmad[11] earlier stated that three Sorgaab sprays increased maize grain yield by 33%.

The primary objective of weed control treatment is to increase the yield unit$^{-1}$ area with minimum expenditure. Now a day there is much emphasis on search for new methods of weed control that are safe, harmless and less expensive and uses farm-produced material. Allelopathy has emerged as an important area of weed research and has been accepted very recently as important ecological phenomena. Allelopathic plants for example sorghum, sunflower and oats, contain a number of allelochemicals in low quality act as hormones and in high amount as herbicides. Allelopathic crop plants not only control weeds but also enhance crop growth and yield.

## MATERIALS AND METHODS

The field experiment on "Comparison of sorghum extracts chemical and hand weeding management in wheat (*Triticum aestivum* L.) crop" was conducted during Rabi season of 1999-2000 at Agriculture Research Farm of the NWFP Agricultural University, Peshawar.

The following treatments were studied in the experiment.

1. Check (No weeding)
2. Hand weeding
3. Assert herbicides applied at the rate of 2.4 l ha$^{-1}$.
4. Diazon herbicides applied at the rate of 2.5 l ha$^{-1}$
5. Extract of 20 kg sorghum ha$^{-1}$ sprayed once
6. Extract of 30 kg sorghum ha$^{-1}$ sprayed once
7. Extract of 40 kg sorghum ha$^{-1}$ sprayed once
8. Extract of 20 kg sorghum ha$^{-1}$ sprayed twice
9. Extract of 30 kg sorghum ha$^{-1}$ sprayed twice
10. Extract of 40 kg sorghum ha$^{-1}$ sprayed twice

The experiment was conducted using a randomized complete block design with 4 replications. Wheat variety Inqilab-91 was used in the experiment, which was sown at the rate 100 kg ha$^{-1}$ in 22 cm apart rows. Mature sorghum herbage was used for obtaining water extract for weeds control. The sorghum plants with stem and leaves were cut in small pieces. The material was soaked in water for 24 h in 1:20 ratio i.e. 1 kg plant herbage and 20 liters of water. Prior to spraying volume of the spray was calibrated by using ordinary water. Water extract of sorghum and herbicides in respective plots were sprayed 55 days after sowing wheat. Second spray was done 85 days after sowing.

Data were recorded on the following observations i.e. seed filling duration, mean tiller growth rate upto anthesis stage, fresh weight of weeds at 65 days after sowing, dry weight of weeds at 65 days after sowing, fresh weight of weeds at 95 days after sowing, dry weight of weeds at 95 days after sowing grains, weeds number at 65 days after sowing, spike$^{-1}$, weeds number at 95 days after sowing and grain yield (kg ha$^{-1}$).

## RESULTS AND DISCUSSION

**Seed filling duration:** Data recorded on seed filling duration of wheat as affected by weed control methods are presented in Table 1. Analysis of the data revealed that weed control treatments had significant effect on seed filling duration. The LSD test revealed that all the weed control treatments slightly effect on the seed filling duration as their differences with check were not significant except the plots that were sprayed with Assert and Diazon herbicides which significantly increased seed

Table 1: Seed filling duration (days to maturity – days to anthesis) of wheat as affected by weed control treatments with means for the meaningful comparisons

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 31.00 | - | - |
| Hand weeding | 31.75 | 0.75 | ^ |
| Asert | 33.50 | 2.50 | ^ |
| Diazon | 33.75 | 2.75 | NS |
| Extract of 20 kg sorghum ha$^{-1}$ sprayed once | 31.00 | 0.00 | NS |
| Extract of 30 kg sorghum ha$^{-1}$ sprayed once | 31.25 | 0.25 | NS |
| Extract of 40 kg sorghum ha$^{-1}$ sprayed once | 31.25 | 0.25 | NS |
| Extract of 20 kg sorghum ha$^{-1}$ sprayed twice | 32.25 | 1.25 | NS |
| Extract of 30 kg sorghum ha$^{-1}$ sprayed twice | 32.25 | 1.25 | NS |
| Extract of 40 kg sorghum ha$^{-1}$ sprayed twice | 31.25 | 0.25 | NS |
| LSD at 0.05 alpha level | 1.47 | - | - |

| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
|---|---|---|---|---|
| Check vs. weed control treatment | 31.00 | 32.03 | 1.03 | ^^^ |
| Hand weeding vs. all other | 31.75 | 32.06 | 0.31 | NS |
| Herbicides vs. sorghum extract | 33.63 | 31.54 | 2.08 | ** |
| Asert vs. Diazon | 31.50 | 33.75 | 0.25 | NS |
| Sorghum extract once sorghum extract twice | 31.17 | 31.92 | 0.75 | ^^^ |
| Sorghum extract once linear | - | - | - | NS |
| Sorghum extract once quadratic | - | - | - | NS |
| Sorghum extract twice linear | - | - | - | NS |
| Sorghum extract twice quadratic | - | - | - | NS |

NS = Non significant
^ = Significant as compared to check using LSD test
^^^ = Significant at 10% level of probability using F test
** = Significant at 1% level of probability using F test

Table 2: Mean tiller growth rate (g day$^{-1}$ tiller$^{-1}$) upto anthesis of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 0.026 | - | - |
| Hand weeding | 0.040 | 0.014 | ^ |
| Asert | 0.047 | 0.021 | ^ |
| Diazon | 0.051 | 0.025 | ^ |
| Extract of 20 kg sorghum ha$^{-1}$ sprayed once | 0.032 | 0.006 | ^ |
| Extract of 30 kg sorghum ha$^{-1}$ sprayed once | 0.035 | 0.009 | ^ |
| Extract of 40 kg sorghum ha$^{-1}$ sprayed once | 0.037 | 0.011 | ^ |
| Extract of 20 kg sorghum ha$^{-1}$ sprayed twice | 0.045 | 0.019 | ^ |
| Extract of 30 kg sorghum ha$^{-1}$ sprayed twice | 0.045 | 0.019 | ^ |
| Extract of 40 kg sorghum ha$^{-1}$ sprayed twice | 0.042 | 0.016 | ^ |
| LSD at 0.05 alpha level | 0.006 | - | - |

| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
|---|---|---|---|---|
| Check vs. weed control treatment | 0.026 | 0.042 | 0.016 | ** |
| Hand weeding vs. all other | 0.040 | 0.042 | 0.002 | NS |
| Herbicides vs. sorghum extract | 0.049 | 0.039 | 0.010 | ** |
| Asert vs. Diazon 0.047 | 0.051 | 0.004 | NS | |
| Sorghum extract vs. extract twice | 0.035 | 0.044 | 0.009 | ** |
| Sorghum extract once linear | - | - | - | NS |
| Sorghum extract once quadratic | - | - | - | NS |
| Sorghum extract twice linear | - | - | - | NS |
| Sorghum extract twice quadratic | - | - | - | NS |

NS = Non significant,
^ = Significant as compared to check using LSD test,
** = Significant at 10, 5 and 1% level of probability using F test

filling duration. Maximum seed filling duration of 33.75 days was recorded in plots sprayed with Diazon followed by 33.50 days noted in wheat sprayed with Assert as compared to check treatment with 31 days seed filling duration. The data given in lower part of the (Table) show that the comparison of check with average of all other treatments was significant at the 10% level of probability and on the average weed control treatments increased seed filling duration by 1.03 days. Similarly, the difference in seed filling duration of wheat treated with herbicides and sorghum extract plants was also significant and plots that received sorghum extract had 2.08 days shorter seed filling duration as compared to herbicides application. Wheat treated with sorghum extract twice slightly increase seed filling duration by 0.75 days as compared to sorghum extract applied once and their difference was significantly at the 10% level of probability.

**Mean tiller growth rate upto anthesis stage:** Mean tiller growth rate of wheat upto anthesis stage as affected by weed control treatments are presented in Table 2. Statistical analysis of the data revealed that weed control treatments had significant effect on mean tiller growth rate upto anthesis. The LSD test showed that all the weed

Table 3: Fresh weights of weeds (g $m^{-2}$) recorded at 65 days after sowing of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 13.83 | - | - |
| Hand weeding | 7.63 | 6.20 | ^ |
| Asert | 3.73 | 10.11 | ^ |
| Diazon | 2.76 | 11.07 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed once | 9.76 | 4.07 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed once | 9.28 | 4.55 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed once | 8.46 | 5.37 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed twice | 8.30 | 5.53 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed twice | 7.16 | 6.67 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed twice | 6.60 | 7.23 | ^ |
| LSD at 0.05 alpha level | 1.28 | - | - |

| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
|---|---|---|---|---|
| Check vs. weed control treatment | 13.83 | 7.07 | 6.76 | ** |
| Hand weeding vs. all other | 7.63 | 7.00 | 0.63 | NS |
| Herbicides vs. sorghum extract | 3.24 | 8.26 | 5.01 | ** |
| Asert vs. Diazon | 3.73 | 2.76 | 0.97 | NS |
| Sorghum extract once sorghum extract twice | 9.16 | 7.35 | 1.81 | ** |
| Sorghum extract once linear | - - | - | * | |
| Sorghum extract once quadratic | - - | - | NS | |
| Sorghum extract twice linear | - - | - | * | |
| Sorghum extract twice quadratic | - - | - | NS | |

NS = Non significant
^ = Significant as compared to check using LSD test
* = Significant at 5% level of probability using F test
** = Significant at 10, 5 and 1% level of probability using F test

Table 4: Dry weights of weeds (g $m^2$) recorded at 65 days after sowing of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 9.45 | - | - |
| Hand weeding | 4.89 | 4.56 | ^ |
| Asert | 2.47 | 6.98 | ^ |
| Diazon | 1.37 | 8.08 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed once | 5.91 | 3.54 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed once | 5.66 | 3.79 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed once | 5.37 | 4.08 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed twice | 5.10 | 4.35 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed twice | 4.70 | 4.75 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed twice | 4.15 | 5.30 | ^ |
| LSD at 0.05 alpha level | 0.82 | - | - |

| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
|---|---|---|---|---|
| Check vs. weed control treatment | 9.45 | 4.40 | 5.04 | ** |
| Hand weeding vs. all other | 4.89 | 4.34 | 0.55 | ^^^ |
| Herbicides vs. sorghum extract | 1.92 | 5.15 | 3.23 | ** |
| Asert vs. Diazon | 2.47 | 1.37 | 1.10 | * |
| Sorghum extract once sorghum extract twice | 5.65 | 4.65 | 1.00 | ** |
| Sorghum extract once linear | - | - | - | NS |
| Sorghum extract once quadratic | - | - | - | NS |
| Sorghum extract twice linear | - | - | - | * |
| Sorghum extract twice quadratic | - | - | - | NS |

NS = Non significant
^^^ = Significant at 10% level of probability using F test
* = Significant at 5% level of probability using F test
** = Significant at 1% level of probability using F test

control treatments significantly increased the mean tiller growth rate, as their differences with check were significant. Maximum mean tiller growth rate of 0.51 g $days^{-1}$ upto anthesis was recorded in plots sprayed with Diazon herbicide followed by 0/047 g $day^{-1}$ noted in plots sprayed with assert. The lowest mean tiller growth rate of 0.26 g $day^{-1}$ recorded in check treatment. The data in lower part of the (Table 2) show that the comparison of check with average of all treatments was significant and the average weed control treatments increased mean tiller growth rate of wheat. Similarly, the difference in mean tiller growth rate of wheat from herbicides and sorghum extract plots was also significant and plots treated with sorghum extract had 0.010 g $day^{-1}$ lower mean tiller growth as compared to herbicides application. Plots treated with sorghum extract twice gave 0.009 g $day^{-1}$ more mean tiller growth rate than sorghum extract applied once and their difference was significant. The reason could be that herbicides and sorghum extract improved the availability of nutrients that stimulate vegetative growth, increased cell size and favor rapid plant growth hence resulting in maximum mean tiller growth rate.

**Fresh weight of weeds at 65 days after sowing:** Data recorded on fresh weight of weeds at 65 days after sowing of wheat are presented in Table 3. Analysis of the data

Table 5: Fresh weights of weeds (g $m^{-2}$) recorded at 95 days after sowing of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 17.31 | - | - |
| Hand weeding | 7.78 | 9.53 | ^ |
| Asert | 4.00 | 13.31 | ^ |
| Diazon | 3.87 | 13.44 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed once | 9.50 | 7.81 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed once | 8.84 | 8.47 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed once | 7.40 | 9.91 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed twice | 4.68 | 12.63 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed twice | 4.68 | 12.63 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed twice | 4.85 | 12.46 | ^ |
| LSD at 0.05 alpha level | 1.45 | - | - |

| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
|---|---|---|---|---|
| Check vs. weed control treatment | 17.31 | 6.18 | 11.13 | ** |
| Hand weeding vs. all other | 7.78 | 5.98 | 1.80 | ** |
| Herbicides vs. sorghum extract | 3.93 | 6.66 | 2.73 | ** |
| Asert vs. Diazon | 4.00 | 3.87 | 0.13 | NS |
| Sorghum extract once sorghum extract twice | 8.58 | 4.74 | 3.85 | ** |
| Sorghum extract once linear | - - | - | NS | |
| Sorghum extract once quadratic | - - | - | ** | |
| Sorghum extract twice linear | - - | - | NS | |
| Sorghum extract twice quadratic | - - | - | NS | |

NS = Non significant ^ = Significant as compared to check using LSD test
** = Significant at 1% level of probability using F test

Table 6: Dry weights of weeds (g $m^{-2}$) recorded at 95 days after sowing of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 12.97 | - | - |
| Hand weeding | 4.74 | 8.23 | ^ |
| Asert | 2.39 | 10.58 | ^ |
| Diazon | 2.40 | 10.57 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed once | 5.71 | 7.26 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed once | 5.46 | 7.51 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed once | 4.52 | 8.45 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed twice | 2.98 | 9.99 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed twice | 2.98 | 9.99 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed twice | 3.09 | 9.88 | ^ |
| LSD at 0.05 alpha level | - | - | - |

| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
|---|---|---|---|---|
| Check vs. weed control treatment | 12.97 | 3.81 | 9.16 | ** |
| Hand weeding vs. all other | 4.74 | 3.69 | 1.05 | ** |
| Herbicides vs. sorghum extract | 2.40 | 4.12 | 1.73 | ** |
| Asert vs. Diazon | 2.39 | 2.40 | 0.00 | NS |
| Sorghum extract once sorghum extract twice | 5.23 | 3.02 | 2.21 | ** |
| Sorghum extract once linear | - | - | - | * |
| Sorghum extract once quadratic | - | - | - | NS |
| Sorghum extract twice linear | - | - | - | NS |
| Sorghum extract twice quadratic | - | - | - | NS |

NS = Non significant ^ = Significant as compared to check using LSD test
* = Significant at 5% level of probability using F test ** = Significant at 1% level of probability using F test

showed that all the weed control treatments had significant effect on fresh weeds eight. The major weeds, which were noted in this experimental trial, were *Convolvulus arvensis, Vicia sativa, Avena fatua, Cronopus didymus, Ranoculus muricatus, Silybium merianum, Medicago denticulate, Eubhoribia helioscopia, Cynodon dectylon, Rumex dantatus, Fumaria parviflora* and *Phalaris minor*. The LSD test revealed that the differences of weed control treatment with check were significant which means that weed control treatments significantly reduced the fresh weight of weeds. The lowest fresh weight of 2.76 g $m^{-2}$ was recorded in plots sprayed with Diazon followed by 3.73 g $m^{-2}$ in the plots, which were sprayed with Assert. In this way herbicides greatly reduced the fresh weight of weeds as compared to 13.83 g $m^{-2}$ fresh weeds weight noted in check treatment. The data given in the lower part of the (Table 3) shows that the comparison of check with average of all other treatments was significantly and on the average weed control treatments reduced fresh weight of weeds by 6.76 g $m^{-2}$. The difference in fresh weight of weeds obtained from herbicides and sorghum extract was significant and plots treated with sorghum extract had about 5.01 g $m^{-2}$ more fresh weeds weight as compared to

Table 7: Weeds number at 65 days after sowing of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | | Significance |
|---|---|---|---|---|
| Check (No weeding) | 18.75 | - | | - |
| Hand weeding | 10.00 | 8.75 | | ^ |
| Asert | 5.50 | 13.25 | | ^ |
| Diazon | 4.00 | 14.75 | | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed once | 13.00 | 5.75 | | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed once | 12.25 | 6.50 | | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed once | 11.25 | 7.50 | | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed twice | 10.52 | 8.30 | | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed twice | 10.00 | 8.75 | | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed twice | 9.25 | 9.50 | | ^ |
| LSD at 0.05 alpha level | 1.69 | - | | - |
| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
| Check vs. weed control treatment | 18.75 | 9.53 | 9.22 | ** |
| Hand weeding vs. all other | 10.00 | 9.47 | 0.53 | NS |
| Herbicides vs. sorghum extract | 4.75 | 11.04 | 6.29 | ** |
| Asert vs. Diazon | 5.50 | 4.00 | 1.50 | ^^^ |
| Sorghum extract once sorghum extract twice | 12.17 | 9.92 | 2.25 | ** |
| Sorghum extract once linear | - | - | - | * |
| Sorghum extract once quadratic | - | - | - | NS |
| Sorghum extract twice linear | - | - | - | NS |
| Sorghum extract twice quadratic | - | - | - | NS |

NS = Non significant
^ = Significant as compared to check using LSD test
* = Significant at 5% level of probability using F test
** = Significant at 1% level of probability using F test

Table 8: Weeds number at 95 days after sowing of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 20.75 | - | - |
| Hand weeding | 10.25 | 10.50 | ^ |
| Asert | 5.25 | 15.50 | ^ |
| Diazon | 5.25 | 15.50 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed once | 12.00 | 8.75 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed once | 11.25 | 9.50 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed once | 9.50 | 11.25 | ^ |
| Extract of 20 kg sorghum $ha^{-1}$ sprayed twice | 6.25 | 14.50 | ^ |
| Extract of 30 kg sorghum $ha^{-1}$ sprayed twice | 6.25 | 14.50 | ^ |
| Extract of 40 kg sorghum $ha^{-1}$ sprayed twice | 6.75 | 6.00 | - |
| LSD at 0.05 alpha level | 1.81 | - | - |

herbicides application. Wheat treated with sorghum extract twice gave 1.81 g $m^{-2}$ less fresh weeds weight as compared to sorghum extract applied once and their difference was significant. The trend analysis showed that the linear effects of sorghum extract applied once and twice were significant. Similar results were obtained by Saleem and Fawusi[12], who stated that lower concentration of sorghum extract promoted the germination of some weeds while high germination of some weeds while high concentration, inhibited their germination. Lower fresh weeds weight in herbicides plots may be due to the lower number of weed found in the herbicides treated plots. Theses results are in conformity with those of Mukhapadhyay and Gosh[13], who on comparison of mechanical and chemical weed control methods reported that herbicides controlled weeds more efficiently.

**Dry weight of weeds at 65 days after sowing:** Data recorded on dry weight of weeds at 65 days after sowing of wheat are presented in Table 4. Statistical analysis of the data showed that all the weed control treatments had significant effect on dry weeds weight. The LSD test revealed that the differences between dry weeds weights of weed control treatments and check treatment were significant which means that weed control treatments significantly reduced the dry weight of weeds. The lowest dry weeds weight of 1.37 g $m^{-2}$ was recorded in plots sprayed with Diazon followed by 2.47 g $m^{-2}$ in the plots, which were sprayed with Assert. In this way herbicides greatly reduced the dry matter weight of weeds as compared to 9.45 g $m^{-2}$ weeds dry weight noted in check treatment. The data given in the lower part of Table shows that the comparison of check with average of all other treatments was significant and on the average weed control treatments reduced dry weight of weeds by 5.04 g $m^{-2}$. Similarly, the comparison of hand weeded plots with average of all other weed control treatments was also significant and on the average weed control treatments had lowered the dry weight by 0.55 g $m^{-2}$. The difference in dry weight of weeds obtained from herbicides and sorghum extract plots was significant and plots treated with sorghum extract had about 3.23 g $m^{-2}$ more dry weeds weight as compared to herbicides application. Wheat plots sprayed with Assert gave 1.10 g$m^{-2}$ more weeds dry weight as compared to plots, which

Table 9: Grain yield (kg ha$^{-1}$) of wheat as affected by weed control treatment with means for the meaningful comparison

| Treatments | Mean | Difference with check | Significance |
|---|---|---|---|
| Check (No weeding) | 3279.00 | - | - |
| Hand weeding | 4253.00 | 974.00 | ^ |
| Asert | 4285.00 | 1006.00 | ^ |
| Diazon | 4545.00 | 1266.00 | ^ |
| Extract of 20 kg sorghum ha$^{-1}$ sprayed once | 3831.00 | 551.00 | ^ |
| Extract of 30 kg sorghum ha$^{-1}$ sprayed once | 4058.00 | 779.00 | NS |
| Extract of 40 kg sorghum ha$^{-1}$ sprayed once | 3896.00 | 616.00 | ^ |
| Extract of 20 kg sorghum ha$^{-1}$ sprayed twice | 4253.00 | 974.00 | ^ |
| Extract of 30 kg sorghum ha$^{-1}$ sprayed twice | 4318.00 | 1038.00 | ^ |
| Extract of 40 kg sorghum ha$^{-1}$ sprayed twice | 4025.00 | 746.00 | ^ |
| LSD at 0.05 alpha level | 554.00 | - | - |

| Contrast/comparison | Mean 1 | Mean 2 | Difference | Significance |
|---|---|---|---|---|
| Check vs. weed control treatment | 3279.00 | 4163.00 | 884.00 | ** |
| Hand weeding vs. all other | 4253.00 | 4151.00 | 101.00 | NS |
| Herbicides vs. sorghum extract | 4415.00 | 4063.00 | 352.00 | * |
| Asert vs. Diazon | 4285.00 | 4545.00 | 260.00 | NS |
| Sorghum extract once sorghum extract twice | 3928.00 | 4199.00 | 271.00 | ^^^ |
| Sorghum extract once linear | - | - | - | NS |
| Sorghum extract once quadratic | - | - | - | NS |
| Sorghum extract twice linear | - | - | - | NS |
| Sorghum extract twice quadratic | - | - | - | NS |

NS = Non significant
^ = Significant as compared to check using LSD test
^^^ = Significant at 10% level of probability using F test
* = Significant at 5% level of probability using F test
** = Significant at 1% level of probability using F test

received Diazon application and their difference was significant. Wheat treated with sorghum extract twice gave 1.00 g m$^{-2}$ less fresh weeds weight as compared to sorghum extract applied once and their difference was significant. The trend analysis showed that the linear effect of sorghum extract applied once was significant. These results are in conformity with those of Jalis and Shah[14] and Hatam[15]. They reported that herbicides proved most effective even at their minimum rate. Similar results are also reported by Saleem and Fawusi[12], who observed that lower concentration of sorghum extract promoted the germination while higher concentration inhibited the germination and growth of weeds.

**Fresh weight of weeds at 95 days after sowing:** Data recorded on fresh weight of weeds at 95 days after sowing of wheat are presented in Table 5. Analysis of the data revealed that all the weed control treatments had significant effect on the fresh weight of weeds. The LSD test showed that all the weed control treatments significantly reduced the fresh weeds weight, as their differences with check were significant. The lowest fresh weeds weight of 3.87 g m$^{-2}$ was recorded in plots treated with Diazon followed by 4.00 g m$^{-2}$ in the plots to which Assert had been sprayed. Among the weed control treatments, the highest fresh weeds weight of 9.50 g m$^{-2}$ was noted in plots to which 20 kg sorghum extract had been applied once. The herbicides and sorghum extracts as well as hand weeding reduced fresh weight of weeds as compared to 71.31 g m$^{-2}$ fresh weeds weight recorded in check treatment. The preplanned meaningful comparison given in lower part of the table reveal that comparison of check with average of all other treatments was significant and on the average weed control treatments reduced fresh weight of weeds by 11.13 g m$^{-2}$. Similarly the comparison of hand weeding with average of all other weed control treatments was also significant and on the average weed control treatments had lowered the fresh weight of weeds by 1.80 g m$^{-2}$ as compared to hand weeding. The difference in the fresh weeds weight from herbicides and sorghum extract plots was significant and plots to which sorghum extract had been applied had 2.73 g m$^{-2}$ fresher weight of weeds as compared to plots that received herbicides application. Wheat plots treated with sorghum applied twice gave 3.85 g m$^{-2}$ lower weeds fresh weight as compared to sorghum extract applied once and their difference was significant. The trend analysis showed that linear effect of sorghum extract applied once was significant. Similar results were obtained by Saleem and Fawusi[12], who stated that lower concentration of sorghum extract promoted the germination of some weeds while high germination of some weeds while high concentration, inhibited their germination. Lower fresh weeds weight in herbicides plots may be due to the lower number of weed found in the herbicides treated plots. Theses results are in conformity with those of Mukhapadhyay and Gosh[13], who on comparison of mechanical and chemical weed control methods reported that herbicides controlled weeds more efficiently.

**Dry weight of weeds at 95 days after sowing:** Data recorded dry weight of weeds at 95 days after sowing of wheat are presented in Table 6. Statistical analysis of the data revealed that the weed control treatments had significant effect on the dry matter weight of weeds. The LSD test showed that all the weed control treatments

significantly reduced the dry matter weight of weeds, as their differences with check were significant. The lowest dry weeds weight of 2.39 g $m^{-2}$ was recorded in plots treated with Assert followed by 2.40 g $m^{-2}$ in the plots to which Diazon had been sprayed. Among the weed control treatments, the highest dry weeds weight of 5.71 g $m^{-2}$ was noted in plants to which 20 kg sorghum extract had been applied once. The herbicides, sorghum extracts and hand weeding reduced dry weight of weeds as compared to 12.97 g $m^{-2}$ dry weeds weight recorded in check treatment. The preplanned meaningful comparison of check with average of all other treatments was significant and on the average weed control treatments reduced dry weight of weeds by 6.76 g $m^{-2}$. The differences in the dry weight of weeds from herbicides and sorghum extract plots was significant and plots to which sorghum extract had been applied had 5.01 g $m^{-2}$ more dry weight of weeds as compared to plots that received herbicides application. Wheat plots treated with sorghum applied twice gave 1.81 g $m^{-2}$ lower weeds dry weight as compared to sorghum extract applied once and their difference was significant. The trend analysis showed that linear effect of sorghum extract applied twice was significant. These results are in conformity with those of Jalis and Shah[14] and Hatami[15]. They reported that herbicides proved most effective even at their minimum rate. Similar results are also reported by Saleem and Fawusi[12], who observed that lower concentration of sorghum extract promoted the germination while higher concentration inhibited the germination and growth of weeds.

**Weeds number at 65 days after sowing:** Data recorded on number of weeds at 65 days after sowing of wheat are presented in Table 7. The statistical analysis of the data showed that weed control treatments had significant effect on number of weeds $m^{-2}$. The LSD test showed that the weed control treatments significantly lowered the number of weeds, as their differences with check were significant. About 13 weeds $m^{-2}$ was observed in plots to which 20 kg sorghum extract had been applied once, while minimum number of 4 weeds $m^{-2}$ was noted in plots sprayed with Diazon herbicides as compared to the maximum number of 18.75 weeds $m^{-2}$ that were observed in check treatment. The preplanned meaningful comparison given in lower part of the table show that the comparison of check with average of all other treatments was significant and on the average weed control treatments reduced number of weeds by 9.22 $m^{-2}$. The difference in number of weeds from herbicides and sorghum extract had been applied enhanced number of weeds by 6.29 weeds $m^{-2}$ as compared to plots to which herbicides had been applied. Wheat plots sprayed with Assert produced more number of weeds $m^{-2}$ as compared to plots that had received Diazon and their difference was significant. Plots treated with sorghum extract twice-reduced number of weeds by 2.25 $m^{-2}$ than sorghum extract applied once and their difference was significant. The trend analysis showed that the linear effect in sorghum extract applied once was significant. It was noted that growth of most weeds was suppressed more than that of their density. Bhowmik and Dolt[16] and Purvis and Jassep[17], they reported that sorghum water extract suppressed weeds germination and growth more than that of weeds.

**Weeds number at 95 days after sowing:** Data recorded on number of weeds at 95 days after sowing of wheat are presented in Table 8. Analysis of the data showed that weed control treatments had significant effects on number of weeds $m^{-2}$. The LSD test showed that the weed control treatments significantly lowered the number of weeds, as their differences with check were significant. Among the weed control treatments the greatest number of 12 weeds $m^{-2}$ was observed in plots to which 20 kg sorghum extract had been applied once, while minimum number of 5 weeds $m^{-2}$ was noted in plots prayed with Diazon and Assert herbicides. Maximum weeds (2075 weeds $m^{-2}$) were observed in check treatment. The preplanned meaningful comparison given in lower part of the table show that the comparison of check with average of all other treatments reduced number of weeds by 12.67 $m^{-2}$. Similarly, the comparison of hand weeding with average weed control treatments had lower number of weeds. The difference in number of weeds from herbicides ad sorghum extract treated plots was significant and plots to which herbicides had been applied. Plots treated with sorghum extract twice decreased number of weeds by 4.50 weeds $m^{-2}$ as compared to sorghum extract applied once and their difference was significant. The trend analysis showed that the linear effect of sorghum extract applied once was significant. These results are in agreement with the findings of Bhowmik and Dolt[16] and Purvis and Jassep[17] they reported that sorghum water extract suppressed weeds germination and growth more than that of weeds.

**Grain yield (kg $ha^{-1}$):** Data recorded on grain yield are presented in Table 9. The statistical analysis of the data revealed that the weed control treatments had no significant effect on grain yield. The LSD test comparing the weed control treatments with check showed that all the weed control treatments significantly increased grain yield, except 20 kg sorghum extract applied once which slightly increased grain yield, as its difference with check was not significant. The maximum grain yield of 4544 kg $ha^{-1}$ was produced in plots sprayed with Diazon herbicides followed by 4318 kg $ha^{-1}$ in plots treated with 30 kg of sorghum extract applied twice as compared to

3279 kg $ha^{-1}$ grain yield recorded in check treatment. The data given in lower part of the Table show that the comparison of check with average of all weed control treatments was significant and on the average weed control treatments produced 884 kg $ha^{-1}$ more grain yield than check plots. Similarly, the difference in grain yield of wheat obtained from herbicides and sorghum extract plots was also significant and plots treated with sorghum extract produced 352 kg $ha^{-1}$ less grain yield as compared to herbicides application. The possible reason for high grain yield in the different weed control treatment may be that increase availability of nutrients and reduced competition stimulated vegetative growth, which resulted in better spike population and more grains $spike^{-1}$ and ultimately higher grain yield.

It is concluded that among all the weed control treatments, herbicides gave the best results but the alleochemic effects of sorghum extract were also prominent and followed the herbicides. In case of sorghum increase the rate upto 30 kg $ha^{-1}$ and number of application, gave better results accordingly. Sorghum extract affect weeds and wheat growth due to either inhibitory or stimulatory effects depending upon the quantity of sorghum and stage of growth of wheat. So the Allelopathic potential of sorghum and its effects on weed flora should be further explored as less expensive, safe and harmless of weeds control in wheat.

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