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REDUCED HERBICIDE DOSES IN COMBINATION WITH ALLELOPATHIC SORGHUM WATER FOR WEED CONTROL IN SUNFLOWER (*Helianthus annuus* L.)

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ABSTRACT

A field trial to investigate the response of sunflower and its weeds to sorghum water extract (Sorgaab) in combination with reduced doses of herbicide (i.e. Dual gold) was carried out at Agronomic Research Area, Faculty of Agriculture, Gomal University, Dera Ismail Khan during the year 2007. The experiment was laid out in Randomized Complete Block Design (RCBD) with seven treatments and four replications using a sub plot size of 2.8m x 4m. Results revealed that Sorgaab @ 15 L ha^{-1} +Dual gold @ 1.6 L ha^{-1}, 1/3 dose reduced Chenopodium album density by 92% at 70 DAS. Sorgaab alone @ 15 L ha^{-1}, full dose reduced Chenopodium album density by 81% at 70 DAS. Sorgaab + Dual gold, 1/3 dose reduced Coronopus didymus density by 68%. While Sorgaab alone @ 15 L ha^{-1}, decreased Coronopus didymus density by 36%. Sorgaab + Dual gold, 1/3 dose decreased total weed density by 89%, over control at 70 DAS. While Sorgaab alone @ 15 L ha^{-1} reduced weed density by 76% at 70 DAS. Total dry weed biomass suppressed by Sorgaab + Dual gold, 1/3 dose was 92% at 70 DAS. While Sorgaab alone @ 15 L ha^{-1} reduced total dry weed biomass by 85% at 70 DAS. It was also observed during this study that plant height, head diameter, stem diameter, number of achenes per head, 1000-achene weight and achene yield were significantly affected by the combination of Sorgaab @15L ha^{-1}, full dose and Dual gold @ 1.6 ha^{-1} 1/3 dose.

Key words: Sorghum, Water Extract, Weed Control, Sunflower.

INTRODUCTION

Sunflower belongs to family Compositeae and is a major source of vegetable oil in the world. Edible oil in the country either comes from conventional or non-conventional oil seed crops. Among non-conventional crops, sunflower (*Helianthus annuus* L.) is the most important oil seed crop due to its wide range of adaptability and very high seed oil (40-50%) and 23% protein contents (Hatim and Abbasi, 1994). But the average yield of sunflower in Pakistan is very low as compared to potential yield of many available sunflower hybrids. There are many

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reasons for low yield of sunflower in Pakistan; improper weed management is one of the major reasons for its low yield. Allelopathy seems to be an effective, economic and natural method as well as alternative of herbicides for weed control (Cheema *et al.* 2005a). Although we cannot eliminate the use of herbicides, their use can be reduced by exploiting allelopathy as an alternate weed management tool for crop production against weeds and other pests (Bhatti *et al.* 2000; Cheema and Ahmad, 992); Jamil, 2004). Allelopathic effects are concentration dependent (Hassan *et al.* 2007). So, if sorghum water extract (Sorgaab) and other plant extracts are concentrated and used in combination, they may be more effective against weeds. The present study, therefore, has designed to look into feasibility of reducing herbicide doses in combination with allelopathic crop water extracts for effective weed control in sunflower.

MATERIALS AND METHODS

A field study was conducted at Agronomic Research Area, Faculty of Agriculture, Gomal University, Dera Ismail Khan during the year 2007. The experiment was laid out in RCB Design with four replications. The net sub plot size was 4x2.8m^2. Sunflower hybrid '64-A93' was sown on 20th February, 2007, on a well prepared seed bed in furrows 70 cm apart with hand dibbler. There were four rows in each plot. The plant-to-plant distance (30 cm) was maintained by thinning. A Seed rate of 7 kg ha^{-1}was used. Sorgaab (sorghum water extract) was prepared by following the procedure devised by Cheema (1998). Sorghum herbage was harvested at maturity, dried, chaffed with fodder cutter into 2 cm pieces and stored under shade. Chaffed sorghum material was soaked in distilled water in the ratio of 1:10 (w/v) for 24 hours at ambient room temperature. This mixture (herbage+water) was passed through a Whattman filter paper # 40 to obtain Sorgaab. The experiment comprised of the following treatments: Weedy Check (Control), Sorgaab @ 15 L ha^{-1} (Early Post Emergence, 15-20 DAS), Sorgaab @ 15 L ha^{-1}, full dose+Dual gold @ 1.6 L ha^{-1}, 1/3 dose (Pre-Emergence), Sorgaab @ 15 L ha^{-1}, 1/2 dose (Early Post Emergence), 1/2 dose of Dual gold @ 1.6 L ha^{-1} (Pre-Emergence), 1/3 dose of Dual gold @ 1.6 L ha^{-1} (Early Post Emergence) and full dose of Dual gold @ 1.6 L per ha (Pre-Emergence).

A basal fertilizer dose @ 100 kg N and 75 kg P_2O_5 ha^{-1} in the form of Urea and DAP was used. All the phosphatic fertilizer was applied at the time of sowing; while nitrogen was applied in two splits i.e. half at the time of sowing and remaining half at the time of first irrigation by broadcast method. The crop was irrigated as per requirement. Prior to spraying of Sorgaab and Dual gold, volume of spray was calibrated by

using tap water. Dual gold and Sorgaab were sprayed in respective plots with the help of Knapsack hand sprayer fitted with flat fan nozzle.

Data on weed dynamics (density, fresh and dry weight) was recorded thrice at 50, 70 and 90 DAS from randomly selected area of $1m^2$ from each experimental plot. Total and individual weed count was made. Fresh weed biomass was recorded by mowing the weeds at ground level and weighed while dry biomass was recorded after keeping the weed samples in oven at 70°C for 48 hours. Data on sunflower plant growth parameters were recorded from randomly selected samples. Biological and achene yield were recorded in kg per plot and subsequently converted into t ha^{-1}. Data collected were subjected to Fisher's Analysis of Variance Technique and treatment means were compared using Least Significant Difference Test (LSD) at 5% level of probability (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

Common lambsquarters (*Chenopodium album* L.) and swinecress (*Coronopus didymus* L.) were the major weeds in the experimental field. Other weeds recorded were Broad-leaved dock (*Rumex dentatus* L.), Yellow sweet clover (*Melilotus indica*), Green amaranth *(Amaranthus viridis*) and Nettled leaved goosefoot (*Chenopodium murale*).

Weed Density (m^{-2})

Weed density at 50, 70 and 90 days after sowing (DAS) was significantly affected by all the treatments (Table-I). Maximum suppression was observed in plots where Sorgaab @ 15 L ha^{-1} + Dual gold @ 1.6 L ha^{-1}, 1/3 dose was applied which gave 89, 90 and 94% weed suppression at 50, 70 and 90 DAS respectively, over the weedy check. It was followed by the full dose of Dual gold @ 1.6 L ha^{-1} which gave weed suppression at 50, 70 and 90 DAS as 89, 87 and 90%, respectively, over control. Minimum weed suppression was observed in plots where Sorgaab @ 15 L ha^{-1}, ½ dose (alone) was applied. These findings are in accordance with those of Leather (1983) who also reported less weed suppression, over control where only allellechemicals were applied. Density of common lambasquartes (*Chenopodium album* L.) was significantly inhibited by all the treatments (Table-1). Combined application of Sorgaab and Dual gold (i.e. Sorgaab @ 15 L ha^{-1} + Dual gold @ 1.6 l per ha, 1/3 dose) gave maximum suppression of *C.album* at 50, 70 and 90 DAS as 92, 93 and 100%, respectively, over control. It was followed by full dose of Dual gold @ 1.6 L ha^{-1} which gave 89, 92 and 100% weed suppression, respectively, over control. Minimum weed suppression was observed in plots where only allelochemicals were applied. The results of the present study supported the findings of Cheema *et al.* (2005a) who reported that Sorgaab could be used with reduced doses of herbicide for effective weed control in cotton. Density of

Table-I. Effect of allelopathic sorghum water extract in combination with reduced doses of Dual gold on weed density (m^{-2}) and its reduction (%) over check in Sunflower.

TREAT.	L ha^{-1}	Weed density			Density of *C. album*			Density of *C. didymus*		
		50 DAS	70 DAS	90 DAS	50 DAS	70 DAS	90 DAS	50 DAS	70 DAS	90 DAS
Control (Weedy Check)	-	54.75 a	40.50 a	32.00 a	9.25 a	6.750	6.00 a	8.25 a	5.50 a	3.50 a
Sorgaab alone	15	15.25 b (72.14)†	9.50 bc (76.54)	6.50 bc (79.68)	2.50 c (72.97)	1.25 bc (81.48)	1.00 b (83.33)	4.00 bc (51.51)	3.50 bc (36.36)	1.50 b (57.14)
Sorgaab + Dual gold (1/3 Dose)	15 + 0.53	5.750 b (89.49)	4.25 d (89.50)	2.00 e (93.75)	0.75 e (91.89)	0.500 c (92.59)	0.00 c (100)	2.50 d (69.69)	1.750 d (68.18)	0.50 b (85.71)
Sorgaab (½ Dose) alone	7.5	16.50 b (69.86)	13.50 b (66.67)	9.00 b (71.87)	4.25 b (54.05)	1.50 b (77.78)	1.25 b (79.16)	4.50 b (45.45)	4.00 b (27.27)	2.00 ab (42.85)
Dual gold (½ Dose) alone	0.8	8.500 cd (84.47)	6.00 cd (85.18)	4.25 c-e (86.71)	1.25 de (86.48)	0.75 bc (88.89)	0.50 bc (91.67)	3.00 cd (63.63)	2.50 cd (54.54)	1.25 b (64.28)
Dual gold (1/3 Dose) alone	0.53	11.25 c (79.45)	8.50 cd (79.01)	5.50 cd (82.81)	1.50 d (83.78)	1.00 bc (85.18)	0.750 bc (87.5)	3.25bcd (60.60)	3.0bcd (45.45)	1.50 b (57.14)
Dual gold (Full dose) alone	1.6	6.00 d (89.04)	5.25 cd (87.03)	3.00 de (90.62)	1.00 de (89.18)	0.500 c (92.59)	0.00 c (100)	2.75 cd (66.66)	2.00 d (63.63)	0.750 b (78.57)
$LSD_{0.05}$		3.708	4.251	2.527	0.725	0.8985	0.883	1.317	1.266	1.656

† Values in parentheses denote % reduction as compared to weedy check

❖ DAS: Days after sowing; Sorgaab: Sorghum water extract.

❖ Any two means having common letters are not significantly different by LSD test at 5% level of probability.

❖ Figures given in parenthesis show % decrease over control.

swinecress (*Coronopus didymus* L.) was significantly reduced by all the treatments (Table–1). Sorgaab @ 15 L ha^{-1} + Dual gold @ 1.6 L ha^{-1}showed maximum suppression (70%). While full dose of Dual gold @ 1.6 L ha^{-1}gave 70% weed suppression, over control. Less weed suppression was recorded in plots where only Sorgaab was applied in full & half doses alone (Table-1). These results support the work of Cheema *et al.* (2005a, 2005b), who stated that the efficacy of Sorgaab could be enhanced by using with lower rates of herbicides.

Fresh weed biomass (g m^{-2})

A perusal of data (Table-2) indicated the overall suppressive influence of sorgaab and various doses of Dual gold on fresh weight of all weeds. The reduction in total fresh weed biomass was 95% due to application of Sorgaab @ 15 L ha^{-1} + Dual gold @ 1.6 L ha^{-1}, 1/3 dose, over control. It was statistically at par with full dose of Dual gold @ 1.6 L ha^{-1} which reduced total fresh weed biomass by 94%. Full and half doses of Sorgaab reduced the total fresh weed biomass by 81 and 65%, respectively, over control. Fresh weight of common lambasquarters (*C.album*) was significantly reduced by all the treatments (Table-2). More reduction in biomass of *C. album* was 97% compared to control. Reduction in weed fresh biomass to the extent of 96% was observed due to the application of full dose of Dual gold @ 1.6 L ha^{-1}at 70 DAS. Fresh weight of swine cress (*C. didymus*) was significantly suppressed by all of the treatments (Table-2). Maximum reduction in fresh biomass of *C. didymus* was observed in plots where Sorgaab @ 15 L ha^{-1}, full dose + Dual gold @ 1.6 L ha^{-1}, 1/3 dose by 68 and 89% at 70 and 90 DAS, respectively, over control. It was followed by full dose of Dual gold @ 1.6 L ha^{-1}which gave 67 and 84% reduction in fresh weight of *C. didymus* at 70 and 90 DAS, respectively, over the control. In this study lesser fresh weight of *C.didymus* was observed as compared to *C. album*. These results are harmonious with the findings of Rice (1984) and Khan *et al.* (2004) who reported the concentration (amount) and species-specific behavior of allelochemicals on weed flora.

Dry weed biomass (g m^{-2})

Total dry weed biomass was significantly suppressed by all the treatments (Table-3). Combined application of herbicide (i.e. Dual gold @ 1.6 L ha^{-1}, 1/3 dose) and crop water extract (i.e. Sorgaab @ 15 L ha^{-1}, full dose) showed maximum suppression (92 and 97%) at 70 DAS and 90 DAS, respectively, over control. It was followed by full dose of Dual gold @ 1.6 L ha^{-1} which showed 90 and 97% reduction in dry weed biomass at 70 and 90 DAS respectively, over control. Half dose of Sorgaab @ 7.5 L ha^{-1} gave minimum suppression of dry weed biomass, over control. Dry weight of *C. album* was significantly reduced by all the treatments (Table-3).

Table-2. Effect of allelopathic sorghum water extract in combination with reduced doses of Dual gold on fresh weed biomass and its reduction over weedy check in Sunflower (g m^{-2})

TREATMENTS	RATE L ha^{-1}	Weed fresh biomass		Fresh weight of *C. album*		Fresh weight of *C. didymus*	
		70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS
Control (Weedy Check)		22.66 a	18.12 a	4.39 a	4.878 a	1.188 a	0.84 a
Sorgaab alone	15	4.29 c (81.05)†	2.57 c (85.83)	0.55 bc (87.40)	0.35 c (92.77)	0.74 bc (38.13)	0.36 bc (57.14)
Sorgaab + Dual gold (1/3 Dose)	15+0.53	0.95 d (95.81)	0.45 d (97.51)	0.13 c (97.09)	0.00 e (100)	0.38 d (68.22)	0.09 c (89.28)
Sorgaab (½ Dose) alone	7.5	7.77 b (65.73)	5.09 b (72.02)	0.93 b (78.74)	0.87 b (82.16)	0.75 bc (37.28)	0.45 ab (42.26)
Dual gold (½ Dose) alone	0.8	1.53 d (93.25)	1.12 cd (93.85)	0.20 c (95.38)	0.12 de (97.53)	0.46 cd (61.70)	0.22 bc (73.80)
Dual gold (1/3 Dose) alone	0.53	2.38 cd (89.490	1.81 cd (90.02)	0.29 c (93.44)	0.20 cd (95.89)	1.04 ab (12.87)	0.36bc (57.44)
Dual gold (Full dose) alone	1.6	1.16 d (94.90)	0.66 d (96.36)	0.14 c (96.92)	0.00 e (100)	0.39 d (67.38)	0.13 bc (84.22)
$LSD_{0.05}$		2.163	1.530	0.339	0.382	0.458	0.189

† Values in parentheses denote % reduction as compared to weedy check

❖ DAS: Days after sowing; Sorgaab: Sorghum water extract.

❖ Any two means having common letters are not significantly different by LSD test at 5% level of probability.

❖ Figures given in parenthesis show % decrease over control. (already given just below the table)

Table-3. Effect of allelopathic sorghum water extract in combination with reduced doses of Dual gold on dry weed biomass in Sunflower (g m^{-2}).

TREATMENTS	L ha^{-1}	Total dry weed biomass		Dry weight of *C. album*		Dry weight of *C. didymus*	
		70 DAS	90 DAS	70 DAS	90 DAS	70 DAS	90 DAS
Control (Weedy Check)	-	4.76 a	3.80a	0.79 a	0.618a	0.313a	0.243a
Sorgaab alone	15	0.70bc (-85.34)	0.68 bc (-83.09)	0.15 bc (-80.63	0.048b (92.30)	0.129 c (-58.78)	0.098bc (-59.79)
Sorgaab + Dual gold (1/3 Dose)	15+0.53	0.34 d (-92.85)	0.08 d (-97.89)	0.013d (-98.41)	0.000 b (-100)	0.049e (-84.50)	0.008 c (-96.90)
Sorgaab (½ Dose) alone	7.5	0.84b (-82.30)	0.91 d (-76.16)	0.18b (-77.14)	0.068b (-89.06)	0.217 b (-30.57)	0.150ab (-38.14)
Dual gold (½ Dose) alone	0.8	0.55 bcd (-88.44)	0.48 c (-87.29)	0.07cd (-91.74)	0.013b (-97.97)	0.071 de (77.31)	0.005 bc (-81.44)
Dual gold (1/3 Dose) alone	0.53	0.67 bc (-85.97)	0.63 c (-83.53)	0.12bcd (-85.07)	0.038b (-9392)	0.100 cd (-68.05)	0.083bc (-65.97)
Dual gold (Full dose) alone	1.6	0.44cd (-90.70)	0.09 d (-97.56)	0.03d (-96.82)	0.000 b (-100)	0.059de (-81.07)	0.023 c (-90.72)
$LSD_{0.05}$		0.305	0.278	0.107	0.07	0.047	0.105

- DAS: Days after sowing; Sorgaab= Sorghum water extract.
- Any two means having common letters are not significantly different by LSD test at 5% level of probability.
- Figures given in parenthesis show % decrease over control.

Sorgaab @ 15 L ha^{-1} + Dual gold @ 0.53 L ha^{-1}, 1/3 dose showed maximum suppression, 92 and 98 at 70 and 90 DAS, respectively, over control. Further reduction in dry weight was recorded by full dose of Dual gold @ 1.6 L ha^{-1}, which showed 90 and 97% reduction at 70 and 90 DAS, respectively, over control. Dry weight of *C. didymus* was significantly reduced by all the treatments (Table-3). Maximum suppression was recorded in plots where Sorgaab @ 15 L ha^{-1} + Dual gold @ 0.53 L ha^{-1}, 1/3 dose was applied which showed 98 and 100% suppression in dry weight at 70 and 90 DAS, respectively, over control. It was followed by full dose of Dual gold @ 1.6 L ha^{-1} which gave 96% suppression in dry weight of *C. didymus* at 70 and 90 DAS, respectively, over control. Full dose of Sorgaab @ 15 L ha^{-1} alone showed lesser suppression in dry weight (59%), over control. Half dose of Sorgaab @ 7.5 L ha^{-1} showed 34% suppression in dry weight of *C. didymus*, over control. These results are in line with the work of Lehle and Putnam (1983) and Cheema and Ahmad (1992) who reported that sorghum residues suppressed weeds due to presence of allelochemicals.

Response of Sunflower

The data pertaining to sunflower achene yield and different yield contributing characters (Table-4) revealed that grain yield was increased significantly, by various doses of Sorgaab and Dual gold and also by their combination. Maximum achene yield (2.68 t ha^{-1}) was recorded in plots where Sorgaab @ 15 L ha^{-1}, full dose + Dual gold @ 0.53 L ha^{-1}, 1/3 dose was applied. This was due to more number of plants per unit area, more head size, more number of achenes per head and more 1000-achene weight in this treatment. The reason is that in this treatment density of weeds was the lowest among all other treatments. While full dose of Dual gold @1.6 L ha^{-1} showed 2.47 t ha^{-1} achene yield. Sorgaab @ 15 L ha^{-1}, full dose and Sorgaab @ 15 L ha^{-1}, 1/2 dose gave 2.28 and 2.27 t ha^{-1} achene yield, respectively. The results of the present study support the hypothesis that herbicide dose could be reduced up to 70% in combination with allelopathic crop water extracts. Bhatti *et al*. (2000) also reported the similar results.

CONCLUSIONS

The technique of sorghum allelopathy is extremely safe, easy, cheap and handy. Therefore, farming community may use sorghum allelopathy for improving their sunflower yield by controlling weeds such as Common lambsquarters (*C. album*), Swine Cress *(C. didymus*), Broad leaved dock (*Rumex dentatus* L.), Yellow Sweet Clover *(Melilotus indica*), green amaranth *(Amaranthus viridis*) and Nettled leaved goosefoot (*Chenopodium murale*).

Table-4. Effect of allelopathic sorghum water extract in combination with reduced doses of Dual gold on different growth and yield parameters of Sunflower (m^{-2}).

Treatments	Rates L ha^{-1}	No. of plants	Plant height (cm)	Head diameter (cm)	Stem diameter (cm)	No. of achene $head^{-1}$	1000-achene wt. (g)	Achene yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Control (Weedy Check)	-	4.250 NS	137.8 C	11.88 C	1.850 C	957.8 D	44.22 C	1.842 D	6.580 E	28.03 C
Sorgaab	15	3.750	140.9 BC	13.13 C	2.318 B	1014.0 BC	51.72 B	2.28 C (23.77)	7.140 CD	31.93 B
Sorgaab + Dual gold (1/3 Dose)	15 + 0.53	4.50	148.8 A	19.75 A	2.495 A	1052 A	58.10 A	2.68 A (45.49)	7.477 A	35.85 A
Sorgaab (½ Dose)	7.5	4.000	138.1 C	12.13 C	1.890 C	1009 C	46.81 C	2.275 C (23.50)	7.030 D	32.37 B
Dual gold (½ Dose)	0.8	4.250	146.1 A	18.56 A	2.415 AB	1026 B	53.33 B	2.322 BC (26.05)	7.347 AB	31.61 B
Dual gold (1/3 Dose)	0.53	4.250	141.8 B	16.88 B	2.488 AB	1018 BC	51.81 C	2.290 BC (24.32)	7.253 BC	31.57 B
Dual gold (Full dose)	1.6	4.500	148.3 A	19.38 A	2.493 A	1050 A	56.51 A	2.470 B (34.09)	7.435 A	33.23 AB
LSD		1.388	3.454	1.574	0.1409	13.55	3.035	0.1879	1.1627	2.821

- Any two means having common letters are not significantly different by LSD test at 5% level of probability.
- Figures given in parenthesis show % increase over control.

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