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Effect of herbicides on distribution and interference of weeds, growth and yield of wheat (*Triticum aestivum*) in Kandahar, Afghanistan

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ABSTRACT

Weeds are the major constraint to achieving higher wheat yield in Afghanistan. To evaluate weed interference and its impact on wheat, a field experiment was undertaken during winter season in 2014–15 at Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar. Seven weed control treatments comprising isoproturon 0.75 and 1.0 kg/ha at 35 days after sowing (DAS), sulfosulfuron 20 and 25 g/ha at 35 DAS, isoproturon + 2,4-D 0.75 + 0.5 kg/ha at 35 DAS (tank-mix), weed-free check and weedy check were laid out in a randomized complete block design with three replications. Results showed that grassy weeds constituted 62.7% of the total weeds and were mostly dominant. All herbicides/weed control treatments influenced weed interference, wheat crop growth and yield significantly. Sulfosulfuron 25 g/ha at 35 DAS resulted in significant reduction in weed density by 95.2% (i.e. weed control efficiency) and dry weight by 95.1% (i.e. weed control index), respectively. This treatment led to significant improvements in wheat growth (Leaf area index, dry matter accumulation) and grain (4.6 t/ha) and biological yields (10.6 t/ha), and was superior to other herbicide treatments. It increased wheat grain and biological yields by 24.3% and 17.8%, respectively, compared to weedy check. Therefore, the application of sulfosulfuron 25 g/ha at 35 DAS may be recommended for better weed control and higher wheat yield in Kandahar, Afghanistan, and in similar agro-ecologies of the tropics and sub-tropics.

Keywords: Broad-leaved weeds, Isoproturon, Narrow-leaved weeds, Sulfosulfuron, Weed control efficiency

Wheat is a staple food crop in Afghanistan, accounting for about 83% of the total cereal consumption. Several biotic and abiotic factors influence wheat production in Afghanistan. Among the biotic factors, weeds are the major constraint to achieve higher yield in wheat (Asres and Das 2011). Depending on the nature of weed infestation, average yield losses in wheat due to weeds vary between 30–50% (Das and Das 2018). Weeds not only reduce yield, but also lower the quality of produce (Chaudhary *et al.* 2011). Thus, timely and effective weed control to keep weeds population below the damage level (Dodamani and Das 2013) is important to achieve higher yield of wheat. Chemical weed control through selective herbicides offers timely and cost-effective control of weeds than other methods. Presently, several post-emergence herbicides are being used for weed control in wheat across the world. But, there is a need to identify and evaluate the response of newer low-dose high potency post-emergence herbicides and/or tank-mix herbicides for broad-spectrum weed control. This can delay evolution herbicide resistance in weeds (Das *et al.* 2014). Weed control efficacy of herbicides is location-specific, depending on climate and soil, and needs to be evaluated across locations. Herbicides use in crops in Afghanistan is still in its infancy. Till date, systematic studies involving low-dose post-emergence herbicides like sulfosulfuron and/or tank-mix herbicides with different modes of action for weed control in wheat are lacking in Afghanistan. Keeping these in view, this study was formulated to evaluate appropriate herbicide and its dose and time of application for effective weed control in wheat in Afghanistan.

MATERIALS AND METHODS

The field experiment was conducted during winter in 2014–15 at Tarnak Research Farm, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar. The soil was sandy clay loam, having *p*H 8.3, electrical conductivity 0.21 dS/m, organic carbon 0.8%, available N 0.06% (w/w), available P 27.6 kg/ha, and available K 243.9 kg/ha. Seven weed control treatments, viz. isoproturon 0.75 kg/ha at 35 DAS, isoproturon 1.0 kg/ha at 35 DAS, sulfosulfuron 20 g/ha at 35 DAS, sulfosulfuron 25 g/ha at 35 DAS, isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha (tank-mix treatment) at 35 DAS,

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Table 1 Weed distribution in experimental wheat field under weedy situation

Botanical name	Common name	Habit	Family	Relative density (%)
Cynodon dactylon (L.) Pers.	Bermuda grass	Perennial grass	Poaceae	22.7
Avena fatua L.	Wild oat	Annual grass	Poaceae	13.4
Phalaris minor Retz.	Littleseed canarygrass	Annual grass	Poaceae	10.1
Chenopodium album L.	Common lambsquarters	Annual broad-leaved	Chenopodiaceae	9.6
Convolvulus arvensis L.	Field bind weed	Perennial broad-leaved	Convolvulaceae	9.4
Polypogon monspeliensis L. Desf.	Foxtail grass	Annual grass	Poaceae	6.1
Launaea cornuta/asplenifolia	Wild lettuce	Perennial broad-leaved	Asteraceae	5.7
Lolium temulentum L.	Darnel ryegrass	Annual grass	Poaceae	5.4
Melilotus indica (L.) All.	Yellow sweet clover	Annual broad-leaved	Fabaceae	3.4
Carthamus oxycantha Bieb.	Wild safflower	Annual broad-leaved	Asteraceae	3.1
Polygonum aviculare L.	Prostrate knotweed	Annual broad-leaved	Polygonaceae	3.1
Fumaria indica L.	Fumitory	Annual broad-leaved	Papaveraceae	2.2
Bromus arvensis L.	Field brome	Annual grass	Poaceae	2.0
Bromus pectatum Scop.	Brome grasses	Annual grass	Poaceae	1.8
Setaria viridis L. Beauv.	Green foxtail	Annual grass	Poaceae	1.2
Alhagi maurorum Medik.	Camelthorn	Perennial broad-leaved	Fabaceae	0.8

weed-free check (season-long weed-free condition through manual weeding), and weedy check (season-long weedy situation) were laid out in a randomized complete block design with three replications. Each plot was 5 m (along the row) × 2.4 m (across the row) and was separated by 1.0 m buffer zone. Blocks were separated by 2.0 m inter-block space. Wheat cultivar 'PBW-154' was sown on 28 December, 2014 using a seed rate of 100 kg/ha at 24 cm inter-row spacing. All herbicides (post-emergence) were applied at 35 DAS by a knapsack sprayer fitted with a flat-fan nozzle. The sprayer was calibrated to 400 L water/ha. Recommended dose of $N:P_2O_5:K_2O$ was 120:60:30 kg/ha. Full dose of P and K and 1/3rd dose of N were applied to wheat as basal at final land preparation. Rest N was top-dressed in two equal splits at crown root initiation (CRI) and panicle initiation stages of wheat. For

Table 2 Weed density, dry weight and crop growth at 45 and 75 DAS.

Treatment	Narrow-leaved weed				Broad-leaved weed				WCE (%)	WCI (%)	Wheat leaf area index	
	Density (no./m^2)		Dry weight (g/m^2)		Density (no./m^2)		Dry weight (g/m^2)					
	45 DAS	75 DAS	45 DAS	75 DAS	45 DAS	75 DAS	45 DAS	75 DAS			45 DAS	75 DAS
Isoproturon 0.75 kg/ha	11.5‡ (136.3)†	11.7 (151.7)	5.6 (31.7)	3.8 (16.5)	4.9 (26.7)	4.5 (23.0)	1.5 (2.0)	3.8 (16.5)	22.9	44.8	2.4	3.4
Isoproturon 1.0 kg/ha	7.0 (50.0)	7.5 (66.7)	4.7 (21.9)	2.8 (7.1)	4.5 (20.0)	5.3 (34.3)	2.3 (4.8)	3.6 (15.5)	64.1	56.3	2.4	3.5
Sulfosulfuron 20 g/ha	1.9 (3.7)	1.5 (2.0)	1.1 (0.6)	2.7 (7.0)	3.3 (10.7)	2.2 (4.7)	1.8 (3.3)	3.0 (11.7)	93.0	93.6	2.6	3.6
Sulfosulfuron 25 g/ha	1.5 (2.3)	1.3 (1.3)	0.9 (0.3)	2.0 (6.8)	2.9 (9.0)	2.3 (5.0)	1.6 (2.7)	2.5 (7.0)	95.2	95.1	2.7	3.8
Isoproturon + 2,4-D (0.75 + 0.5kg/ha)	7.0 (50.0)	8.0 (63.3)	3.1 (9.3)	3.6 (14.2)	3.4 (11.0)	2.1 (5.0)	1.9 (3.8)	2.6 (6.2)	65.3	78.6	2.5	3.6
Weed-free check	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	100.0	100.0	2.6	3.5
Weedy check	12.5 (161.3)	16.1 (266.7)	5.2 (26.6)	4.8 (27.1)	5.7 (32.3)	6.3 (47.0)	5.7 (34.5)	5.6 (33.9)	0.0	0.0	2.2	3.3
LSD (P=0.05)	2.5	4.3	0.9	1.3	1.9	3.3	1.9	2.2	18.9	17.7	0.3	0.2

‡Square-root transformed values; †Figures in the parentheses are original values; WCE, weed control efficiency (%) and WCI, weed control index (%) of weed control treatments at 45 DAS

evaluating bio-efficacy of herbicides against the spectrum of weeds (Das 2001), species-wise weeds were collected at 45 and 75 DAS using a quadrat of 0.5m × 0.5m, counted and categorized into narrow-leaved and broad-leaved weeds. Wheat plants also were collected from the above-mentioned quadrat area for estimating dry weight. Collected weed and wheat samples were sun-dried for 2 days and then oven-dried at 70±5°C until constant dry weight. Weed data were transformed through square-root method $[(x+0.5)^{1/2}]$ before analysis to improve homogeneity of variance (Das 1999). Weed control efficiency (WCE) based on weed density and weed control index (WCI) based on weed dry weight were determined as per Asres and Das (2011). Wheat was harvested from the net plot at physiological maturity and grain yield was expressed at 14% moisture content. Data were analyzed through analysis of variance (ANOVA). Treatment means were separated using least significant difference (LSD) method at $p \leq 0.05$ (Snedecor and Cochran 1989).

RESULTS AND DISCUSSION

Weed flora distribution: There were 16 weed species belonging to 7 botanical families present under weedy situation in the experimental wheat field (Table 1). Narrow-leaved grassy weeds were most dominant, constituting 62.7% of the total weeds. *Cynodon dactylon* (L.) Pers., *Avena fatua* L. and *Phalaris minor* Retz. had recorded higher density than other grassy weeds. *Chenopodium album* L. and *Convolvulus arvensis* L. were dominant broad-leaved weeds. *Cynodon dactylon* was the single most dominant weed, comprising 22.7% of the total weeds followed by *Avena fatua* (13.4%) and *Phalaris minor* (10.1%).

Weed interference and control efficiency: Weed management practices caused significant reductions in weed population and dry weight in wheat at 45 and 75 DAS compared to weedy check. Weed interference was significantly reduced by the application of sulfosulfuron 25 g/ha at 35 DAS, which brought about significant reductions in density and dry weight of narrow-leaved weeds by 98.6% and 99.5% at 45 DAS, and 98.9 and 74.9% at 75 DAS, respectively over weedy check (Table 2). This treatment led to similar reduction in the growth of broad-leaved weeds. Further, this treatment resulted in highest weed control efficiency (WCE; 95.2%) and weed control index (WCI; 95.1%) and was found to be most effective against weeds in wheat. Higher efficacy of sulfosulfuron in controlling diverse weeds in wheat have been reported in several studies (Baghestani *et al.* 2007, Jamil *et al.* 2007, Malekian *et al.* 2013, Nath *et al.* 2015) carried out across different locations in the world. Sulfosulfuron (~sulfonylureas) is a new low-dose high potency broad-spectrum herbicide that inhibits acetolactate synthase/ acetohydroxyacid synthase (ALS/AHAS) enzyme in plants/weeds and is more effective against grassy weeds. In this study, wheat was infested more with grassy weeds, which were effectively controlled by sulfosulfuron as evident from higher WCE and WCI (Table 2). Sulfosulfuron 20 g/ha and the tank-mix application of isoproturon + 2, 4-D (0.75 + 0.5 kg/ha) were the next best treatments.

Wheat crop growth and yield: Differential weed control efficiencies of the treatments led to variable effects on wheat growth and yield. Sulfosulfuron 25 g/ha being at par with sulfosulfuron 20 g/ha led to highest leaf area index (LAI) of wheat, which was 22.7% and 15.2% higher than that in weedy check at 45 and 75 DAS, respectively (Table 2). It

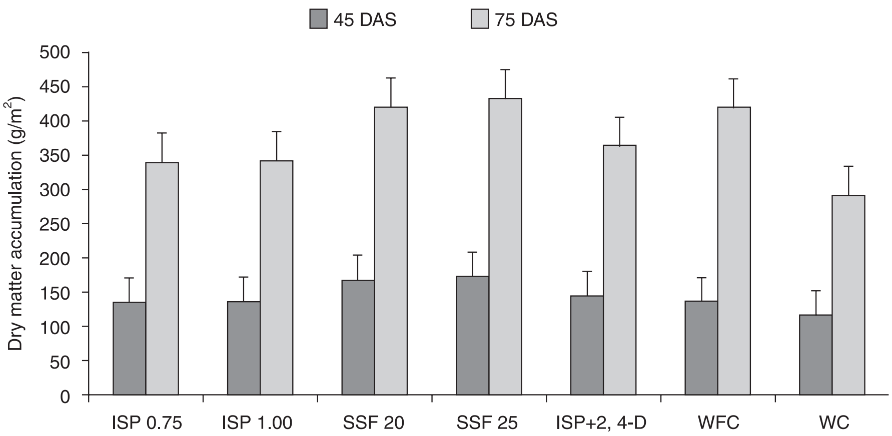

Fig 1 Wheat dry matter accumulation at 45 and 75 DAS across weed control treatments (ISP, isoproturon; SSF, sulfosulfuron; WFC, weed-free check; WC, weedy check. Error bars represent the LSD values at P≤0.05. Treatment details are mentioned in Table 2)

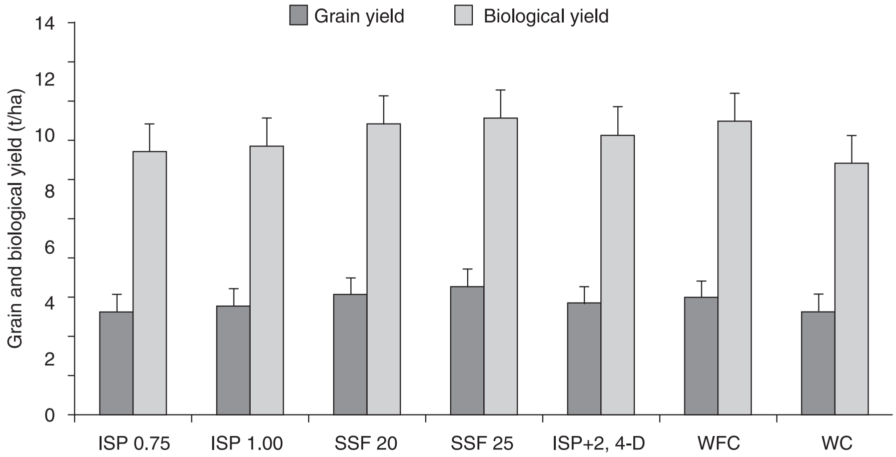

Fig 2 Grain and biological yields of wheat across weed control treatments (ISP, isoproturon; SSF, sulfosulfuron; WFC, weed-free check; WC, weedy check. Error bars represent the LSD values at P≤0.05. Treatment details are mentioned in Table 2)

had even 3.8% and 3.6% higher LAI than weed-free check at 45 and 75 DAS, respectively. Higher LAI in this treatment facilitated greater photosynthesis, resulting in significantly higher dry matter accumulation in wheat compared to others. It led to 48.5% and 48.5% higher dry weight of wheat than weedy check, and 27.4% and 3.2% higher dry weight than weed-free check at 45 and 75 DAS, respectively (Fig 1). Again, it being comparable with sulfosulfuron 20 g/ha gave highest grain (4.6 t/ha) and biological (10.6 t/ha) yields of wheat (Fig 2). Higher wheat growth in terms of leaf area and biomass accumulation in this treatment could be attributed to significant yield improvement of wheat (Das and Yaduraju 2011). Wheat grain and biological yields in this treatment increased by 24.3% and 17.8% over weedy check, and by 9.5% and 1.0% over weed-free check, respectively. Higher bio-efficacy of sulfosulfuron (25–30 g/ha) leading to improved growth and maximized yield of wheat without any crop phytotoxicity has been highlighted by Saquib *et al.* (2012), Malekian *et al.* (2013) and Shyam *et al.* (2014). Gopinath *et al.* (2007) reported that sulfosulfuron (33 g/ha) and metribuzin (250 g/ha) gave similar but significantly higher grain yields than the tank-mix application of isoproturon + 2, 4-D (0.75 + 0.50 kg/ha) and weedy check. In a crop-weed ecosystem, crop growth/yield is inversely related with weed growth (Das and Das 2018), and directly related with WCE/WCI of a weed control practice. Having highest WCE/WCI, sulfosulfuron (25 g/ha) provided almost complete weed control, which boosted up/promoted wheat growth through better canopy formation and higher photosynthesis. The vigorously-growing wheat plants smoothened residual weeds and greatly reduced the negative impacts of weeds on wheat. Besides, sulfosulfuron resulted in more tillering of wheat, resulting in significant improvement in wheat yields than weed-free check. Weed-free check was maintained by manual weeding, which at later stages might have caused minor damage to wheat through stalks breakage. Further, sulfosulfuron may possess pest-repelling/suppressing action, neither studied here nor established elsewhere, but can explain little about the better performance of sulfosulfuron over weed-free check. There are reports that herbicide atrazine suppressed plant-parasitic nematodes in maize (Das *et al.* 2010), and shoot fly and spotted stem borer in sorghum (Tadesse *et al.* 2010), which are added usefulness of herbicides application in crops.

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