Indian Journal of Agronomy **59** (2): 281–285 (June 2014)

Research Paper

Effect of nitrogen and weed management on productivity and quality of durum wheat (*Triticum durum*)

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Received : October 2013; Revised accepted : February 2014

ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2007–08 and 2008–09 at Udaipur, Rajasthan, to study the effect of different herbicides and nitrogen levels on productivity and quality of *durum* wheat (*Triticum durum* Desf.). Tank-mix application of metsulfuron + sulfosulfuron (4+25 g/ha) reduced weed population and biomass significantly and thereby caused increase in plant height, crop dry matter and grain yield (5.22 tonnes/ha). The highest net returns (₹52,400) and benefit: cost ratio (3.78) were also recorded with tank-mix application of metsulfuron + sulfosulfuron. Application of metsulfuron + sulfosulfuron significantly increased the protein content, β-carotene and sedimentation value. This was at par with metsulfuron + isoproturon and 2,4-D + sulfosulfuron. Weed biomass increased significantly with the increase in N level up to 120 kg/ha. Increasing nitrogen level up to 120 kg/ha showed marked improvement in plant height, dry matter, ear-bearing tillers, grains/ear, 1,000-grains weight, thereby resulted in significantly highest grain yield of 4.81 tonnes/ha with net returns of ₹47,700/ha and benefit: cost ratio 3.44.

Key words: Durum wheat, Herbicide mixtures, Isoproturon, Metsulfuron, Nitrogen, Quality, Sulfosulfuron

Wheat is the most important cereal among the foodgrain crops in the world. It is produced in wide range of climatic environments and geographic regions (Dixon *et al*., 2009). Among different species of this crop, *durum* is next in importance to *aestivum*. Durum wheat is known for its hardiness, protein, intense yellow colour, nutty flavour and excellent cooking qualities (Kneipp, 2008). In India, it is highly valued for making semolina (*suji*) and vermicelli. It is extensively used in the preparation of noodles, snacks, roasted doughs (*batti*), porridge, *upma* and *ladoos*. In our country *durum* is traditionally grown in central and peninsular regions which share nearly 85% of its acreage (Behera *et al.,* 2007). Among several constraints of wheat production, weeds are one of the major constraint causing yield losses to the extent of 50% (Azad, 2003). Weeds growing in association with irrigated and heavy fertilized crop decline its yield besides lowering down the quality of produce by way of weed seed contamination (Yadav *et al*., 2006). The crop is infested with heavy population of common broad-leaf weeds, annual grassy weeds like *Phalaris minor, Avena fatua, Poa annua* etc. Of which *P. minor* is considered most damaging (Inderjit and Kaushik, 2009). It has been proved that continuous use of single herbicide has developed the resistance. New herbicides such as sulfosulfuron have shown high efficiency against grasses in wheat. Use of this herbicide against non-grassy weeds has resulted in proliferation of non-grassy weeds like *Chenopodium album* etc. But to control mixed population of weeds and also to avoid herbicides resistance by continuous use of single herbicide, compatible mixtures can be employed to widen the spectrum of weed control (Das and Yaduraju, 2012). Like other crops, *durum* wheat productivity and quality also depend on proper nutrient supply (Behera *et al*., 2008). Among the essential plant nutrients, nitrogen plays the most important role in augmenting agricultural production and its deficiency limits crop production (Aradwad *et al*., 2008; Mattas *et al.,* 2011). Keeping the above facts in view, a field experiment was conducted to screen out compatible/suitable herbicide combination for broad- spectrum weed control in durum wheat and to standardize rate of nitrogen application.

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MATERIALS AND METHODS

A field study was conducted during the winter seasons of 2007–08 and 2008–09 at Instructional Agronomy Farm, Rajasthan College of Agriculture, Udaipur (24°.35' N, 74°.42' E and 579.5 m above mean sea-level). The experimental soil was clay loam with pH 8.2. The soil was low in available nitrogen (251.27 kg/ha), medium in available phosphorus (19.89 kg/ha) and high in available potassium (369.53 kg/ha). The experiment was conducted in split-plot design having 27 treatments with 3 replications. Herbicides as main plot treatments comprised weedy check, 2, 4-D (400 g/ha), metsulfuron (4 g/ha), isoproturon (750 g/ha), sulfosulfuron (25 g/ha), 2, 4-D + isoproturon (400 + 750 g/ha), 2, 4-D + sulfosulfuron (400 + 25 g/ha), metsulfuron + isoproturon (4 + 750 g/ha) and metsulfuron + sulfosulfuron (4 + 25 g/ha) and nitrogen levels in sub-plots comprised 3 treatments, viz. 60, 90 and 120 kg/ha. Durum wheat cv. 'HI 8498' was sown in the second fortnight of November, using 125 kg/ha seed rate. All herbicides were sprayed by knapsack sprayer fitted with flat-fan nozzle using a spray volume of 600 litres/ha 32 days after sowing (DAS). The recommended dose of phosphorus (27.2 kg P/ha) was applied uniformly as basal application. Half nitrogen was applied basal at the time of sowing, whereas remaining nitrogen was top dressed in 2 equal splits–at the time of first and second irrigation. Observations on weed composition and dry matter were recorded from 2 random quadrates of 0.25 m^2 in each plot. Total number of weeds falling within the quadrate were counted-category wise in each plot and collected for dry-matter accumulation. The samples were first dried in sun and then kept in oven at 65° C. The dried samples were weighed and expressed in g/m^2. The chemical quality traits of *durum* wheat were estimated as per the procedure laid out in protocols for evaluation of wheat quality (Mishra and Gupta, 1995). Economic analysis was done on the basis of prevailing market price of inputs and output obtained from each treatment.

RESULTS AND DISCUSSION

Density and dry weight of weeds

The field was infested with broad-leaf weeds, viz. *Anagallis arvensis* L., *Chenopodium album* L., *Chenopodium murale* L., *Cichorium intybus* L., *Convolvulus arvensis* L., *Coronopus didymus* (L.) Sm., *Melilotus indica* (L.) All., *Spergula arvensis* L.; and annual grasses, viz. *Phalaris minor* Retz. and *Avena fatua* L.

The lowest density of broad-leaf weeds was observed in metsulfuron + sulfosulfuron treated plots Application of tank-mixture of metsulfuron + isoproturon and single application of metsulfuron was found at par with it. While the density observed in plots treated with 2, 4-D + either isoproturon or sulfosulfuron were at par. The resulted obtained with singly applied 2, 4-D, sulfosulfuron and isoproturon lagged behind in significance in respect of broad-leaf weed density. In comparison to weedy check, all the herbicide mixtures and alone application of sulfosulfuron significantly reduced the density of grassy weeds. While effects of 2, 4-D and metsulfuron were at par with weedy check. The effect of the tank mixtures comprising 2, 4-D and metsulfuron with either isoproturon or sulfosulfuron were significantly superior to rest of the treatments in controlling total weeds. Amongst singly applied herbicides, isoproturon and sulfosulfuron gave statistically superior results over 2, 4-D and metsulfuron. The weed density at 70 DAS was unaffected due to change in rate of N application.

The minimum dry-matter of broad-leaf weeds was obtained by the application metsulfuron + sulfosulfuron mixture. However, it was on par with metsulfuron + isoproturon and 2, 4-D + sulfosulfuron. Amongst singly applied herbicides, metsulfuron was found significantly superior with 81.6% decrease in broad-leaf weed dry-matter (Table 1). Minimum grassy weed dry matter was obtained under metsulfuron + sulfosulfuron treated plots; however, it was on a par with metsulfuron + isoproturon. The order of significance was followed by 2,4-D + sulfosulfuron and 2,4-D + isoproturon. Application of metsulfuron + sulfosulfuron accounted for minimum total weed dry-matter, which was at par with metsulfuron + isoproturon. The order of significance was followed by 2,4-D + sulfosulfuron. Amongst singly applied herbicides, metsulfuron resulted in the the minimum dry matter followed by 2,4-D, isoproturon and sulfosulfuron. Better performance of herbicide mixtures in reducing the density and dry matter of weeds could be attributed to their synergetic interactions and compatibility that was responsible for broad spectrum suppression of different categories of weeds. Bharat and Kachroo (2007) also reported similar results with herbicide mixtures. A symmetrical trend of results was obtained for dry-matter increment in relation to rate of nitrogen application. Significant increase in dry matter was observed by successive increase in N up to 120 kg/ha. The tank-mix application of metsulfuron + sulfosulfuron resulted in the highest weed-control efficiency of broad-lead, grassy and total weeds; however, it was at par with metsulfuron + isoproturon and 2, 4-D + sulfosulfuron. Higher weed-control efficiency of these mixtures over their single application could be attributed to widening of spectrum of weed flora.

Crop growth

The tallest plants were observed under metsulfuron + sulfosulforon-treated plots; however, it was at par with

Table 1. Effect of herbicides and nitrogen on weed dynamics 70 days after sowing (pooled data of 2 years)

Treatment	Weed density* (No./m^2)			Weed dry-matter (g/m^2)			Weed-control efficiency (%)		
	Broad-leaf	Grassy	Total	Broad-leaf	Grassy	Total	Broad-leaf	Grassy	Total
Herbicides									
Weedy check	13.4 (178.0)	7.1 (50.1)	15.1 (228.6)	180.4	68.0	248.5	0.00	0.0	0.0
2, 4-D 400 g/ha	4.4 (18.8)	6.9 (46.6)	8.1 (65.9)	41.3	66.7	108.0	77.02	1.6	56.4
Metsulfuron 4 g/ha	3.5 (12.0)	6.9 (46.8)	7.7 (59.2)	33.1	66.1	99.3	81.59	2.4	60.0
Isoproturon 750 g/ha	5.1 (25.1)	3.3 (10.2)	6.0 (35.7)	88.9	20.8	109.7	50.61	69.3	55.8
Sulfosulfuron 25 g/ha	4.7 (21.8)	3.1 (9.4)	5.7 (31.8)	98.9	16.8	115.7	44.90	75.3	53.3
2,4-D + Isoproturon 400 + 750 g/ha	3.7 (13.3)	3.2 (9.6)	4.9 (23.5)	25.7	15.1	40.8	85.73	77.8	83.6
2,4-D + Sulfosulfuron 450 + 25 g/ha	3.7 (13.5)	3.2 (9.5)	4.9 (23.4)	23.6	12.9	36.6	86.88	80.9	85.3
Metsulfuron + Isoproturon 4 + 750 g/ha	3.4 (11.1)	3.2 (9.5)	4.6 (20.8)	21.0	10.5	31.6	88.31	84.5	87.5
Metsulfuron + Sulfosulfuron 4 + 25 g/ha	3.1 (8.8)	3.2 (9.9)	4.4 (19.2)	18.2	9.7	27.9	89.90	85.8	88.8
SEm±	0.2	0.2	0.2	1.7	0.9	2.1	1.28	1.4	1.6
CD (P=0.05)	0.5	0.6	0.6	5.0	2.5	6.0	3.67	4.1	4.6
Nitrogen (kg/ha)									
60	4.8 (23.1)	4.4 (19.2)	6.7 (44.4)	55.7	30.0	85.8	68.1	55.4	64.4
90	5.0 (24.4)	4.4 (19.0)	6.8 (46.1)	59.4	32.1	91.5	67.0	53.1	63.3
120	5.1 (26.0)	4.5 (19.6)	7.00 (48.48)	61.9	33.4	95.3	66.5	52.2	62.6
SEm±	0.1	0.1	0.1	0.8	0.4	0.9	0.6	0.7	0.7
CD (P=0.05)	NS	NS	NS	2.4	1.2	2.7	NS	NS	NS

* Data subjected to $\sqrt{x + 0.5}$ transformation and figures in parentheses are original weed count/ m^2

metsulfuron + isoproturon, followed by other treatments. Significant increase in plant height was registered by increasing N rate from 60 to 90 (3.7%) and 90 to 120 kg/ha (4.4%). Maximum crop dry-matter at harvest was produced when weeds were controlled by metsulfuron + sulfosulfuron which was at par with other mixtures except 2, 4-D + sulfosulforon but significantly superior to singly applied herbicides. The herbicide mixtures showed 42.9–50.4% increase in crop dry-matter over weedy check. Advancing rates of N application over a range of 60–120 kg/ha recorded significant increase of the order of 4.8 and 4.9% by raising rate of N application from 60–90 and further from 90–120 kg/ha.

Yield attributes and yield

Highest numbers of effective tillers/m row length were produced when weeds were controlled by tank mix application of metsulfuron + isoproturon. It was at par with all other herbicidal treatments except isoproturon and sulfosulfuron. Alleviating stress caused by weeds through herbicidal weed control significantly improved grains/ear. Highest number of grains/ear were produced in the plots treated with metsulfuron + sulfosulfuron, but it was at par with all other herbicidal treatments except singly applied herbicides and metsulfuron + isoproturon mixture. Metsulfuron + sulfosulfuron and metsulfuron + isoproturon mixtures resulted in the highest grain weight/ear but these were at par with other mixtures. Graded increase (60–90 and 90–120 kg/ha) in N application were associated with 17.1 and 4.0% increase in effective tillers/m row length, 9.6 and 3.7% in grains/ear, and 3.6% and 3.2% in 1,000-grain weight. Tank mix post-emergence application of metsulfuron + sulfosulfuron resulted in significantly higher grain yield than all other treatments. The better expression of yield attributes of *durum* wheat plants under the influence of herbicide mixtures was owing to poor resurgence and growth of weeds as is evident from the weed density and dry matter studies. Significant increase in yield attributes finally manifested into higher yield. Bharat and Kachroo (2007) also reported higher wheat yield with herbicide mixtures. The highest straw yield was recovered from plots under the effect of metsulfuron + sulfosulfuron. It was at par with other herbicidal treatments except 2,4-D + sulfosulfuron mixture and individually applied isoproturon and 2,4-D. The maximum biological yield was produced by weed control through metsulfuron + sulfosulfuron. However, it was at par with metsulfuron + isoproturon, but significantly superior to the other treatments. As the nitrogen application rate was progressively increased, the grain and biological yields of *durum* wheat increased significantly. Increasing the rate of nitrogen use from 60 to 90 and 90 to 120 kg/ha brought 16.5 and 7.5% and 10.7 and 4.6% increase in grain and biological yields, respectively. However, the straw yield increased significantly (7.1%) only up to 90 kg/ha of N application. The ascending rate of nitrogen application up to 120 kg/ha helped in improved plant growth as evident from higher dry-matter production which acted as source to provide greater amount of photosynthates to the sink i.e. reproductive organs thus helping in significant increase in yield attributes. In addition, increased availability of N from soil media was also responsible for increased ear-bearing tillers/plant, grains/ear and 1,000-grain weight which were responsible for better expression of yield. Kumar *et al*. (2007) also reported significance of nitrogen application in wheat.

Economical returns

In comparison to *durum* wheat crop facing stress on account of uncontrolled weeds, weed control through different herbicides and their mixtures enhanced net returns and benefit: cost ratio. The results of the best performing treatment (metsulfuron + sulfosulfuron) was significantly superior to rest of the treatments with highest net returns (₹52,400) and benefit: cost ratio (3.78). There was a significant increase in net returns (₹47,700) and benefit: cost ratio (3.44) by raising rate of N application up to 120 kg/ha.

Quality traits

A consistent trend of results was observed while analysing the data on the effect of weed control on quality of *durum* wheat grain; however, the treatments varied in their effect. The yellow berry prevalence was not affected by herbicides. Highest hectolitre weight and sedimentation value were recorded by controlling weeds with metsulfuron + sulfosulfuron, but it was at par with metsulfuron + isoproturon and 2, 4-D + sulfosulfuron. Highest β-carotene and protein content of grain were recorded with metsulfuron + sulfosulfuron and metsulfuron + isoproturon, respectively; however, these were at par with all other herbicide mixtures. Amongst quality traits, the hectoliter weight and yellow berry prevalence decreased significantly while protein content, β-carotene and sedimentation value of grain increased significantly by raising rate of nitrogen application up to 120 kg/ha. Profound effect of nitrogen in protein synthesis is well established, as it is required in synthesis of amino acids, the basic units of protein. Further, increased protein content owing to improved N status of grain manifested into higher sedimentation value by applying 120 kg N/ha. While reduction in yellow berry incidence could be attributed to proper functioning of nitrogen in correct synthesis and packing of protein with increasing N levels (Mishra

Table 2. Effect of herbicides and nitrogen on growth and yield attributes of *durum* wheat (pooled data of 2 years)

	Plant height at harvest (cm)	Dry matter/m row at harvest (g)	Ear-bearing tillers/ meter row	Grains/ ear	Grains weight/ ear (g)	1,000-grains weight (g)	Yields (tonnes/ha)		Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
							Grain	Biological		
Herbicides										
Weedy check	84.3	289.3	98.8	40.7	1.6	38.8	3.54	10.00	33.3	2.59
2, 4-D 400 g/ha	100.0	391.8	115.2	45.1	1.8	42.4	4.46	10.67	40.8	3.09
Metsulfuron 4 g/ha	100.0	407.1	117.9	45.3	1.9	43.6	4.22	10.94	41.6	3.12
Isoproturon 750 g/ha	97.0	383.7	113.3	43.4	1.9	43.0	4.12	10.68	40.3	3.00
Sulfosulfuron 25 g/ha	98.4	389.7	113.2	44.4	2.0	43.5	4.24	11.04	41.7	3.09
2,4-D + Isoproturon 400 + 750 g/ha	99.6	418.1	120.6	46.3	2.0	45.3	4.57	11.39	45.3	3.32
2,4-D + Sulfosulfuron 450 + 25 g/ha	99.9	413.4	119.9	47.0	2.0	46.3	4.41	10.96	43.0	3.13
Metsulfuron + Isoproturon 4 + 750 g/ha	102.7	426.8	121.7	45.6	2.1	46.9	4.86	11.88	48.5	3.52
Metsulfuron + Sulfosulfuron 4 + 25 g/ha	103.8	435.2	121.5	47.5	2.1	47.3	5.22	12.34	52.4	3.78
SEm±	1.1	6.9	2.5	0.6	0.02	0.6	0.08	0.21	1.0	0.08
CD (P=0.05)	3.2	19.8	7.3	1.8	0.07	1.7	0.24	0.60	2.9	0.22
Nitrogen (kg/ha)										
60	94.6	376.5	102.5	41.8	1.9	42.6	3.84	10.12	37.1	2.83
90	98.1	394.6	120.0	45.8	2.0	44.2	4.47	11.20	44.2	3.28
120	102.5	413.8	124.8	47.5	2.0	45.6	4.81	11.71	47.7	3.44
SEm±	0.6	3.6	1.3	0.3	0.01	0.3	0.05	0.12	06	0.04
CD (P=0.05)	1.7	10.2	3.7	0.9	0.03	1.0	0.13	0.33	1.6	0.12

Table 3. Effect of nitrogen and herbicides quality of *durum* wheat (pooled data of 2 years)

Treatment	Hectoliter weight (kg/hectoliter)	Protein (%)	β-carotene (ppm)	Yellow berry (%)	Sedimentation value (ml)
Herbicides					
Weedy check	77.62	12.6	4.68	6.39	36.5
2,4-D 400 g/ha	80.52	13.4	5.32	6.94	38.2
Metsulfuron 4 g/ha	82.89	13.4	5.40	6.94	39.2
Isoproturon 750 g/ha	82.48	13.6	5.35	7.00	39.0
Sulfosulfuron 25 g/ha	83.52	13.6	5.48	7.06	39.5
2,4-D + Isoproturon 400 + 750 g/ha	83.68	14.1	5.61	6.83	39.5
2,4-D + Sulfosulfuron 450 + 25 g/ha	85.37	13.8	5.66	7.00	40.3
Metsulfuron + Isoproturon 4 + 750 g/ha	85.47	14.1	5.69	6.72	40.3
Metsulfuron + Sulfosulfuron 4 + 25 g/ha	86.52	14.0	5.73	6.78	40.8
SEm±	0.73	0.1	0.07	0.15	0.4
CD (P=0.05)	2.10	0.3	0.19	NS	1.1
Nitrogen (kg/ha)					
60	86.56	13.3	5.22	7.11	37.0
90	83.80	13.6	5.52	6.83	39.6
120	78.99	13.9	5.57	6.61	41.1
SEm±	0.37	0.05	0.03	0.08	0.2
CD (P=0.05)	1.04	0.14	0.09	0.22	0.6

and Gupta, 1995). The results on effect of nitrogen on quality traits of *durum* wheat corroborate the findings of Mattas *et al*. (2011).

It was concluded that under the presence of mix weed flora, weed control in durum wheat should be done by tank-mix post-emergence application of metsulfuron + sulfosulfuron (4+25 g/ha) at 30 – 32 DAS and the crop should be fertilized with 120 kg/ha.

REFERENCES

Aradwad, P.D., Bavalgave, V.G., Waghmare, M.S. and Thete, N.M. 2008. Effect of nitrogen and irrigation levels on growth and yield of durum wheat. *An Asian Journal of Soil Science* **3**(2): 297–98.

Azad, B.S. 2003. Efficiency of herbicides for controlling weeds in wheat with special reference to *Phalaris minor*. *Annals of Plant Protection Sciences* **11**(1): 119–22.

Behera, U.K., Saiprasad, S.V. and Pradhan, S. 2008. Nitrogen scheduling for improving productivity and quality of *durum* wheat (*Triticum turgidum*) in central India. *Indian Journal of Agricultural Sciences* **78**(7): 599–03.

Behera, U.K., Sharma, A.R. and Pandey, H.N. 2007. Sustaining productivity of wheat–soybean cropping system through integrated nutrient management practices on vertisols of central India. *Plant and Soil* **297**(1–2): 185–99.

Bharat, R. and Kachroo, D. 2007. Effect of different herbicides on mixed weed flora, yield and economics of wheat (*Triticum aestivum*) under irrigated conditions of Jammu. *Indian Journal of Agricultural Sciences* **77**(6): 383–86.

Das, T. K. and Yaduraju, N.T. 2012. The effects of combining modified sowing methods with herbicide mixtures on weed interference in wheat. *International Journal of Pest Management* **58**(4): 311–20.

Dixon, J., Braun, H. J. and Crouch, J.H. 2009. Overview: Transitioning wheat research to serve future needs of developing world. In: *Wheat Facts and Futures,* pp. 1–25. Dixon, J., Braun, H.J., Kosina, P. and Crouch, J.H. (Eds.). CYMMIT, Mexico.

Inderjit and Kaushik, S. 2009. Management of *Phalaris minor,* an exotic weed of cropland (In) *Management of Invasive Weeds,* pp. 279–286 Inderjit (Ed.)–Springer series in Invasion Ecology.

Kneipp, J. 2008. *Durum wheat production,* pp. 1–16. NSW Department of Primary Industries, Orange, State of New South Wales, Australia.

Kumar, R., Aggarwal, S.K. and Nanwal, R.K. 2007. Effect of planting system, seed rates and nitrogen levels on bread wheat (*Triticum aestivum)*. *Indian Journal of Agricultural Sciences* **77**(10): 669–71.

Mattas, K.K, Uppal, R.S. and Singh, R.P. 2011. Nitrogen management and varietal effects on the quality of *durum* wheat. *Research Journal of Agricultural Sciences* **2**(2): 279–83.

Mishra, J.S. and Gupta, K.C. 1995. Protocols for evaluation of wheat quality. Directorate of Wheat Research, Karnal, India. *Bulletin* **3**:98.

Yadav, A., Malik, R.K., Gill, G., Singh, S., Chauhan, B.S. and Bellinder, R.R. 2006. Current status of weed resistance to herbicides in rice–wheat cropping system in Haryana and its management. *Indian Journal of Weed Science* **38**(3 and 4): 194–206.