



Weed management in irrigated wheat (*Triticum aestivum*) with special reference to buttercup weed (*Ranunculus* spp) in north-west Himalayas

RAMAN JEET SINGH

Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttrakhand 263 601

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ABSTRACT

An on-farm trial was conducted at five farmer fields of Bageshwar district of Uttrakhand to validate, refine and popularize the technology developed by VPKAS, Almora for managing Buttercup (*Ranunculus* spp) during 2007–10. The aim of the study was to find out the effectiveness of 2,4-D @ 1.0 kg ai/ha, isoproturon @ 1.0 kg ai/ha and tank mix application of 2,4-D @ 0.5 kg ai/ha with isoproturon @ 1.0 kg ai/ha over farmers practice of hand weeding twice at 30 and 60 DAS and unweeded control on the infestation of weeds and profitability of wheat (*Triticum aestivum* L. emend. Fiori and Paol.). Tank mix application of 2, 4-D+isoproturon (0.50+1.0 kg/ha) at 35-40 DAS reduced the density and dry weight of *Ranunculus* and other weeds and nutrient uptake by weeds (3.9 kg N, 0.9 kg P and 6.2 kg K/ha) compared to farmers practice. This combination also resulted in 12.5% higher grain yield, nutrients by wheat (73.5 kg N, 11.6 kg P and 60.0 kg K/ha) and net returns (₹ 19 030/ha) With this technology, drudgery reduction of about 475-man days/ha can be made possible, which could be used in other fruitful activities of hilly farmers, particularly women.

Key words: 2, 4-D, Hand weeding, Isoproturon, *Ranunculus*, Weed, Wheat

Irrigated wheat (*Triticum aestivum* L. emend. Fiori & Paol.) with an area of 0.4 million ha is the most widely cultivated winter cereal in Uttrakhand. Owing to favourable weather and soil moisture regimes *Ranunculus* spp (L.) infestation is a major biotic constraint to irrigated wheat production. In irrigated valleys of north-west Himalayas, four species of buttercup weed namely *Ranunculus arvensis*, *R. muricatus*, *R. diffuses* and *R. leutus* have been found infesting different field crops during winter especially irrigated wheat. Among these species, *R. arvensis* is predominant. Season-long infestation of this weed alone causes grain yield reduction by 20 to 40% and removes considerable amount of soil nutrients (Kumar *et al.* 2010). Leaves of this weed contain an acrid-tasting protoanemonin, i e ranunculin which makes the plant unpalatable to dairy animals (Connor 1977). This weed once well established, forms a vigorous deep-root system (corms) that restricts its control manually. Manual weeding is a common practice in the region but it is less efficient, labour intensive and often not done on time because of adverse soil and weather conditions. Use of suitable and conventional herbicides like 2,4-D and isoproturon provide more efficient and cost-effective control of *Ranunculus* and

other weed flora in wheat. To manage the dynamic weed flora, there is a need to evaluate a range of herbicides alone and as tank mixture to have a broad spectrum weed control (Dixit and Singh 2008). Several on station trials conducted at VPKAS, Almora have revealed that *R. arvensis* can be effectively controlled with 2, 4-D and isoproturon spray at 35–40 days after sowing (Prakash *et. al.* 2008). Present investigation was conducted at selected farmer fields with the objective to validate, assess and refine the sustainability and energy-use efficiency of improved technology of weed management over traditional farmers practice.

MATERIALS AND METHODS

Initial Participatory Rural Appraisal (PRA) exercises identified poor wheat yield and high cost of production due to heavy infestation of weeds, particularly *Ranunculus* which is a serious constraint in hilly areas. Therefore, replicated (five) on-farm trials were conducted at five farmers fields in five villages (similar agroclimatic conditions) namely Garigad, Begad, Karalagaon, Kholseer and Okhlisirod of Bageshwar district of Uttrakhand during 2007–10 and means were used for the study. These locations were in the valley areas in the mid–hill conditions of north–west Himalayas at an elevation of around 1 300 m above mean sea level. All the farmers selected for on-farm trials were small farmers. The soil of the sites was sandy loam to silty clay loam, acidic in

Scientist (e mail: rdxsingh@gmail.com), Division of Soil Science and Agronomy, Central Soil and Water Conservation Research and Training Institute, Dehradun, Uttarakhand 248 195

pH and high in available N (530 kg/ha), medium in P (13.1 kg/ha) and K (207 kg/ha). The bulk density of the soil was 1.26 Mg/M³. The experiment comprised five treatments, viz. unweeded control, 2,4-D @ 1.0 kg ai/ha, isoproturon @ 1.0 kg ai/ha, tank mix application of 2,4-D @ 0.5 kg ai/ha with isoproturon @ 1.0 kg ai/ha and farmers practice of hand weeding twice at 30 and 60 days after sowing (DAS), were laid-out in a randomized block design at each farmers field. Wheat VL-Gehun 832 was sown by broadcasting (traditional method) @ 120 kg seed/ha during second fortnight of October in all the years. The crop was fertilized with 10 tonnes/ha of FYM only. Herbicides were applied with a manually operated knapsack sprayer delivering a spray volume of 500 litres/ha through flat-fan nozzle. Data on weed density and dry weight were recorded at 90 days after sowing in each plot in two quadrates, each of 1m × 1m. Weeds were counted species-wise and removed for recording their dry weight. Weeds samples were sun-dried until constant weight was attained. Crop was manually harvested on first fortnight of April in all the years. The grain yield data were recorded and adjusted to 14% of the moisture content. Data on weeds were subjected to square root transformation ($\sqrt{vx + 0.5}$) before statistical analysis. For estimation of energy inputs and outputs, energy equivalents were worked out as suggested by Devasenapathy *et al.* (2009). All data were analyzed by using ANOVA, and the least significant difference (LSD) values at 5% level of significance were calculated and used to test significance difference between treatment means. At harvest, N, P, and K contents of weeds and wheat (grain and straw) were estimated using Kjeldahl method, spectrophotometer and flame-photometer, respectively and their uptakes were obtained from their respective dry weights across treatments. Weed

control efficiency, weed index and herbicide efficiency index were calculated as suggested by Kumar *et al.* (2012). Treatment -wise data were computed using the prevailing market price of inputs such as 2, 4-D ester @ ₹ 250/litre, isoproturon @ ₹ 450/kg, labour wages @ 120/man-day and outputs, viz. wheat grain @ ₹ 11/kg and straw ₹ 1/kg.

RESULTS AND DISCUSSION

Effect on weeds

The weed flora as observed from the unweeded control plots consisted of *Ranunculus* (71%) and among rest (29%), *Phalaris minor* (Littleseed canary grass), *Anagalis arvensis* (Blue pimpernel), *Polygonum plebejum* (Indian knot-weed) and *Avena fatua* (Wild oats) were observed. All herbicidal treatments significantly reduced population of weed compared to farmers' practice (Table 1). It was mainly because of effective weed control during early stages of crop growth. In farmers' practice (hand weeding twice at 30 and 60 DAS), weeds particularly *Ranunculus* were not controlled due to its deep-tap root system and faster regrowth soon after weeding. Tank mix application of 2, 4-D along with isoproturon being at par with alone isoproturon spray significantly reduced weed density and dry weight of total weeds compared to other treatments and resulted in the highest weed control efficiency (92.7%) and herbicide efficiency index (5.79). Similarly, one spray of isoproturon @ 1.0 kg ai/ha resulted in the lowest weed index (2.8) in comparison to other treatments. Dry weight of *Ranunculus* was remained at par with all herbicide treatments while it was significantly lesser with combined application of 2, 4-D and isoproturon over farmers' practice. Total weed dry weight was significantly less with

Table 1 Effect of different weed control treatments on density and dry weight of weeds, weed-control efficiency, weed index and herbicide efficiency index in wheat at 90 DAS (mean data of three years)

Treatment	Weed density (no./m ²)			Dry weight of weeds (g/m ²)			Weed-control efficiency (%)	Weed index (%)	Herbicide efficiency index
	<i>R. arvensis</i>	Others	Total	<i>R. arvensis</i>	Others	Total			
Unwedded control	10.77 (125.2)	7.21 (53.8)	12.90 (177.0)	9.88 (100.4)	4.83 (25.2)	11.18 (126.0)		25.0	
2,4-D @ 1.0 kg ai/ha	4.76 (23.4)	3.98 (15.6)	6.20 (39.0)	3.28 (10.4)	3.32 (10.6)	4.61 (21.0)	83.3	5.5	1.17
Isoproturon @ 1.0 kg ai/ha	3.11 (9.4)	2.98 (8.6)	4.28 (18.0)	3.10 (9.4)	2.83 (7.8)	4.17 (17.2)	86.4	2.8	2.91
2,4-D @ 0.5 kg ai/ha + Isoproturon @ 1.0 kg ai/ha	2.84 (7.8)	1.41 (2.4)	3.25 (10.2)	2.43 (5.6)	1.97 (3.6)	3.07 (9.2)	92.7		5.79
Farmers' practice (two hand weedings at 30 and 60 DAS)	7.62 (60.0)	5.09 (25.6)	9.17 (85.6)	4.17 (17.6)	4.90 (24.4)	6.43 (42.0)	66.7	11.1	0.38
SEm ±	0.742	0.418	0.724	0.502	0.473	0.438			
CD (P=0.05)	1.793	1.009	1.749	1.214	1.144	1.059			

*Figures in parentheses are original values; data were transformed through $\sqrt{vx + 0.5}$

all herbicide treatments in comparison to farmers' practice, however, individual application of 2, 4-D and isoproturon behaved similarly in terms of weed population and biomass. Prakash *et al.* (2008) also observed the same results in similar agro-climatic conditions.

Effect on wheat

Lesser weed-crop competition due to effective control of weeds (Table 1) in all herbicide treatments resulted in significant improvement in crop growth, yield attributes and grain yield of wheat in comparison to farmers' practice except with alone application of 2, 4-D (Table 2). It was because of 2, 4-D controls only broad-leaved weeds and other weeds offer competition to wheat. Among herbicide treatments, tank mix application of 2, 4-D and isoproturon produced significantly higher spikes/m² of wheat over other herbicide treatments due to lesser crop- weed competition (Chopra *et al.* 2008). However, wheat grain yield was not significantly affected within herbicide treatments. Tank mix application of 2, 4-D and isoproturon produced the highest

yield attributes which concurrently recorded the highest grain yield of wheat (12.5% higher over farmers' practice). Similarly application of 2, 4-D and isoproturon alone produced, 6.2% and 9.4% more grain yield of wheat over farmers practice (3.2 tonnes/ha). Grain yield of wheat had a significant negative correlation (0.51* to 0.99**) with weed parameters such as total weed population/m², total dry matter production (DMP) of weeds and N removal by the weeds, as well as a positive linear correlation with wheat DMP and N uptake (0.39 to 0.97**) (Table 4). Straw yield also showed same trend. Further, association between weeds, yield parameters and grain yield was also confirmed through correlation and regression studies by Ravisankar *et al.* (2008).

Economic returns

Due to higher crop yields and low cost of herbicides application over farmer's practice of expensive manual weeding, all herbicide treatments produced higher net returns and B: C ratios (Table 2). Tank mix application of 2, 4-D and isoproturon produced higher net return (₹ 19 030/ha) and

Table 2 Effect of weed control treatments on yield attributes, grain yield, economics and energetics of wheat (mean data of three years)

Treatment	Spikes/ m ²	Grains/ spike	Test weight (gm)	Grain yield* (tonnes/ha)	Net return (₹ /ha)	B: C ratio	Energy input (MJ/ha)	Energy output (MJ/ha)	Energy use efficiency	Net energy (MJ/ha)	Energy productivity (kg/MJ)	SYI
Unweeded control	167	42.6	34.6	2.7	9 650	0.42	8 202	102 940	12.5	94 738	0.33	0.68
2,4-D @ 1.0 kg ai/ha	188	47.6	37.4	3.4	16 980	0.71	8 852	124 730	14.1	115 878	0.38	0.88
Isoproturon @ 1.0 kg ai/ha	209	50.4	38.2	3.5	18 330	0.77	8 552	133 950	15.7	125 398	0.41	0.91
2,4-D @ 0.5 kg ai/ ha + Isoproturon @ 1.0 kg ai/ha	233	53.4	40.2	3.6	19 030	0.79	8 852	141 795	16.0	132 943	0.41	0.93
Farmers' practice (two hand weedings at 30 and 60 DAS)	185	46.6	36.6	3.2	13 250	0.52	8 988	111 790	12.4	102 802	0.36	0.82
SEm ±	5.8	1.76	0.73	0.10								
CD (P=0.05)	14	4.26	1.76	0.25								

* pooled data

Table 3 Effect of different weed control treatments in wheat on nutrient uptake by weeds and wheat (mean data of three years)

Treatment	Nutrient uptake by weeds (kg/ha)			Nutrient uptake by wheat (kg/ha)		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Unweeded control	15.6	3.9	26.1	57.0	8.1	51.5
2,4-D @ 1.0 kg ai/ha	6.2	1.5	9.4	67.7	10.3	56.9
Isoproturon @ 1.0 kg ai/ha	5.4	1.3	8.4	72.3	10.5	58.4
2,4-D @ 0.5 kg ai/ha + Isoproturon @ 1.0 kg ai/ha	3.9	0.9	6.2	73.5	11.6	60.0
Farmers' practice (two hand weedings at 30 and 60 DAS)	8.9	2.1	13.6	64.6	9.7	53.4
SEm ±	0.69	0.16	1.18	1.09	0.77	1.23
CD (P=0.05)	1.66	0.39	2.85	2.65	1.86	2.97

Table 4 Correlation and regression between grain yield and weed parameters in wheat (mean data of three years)

Y	X	Correlation coefficient (R ²) (n=25)	Regression equation
Grain yield (kg/ha)	Total weed population/m ²	0.509*	y = 29.36-6.745(x)
Grain yield (kg/ha)	Total weed DMP (g/m ²)	0.628**	y = 24.71-5.718(x)
Grain yield (kg/ha)	N removal by weed (kg/ha)	0.998**	y = 50.48-12.95(x)
Grain yield (kg/ha)	Wheat DMP (g/m ²)	0.391	y = 414.9+154.2(x)
Grain yield (kg/ha)	N uptake by wheat (kg/ha)	0.968**	y = 6.830+0.018(x)

DMP: Dry matter production

B:C ratio (0.79) which were ₹ 5 780 and 0.27 higher over farmers practice. This was mainly due to higher cost of cultivation (₹ 25 450) and poor weed control and grain yield in farmers practice. These findings are in confirmation with the findings of Prakash *et al.* (2008).

Energetics and sustainability

Highest energy output and sustainable yield index (SYI) was recorded under tank mix application of 2, 4-D and isoproturon (Table 2). Under farmers' practice, weeds were removed manually with sharp pointed *kutla* (a local intercultural small hand tool) and thus cover less area/unit time. To carry-out weeding operation in a hectare area, farmers' practice requires 475 more man-days than herbicides. Thus the energy requirement under the farmers' practice was higher than herbicide application. Energy output has direct relation with total biomass production and were highest with tank mix application of 2, 4-D and isoproturon and lower under unweeded control. Similarly, energy-use efficiency (EUE) was highest under this treatment (16.0), followed by isoproturon alone (15.7) and lowest under farmers practice (12.4). The higher EUE and energy productivity; and low energy requirement under weed management through herbicides may help in reducing women drudgery because most of farm operations in hills were carried out by women farmers. Higher energy output and use efficiency under improved weed management practices was also reported by Kumar *et al.* (2010).

Nutrient uptake by weeds and wheat

Unweeded control recorded the highest N, P and K by weeds (Table 3) mainly because of higher dry matter accumulation by weeds which enabled them to absorb more nutrients in this treatment. Tank mix application of 2, 4-D and isoproturon treatment recorded significantly the lowest N, P and K uptake by weeds over other treatments due to efficient control of weeds. However, individual applications of 2, 4-D and isoproturon being at par with each other recorded lower N, P and K uptake by weeds over farmers practice and unweeded control. Similar results were also reported by Kumar and Das (2008).

Similarly, N, P and K uptake by wheat (grain and straw) were significantly higher in treatment involving tank mix

application of 2, 4-D and isoproturon over farmers' practice because of greater weed control due to their lower density and dry weight of weeds and higher grain and straw yields (Table 3). The lower N, P and K uptake by weeds allowed wheat to grow more vigorously and accumulate more dry matter, which consequently led to higher uptake of these nutrients. Kumar *et al.* (2010) also reported that nitrogen uptake by grain and straw was inversely proportional to the nutrient depletion by weeds supports our finding on nutrient uptake by wheat and weeds.

It can be concluded from present investigation that buttercup (*Ranunculus*) and other associated weeds of irrigated wheat of valley areas of north- west Himalayan conditions can be effectively managed with tank mix spray of 2, 4-D + isoproturon (0.50+1.0 kg/ha) at 35–40 DAS. With this technology, drudgery reduction of about 475 man days/ha can be made possible, which can be used in other fruitful activities of hilly farmers' particularly women.

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REFERENCES

- Chopra N K, Chopra Nisha and Singh H P. 2008. Assessment of nutrient uptake by weeds and crop and its subsequent effect on grain quality in wheat (*Triticum aestivum*). *Indian Journal of Agricultural Sciences* **78** (6): 540–2.
- Connor H E. 1977. *The Poisonous Plants in New Zealand*, 247 pp. Wellington, Government Printer.
- Devasenapathy P, Senthilkumar G and Shanmugam P M. 2009. Energy management in crop production. *Indian Journal of Agronomy* **54** (1): 80–90.
- Dixit Anil and Singh V P. 2008. Efficacy of a ready mix application of carfentrazone plus isoproturon (affinity) to control weed in wheat (*Triticum aestivum*). *Indian Journal of Agricultural Sciences* **78** (6): 495–7.
- Kumar Mukesh and Das T K. 2008. Integrated weed management for system productivity and economics in soybean (*Glycine max*) – wheat (*Triticum aestivum*) system. *Indian Journal of Agronomy* **53** (3): 189–94.

- Kumar Mukesh, Das T K, and Yaduraju N T. 2012. An integrated approach for management of *Cyperus rotundus* (purple nutsedge) in soybean - wheat cropping system. *Crop Protection* **33**: 74–81.
- Kumar Narendra, Mina B L, Singh K P, Chandra S, Kumar Mukesh and Srivastva A K. 2010. Weed control for yield and profit maximization in wheat (*Triticum aestivum*) in Indian Himalayas. *Indian Journal of Agronomy* **55** (2): 119–22.
- Prakash Ved, Gopinath K A and Srivastva A K. 2008. Buttercup managed by herbicides in irrigated wheat of Utrakhand valleys. *Indian Farming* **58** (7): 15–6.
- Ravisankar N, Chandrasekaran B, Raja R, Din M and Ghosal Chaudhuri S. 2008. Influence of integrated weed management practices on productivity and profitability of wet- seeded rice (*Oryza sativa*). *Indian Journal of Agronomy* **53** (1): 57–61.