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Effect of irrigation, pre and post-emergence herbicides on *Chenopodium album* in wheat (*Triticum aestivum* L.)

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Abstract

A research experiment was conducted during *Rabi* 2017-18 and 2018-19 at Kanpur to study the effect of irrigation, pre and post-emergence herbicides on *Chenopodium album* in wheat under split-plot design with four replication having four irrigation schedule and eight factors of weed management. Results revealed that application of two irrigations at CRI and active tillering stage (I₁) significantly reduces the density of *C. album* and their fresh and dry weight with highest weed control efficiency (WCE) irrigation at CRI+ jointing+ booting+ flowering+ milking stage (I₄) and irrigation at CRI + active tillering + booting + flowering stage (I₃) and it was statistically at par with irrigation at CRI + jointing + booting (I₂). Among weed management practices, significantly the lowest density, fresh and dry weight of *C. album* and the highest WCE was recorded with the post-emergence application of broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) @ 100 g a.i. ha⁻¹ at 35 DAS as compared to other treatments. None of the weed management treatments as effective as hand at 20 and 40 DAS.

Keywords: irrigation, herbicides, absolute density, weed weight, WCE

Introduction

Wheat (*Triticum aestivum* L.) is an important winter crops of North-West India not only in terms of providing calories but also in terms of versatile adoption under wide range of agro climatic conditions [1]. In India wheat area under cultivation is about 29.32 m ha which produces 103.6 mt of wheat with a record average productivity of 3.53 t/ha during 2019-20 [2]. Uttar Pradesh is the major wheat growing state in India with an area of 9.75 m ha (32%), followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%) and Bihar (6.82%), respectively. However, a major expansion in wheat area was observed in the states such as Jharkhand (51%), Madhya Pradesh (27%) and Rajasthan (13%). Wheat production largely depends on adaptability to environmental conditions and agronomic practices. Timely supply of irrigation water and opting good weed management strategy required for booting wheat productivity [3].

Water is one of the most important factor which is necessary for proper growth and development of crop plants. Insufficient and improper application of irrigation water leads to drastic reduction in production and productivity of wheat. Proper growth and development of wheat needs sufficient soil moisture in the root zone. Extractable water capacity of soil has significant influence on grain yield and water productivity of wheat. The moisture content in the soil gradually decreases with time in dry season and simultaneously soil moisture tension increases. Excessive irrigation increases evapotranspiration and decreases water use efficiency and may also reduce grain yield [4, 5].

Among different production constraints, weeds pose serious threat to the productivity of wheat. It competes with crops for water, soil, nutrients, light, and space and thus reduces crop yields [4, 6] and remove considerable quantity of applied nutrients and water in absence of an effective control measures resulting greater loss in yield [7, 8]. Depending on the weed density and type of weed flora present, uncontrolled weeds throughout the crop period causes more than 50% reduction in grain yield [4, 9].

Wheat is infested with diverse weed flora, as it is grown in diverse agro-climatic conditions, under different cropping sequences, tillage and irrigation regimes [10, 11]. The crop rotations, tillage and herbicides have pronounced effect on the type of weed flora. Although *Chenopodium album* infests several winter season crops with prolific seed production, unsynchronous and early maturity and continuous shattering of seeds before harvesting of the

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crop have ensured heavy prevalence of this weed in wheat growing belts. Heavy infestation of this weed in wheat has become a serious problem there by hindering in increasing the productivity^[10, 12]. Herbicides play an important role for weed control in close spaced crops like wheat, where manual or mechanical weeding is difficult and costly^[13]. Technologies like use of herbicides coupled with cultural practices such as higher seed rate, mechanical weeding, mulching, time and number of irrigation etc. as a component of efficient weed management programme play a significant role in weed suppression, besides being economical and eco-friendly^[14, 15]. Keeping this in view, the present investigation was therefore, done with an objective to study the effect of irrigation methods, pre and post-emergence herbicides on *Chenopodium album* in wheat.

Materials and Methods

The field experiment was conducted during winter (rabi) season of 2012-13 at Students Instructional Farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. (U.P). It is situated at an elevation of 125.9 meter above mean sea level 26°20' 35" North latitude and 80°18'35" East longitude of Indo-Gangetic Plain in the Central part of Uttar Pradesh. The soil of experimental site is sandy loam, pH (7.1), low in OC (0.35%), available nitrogen (172.4 kg ha⁻¹), sulphur (15.7 kg ha⁻¹) and zinc (0.456 ppm), and medium in available phosphorus (12.8 kg ha⁻¹) and potassium (156.5 kg ha⁻¹). The experiment was laid out in Split Plot Design and replicated four times having 32 treatment combinations. The wheat variety 'K-9423' was sown at row distance of 22.5 cm by opening slits with seed-drill machine. Treatments consisted of four irrigation schedule viz. irrigation at CRI and active tillering stage (I₁), irrigation at CRI + jointing + booting (I₂), CRI + active tillering + booting + flowering stage (I₃) and irrigation at CRI + jointing + booting + flowering + milking stage (I₄) were assigned to main plots and weed management practices viz. W₁-weedy check, W₂-two hand weeding at 20 and 40 DAS, W₃-sulfosulfuron @25 g ha⁻¹ at 35 DAS, W₄-pendimethalin (pre-em) fb WCPL-15@400 g ha⁻¹ at 35 DAS, W₅-broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) @ 100 g a.i. ha⁻¹ at 35 DAS, W₆-halauxafen + penxasulam 23.5% @ 75 g a.i. ha⁻¹ at 35 DAS, W₇-halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS and W₈-clodinafop-propargyl 15% + metsulfuron 1% @ 400 g a.i. ha⁻¹ 35 DAS were allocated to sub plots. The experimental crop was sown in lines 22.5 cm a part using 100 kg ha⁻¹ seed by opening slits with seed-drill machine. All the plots were treated alike for inputs and agronomic practices except treatments.

The number of *C. album* enclosed within quadrat (0.25 m²) randomly thrown in each plot from three places were identified as well as counted and expressed as number m². Absolute density of *C. album* was calculated with the help of following formula:

$$\text{Absolute density (AD)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats employed}}$$

Fresh weight of weeds from each plot was taken and sun dried. After sun drying, samples were placed in the electric oven at 70 ± 5 °C for 48 hours for complete drying. The dry weight obtained was expressed in g m². Weed control efficiency was calculated at 60 and 90 DAS using following formula:

$$\text{W.C.E. (\%)} = \frac{\text{D.M.C} - \text{D.M.T.}}{\text{D.M.C.}} \times 100$$

Where, D.M.C. =Dry matter production of weeds per unit area in weedy check. D.M.T. = Dry matter production of weeds per unit area in the treatment to be compared. The recorded data was analysed by using analysis of variance technique Gomez and Gomez (1984) in computer based statistical programme. The means were compared at p ≤ 0.05 by using LSD test.

Results and Discussion

Density of *Chenopodium album*

The density of *C. album* was increased up to 60 DAS and thereafter a decreasing trend was noticed, irrespective of irrigation and the herbicides application (Table 1). It might be due to the fact that at later stages, growth of *C. album* ceased due to senescence and completion of life cycle that resulted in reduced density. The density of *C. album* were recorded under different irrigation was significantly reduced as compare to weedy check. Decrease in number of irrigation significantly decreased the population of *C. album*. The maximum density of *C. album* was recorded with the application of irrigation at CRI + jointing + booting + flowering + milking stage (I₄) followed by irrigation at irrigation at CRI + active tillering + booting + flowering stage (I₃), which facilitates an adequate growing environment to *C. album*. Irrigation at CRI and active tillering stage (I₁) was recorded minimum density of *C. album* as compared to other irrigation treatments. The increase in density of weeds at higher rate of irrigation resulted from the greater availability of moisture^[16]. Maximum density of weeds were observed under more number of irrigations, which facilitates an adequate growing environment to the weeds^[4] and reduction in the weed density under lower number of irrigation due is to inadequate supply of moisture^[7].

Among herbicidal treatments, application of roadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 g a.i. ha⁻¹ at 35 DAS caused significant reduction in *C. album* density than clodinafop-propargyl 15% + metsulfuron 1% 400 g a.i. ha⁻¹ at 35 DAS, pendimethalin (pre-em) fb WCPL-15 400 g ha⁻¹ at 35 DAS, halauxafen + penxasulam 23.5% 75 g a.i. ha⁻¹ at 35 DAS, sulfosulfuron 25 g ha⁻¹ at 35 DAS and halauxafen 1.21% w/w + fluroxypyr at 35 DAS, respectively^[4, 17]. Significantly lowest density of *C. album* was recorded with the post-emergence application of sulfosulfuron at 25 g ha⁻¹ + metsulfuron methyl at 4 g ha⁻¹ and clodinafop + metsulfuron-methyl 64 g ha⁻¹^[12].

Fresh and dry weight of *Chenopodium album*

The fresh and dry weight of *C. album* was increased up to 60 DAS and thereafter a decreasing trend was noticed (Table 2). The maximum fresh and dry weight of *C. album* was recorded with the application of irrigation at CRI + jointing + booting + flowering + milking stage (I₄) and it decreased significantly with decreased in the number of irrigations. Irrigation at CRI and active tillering stage (I₁) was recorded minimum fresh and dry weight of *C. album* as compared to other irrigation level. The increase in fresh and dry weight of *C. album* with more number of irrigation resulted from the greater availability of moisture throughout the crop growth period^[7, 16]. Reduction in the fresh and dry weight of *C. album* was observed under lower number of irrigation due to inadequate supply of moisture^[4].

Significant reduction in fresh and dry weight of *C. album* was observed with the post emergence application of broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 g a.i. ha⁻¹ at 35 DAS followed by reduction in fresh and dry weight of *C. album* with the application of clodinafop-propargyl 15% + metsulfuron 1% 400 g a.i. ha⁻¹ at 35 DAS, pendimethalin (pre-em) fb WCPL-15 400 g ha⁻¹ at 35 DAS, halauxafen + penxasulam 23.5% 75 g a.i. ha⁻¹ at 35 DAS, sulfosulfuron 25 g ha⁻¹ at 35 DAS and halauxafen 1.21% w/w + fluroxypyr at 35 DAS, respectively. None of the herbicidal treatments as effective as hand weeding at 20 and 40 DAS [17].

Control efficiency of *Chenopodium album*

Weed control efficiency (WCE) denotes the relative efficiency of weed control treatments compared to weedy check (Table 3). The highest weed control efficiency was recorded under application of irrigation at CRI and active

tillering stage (I₁) as compare to I₄ (irrigation at CRI + jointing + booting + flowering + milking), I₃ (irrigation at CRI + active tillering + booting + flowering) and I₂ (irrigation at CRI + jointing + booting), respectively. Reduction in the number of irrigation increases the weed control efficiency [4, 16].

Among herbicidal treatments, application of broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 g a.i. ha⁻¹ at 35 DAS was recorded the highest weed control efficiency of *C. album* followed by the WCE with clodinafop-propargyl 15% + metsulfuron 1% 400 g a.i. ha⁻¹ at 35 DAS. Highest weed control efficiency indicate its relative performance of particular set of treatment [4, 17]. However, hand weeding at 20 and 40 DAS (weed free) treatments proved superiority over herbicidal treatments. Highest WCE associated with hand weeding can be attributed to its effective control of all types of weeds [9, 14, 15].

Table 1: Effect of irrigation and herbicides on density of *Chenopodium album*

Treatments	Density (No. m ⁻²)				Absolute density of (No. m ⁻²)			
	2017-18		2018-19		2017-18		2018-19	
Irrigation schedule	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
I ₁ -Two irrigation (CRI+ active tillering)	10.50	9.14	8.66	8.51	3.50	3.05	2.89	2.50
I ₂ -Three irrigation(CRI+ jointing+ booting)	12.86	10.84	11.02	9.21	4.29	3.61	3.67	3.07
I ₃ - Four irrigation (CRI+ Active tillering+ booting+ flowering)	16.96	14.95	15.13	12.32	5.65	4.98	5.04	4.44
I ₄ -Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	18.38	16.37	16.55	14.74	6.13	5.46	5.52	4.91
LSD (P=0.05)	2.92	2.73	2.92	2.73	0.97	0.91	0.97	0.91
Weed management practices								
W ₁ -Weedy check	40.72	38.61	38.62	36.74	13.57	12.87	12.87	12.25
W ₂ - Two hand weeding (20 and 40 DAS)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W ₃ -Sulfosulfuron @25 g ha ⁻¹ at 35 DAS	15.71	13.60	13.61	11.73	5.24	4.53	4.54	3.91
W ₄ - Pendimethalin (pre-em) fb WCPL-15@400 g ha ⁻¹ at 35 DAS	12.68	10.57	10.58	8.70	4.23	3.52	3.53	2.90
W ₅ - Broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) @ 100 g a.i. ha ⁻¹ at 35 DAS	8.65	6.54	6.55	4.67	2.88	2.18	2.18	1.56
W ₆ - Halauxafen + penxasulam 23.5% @ 75 g a.i. ha ⁻¹ at 35 DAS	12.60	10.49	10.50	8.62	4.20	3.50	3.50	2.87
W ₇ - Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	15.96	13.84	13.86	11.97	5.32	4.61	4.62	3.99
W ₈ - Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g a.i. ha ⁻¹ 35 DAS	11.09	8.98	8.99	7.11	3.70	2.99	3.00	2.37
LSD (P=0.05)	4.15	4.02	4.02	3.92	1.38	1.34	1.34	1.31

Table 2: Effect of irrigation and herbicides on fresh and dry weight of *Chenopodium album*

Treatments	Fresh weight(g m ⁻²)				Dry weight (g m ⁻²)			
	2017-18		2018-19		2017-18		2018-19	
Irrigation schedule	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
I ₁ -Two irrigation (CRI+ active tillering)	10.26	8.84	9.44	8.22	2.78	2.12	2.21	1.54
I ₂ -Three irrigation(CRI+ jointing+ booting)	13.09	11.67	12.28	11.05	3.39	2.73	2.82	2.15
I ₃ - Four irrigation (CRI+ Active tillering+ booting+ flowering)	15.92	14.50	15.11	13.88	4.01	3.34	3.44	2.76
I ₄ -Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	17.06	15.64	16.24	15.02	4.25	3.59	3.68	3.01
LSD (P=0.05)	2.44	2.44	2.44	2.44	0.53	0.53	0.53	0.53
Weed management practices								
W ₁ -Weedy check	36.29	33.81	35.36	33.10	9.84	9.69	9.19	9.03
W ₂ - Two hand weeding (20 and 40 DAS)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W ₃ -Sulfosulfuron @25 g ha ⁻¹ at 35 DAS	14.70	13.22	13.77	12.51	3.84	2.98	3.19	2.32
W ₄ - Pendimethalin (pre-em) fb WCPL-15@400 g ha ⁻¹ at 35 DAS	12.61	11.13	11.68	10.42	3.39	2.53	2.74	1.87
W ₅ - Broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) @ 100 g a.i. ha ⁻¹ at 35 DAS	10.14	8.66	9.21	7.95	2.85	1.99	2.2	1.33
W ₆ - Halauxafen + penxasulam 23.5% @ 75 g a.i. ha ⁻¹ at 35 DAS	12.55	11.07	11.62	10.36	3.38	2.52	2.73	1.86
W ₇ - Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	14.87	13.39	13.94	12.68	3.88	3.02	3.23	2.36

W ₈ - Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g a.i. ha ⁻¹ 35 DAS	11.51	10.03	10.58	9.32	3.15	2.29	2.5	1.63
LSD (P=0.05)	3.59	3.38	3.53	3.33	1.08	1.09	1.03	1.04

Table 3: Effect of irrigation and herbicides on control efficiency of *Chenopodium album*

Treatments	Weed control efficiency (%)			
	2017-18		2018-19	
Irrigation schedule	60 DAS	90 DAS	60 DAS	90 DAS
I ₁ -Two irrigation (CRI+ active tillering)	71.7	78.1	76.0	82.9
I ₂ -Three irrigation (CRI+ jointing+ booting)	65.5	71.8	69.3	76.2
I ₃ - Four irrigation (CRI+ Active tillering+ booting+ flowering)	59.2	65.5	62.6	69.4
I ₄ -Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	56.8	63.0	60.0	66.7
Weed management practices				
W ₁ -Weedy check	0.0	0.0	0.0	0.0
W ₂ - Two hand weeding (20 and 40 DAS)	100.0	100.0	100.0	100.0
W ₃ -Sulfosulfuron @25 g ha ⁻¹ at 35 DAS	61.0	69.2	65.3	74.3
W ₄ - Pendimethalin (pre-em) fb WCPL-15@400 g ha ⁻¹ at 35 DAS	65.5	73.9	70.2	79.3
W ₅ - Broadway (carfentrazone ethyl 20% + sulfosulfuron 25% WG) @ 100 g a.i. ha ⁻¹ at 35 DAS	71.0	79.5	76.1	85.3
W ₆ - Halauxafen + penxasulam 23.5% @ 75 g a.i. ha ⁻¹ at 35 DAS	65.7	74.0	70.3	79.4
W ₇ - Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	60.6	68.8	64.9	73.9
W ₈ - Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g a.i. ha ⁻¹ 35 DAS	68.0	76.4	72.8	81.9

Conclusion

Looking into above discussion, it is concluded that application of two irrigation in wheat at CRI and active tillering stage (I₁) and post-emergence application of Broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 g a.i. ha⁻¹ at 35 DAS was the best options for managing *Chenopodium album* problem in central parts of Uttar Pradesh.

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