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Study on the Action of Herbicide Combinations with Varying Irrigation Regimes for Control of Grassy Weeds in Wheat (*Triticum aestivum* L.)

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Phalaris minor and *Cynodon dactylon* is the very problematic grassy weeds of wheat crop are responsible for significant yield reduction. Therefore, the present experiment was conducted at CSAUAT, Kanpur during *Rabi* season 2017-18 and 2018-19 in split-plot design with four replication having four irrigation regimes in main plot *viz*. irrigation at CRI and active tillering stage (I_1), irrigation at CRI + jointing + booting (I_2), CRI + active tillering + booting + flowering stage (I_3) and irrigation at CRI + jointing + booting + flowering + milking stage (I_4), and eight factors of weed management (W_1-weedy check, W_2-two hand weeding at 20 and 40 days after sowing (DAS), W_3-sulfosulfuron 25 gha^{-1}at 35 DAS, W_4- pendimethalin (pre-em) *fb* WCPL-15, 400 gha^{-1}at 35 DAS, W_5- broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) 100 gha^{-1}at 35 DAS, W_6-halauxafen + penxasulam 23.5%, 75 gha^{-1}at 35 DAS, W_7- halauxafen - methyl 1.21% w/w + fluroxypyr at 35 DAS and W_8- clodinafop- propargyl 15% + metsulfuron 1%, 400 gha^{-1}35 DAS) were allocated to sub plots for assessing the effect of these treatments on grassy weeds. Irrigations at crown root initiation (CRI) and active tillering stage (I_1) significantly reduce the density and weight of grassy weeds with highest WCE and crop resistance index (CRI) over other irrigation regimes. However, I_4 irrigation recorded highest weed effectiveness (WE) and crop dry matter yield (CDMY) followed by I_3. All the weed management options are significantly superior over weedy check. Among herbicidal treatments, lowest weed density and their weight, WE and the highest

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WCE, CRI, WPI and CDMY was recorded with the application of broadway (W_5) followed by W_8. Reducing irrigation frequency and the post emergence application of broadway are the best option for managing grassy weeds in wheat, but for higher CDMY more number of irrigations required.

Keywords: CRI; irrigation; herbicides; WCE; WPI; WE; wheat.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) contributes significantly to the world's agricultural economy by occupying about 220Mha of arable land, more than any other cultivated food crop, with grain production of 764.4 million tons with the average productivity of 3.53 t/ha during 2019-20 [1]. Sustainable wheat production is critical to meet global food security as the arableland area for cropping is decreasing [2,3]. Weed infestation andinterference during critical growth stages of wheat is amajor impediment and threat to wheat production across theglobe [4]. The use of herbicides to kill weeds of wheat crop in modern agriculture is of particular importance. Getting high yield is unthinkable without use of herbicides [5,6]. The large number of herbicides registered for weed control with different spectrum of action requires a study on their efficacy, the sensitivity of crops to them, to offer the most effective scheme for chemical control of weeds under certain climatic conditions [4,7]. However, repeated use and dependence on single herbicides having same mode and mechanism of action for weed management led to selection pressure and thus, the evolution of herbicide-resistant and shift of weed flora [8,9]. Wheat ranks first, reporteda total of 77weed species with 140 unique herbicide resistance cases globally [10].

The most common and economically troublesome grassy weeds in wheat include *Phalaris minor* (little seed canary grass), *Avena ludoviciana* (wild oats) and *Cynodon dactylon* Bermuda grass [11-13]. Thus, the heavy infestation these weed flora in wheat has become a serious problem in increasing the productivity [14,15]. Whenweeds are left uncontrolled yield losses in wheat range from 10%to 50% depending on the weed density and duration ofinterference [16]. Application of herbicides to control weedshas been very effective and efficient in terms of production costsand benefits [17]. Few herbicides such as sulfosulfuron, metsulfuron, fenoxaprop, iodosulfuron, mesosulfuron, pinoxadim and clodinafop have shown their high efficacy against weeds in wheat. At present, some herbicides molecules (ready mixed combination) having its very high potency at lower doses to kill grassy along with other weeds have been developed [15]. These molecules may be more effective to control various weed species as well as relatively safer for environmental pollution point of view. This was routes testing of new molecules and their mixtures to develop an alternative of existing recommendation for weed control in wheat crop [14]. Both poor irrigation schedule [9,18] and improper weed management are the major causes of yield reduction in wheat [2]. The judicious application of water need immediate attention and this is possible only by application of water to the crop with efficient water practices [19]. The number of approaches has been investigated for scheduling irrigation in wheat; however, irrigation based on critical stages approach has been most widely accepted. Therefore, research efforts are urgently needed to develop and promote new technologies to enhance the herbicide efficiency and productivity of water and its judicious use [8,15]. Hence, there is a need to find out the suitable irrigation regime and herbicide combination to tackle the grassy weed problem in wheat. Keeping above facts in mind the present study was carried out the action of herbicide combinations with varying irrigation regimes for control of grassy weeds in wheat.

2. MATERIALS AND METHODS

To evaluate the effect of irrigation regimes and combined use of herbicides on existence of grassy weeds and crop dry matter yield of wheat crop, this investigation was conducted during Rabi season 2017-18 and 2018-19 at Students Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P).

2.1 Experimental Site

The experimental farm is situated between Latitudes 26º 20′′ and 26º 35′ N and Longitudes 80º 18′ and 80º 35′ E and having an altitude of 125.9 m above sea level. Kanpur's climate is classified as warm and semi-arid. The soil of experimental field was sandy loam (Inceptisols) shallow, flat, well drained and moderately fertile, being low in available organic carbon (0.35%), available nitrogen (172.4 kg ha^{-1}), sulphur (15.7 kg ha^{-1}) and zinc (1.02 kg ha^{-1}, and medium in available phosphorus (12.8 kg ha^{-1}) and potassium (156.5 kg ha^{-1}). A composite sample from each plot, 0- 30 cm of soil depth, was collected and analyzed before sowing.

2.2 Experimental Treatments Details

The experiment was laid out in Split Plot Design and replicated four times having 32 treatment combinations. Treatments consisted of four irrigation schedule *viz*. irrigation at CRI and active tillering stage (I_1), irrigation at CRI + jointing + booting (I_2), CRI + active tillering + booting + flowering stage (I_3) and irrigation at CRI + jointing + booting + flowering + milking stage (I_4) were assigned to main plots and weed management practices *viz*. W_1-weedy check, W_2-two hand weeding at 20 and 40 DAS, W_3-sulfosulfuron 25 gha^{-1}at 35 DAS, W_4-pendimethalin (pre-em) *fb* WCPL-15, 400 gha^{-1}at 35 DAS, W_5- broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) 100 gha^{-1}at 35 DAS, W_6- halauxafen + penxasulam 23.5%, 75 gha^{-1}at 35 DAS, W_7- halauxafen - methyl 1.21% w/w + fluroxypyr at 35 DAS and W_8- clodinafop-propargyl 15% + metsulfuron 1%, 400 gha^{-1}35 DAS were allocated to sub plots.

2.3 Agronomic Practices

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 herbicides were applied as per the treatments with the help of foot sprayer fitted with flat fan nozzle. The spray volume was 500 litres water/ha. Half amount of nitrogen and full dose of phosphorus and potash were applied as basal at the time of sowing, ¼ part of nitrogen was top dressed after first irrigation and remaining ¼ part of nitrogen was top dress at spike initiation stage. The nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and murate of potash, respectively. All the agronomic practices were done for the success of crop.

2.4 Observations Recorded

2.4.1 Weed density

An area of 0.25 m^2 was selected randomly at three spots by throughing a quadrate of 0.5x0.5m^2, weed species were counted from that area, and density (No.m^{-2}) was taken at 60 and 90 DAS.

2.4.2 Absolute density

Absolute density of grassy weedswas calculated with the help of formula 1:

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

(Formula 1)

The grassy weeds inside the quadrate were counted and the average of three quadrates was taken. The actual values were subjected to square root transformation $\sqrt{(x+1)}$ for analysis (Fisher and Yates 1947). The grassy weeds present within the quadrate from each plot were taken for fresh and dry matter accumulation. These samples were first dried under the sun for two days at 22.4-23.3°C and 22.9-23.1°C temperature during 2017-18 and 2018-19, respectively and then kept in oven at 70±5°C until a constant weight was achieved by Gravimetric method. The dried samples were weighed and the final dry weight of grassy weedswas expressed as gm^{-2}.

2.4.3 Weed control efficiency

WCE was calculated at 30, 60 and 90 DAS using formula 2:

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

(Formula 2)

Where, D.M.C. =Dry matter production of grassy weeds per unit area in weedy check. D.M.T. = Dry matter production of grassy weeds per unit area in the treatment to be compared.

2.4.4 Crop resistance index (CRI)

It gives the relationship between a proportionate increase in crop biomass and a proportionate decrease in weed biomass in the treated plots. CRI of grassy weeds are calculated using formula 3:

$$\text{CRI} = \frac{\text{Dry matter production by the crop in treated plot}}{\text{dry matter production by the crop in control plot}} \times \frac{\text{Dry matter production of weed in control plot}}{\text{Dry matter production of weed in treated plot}}$$

(Formula 3)

2.4.5 Weed persistence index

Weed persistence index are calculated by using formula 4:

$$WMI= \frac{\text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in control plot}} X \frac{\text{Weed density in control plot}}{\text{Weed density in treated plot}} \quad \text{(Formula 4)}$$

2.4.6 Weed effectiveness (%)

Grassy weed effectiveness calculated by using the formula 5 as suggested by U.S.D.A/I.C.A.R. A.I.C.R.P.W.C. (1988). It refers to the number of weed in treatment plot to the number of weeds in weedy plot.

$$\text{Weed effectiveness (\%)} = \frac{\text{Number of weed in treatment plot}}{\text{Number of weed in weedy plot}} \times 100 \quad \text{(Formula 5)}$$

2.4.7 Crop dry matter yield (kg ha^{-1})

After complete sun drying, harvested produce of each net plot were weighed for biological yield and converted in terms of kg ha^{-1}.

2.5 Statistical Analysis Applied

For statistical analysis “Analysis of variance” technique was applied to the data recorded for each character. Overall differences were tested by “F” test of significance at 5% level of significance as suggested by Fisher and Yates (1947). Critical differences at 5% level of probability were worked out for comparing the treatments.

3. RESULTS AND DISCUSSION

3.1 Effect on Density of Grassy Weeds

On an average of two years, *Cynodon dactylon* and *Phalaris minor*was recorded dominant grassy weeds under weedy check. This can be discussed in light of the fact that the experimental field was under continuous blackgram-wheat, toria-wheat and rice-wheat sequence during previous years resulting in uniform distribution of weed seeds over entire area of experiment [3,8]. Singh et al. [15] was also observed similar association of these weed species with wheat crop.

The total and absolute density of grassy weedswas 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 grassy weeds ceased due to senescence and completion of life cycle that resulted in reduced density. The density of grassy weeds was recorded under different irrigation regimes and herbicides were significantly reduced as compare to weedy check. Decrease in number of irrigation significantly decreased the population of grassy weeds. Among irrigation regimes, significantly the highest density of grassy weeds were recorded with application of irrigation at CRI + jointing + booting + flowering + milking stage (I_4) *fb* same was with irrigation at irrigation at CRI + active tillering + booting + flowering stage (I_3), which facilitates an adequate growing environment to weeds. The increase in density of weed at higher rate of irrigation resulted from the greater availability of moisture [2,9,18]. Decrease in the number of irrigation significantly decreased the density of grassy weeds. Application of irrigation at CRI and active tillering stage (I_1) was recorded significantly lowest density of grassy weedsas compared to other irrigation treatments. The decrease in weed density at lower rate of irrigation was the result of inadequate supply of soil moisture [18].

Weed management practices significantly reduced the population of *Phalaris minor* and *Cynodon dactylon* as compared to weedy check. Application of broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 gha^{-1} at 35 DAS were significantly at par withclodinafop-propagyl 15% + metsulfuron 1% 400 gha^{-1}at 35 DAS, which recorded the lowest weed density of these grassy weedsas compared to rest of the herbicidal treatments. Sequential application of pendimethalin (pre-em) *fb* WCPL-15 400 gha^{-1}at 35 DAS; and the combined application halauxafen + penxasulam 23.5 % 75 gha^{-1}at 35 DAS and halauxafen 1.21% w/w + fluroxpyr at 35 DAS significantly superior over weedy check. However, alone application sulfosulfuron 25 gha^{-1}at 35 DAS significantly superior over weedy check but found to be least effective against these grassy weeds as compared to mix application of the herbicide treatments. Excellent control of complex weed flora in wheat was achieved with the combined (tank mix or ready mix) application of herbicides as compare to their alone application [3,17]. However, hand weedingsat 20 and 40 DAS (weed free) was found more effective than the herbicidal treatments, due to slowpace of growth of first flush of weeds at 20 days after sowing thereafter the emergence of new flushes of weeds could not attain full growth under the shade of crop plants [2,9]. The results are close conformity with the research findings of Singh et al. [3]. He was reported the superiority of hand weeding over among the herbicidal treatments.

3.2 Fresh and Dry Weighty of Grassy Weeds

The fresh and dry weight of grassy weeds were recorded under different irrigation was significantly reduced as compare to weedy check (Table 1). The maximum fresh and dry weight of grassy weeds was recorded with the application of irrigation at CRI + jointing + booting + flowering + milking stage (I_4) followed by irrigation at irrigation at CRI + active tillering + booting + flowering stage (I_3), which facilitates an adequate growing environment to grassy weeds. Irrigation at CRI and active tillering stage (I_1) was recorded significantly the lowest fresh and dry weight of grassy weeds as compared to other irrigation treatments. Results are close conformity with the results of Verma et al. [2,11,18] who observed that, more number of irrigations facilitates adequate growing environment to the weeds. Reduction in the fresh and dry weight of grassy weeds was observed under lower number of irrigation due to inadequate supply of moisture [9].

All the weed control treatments significantly reduced fresh and dry weight of grassy weeds as compared to weedy check at 60 and 90 DAS. It was observed that the combined application of post-emergence herbicide treatments had significant advantage over alone post-emergence herbicide and sequential herbicide treatments in controlling grassy weeds. The lowest fresh and dry weight of grassy weeds was observed with broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 gha^{-1}at 35 DAS fb clodinafop- propagyl 15% + metsulfuron 1% 400 gha^{-1}at 35 DAS, pendimethalin (pre-em) *fb* WCPL-15 400 gha^{-1}at 35 DAS, halauxafen + penxasulam 23.5% 75 gha^{-1}at 35 DAS, sulfosulfuron 25 gha^{-1}at 35 DAS and halauxafen 1.21% w/w + fluroxpyr at 35 DAS, respectively. All the herbicide treatments significantly decreased the fresh and dry weight of grassy weeds [4,15,17]. None of the herbicidal treatments as effective as hand weeding at 20 and 40 DAS [11,12]. Singh et al. [3] reported the superiority of hand weeding over herbicidal treatments.

3.3 Weed Control Efficiency (WCE)

Irrigation at CRI and active tillering stage (I_1) was recorded highest WCEof grassy weedsas compare to I_4 (irrigation at CRI + jointing + booting + flowering + milking), I_3 (irrigation at CRI + active tillering + booting + flowering) and I_2 (irrigation at CRI + jointing + booting), respectively (Table 2). Reduction in the number of irrigation increases the weed control efficiency [2,9,18].

Among herbicidal treatments, application of broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 gha^{-1}at 35 DAS was recorded the highest weed control efficiency of grassy weeds*fb* the WCE with clodinafop- propagyl 15% + metsulfuron 1% 400 gha^{-1}at 35 DAS. Among herbicidal treatments, the lowest weed control efficiency was recorded in plots treated with sulfosulfuron 25 gha^{-1}at 35 DAS followed by sequential application of pendimethalin (pre-em) *fb* WCPL-15 400 gha^{-1}at 35 DAS. Highest weed control efficiency indicate its relative performance of particular set of treatment [4,7,18]. However, hand weeding at 20 and 40 DAS (weed free) treatments proved superiority over herbicidal treatments [3,5,13].

3.4 Weed Indices

The maximum crop resistance index of grassy weeds was recorded with irrigation at CRI+ active tillering stage over other irrigation schedule (Table 2). Whereas, weed persistence index and weed effectiveness index was the highest with the application of irrigation at CRI + jointing + booting + flowering + milking stage (I_4) and these were reduced with decreased in the number of irrigations.

Among herbicidal treatments, application of broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 gha^{-1}at 35 DAS was recorded maximum crop resistance index weed persistence index and the lowest weed effectiveness percentage as compared to clodinafop- propagyl 15% + metsulfuron 1% 400 gha^{-1}at 35 DAS, pendimethalin (pre-em) *fb*

Table 1. Effect of irrigation and herbicides on density, fresh and dry weight of grassy weeds (pooled data of two years)

Treatments	Density (No. m^{-2})		Absolute density (No. m^{-2})		Fresh weight (g/m^2)		Dry weight (g/m^2)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
Irrigation schedule								
I_1-Two irrigation (CRI+ active tillering)	26.89 (5.28)	22.83 (4.88)	8.96 (3.16)	7.61 (2.93)	27.59 (5.35)	21.36 (4.73)	8.65 (3.11)	8.32 (3.05)
I_2-Three irrigation(CRI+ jointing+ booting)	28.09 (5.39)	24.90 (5.09)	9.36 (3.22)	8.30 (3.05)	33.02 (5.83)	26.80 (5.27)	10.09 (3.33)	9.17 (3.19)
I_3- Four irrigation (CRI+ Active tillering+ booting+ flowering)	35.09 (6.01)	31.91 (5.74)	11.70 (3.56)	10.64 (3.41)	38.46 (6.28)	32.24 (5.76)	11.93 (3.60)	11.02 (3.47)
I_4-Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	37.82 (6.23)	33.53 (5.88)	12.61 (3.69)	11.18 (3.49)	40.63 (6.45)	34.41 (5.95)	12.67 (3.70)	11.76 (3.57)
CD (P=0.05)	0.10	0.18	0.05	0.11	0.46	0.49	0.20	0.13
Weed management practices								
W_1-Weedy check	76.63 (8.81)	70.96 (8.48)	25.55 (5.15)	23.66 (4.97)	64.37 (8.09)	56.99 (7.61)	29.50 (5.52)	29.12 (5.49)
W_2- Two hand weeding (20 and 40 DAS)	0.00 (0.67)	0.00 (0.67)	0.00 (0.67)	0.00 (0.67)	0.00 (0.67)	0.00 (0.67)	0.00 (0.67)	0.00 (0.67)
W_3-Sulfosulfuron @25 g ha^{-1} at 35 DAS	35.81 (6.07)	31.51 (5.70)	11.94 (3.60)	10.51 (3.39)	39.61 (6.37)	32.55 (5.79)	11.02 (3.47)	9.78 (3.28)
W_4- Pendimethalin (pre-em) *fb* WCPL-15@400 g ha^{-1} at 35 DAS	30.00 (5.57)	25.70 (5.17)	10.00 (3.32)	8.57 (3.09)	35.60 (6.05)	28.54 (5.43)	9.46 (3.23)	8.32 (3.05)
W_5-Broadway (carfentrazone ethyl 20%+ sulfosulfuron 25%WG) @ 100 g *a.i.* ha^{-1}at 35 DAS	21.27 (4.72)	17.97 (4.36)	7.09 (2.84)	5.99 (2.64)	30.86 (5.64)	23.80 (4.98)	7.85 (2.97)	7.71 (2.95)
W_6- Halauxafen + penxasulam 23.5% @ 75 g *a.i.* ha^{-1} at 35 DAS	29.84 (5.55)	25.54 (5.15)	9.95 (3.31)	8.52 (3.08)	35.49 (6.04)	28.43 (5.42)	9.42 (3.23)	8.28 (3.05)
W_7- Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	36.28 (6.11)	31.98 (5.74)	12.10 (3.62)	10.66 (3.41)	39.93 (6.40)	32.87 (5.82)	10.73 (3.42)	9.69 (3.27)
W_8- Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g *a.i.* ha^{-1} 35 DAS	25.94 (5.19)	22.64 (4.86)	8.65 (3.11)	7.55 (2.92)	33.49 (5.87)	26.43 (5.24)	8.74 (3.12)	7.60 (2.93)
CD (P=0.05)	0.07	0.14	0.03	0.06	0.21	0.22	0.09	0.06

Table 2. Effect of irrigation and herbicides on indices of grassy weeds and yield of wheat (pooled data of two years)

Treatments	**WCE (%)**		**Crop resistance index**		**Weed persistence index**		**Weed effectiveness (%)**		**Crop dry matter yield (kgha^{-1})**
	60 DAS	**90 DAS**	**60 DAS**	**90 DAS**	**60 DAS**	**90 DAS**	**60 DAS**	**90 DAS**	
Irrigation schedule									
I_1-Two irrigation (CRI+ active tillering)	70.7	71.4	3.69	3.78	0.84	0.89	35.09	32.17	6233
I_2-Three irrigation(CRI+ jointing+ booting)	65.8	68.5	3.31	3.60	0.93	0.90	36.66	35.08	6529
I_3- Four irrigation (CRI+ Active tillering+ booting+ flowering)	59.6	62.2	2.88	3.08	0.88	0.84	45.79	44.96	6722
I_4-Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	57.1	59.6	2.79	2.96	0.87	0.85	49.35	47.24	6899
CD (P=0.05)	-	-	-	-	-	-	-	-	231
Weed management practices									
W_1-Weedy check	-	-	-	-	-	-	-	-	5766
W_2- Two hand weeding (20 and 40 DAS)	100.0	100.0	-	-	-	-	-	-	7532
W_3-Sulfosulfuron @25 g ha^{-1} at 35 DAS	62.6	66.4	2.97	3.30	0.80	0.76	46.73	44.41	6400
W_4- Pendimethalin (pre-em) *fb* WCPL-15@400 g ha^{-1} at 35 DAS	67.9	71.4	3.52	3.95	0.82	0.79	39.15	36.22	6503
W_5- Broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) @ 100 g *a.i.* ha^{-1}at 35 DAS	73.4	73.5	4.57	4.59	0.96	1.05	27.76	25.32	7007
W_6- Halauxafen + penxasulam 23.5% @ 75 g *a.i.* ha^{-1} at 35 DAS	68.1	71.6	3.58	4.02	0.82	0.79	38.94	35.99	6581
W_7- Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	63.6	66.7	2.95	3.22	0.77	0.74	47.34	45.07	6181
W_8- Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g *a.i.* ha^{-1} 35 DAS	70.4	73.9	3.98	4.52	0.87	0.82	33.85	31.91	6798
CD (P=0.05)	-	-	-	-	-	-	-	-	196

WCPL-15 400 gha^{-1}at 35 DAS, halauxafen + penxasulam 23.5% 75 gha^{-1}at 35 DAS, halauxafen 1.21% w/w + fluroxpyr at 35 DA and sulfosulfuron 25 gha^{-1}at 35 DAS, respectively [17,18].

3.5 Crop Dry Matter Yield

Irrigation schedule showed significant influence on dry matter yield of wheat (Table 2). Irrigation at CRI + jointing + booting + flowering + milking stage (I_4) was recorded significantly the highest dry matter yield than I_1 and I_2 and it was statistically at par with I_3. These results are further indicating that the increase yields in I_4 and I_3 treatment was due to better soil moisture availability than I_2 and I_1 treatment. The better development of crop under irrigated treatments was a result of better soil moisture availability, which maintained the internal water balance of the plants [18,19,20].

All the herbicidal treatments gave significantly higher dry matter yield as compared to weedy check. Application of broadway (carfentrazone-ethyl 20% + sulfosulfuron 25% WG) 100 gha^{-1}at 35 DAS was recorded maximum dry matter yield *fb* clodinafop- propagyl 15% + metsulfuron 1% 400 gha^{-1}at 35 DAS, pendimethalin (pre-em) *fb* WCPL-15 400 gha^{-1}at 35 DAS, halauxafen + penxasulam 23.5% 75 gha^{-1}at 35 DAS, sulfosulfuron 25 gha^{-1}at 35 DAS and halauxafen 1.21% w/w + fluroxpyr at 35 DAS, respectively. None of the herbicidal treatment as effective as hand weeding at 20 and 40 DAS, which recorded significantly maximum dry matter yield of wheat [9,15].

4. CONCLUSION

Based on the above results it can conclude that irrigation at CRI and active tillering stage (I_1) significantly reduces the grassy weed density and their weight with highest WCE and CRI however, maximum WE and CDMY was achieved with I_4 irrigation. Among weed management treatments, application of broadway (carfentrazone- ethyl 20% + sulfosulfuron 25% WG) 100 gha^{-1}at 35 DAS (W_5) was recorded lowest weed density and their weight, WE and the highest WCE, CRI, WPI and CDMY of wheat followed by W_8.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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