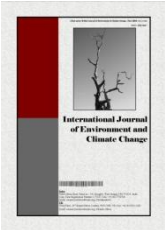

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Effect of Irrigation and Herbicides on Most Tenacious Weed *Cyperus rotundus* in Wheat

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Author's contribution

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

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ABSTRACT

To manage the *Cyperus rotundus* (Purple nut sedge.) is a troublesome, economically damaging weed, widely naturalized in the tropical and subtropical regions of the world. A field experiment was done at Students Instructional Farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P).The study was conducted to investigate the competitive effects of *C. rotundus* in wheat (*Triticum aestivum* L.) under varying irrigation regimes and herbicides in field conditions at Kanpur during *Rabi* 2017-18 and 2018-19 in a split plot design. The experiment was laid out in split-plot design with 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 g/ha , W_4- pendimethalin (pre emergence) *fb*WCPL-15(clodinafop-propargyl 15 %) @400 g/ha , W_5- carfentrazone ethyl 20% + sulfosulfuron 25%WG @ 100 g/ha , W_6- halauxafen + penxasulam 23.5% @ 75 g/ha , W_7- halauxafen - methyl 1.21% w/w + fluroxypyr @ and W_8- clodinafop- propargyl 15% + metsulfuron 1% @ 400 g/ha were allocated to sub plots. Application of two irrigations at CRI and active tillering stage (I_1) significantly reduced the density of *C. rotundus* and their fresh and dry weight with highest weed control efficiency (WCE) over irrigation at CRI+ jointing+ booting+ flowering+ milking stage (I_4), irrigation at CRI + active tillering + booting + flowering stage (I_3) and irrigation at CRI + jointing + booting (I_2). However, maximum yield was recorded with the application of five irrigation at CRI+ jointing+ booting+ flowering+

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milking stage (I_4). Among herbicidal treatments, lowest density, fresh and dry weight of *C. rotundus* with the highest WCE resulted in higher yield of wheat was recorded with the application of carfentrazone ethyl 20% + sulfosulfuron 25%WG as post emergence (35 DAS) at 100 g/ha as compared to other treatments. However, none of the herbicidal treatments as effective as hand weeding twice at 20 and 40 DAS.

Keywords: Absolute density; irrigation; herbicides; C. rotundus; WCE; wheat.

1. INTRODUCTION

The major difficulty in efforts to increase wheat production in India is the lack of applying appropriate agronomic practices [1]. Profitable wheat production can be done in the country by employing good agronomic practices. Out of all management practice used for wheat production, weed management are on the top because weeds can be highly competitive with wheat crop. Many weed species infested wheat crop, among them *Cyperus rotundus* (purple nut sedge) has been described as the world's most noxious and persistent colony forming weed, adversely affecting agro-ecosystems in the various regions of the world. *C. rotundus* indigenous to the Indian subcontinent, its rhizomes and tubers have been traditionally utilized as a home remedy for the treatment of various medical disorders [2]. However, with time, *C. rotundus* has changed status from a precious Ayurvedic plant to become the most widespread, troublesome, and economically damaging weed of tropical and subtropical countries. It is currently counted among the world's most dominant weeds, infesting multiple crops. This weed caused 20-90% yield losses in various crops [3] and lower down the quality of produce [4]. Therefore, management of *C. rotundus* is considered as major factor of crop production system.

Due to industrialization, labour constraints at peak, small family size and under specific situations where weeds are very difficult to be removed manually, the herbicide use becomes inevitable [5] and [6]. Conventional method of physical weed control in wheat is time consuming and labour intensive. However, the additional benefits of providing greater aeration, improving root growth enabling greater absorption of moisture and nutrients from deeper soil layers and moisture conservation cannot be ignored. The chemical control of weeds is cost effective and easy compared to manual weeding [4]. Herbicides form potent tool to check the mixed flora of weeds in close row crops like wheat where manual or mechanical weeding is difficult and certain weeds show mimicry at early growth stage [7]. These necessitate evolving a strategy to screen out more herbicides to control *C. rotundus* weed in the wheat fields. Because, *C. rotundus* is highly competitive and adversely affect the yield of wheat crop. Keeping in view the above facts and paucity of research on above aspects the present investigation was carried out to evaluate the effect of irrigation and herbicides on *C. rotundus in wheat*.

2. MATERIALS AND METHODS

The field experiment was conducted during *Rabi* season of 2017-18 and 2018-19 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 26º20" 35" North latitude and 80º18'35" 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) and potassium (156.5 kg ha^{-1}). The experiment was laid out in Split Plot Design with four replication having 32 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 g/ha , W_4-pendimethalin (pre emergence) *fb*WCPL-15(clodinafop- propargyl 15 %) @400 g/ha , W_5-carfentrazone ethyl 20% + sulfosulfuron 25%WG @ 100 g/ha , W_6- halauxafen + penxasulam 23.5% @ 75 g/ha , W_7- halauxafen - methyl 1.21% w/w + fluroxypyr @ and W_8- clodinafop-propargyl 15% + metsulfuron 1% @ 400 g/ha were allocated to sub plots. Herbicides were applied as post emergence (35 DAS) except pendimethalin. The wheat variety 'K-9423' was

sown at row distance of 22.5 cm by opening slits with seed-drill machine. The experimental crop was sown in lines 22.5 cm apart using 100 kg/ha seed by opening slits with seed-drill machine. All the plots were treated alike for inputs and agronomic practices except treatments. The density of *C. rotundus*was determined by quadrate method. The quadrate (0.25 m^2) was thrown randomly at three places in each plot at 60 and 90 DAS. Absolute density of *C. rotundus* was calculated with the help of following formula [8]:

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

The *C. rotundus* inside the quadrate was counted and the average of three quadrates was taken. The *C. rotundus* present within the quadrate from each plot were taken for fresh and dry matter accumulation. These samples were first sun dried and then kept in oven at 70±5^{0}C until a constant weight was achieved. The dried samples were weighed and the final dry weight of *C. rotundus* was expressed as g m^{-2}. Weed control efficiency was calculated at 60 and 90 DAS using following formula [2]:

$$\text{WCE (\%)} = \frac{\text{D.M.C- D.M.T.}}{\text{D.M.C.}} \text{X } 100$$

Where, D.M.C. =Dry matter production of *C. rotundus* per unit area in weedy check. D.M.T. = Dry matter production of *C. rotundus* per unit area in the treated plot. All the recorded data was statistically analyzed to judge significant differences between means of two treatments.

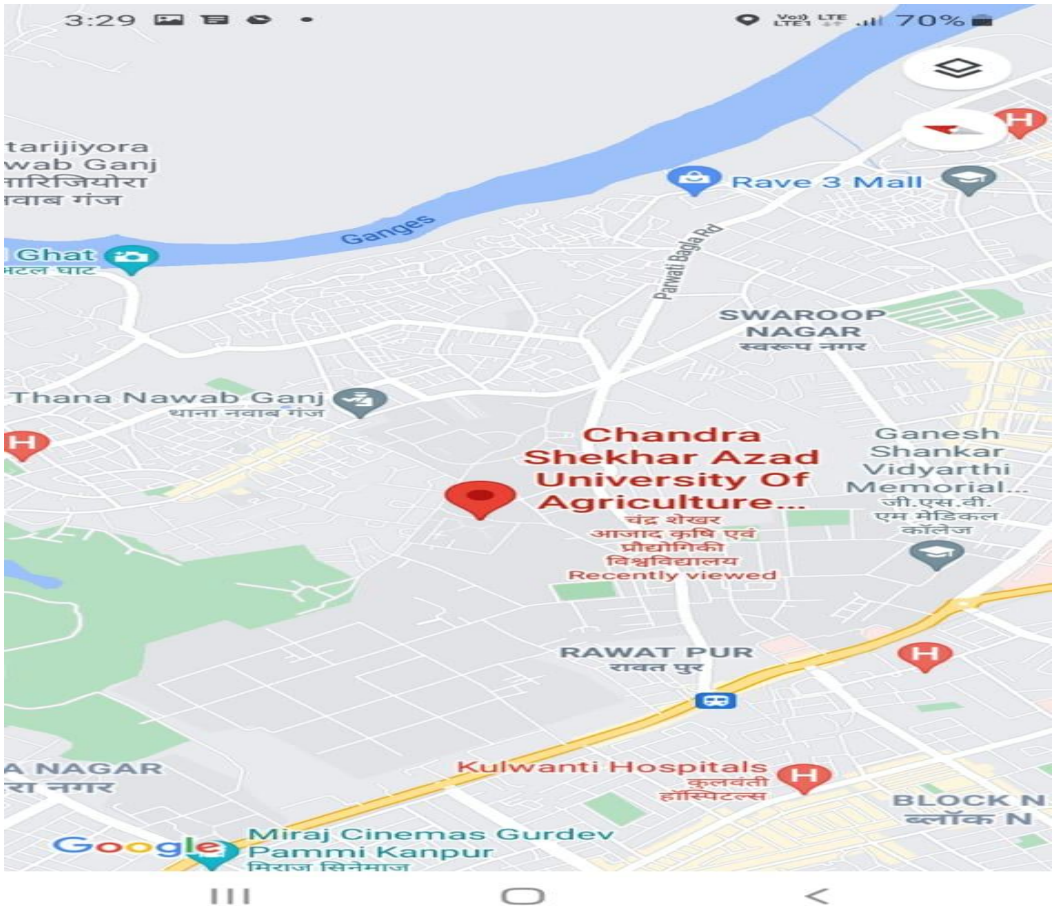

Fig. 1.

3. RESULTS AND DISCUSSION

3.1 Effect on Density and Weight of *C. rotundus*

The total and absolute density, fresh and dry weight of *C. rotundus* was increased up to 60 DAS and thereafter a decreasing trend was noticed, irrespective of irrigation and the herbicides application **(**Table 1 and 2**)**. It might be due to the fact that at later stages, growth of *C. rotundus* ceased due to senescence and completion of life cycle that resulted in reduced density, fresh and dry weight. The density, fresh and dry weight of *C. rotundus* were recorded under different irrigation was significantly reduced as compare to weedy check. Decrease in number of irrigation significantly decreased the population and weight of *C. rotundus.* The maximum density, fresh and dry weight of *C. rotundus* 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 *C. rotundus*. Irrigation at CRI and active tillering stage (I_1) was recorded minimum density, fresh and dry weight of *C. rotundus* as compared to other irrigation treatments. Increase in density and weight of weeds at higher rate of irrigation resulted from the greater availability of moisture [7, 9, 10, 11]. Maximum density, fresh and dry weight of weeds were observed under more number of irrigations, which facilitates an adequate growing environment to the weeds and reduction in the fresh and dry weight of *C. rotundus* was observed under lower number of irrigation due to inadequate supply of moisture [4] and reduction in the weed density under lower number of irrigation due is to inadequate supply of moisture [9, 12].

All the weed control treatments significantly reduced density, fresh and dry weight of *C. rotundus* as compared to weedy check at 60 and 90 DAS. The impact of various herbicide treatments on *C. rotundus* was taken through their impact on density, fresh and dry weight per square meter. 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 *C. rotundus*. The lowest density, fresh and dry weight of *C. rotundus* was observed withcarfentrazone- ethyl 20% + sulfosulfuron 25% WG 100 g ha^{-1} at 35 DAS fb clodinafop- propagyl 15%+metsulfuron 1% 400 g ha^{-1} at 35 DAS, pendimethalin (pre-em) *fb*WCPL-15 400 g ha^{-1} at 35 DAS, halauxafen + penxasulam 23.5% 75 g ha^{-1} at 35 DAS, sulfosulfuron 25 g ha^{-1} at 35 DAS and halauxafen 1.21% w/w + fluroxpyr at 35 DAS, respectively (Table 1&2). All the herbicide treatments significantly decreased the weed density and weight of *C. rotundus* than the weedy check plots. The post emergence application of sulfosulfuron 25 g ha^{-1} at 35 DAS, alone and had higher values for density and weight of *C. rotundus* certainly due to occurrence of resistance problem. This is in conformity with the results of Singh et al. [2] which reported that pre emergence application of pendimethalin or acceptable control of *C. rotundus,* however not adequate to control second flush of weeds after first irrigation. Significantly lowest density of *C. rotundus* was recorded with the post- emergence application of sulfosulfuron at 25 g/ha + metsulfuron methyl at g/ha and clodinafop + metsulfuron-methyl 64 g ha^{-1}[6, 14]. Among the weed management treatments, hand weeding at 20 and 40 DAS (weed free) recorded the lowest density and dry weight of *C. rotundus* when compared to the herbicidal treatments. These results are shows the close conformity with the research findings of [10] and [12] he was reported the superiority of hand weeding over herbicidal treatments.

3.2 Weed Control Efficiency (WCE)

Weed control efficiency (WCE) denotes the relative efficiency of weed control treatments compared to weedy check (Table 3). Irrigation at CRI and active tillering stage (I_1) was recorded highest weed control efficiency of *C. rotundus* as 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. Reduction in the number of irrigation increases the weed control efficiency was reported by [4, 9].

Among herbicidal treatments, application of carfentrazone- ethyl 20% + sulfosulfuron 25% WG 100 g ha^{-1} was recorded the highest weed control efficiency of *C. rotundus fb* clodinafop-propagyl 15% + metsulfuron 1% 400 g/ha. Among herbicidal treatments, the lowest weed control efficiency was recorded in plots treated with sulfosulfuron 25 g/ha followed by sequential application of pendimethalin *fb* WCPL-15 400 g/ha . Highest weed control efficiency indicate its

Table 1. Effect of irrigation and herbicides on density of *C. rotundus*

Treatment	Density of *C. rotundus*(No. m^{-2})				Absolute density of *C. rotundus*(No. m^{-2})			
	2017-18		2018-19		2017-18		2018-19	
	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)	3.83(14.20)	3.46(11.50)	3.73(13.40)	3.33(10.62)	2.29(4.73)	2.08(3.83)	2.23(4.47)	2.01(3.54)
I_2-Three irrigation(CRI+ jointing+ booting)	4.15(16.73)	3.87(14.46)	4.05(15.93)	3.75(13.57)	2.47(5.58)	2.31(4.82)	2.41(5.31)	2.24(4.52)
I_3- Four irrigation (CRI+ Active tillering+ booting+ flowering)	4.47(19.51)	4.23(17.41)	4.38(18.72)	4.13(16.53)	2.65(6.50)	2.51(5.80)	2.60(6.24)	2.45(5.51)
I_4-Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	4.64(20.99)	4.37(18.59)	4.55(20.20)	4.27(17.71)	2.74(7.00)	2.59(6.20)	2.69(6.73)	2.53(5.90)
SEm±	0.08	0.10	0.08	0.12	0.04	0.07	0.05	0.04
CD (P=0.05)	0.27	0.32	0.26	0.36	0.13	0.21	0.17	0.12
Weed management practices								
W_1-Weedy check	5.88(34.12)	5.68(31.81)	5.81(33.21)	5.59(30.80)	3.45(11.37)	3.33(10.60)	3.40(11.07)	3.28(10.27)
W_2- Two hand weeding (20 and 40 DAS)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
W_3-Sulfosulfuron @25 g ha^{-1} at 35 DAS	4.66(21.18)	4.23(17.41)	4.56(20.27)	4.11(16.40)	2.75(7.06)	2.51(5.80)	2.69(6.76)	2.44(5.47)
W_4- Pendimethalin (pre-em) *fb*WCPL-15@400 g ha^{-1} at 35 DAS	4.30(18.02)	3.97(15.23)	4.20(17.11)	3.84(14.22)	2.55(6.01)	2.36(5.08)	2.49(5.70)	2.29(4.74)
W_5- Broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) @ 100 g *a.i.* ha^{-1}at 35 DAS	3.78(13.82)	3.63(12.65)	3.66(12.91)	3.48(11.64)	2.26(4.61)	2.17(4.22)	2.19(4.30)	2.09(3.88)
W_6- Halauxafen + penxasulam 23.5% @ 75 g *a.i.* ha^{-1} at 35 DAS	4.29(17.93)	3.96(15.17)	4.19(17.02)	3.83(14.16)	2.55(5.98)	2.36(5.06)	2.48(5.67)	2.28(4.72)
W_7- Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	4.68(21.43)	4.25(17.58)	4.58(20.52)	4.13(16.57)	2.76(7.14)	2.52(5.86)	2.71(6.84)	2.45(5.52)
W_8- Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g *a.i*. ha^{-1} 35 DAS	4.11(16.36)	3.82(14.08)	3.99(15.45)	3.68(13.07)	2.44(5.45)	2.28(4.69)	2.38(5.15)	2.20(4.36)
SEm±	0.08	0.07	0.07	0.07	0.03	0.03	0.04	0.04
CD (P=0.05)	0.23	0.22	0.22	0.21	0.10	0.11	0.12	0.13

Data given within parentheses are original values and that given outside are square root transformed values $\sqrt{(x+0.5)}$

Table 2. Effect of irrigation and herbicides on fresh weight of *Cyperus rotundus*

Treatment	Fresh weight of *C. rotundus*(No. m^{-2})				Dry weight of *C. rotundus*(No. m^{-2})			
	2017-18		2018-19		2017-18		2018-19	
	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)	3.26(10.12)	2.96(8.24)	3.15(9.43)	2.84(7.59)	1.70(2.38)	1.52(1.81)	1.63(2.15)	1.28(1.15)
I_2-Three irrigation(CRI+ jointing+ booting)	3.68(13.07)	3.42(11.20)	3.59(12.38)	3.32(10.55)	1.92(3.17)	1.76(2.60)	1.85(2.94)	1.56(1.94)
I_3- Four irrigation (CRI+ Active tillering+ booting+ flowering)	4.06(16.02)	3.83(14.15)	3.98(15.33)	3.74(13.50)	2.11(3.95)	1.97(3.39)	2.06(3.73)	1.80(2.73)
I_4-Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	4.21(17.20)	3.98(15.33)	4.12(16.51)	3.90(14.68)	2.18(4.27)	2.05(3.70)	2.13(4.04)	1.88(3.04)
SEm±	0.08	0.12	0.08	0.09	0.06	0.06	0.05	0.07
CD (P=0.05)	0.25	0.36	0.24	0.28	0.19	0.18	0.16	0.18
Weed management practices								
W_1-Weedy check	4.95(24.01)	4.64(21.01)	4.87(23.22)	4.56(20.27)	2.70(6.81)	2.58(6.16)	2.66(6.55)	2.43(5.41)
W_2- Two hand weeding (20 and 40 DAS)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
W_3-Sulfosulfuron @25 g ha^{-1} at 35 DAS	4.17(16.86)	3.92(14.86)	4.07(16.07)	3.82(14.12)	2.12(4.00)	1.96(3.35)	2.06(3.74)	1.76(2.60)
W_4- Pendimethalin (pre-em) *fb*WCPL-15@400 g ha^{-1} at 35 DAS	3.90(14.68)	3.63(12.68)	3.79(13.89)	3.53(11.94)	1.98(3.42)	1.81(2.77)	1.91(3.16)	1.59(2.02)
W_5- Broadway (carfentrazone ethyl 20% + sulfosulfuron 25%WG) @ 100 g *a.i.* ha^{-1}at 35 DAS	3.55(12.10)	3.26(10.10)	3.44(11.31)	3.14(9.36)	1.80(2.73)	1.61(2.08)	1.72(2.47)	1.35(1.33)
W_6- Halauxafen + penxasulam 23.5% @ 75 g *a.i.* ha^{-1} at 35 DAS	3.89(14.62)	3.62(12.62)	3.79(13.83)	3.52(11.88)	1.98(3.41)	1.81(2.76)	1.91(3.15)	1.58(2.01)
W_7- Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	4.19(17.03)	3.94(15.03)	4.09(16.24)	3.85(14.29)	2.13(4.05)	1.97(3.40)	2.07(3.79)	1.77(2.65)
W_8- Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g *a.i*. ha^{-1} 35 DAS	3.75(13.53)	3.47(11.53)	3.64(12.74)	3.36(10.79)	1.90(3.12)	1.72(2.47)	1.83(2.86)	1.49(1.72)
SEm±	0.06	0.07	0.07	0.07	0.03	0.03	0.04	0.05
CD (P=0.05)	0.20	0.21	0.20	0.22	0.11	0.10	0.12	0.15

Data given within parentheses are original values and that given outside are square root transformed values √(x+0.5)

Table 3. Effect of irrigation and herbicides on weed control efficiency (WCE) of *C. rotundus*

Treatments	WCE (%)			
	2017-18		2018-19	
	60 DAS	90 DAS	60 DAS	90 DAS
Irrigation schedule				
I_1-Two irrigation (CRI+ active tillering)	65.1	70.6	67.2	78.7
I_2-Three irrigation(CRI+ jointing+ booting)	53.5	57.8	55.1	64.1
I_3- Four irrigation (CRI+ Active tillering+ booting+ flowering)	42.0	45.0	43.1	49.5
I_4-Five irrigation (CRI+ jointing+ booting+ flowering+ milking)	37.3	39.9	38.3	43.8
Weed management practices				
W_1-Weedy check	-	-	-	-
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	41.3	45.6	42.9	51.9
W_4- Pendimethalin (pre-em) *fb*WCPL-15@400 g ha^{-1} at 35 DAS	49.8	55.0	51.8	62.7
W_5-Broadway (carfentrazone ethyl 20%+ sulfosulfuron 25%WG) @ 100 g *a.i.* ha^{-1}at 35 DAS	59.9	66.2	62.3	75.4
W_6- Halauxafen + penxasulam 23.5% @ 75 g *a.i.* ha^{-1} at 35 DAS	49.9	55.2	51.9	62.8
W_7- Halauxafen - methyl 1.21% w/w + fluroxypyr @ at 35 DAS	40.5	44.8	42.1	51.0
W_8- Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g *a.i*. ha^{-1} 35 DAS	54.2	59.9	56.3	68.2

relative performance of particular set of treatment [4 and 10]. However, hand weeding twice (weed free) proved superiority over other herbicidal treatments. Highest WCE associated with hand weeding can be attributed to its effective control of *C. rotundus*. These findings established support from [13] and [14]. Interaction effect of irrigation and weed management was non significant of *C. rotundus* and wheat yield.

4. CONCLUSION

Irrigation at CRI and active tillering stage was more beneficial than other irrigation regimes as it recorded lowest density of *C. rotundus* and their weight and highest WCE. Among herbicidal treatments, application of broadway (carfentrazone- ethyl 20%+sulfosulfuron 25% WG) 100 g ha^{-1} at 35 DAS was found to be superior over rest of the herbicidal treatments as it significantly recorded lowest density of *C. rotundus* and their weight with maximum WCE followed it was in Clodinafop- propargyl 15% + metsulfuron 1% @ 400 g *a.i*. ha^{-1} 35 DAS.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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