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Efficacy of Herbicidal Combinations Tank Mixed with Zinc and Iron Sulphate against Weeds in Wheat (*Triticum aestivum*)

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Abstract: Weeds are affecting wheat production significantly and now days, micronutrients deficiency is also being observed in wheat growing areas. Field experiment was conducted at RRS, Bawal during *Rabi*season of 2018-19 to evaluate the efficacy of post-emergence herbicidal combinations with Zn or/and Fe against complex weed flora in wheat. Experiment consisted of 18 treatments. Four herbicidal combinations *viz*. clodinafop + metsulfuron@ 60 g ha^{-1}, sulfosulfuron + metsulfuron @ 32 g ha^{-1}, mesosulfuron + iodosulfuron @ 14.4 g ha^{-1}, pinoxaden + carfentrazone @ (50 + 20 g ha^{-1}) were evaluated for efficacy with Zn, Fe and with both Zn as well as Fe. Satisfactory weed control was observed with all the treatments of herbicidal combinations.Among sole herbicidal combinations, application of mesosulfuron + iodosulfuron (14.4 g ha^{-1}) resulted lowest population and dry weight of grassy weeds whereas application of pinoxaden + carfentrazone (50 + 20 g ha^{-1}) was most effective against broad leaved weeds. Tank mixing of Fe improved the efficacy of herbicidal combinations. Efficacy of herbicidal combinations was further increased when Zn was tank mixed with herbicidal combinations. Highest weed control efficiency was recorded when herbicidal combinations were applied as tank mixed with both, Zn and Fe sulphate.

Keywords: Efficacy, Compatibility, Zinc sulphate, Fe sulphate

Wheat (*Triticum aestivum* L.) is one of the major cereal food crops of the world and has very important role in attaining food security. There is more noteworthy extension to build wheat efficiency by conquering any hindrance among potential and accomplished yield. Wheat productivity is an after effect of numerous components, yet weed administration is one of the major and less minded reasons for low yield. Introduction of dwarf wheat varieties coupled with intensive input use led to complex problem of both grassy and broad leaved weeds. Grassy weeds, broadleaf weeds and complex flora reduce wheat yield upto 30, 24 and 48 percent, respectively and wheat yield varies upto the extent of 22 per cent due to the weeds (Khan and Haq 2002). Therefore, weed management is very important for achieving higher wheat production. Among the various methods of weed management, chemical weed control is more efficient, less costly and less time consuming.

Another factor affecting wheat productivity and quality is imbalanced fertilization and deficiency of nutrients specially micronutrients. Zn and Fe which are essential micronutrients for plants. They are involved in many enzymatic reactions and metabolic processes. They play substantial role in basic biological processes like nitrogen fixation, energy transfer and protein synthesis, photosynthesis etc. The deficiency of Zn and Fe in soils is a worldwide problem. Approximately 50 per cent of wheat-cultivated soil globally is considered poor in bio-available Zn (Cakmak and Kutman 2018) and about 30 per cent of arable cultivated soils across the globe are deficient in Zn and Fe both. In India, 49 and 15 per cent soils were deficient in Zn and Fe, respectively (Singh 2008, Shukla et al 2012). Zn and Fe availability have considerable spatial variability in trans-gangetic plains and they are in acute shortage in some regions. Wheat yield as well as its quality can be improved by foliar application of Zn and Fe alone or together. Soil and foliar application of zinc and iron in wheat impacts the yield contributing characteristics. Foliar application of iron and zinc increases their concentration in wheat grain as well as in flour (Zhang et al 2010). Time of spray of micronutrients mostly coincides with the time of application of post-emergence herbicides. The co-application of micronutrients with other agro-chemicals have advantages like reduced production costs and soil compaction. But very less information is available about the efficacy of herbicidal combinations with the zinc and iron sulphate. For instance, application of zinc does not alter the efficiency of herbicide mixture of tribenuron and isoproturon in wheat. Atrazine, chloramben and propachlor are compatible with liquid fertilizers. Therefore, herbicidal combinations tank mixed with zinc and iron sulphate could be viable option. Therefore, it needs to be further explored with herbicidal combinations tank mixed with zinc and iron sulphate.

MATERIAL AND METHODS

Field experiment was conducted was conducted at

Choudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal (Rewari) during Rabi season of 2018 – 19. Soil of experimental site was deficient in available zinc (0.56) and sufficient in available iron (4.51 ppm). Experiment was conducted by using Randomized Block Design (RBD) having 18 treatments, each replicated thrice. Crop was raised with recommended package of practices except weed management. Treatments of weed management were applied at 35 days after sowing (DAS) in different plots of size 6.0 m x 2.2 m. Treatments consist of sole application of four herbicidal combinations *viz*. clodinafop + metsulfuron (60 g ha^{-1}), sulfosulfuron + metsulfuron (32 g ha^{-1}), mesosulfuron + iodosulfuron (14.4 g ha^{-1}) and pinoxaden + carfentrazone (50 + 20 g ha^{-1}); tank mixed application of above herbicidal combinations with $FeSO_4$ (0.5%); tank mixed application of above herbicidal combinations with $ZnSO_4$ (0.5%) + urea (2.5%); tank mixed application of above herbicidal combinations with $ZnSO_4$ (0.5%) + urea (2.5%) + $FeSO_4$ (0.5%); rest two were weedy check and weed free. Observations of weeds were recorded at different stages of crop growth. Observation on weed density and dry matter were recorded using standard methods. Weed control efficiency (WCE) was calculated using formula:

$$WCE\ (\%) = \frac{wb - wa}{wb} \times 100$$

Where,

wb = Dry weight of weeds in weedy plot, and wa = Dry weight of weeds in treated plot.

Statistical analysis of data: All the experimental data for various weed parameters was statistically analysed by online computer programme OPSTAT (Sheoran et al 1998).

RESULTS AND DISCUSSION

Weed Density

Phalaris minor: All the herbicidal combinations alone or mixed with zinc or/and iron significantly reduced the density of *P. minor* over weedy check (Table 1). More reduction in density of *P. minor* was recorded where herbicidal combinations were applied simultaneously with Zn or Fe than alone application of herbicidal combinations. Application of herbicidal combinations with both zinc and iron further reduced the density of *P. minor* as compared to their application with either Zn or Fe separately. However,

Table 1. Effect of herbicidal combinations and their tank mixtures with zinc or/and iron sulphate on density of *P. minor*

Treatment	Dose (g ha^{-1})	*P. minor* (No./m^2)		
		DAS		
		30	60	90
Clodinafop + metsulfuron	60	8.05 (64.30)	3.25 (9.60)	2.96 (7.87)
Sulfosulfuron + metsulfuron	32	7.95 (63.03)	3.24 (9.60)	2.89 (7.47)
Mesosulfuron + iodosulfuron	14.4	7.92 (62.60)	2.93 (8.37)	2.43 (5.47)
Pinoxaden + carfentrazone	50 + 20	7.92 (62.47)	3.24 (9.50)	2.91 (7.50)
Clodinafop + metsulfuron + $ZnSO_4$ + urea	60	8.12 (65.53)	3.18 (9.13)	2.85 (7.17)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea	32	7.68 (58.63)	3.13 (8.80)	2.75 (6.83)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea	14.4	7.88 (61.47)	2.75 (6.83)	2.12 (3.93)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea	50 + 20	7.87 (61.33)	3.04 (8.60)	2.65 (6.63)
Clodinafop + metsulfuron + $FeSO_4$	60	8.09 (64.80)	3.22 (9.37)	2.93 (7.60)
Sulfosulfuron + metsulfuron + $FeSO_4$	32	7.87 (61.27)	3.22 (9.37)	2.84 (7.20)
Mesosulfuron + iodosulfuron + $FeSO_4$	14.4	8.06 (64.40)	2.85 (7.67)	2.24 (4.33)
Pinoxaden + carfentrazone + $FeSO_4$	50 + 20	7.94 (62.47)	3.08 (9.23)	2.70 (7.07)
Clodinafop + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	60	7.45 (54.83)	2.88 (8.60)	2.56 (6.57)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	32	7.80 (60.17)	2.82 (8.20)	2.54 (6.27)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea + $FeSO_4$	14.4	8.11 (65.13)	2.51 (6.30)	2.02 (3.47)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea + $FeSO_4$	50 + 20	7.60 (58.20)	2.77 (8.03)	2.54 (6.17)
Weedy check	--	8.07 (64.47)	7.36(53.87)	7.14(50.37)
Weed free	--	8.02 (63.83)	1.00 (0.00)	1.00 (0.00)
C.D. (p=0.05)		NS	1.36	1.26

Original data given in parenthesis was subjected to square root transformation ($\sqrt{x+1}$)

reduction in density was not significant.

Chenopodium album* and *Chenopodium murale : Density of *C. album* and *C. murale* was statistically similar among all treatments at 30 DAS (Table 2). *C. album and C. murale* population was significantly reduced under all the treatments as compared to weedy check. The population of these weedsunder all herbicidal combinations and their mixtures with Zn or/and Fe was at par with each other at 60 and 90 DAS.

***Angallis arvensis* and miscellaneous weeds:** All the herbicidal treatments significantly reduced the density of *A. arvensis* and miscellaneous weeds over weedy check (Table 3). Among the herbicidal combinations, lowest density of these weeds was recorded under pinoxaden + carfentrazone (50 + 20 g/ha) followed by application of mesosulfuron + iodosulfuron (14.4 g/ha). More reduction in density of these weedswas recorded when herbicidal combinations were applied simultaneously with zinc or iron. Application of combined (Zn + Fe) with respective herbicidal combination further reduced the weeds density. However, reduction in density was not significant. Among all herbicidal treatments, lowest density of these weeds was recorded under

Table 2. Effect of herbicidal combinations and their tank mixtures with zinc or/and iron sulphate on density of *C. album* and *C. murale*

Treatment	Dose (g ha^{-1})	Weed density (No./m^2)					
		30 DAS		60 DAS		90 DAS	
		C. album	*C. murale*	*C. album*	*C. murale*	*C. album*	*C. murale*
Clodinafop + metsulfuron	60	8.17 (65.97)	6.24 (38.30)	3.11 (8.84)	2.56 (5.93)	2.69 (6.40)	2.36 (4.57)
Sulfosulfuron + metsulfuron	32	7.99 (63.03)	5.99 (35.37)	3.10 (8.67)	2.49 (5.47)	2.63 (6.27)	2.27 (4.17)
Mesosulfuron + iodosulfuron	14.4	7.96 (62.60)	5.96 (34.93)	2.70 (6.57)	2.37 (4.67)	2.32 (4.37)	2.11 (3.50)
Pinoxaden + carfentrazone	50 + 20	7.94 (62.47)	5.97 (34.80)	2.38 (4.84)	2.18 (3.80)	1.96 (2.87)	1.76 (2.17)
Clodinafop + metsulfuron + $ZnSO_4$ + urea	60	8.14 (65.53)	6.23 (37.87)	2.88 (8.27)	2.41 (5.03)	2.40 (5.17)	2.23 (4.03)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea	32	7.70 (58.63)	5.63 (30.80)	2.83 (7.27)	2.38 (4.87)	2.38 (5.03)	2.14 (3.67)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea	14.4	8.09 (64.80)	5.88 (33.80)	2.56 (6.23)	2.23 (4.00)	2.21 (3.93)	1.94 (3.20)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea	50 + 20	8.08 (64.67)	6.14 (37.00)	2.23 (4.19)	1.99 (3.13)	1.84 (2.53)	1.59 (1.80)
Clodinafop + metsulfuron + $FeSO_4$	60	8.21 (66.80)	6.33 (39.13)	3.04 (8.48)	2.49 (5.23)	2.55 (5.50)	2.28 (4.23)
Sulfosulfuron + metsulfuron + $FeSO_4$	32	8.07 (64.60)	6.14 (36.93)	2.95 (7.79)	2.46 (5.03)	2.50 (5.27)	2.22 (3.93)
Mesosulfuron + iodosulfuron + $FeSO_4$	14.4	8.27 (67.73)	6.40 (40.07)	2.63 (6.35)	2.34 (4.47)	2.27 (4.20)	2.04 (3.33)
Pinoxaden + carfentrazone + $FeSO_4$	50 + 20	8.15 (65.80)	6.22 (38.13)	2.28 (4.63)	2.11 (3.47)	1.88 (2.60)	1.67 (2.03)
Clodinafop + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	60	7.66 (58.17)	5.61 (30.50)	2.73 (6.92)	2.37 (4.87)	2.19 (4.23)	2.05 (3.60)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	32	8.01 (63.50)	6.07 (35.83)	2.62 (6.23)	2.28 (4.33)	2.07 (4.07)	2.03 (3.17)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea + $FeSO_4$	14.4	8.32 (68.47)	6.41 (40.13)	2.40 (5.19)	2.17 (3.83)	2.02 (3.60)	1.85 (2.53)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea + $FeSO_4$	50 + 20	7.89 (61.53)	5.88 (33.90)	2.17 (3.77)	1.93 (2.77)	1.79 (2.33)	1.52 (1.40)
Weedy check	--	8.28 (67.80)	6.39 (40.13)	7.41 (54.48)	5.89 (34.50)	7.15 (50.17)	5.54 (30.23)
Weed free	--	8.14 (65.83)	5.96 (34.83)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
C.D. (p=0.05)		NS	NS	1.07	0.82	0.92	0.73

Original data given in parenthesis was subjected to square root transformation ($\sqrt{x+1}$)

pinoxaden + carfentrazone (50 + 20 g/ha) + $ZnSO_4$ (0.5 %) + urea (2.5 %) + $FeSO_4$ (0.5 %).

Similar reduction in population was reported by Punia and Yadav (2014). Addition of Zn or/and Fe further reduced the population of these two weeds. Reduction in weed density may be attributed to the robustness and more competition offered by the wheat crop to the weeds. Chinnathurai et al (2012) also reported that foliar spray of micronutrients reduced the weed density. More than 80 per cent reduction in density of *Rumex dentatus* and other broad leaf weeds was reported under mesosulfuron + iodosulfuron earlier also (Kaur et al 2007). Addition of Zn or/and Fe further reduced the population of miscellaneous weeds. Marwat et al (2007) reported that Zn application to crops (seed soaking, foliar or soil application) reduces the density of weeds.

Dry weight of weeds: All treatments recorded significant decrease in dry matter accumulation of grassy weeds as well as broad leaved weeds as compared to weedy check (Table 4). Among the herbicidal combinations, mesosulfuron + iodosulfuron (14.4 g/ha) was most effective which resulted into 2.65 and 5.40 g/m^2 dry weight of grassy weeds followed by 3.70 and 7.81 g/m^2 under pinoxaden + carfentrazone (50

Table 3. Effect of herbicidal combinations and their tank mixtures with zinc or/and iron sulphate on density of *Angallis arvensis* and miscellaneous weeds

Treatment	Dose (g ha^{-1})	Weed density (No./m^2)					
		30 DAS		60 DAS		90 DAS	
		Angallisar vensis	Miscell aneous	*Angallisar vensis*	Miscell aneous	*Angallisar vensis*	Miscell aneous
Clodinafop + metsulfuron	60	3.25 (9.67)	3.56 (11.90)	2.29 (4.30)	2.10 (3.47)	2.05 (3.23)	1.99 (3.01)
Sulfosulfuron + metsulfuron	32	3.42 (10.77)	3.77 (13.23)	2.17 (3.70)	2.06 (3.23)	1.94 (2.80)	1.95 (2.81)
Mesosulfuron + iodosulfuron	14.4	3.08 (8.57)	3.23 (9.43)	2.03 (3.23)	1.91 (2.77)	1.83 (2.43)	1.82 (2.41)
Pinoxaden + carfentrazone	50 + 20	2.97 (7.87)	3.44 (10.83)	1.86 (2.53)	1.76 (2.17)	1.69 (1.93)	1.69 (1.87)
Clodinafop + metsulfuron + $ZnSO_4$ + urea	60	3.15 (9.00)	3.75 (13.13)	2.10 (3.67)	2.00 (3.13)	1.89 (2.77)	1.90 (2.73)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea	32	3.08 (8.67)	3.72 (12.87)	2.02 (3.33)	1.92 (2.87)	1.82 (2.53)	1.84 (2.50)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea	14.4	3.38 (10.53)	3.63 (12.20)	1.94 (2.93)	1.84 (2.53)	1.76 (2.21)	1.75 (2.20)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea	50 + 20	2.93 (7.63)	3.47 (11.13)	1.79 (2.30)	1.70 (1.97)	1.64 (1.73)	1.62 (1.70)
Clodinafop + metsulfuron + $FeSO_4$	60	3.19 (9.20)	3.39 (10.53)	2.17 (3.87)	2.02 (3.33)	1.95 (2.93)	1.94 (2.90)
Sulfosulfuron + metsulfuron + $FeSO_4$	32 |	3.14 (8.93)	3.48 (11.10)	2.13 (3.60)	1.97 (3.10)	1.93 (2.73)	1.89 (2.70)
Mesosulfuron + iodosulfuron + $FeSO_4$	14.4	3.35 (10.40)	3.17 (9.30)	1.97 (3.03)	1.86 (2.63)	1.79 (2.30)	1.77 (2.30)
Pinoxaden + carfentrazone + $FeSO_4$	50 + 20	2.94 (7.67)	3.60 (11.97)	1.82 (2.33)	1.74 (2.03)	1.66 (1.77)	1.66 (1.77)
Clodinafop + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	60	3.02 (8.23)	3.13 (8.83)	1.94 (2.90)	1.83 (2.50)	1.77 (2.20)	1.74 (2.17)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	32	3.39 (10.53)	3.14 (9.13)	1.95 (2.87)	1.82 (2.47)	1.76 (2.17)	1.75 (2.13)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea + $FeSO_4$	14.4	2.95 (7.70)	3.61 (12.03)	1.83 (2.37)	1.73 (2.03)	1.67 (1.80)	1.66 (1.77)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea + $FeSO_4$	50 + 20	2.90 (7.43)	3.50 (11.27)	1.73 (2.10)	1.64 (1.80)	1.59 (1.58)	1.57 (1.57)
Weedy check	--	3.26 (10.10)	3.47 (11.47)	5.39 (28.10)	4.84 (22.47)	4.71 (21.20)	4.53 (19.50)
Weed free	--	3.05 (9.00)	3.53 (11.80)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
C.D. (p=0.05)		NS	NS	0.60	0.60	0.53	0.54

Original data given in parenthesis was subjected to square root transformation (√x+1)

+ 20 g/ha) at 60 and 90 DAS, respectively. Highest reduction in dry weight of broad leaf weeds was under pinoxaden + carfentrazone (50 + 20 g/ha) closely followed by application of mesosulfuron + iodosulfuron (14.4 g/ha). Application of clodinafop + metsulfuron (60 g/ha) was least effective among herbicidal combinations and witnessed highest dry weight of grassy and BLW.The addition of Zn or Fe individually to the herbicidal combinations decreased dry weight of broad leaf weeds insignificantly over sole application of herbicides. The addition of Zn to herbicidal combinations caused more reduction in dry weight of broad leaf weeds than addition of Fe with herbicidal combinations. Application of herbicidal combinations with both, Zn and Fe (Zn + Fe) further reduced dry weight of broad leaf weeds, although insignificantly. Similar reduction in dry weight of grassy as well as broad leaf weeds due to application of herbicidal combinations has been reported by Kumar et al (2014) and Tiwari et al (2016). The reduction in dry weight of weeds (both grassy and broad leaf) was due to mortality of weeds by herbicidal combinations which caused inhibition of some enzymes involved in vital plant processes. This is due to reduction in dry weight of grassy as well as broad leaf weeds due to tank mixing of Zn or/and Fe with herbicidal combinations could be the indirect effect of these micronutrients on weeds by mechanism of competitive advantage to crop plants over weeds. Application of micronutrients might have increased crop competitive ability. Similar reduction in dry weight of weeds due to tank mixing of nutrients with herbicides was reported by Sabeti (2015).

Weed control efficiency: Weed control efficiency of different herbicidal combinations and their mixtures with zinc or/and iron on grassy and BLW in wheat was determined at 60 and 90 DAS (Table 5). Among herbicidal combinations, mesosulfuron + iodosulfuron @ 14.4 g/ha and pinoxaden + carfentrazone (50 + 20 g/ha) were most effective herbicidal combination against grassy and BLW, respectively. Tank mixing of herbicidal combinations with Zn or/and Fe exerted positive effect and improved their weed control efficiency. Mesosulfuron + iodosulfuron @ 14.4 g/ha resulted into maximum control of complex weed flora. Similar results have been reported by Singh (2019) and Pal et al (2016).

Addition of micronutrients to herbicides increased weed control efficiency of herbicides. Application of herbicidal combinations mixed (Zn + Fe) enhanced the efficacy of

Table 4. Effect of herbicidal combinations and their tank mixtures with zinc or/and iron sulphate on dry weight of grassy and broad leaved weeds

Treatment	Dose (g ha^{-1})	Dry weight (g/m^2) of grassy weeds		Dry weight (g/m^2) of broad leaved weeds	
		60 DAS	90 DAS	60 DAS	90 DAS
Clodinafop + metsulfuron	60	2.18 (3.95)	3.04 (8.51)	2.70 (6.48)	3.42 (10.92)
Sulfosulfuron + metsulfuron	32	2.16 (3.74)	2.91 (7.87)	2.61 (5.93)	3.26 (9.78)
Mesosulfuron + iodosulfuron	14.4	1.80 (2.65)	2.43 (5.40)	2.42 (5.07)	2.89 (7.34)
Pinoxaden + carfentrazone	50 + 20	2.14 (3.70)	2.91 (7.81)	2.24 (4.17)	2.43 (5.47)
Clodinafop + metsulfuron + $ZnSO_4$ + urea	60	2.15 (3.71)	2.86 (7.75)	2.54 (5.87)	3.20 (9.73)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea	32	2.07 (3.42)	2.76 (7.02)	2.39 (5.33)	3.10 (8.92)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea	14.4	1.67 (2.36)	2.26 (5.12)	2.21 (4.40)	2.57 (5.92)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea	50 + 20	2.04 (3.29)	2.77 (7.05)	2.13 (3.67)	2.25 (4.55)
Clodinafop + metsulfuron + $FeSO_4$	60	2.13 (3.80)	2.97 (8.05)	2.60 (6.20)	3.31 (10.24)
Sulfosulfuron + metsulfuron + $FeSO_4$	32	2.11 (3.54)	2.81 (7.49)	2.51 (5.77)	3.16 (9.47)
Mesosulfuron + iodosulfuron + $FeSO_4$	14.4	1.74 (2.54)	2.30 (5.17)	2.33 (4.69)	2.83 (7.17)
Pinoxaden + carfentrazone + $FeSO_4$	50 + 20	2.08 (3.51)	2.84 (7.53)	2.21 (3.87)	2.39 (5.16)
Clodinafop + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	60	1.99 (3.63)	2.76 (7.08)	2.30 (4.67)	2.88 (7.73)
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	32	1.92 (3.04)	2.68 (6.45)	2.27 (4.60)	2.83 (7.29)
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea + $FeSO_4$	14.4	1.60 (2.02)	2.18 (4.39)	2.17 (3.80)	2.39 (5.79)
Pinoxaden + carfentrazone + $ZnSO_4$ + urea + $FeSO_4$	50 + 20	1.90 (2.86)	2.60 (6.41)	2.06 (3.37)	2.08 (4.22)
Weedy check	--	4.95 (23.56)	7.38 (53.60)	6.55 (41.97)	8.62 (73.30)
Weed free	--	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
C.D. (p=0.05)		1.05	1.39	0.97	1.27

Original data given in parenthesis was subjected to square root transformation ($\sqrt{x+1}$)

Table 5. WCE of herbicidal combinations and their tank mixtures with zinc or/and iron sulphate on grassy and BLW

Treatment	Dose ($g\ ha^{-1}$)	WCE (%) grassy		WCE (%) BLW	
		60 DAS	90 DAS	60 DAS	90 DAS
Clodinafop + metsulfuron	60	83.23	84.13	84.56	85.11
Sulfosulfuron + metsulfuron	32	84.13	85.32	85.86	86.66
Mesosulfuron + iodosulfuron	14.4	88.74	89.93	87.93	89.98
Pinoxaden + carfentrazone	50 + 20	84.28	85.44	90.07	92.54
Clodinafop + metsulfuron + $ZnSO_4$ + urea	60	84.27	85.55	86.02	86.73
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea	32	85.50	86.90	87.29	87.84
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea	14.4	89.97	90.45	89.52	91.93
Pinoxaden + carfentrazone + $ZnSO_4$ + urea	50 + 20	86.05	86.84	91.26	93.79
Clodinafop + metsulfuron + $FeSO_4$	60	83.87	84.98	85.23	86.03
Sulfosulfuron + metsulfuron + $FeSO_4$	32	84.99	86.02	86.26	87.09
Mesosulfuron + iodosulfuron + $FeSO_4$	14.4	89.20	90.36	88.82	90.22
Pinoxaden + carfentrazone + $FeSO_4$	50 + 20	85.10	85.95	90.79	92.96
Clodinafop + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	60	84.61	86.79	88.88	89.45
Sulfosulfuron + metsulfuron + $ZnSO_4$ + urea + $FeSO_4$	32	87.10	87.96	89.04	90.05
Mesosulfuron + iodosulfuron + $ZnSO_4$ + urea + $FeSO_4$	14.4	91.44	91.80	90.95	92.10
Pinoxaden + carfentrazone + $ZnSO_4$ + urea + $FeSO_4$	50 + 20	87.87	88.03	91.98	94.25
Weedy check	--	0.00	0.00	0.00	0.00
Weed free	--	100.00	100.00	100.00	100.00

herbicides and resulted into more increase in weed control efficiency in comparison to their separate application. This increase in weed control efficiency could be explained as the enhanced competitive ability of the wheat crop to suppress the weeds due to application of micronutrients. Similar results were reported by Sabeti (2015) wherein about 10 per cent increase in herbicide efficacy was reported due to tank mixture of micronutrients and herbicides.

CONCLUSION

Based on the above findings, it is concluded that all four herbicidal combinations tested under study were compatible with Zn or/and Fe. Application of mesosulfuron + iodosulfuron @ 14.4 g/ha + $ZnSO_4$ (0.5 %) + urea (2.5 %) + $FeSO_4$ (0.5 %) was most effective treatment to control the complex weed flora in wheat. This treatment resulted into highest weed control efficiency followed by pinoxaden + carfentrazone @ (50 + 20 g/ha) + $ZnSO_4$ (0.5 %) + urea (2.5 %) + $FeSO_4$ (0.5 %). Further research on different herbicidal combinations with different micronutrients in various crops will explore the new aspects of weed cum nutrient management for efficient and economic weed management.

REFERENCES

Cakmak I and Kutman UB 2018. Agronomic bio-fortification of cereals with zinc: A review. *European Journal of Soil Science* **69**(1): 172-180.

Chinnathurai SJ, Veeramani A and Prema P 2012. Weed dynamics, yield and economics of pigeonpea influenced by growth promoters and mulching. *Indian Journal of Weed Science* **44**(3): 186-190.

Katara P, Kumar S, Rana SS and Chander N 2012. Combination of pinoxaden with other herbicides against complex weed flora in wheat. *Indian Journal of Weed Science* **44**(4): 225-230.

Kaur T, Brar LS and Walia US 2007. Effect of sulfosulfuron and mesosulfuron + iodosulfuron on weeds and wheat yield. *Indian Journal of Weed Science* **39**(1&2): 48-51.

Khan M and Haq N 2002. Wheat crop yield loss assessment due to weeds. *Sarhad Journal of Agriculture* **18**: 449-453.

Kumar S, Yadav RA, Pal V and Verma SS 2014. Bio-efficacy of pinoxaden 5 EC in combination with broad leaf herbicides on weed species with relation to economics of wheat (*Triticum aestivum* L.). *Environment & Ecology* **32**(1): 154-158.

Marwat KB, Arif M and Khan MA 2007. Effect of tillage and zinc application methods on weeds and yield of maize. *Pakistan Journal of Botany* **39**(5): 1583-1591.

Pal S, Sharma R, Sharma HB and Singh R2016. Influence of different herbicides on weed control nutrient removal and yield of wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **61**(1): 59-63.

Punia SS andYadav D 2014. Carfentrazone and pinoxaden with and without surfactant against grasses and broad-leaf weeds in wheat. *Indian Journal of Weed Science* **46**(3): 283-285.

Sabeti P 2015. Evaluation the effect of micronutrients on herbicide mixture 24-D + MCPA Bromoxynil + MCPA and Tribenoron-methyl efficacy in wheat (*Triticum aestivum*). *Biological Forum – An International Journal* **7**(1): 1855-1858.

Sasode DS, Gupta V, Joshi E, Arora A, Dixit JP and Panse R 2017. Management of diverse weed flora of wheat by herbicide combinations. *Indian Journal of Weed Science* **49**(2): 147-150.

Sheoran OP, Tonk DS, Kaushik LS, Hasija RC and Pannu RS 1998. Statistical Software Package for agricultural research workers, pp. 139-143. In: *Recent advances in information theory, statistics & computer applications*. Department of Mathematics Statistics, CCS HAU, Hisar, India.

Shukla AK, Behera SK, Shivay YS, Singh P andSingh AK 2012. Micronutrient and field crop production in India: A review. *Indian Journal of Agronomy* **57**(3s): 123-130.

Singh MV 2008. Micronutrient Deficiencies in Crops and Soils in India, pp 93-125. In: Alloway B J (ed). *Micronutrient Deficiencies in Global Crop Production*. Springer, Dordrecht.

Singh R 2019. *Status of herbicide resistance in Phalaris minor in wheat (Triticum aestivum) and its management options*. Ph.D. Dissertation, CCS Haryana Agricultural University, Hisar, India.

Tiwari A, Verma BK, Tiwari A and Sharma JD 2016. Effect on growth yield and economics of wheat (*Triticum aestivum* L.) as affected by different herbicides. *Research in Environment and Life Sciences* **9**(4): 490-492

Zhang Y, Shi R, Rezaul KM, Zhang F and Zou C 2010. Iron and zinc concentration in grain and flour of winter wheat as affected by foliar application. *Journal of Agricultural and Food Chemistry* **58**(23): 12268-12274.

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