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Influence of pre and post emergence herbicide application on weed growth and nutrient removal in wheat (*Triticum aestivum* L.)

Vasudev Meena, MK Kaushik, Surendra K Meena, Jai Prakash Bhimwal and Bhagwat Singh Chouhan

Abstract
Two years field experiment was conducted during *rabi* seasons of 2015-16 and 2016-17 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment comprised of fifteen treatments *viz.* pendimethalin 0.75 kg ha^{-1}; sulfosulfuron 0.025 kg ha^{-1}; metribuzin 0.21 kg ha^{-1}; clodinafop 0.06 kg ha^{-1}; metsulfuron 0.004 kg ha^{-1}; pendimethalin + metribuzin 0.75 + 0.175 kg ha^{-1}; pendimethalin *fb* sulfosulfuron 0.75 + 0.02 kg ha^{-1}; pendimethalin *fb* clodinafop 0.75 + 0.05 kg ha^{-1}; pendimethalin *fb* metsulfuron 0.75 + 0.004 kg ha^{-1}; metsulfuron + sulfosulfuron 0.003 + 0.02 kg ha^{-1}; pinoxaden + metsulfuron 0.06 + 0.004 kg ha^{-1}; mesosulfuron + iodosulfuron 0.012 + 0.0024 kg ha^{-1}; clodinafop + metsulfuron 0.06 + 0.004 g ha^{-1}, two hand weeding at 30 & 45 DAS and unweeded control, replicated four times in Randomized Block Design. Wheat variety Raj.- 3765 was used as a test crop. All weed control treatments appreciably reduced density and dry matter of monocot and dicot weeds. Among herbicides, application of tank mixed metsulfuron + sulfosulfuron mixture provided maximum per cent reduction in density and dry matter (90.05 & 95.35%) of total weeds over unweeded control followed by mesosulfuron + iodosulfuron, clodinofop + metsulfuron and pinoxaden + metsulfuron (88.8, 88.0 and 87.4 & 94.7, 94.4 and 94.2%) at 60 DAS which resulted into highest weed control efficiency (95.4, 94.7, 94.4 and 94.2%) and proved significantly superior over rest of the herbicidal treatments. However, variations were at par with two hand weedings. The minimum NPK content 2.52, 0.41 and 1.24 per cent, respectively were recorded with weed control through metsulfuron + sulfosulfuron.

Keywords: Dry weight, Herbicide, Nutrients, Weed control efficiency, Weed flora, Wheat

Introduction
Wheat is an important staple food crop in India, serves as backbone of food security in the country by providing more than 50 per cent of the calories. In era of climate change and increasing biotic and abiotic stresses, maintaining yield up to required level is going to be formidable challenge in coming future. The productivity of the wheat depends upon several factors like crop establishment techniques, irrigation, weed management, fertilizers management and other cultural practices. Among these factors, the hidden war with crop starts by weeds and it causes up to 90 per cent failure of the crop. Weeds are the major deterrent to the development of sustainable crop production. Since weeds dictate most of the crop production practices and causes enormous losses (37.0 to 57.1 %) due to their interference (Verma *et al*., 2015) [13].

Wheat usually suffers from stress created by mix flora of weeds through competition along with interference caused by secreting toxic substances to the rhizosphere of the crop plants. Apart from increasing the production cost, they also intensify the disease and insect pest problem by serving as alternative hosts. Presence of weeds especially at early stages was devastating for wheat yield. Yield losses are most severe when resources are limited and weeds with crops emerge simultaneously (Hussain *et al*., 2015) [5]. A strong relationship exists between the duration of competition and competition pressure exerted on the crop, which reduces yield (Fahad *et al*., 2014) [4]. Besides considerable reduction in grain yield, weeds also deplete substantially the soil for its fertility. The nutrients removal by un-interrupted weed growth assumes added significance in the context of increasing cost of fertilizers. It is obvious that for tapping the maximum yield potential of wheat aggressive weed growth has to be checked in time.

The manual and mechanical means besides being laborious and tiresome cannot be practiced until weeds put forth sufficient vegetative growth. Moreover, it is also uneconomical due to increasing cost of labour, draft animals and implements, also weeds cannot effectively be managed merely due to crop mimicry. Thus chemical weed control, in such a situation, offers the most effective measures of weed management. Infestation due to complex weed flora in wheat requires a variety of herbicides for effective control of the weeds. Continuous use of same herbicide or herbicides having similar mode of action for many years resulted in inter and intra-specific weed flora shift and evolution of resistance in weeds. In wheat, sole dependence on post-applied herbicides for weed control has resulted in the evolution of multiple herbicide resistance (Kumar *et al*., 2013) [9]. Hence, the herbicide used patterns need to be rationalized in such a way that problem associated with such type of use pattern can be avoided in the future. Under such conditions adoption of suitable herbicide combinations for the control of complex weed flora in wheat can substantially contribute to reduce the weed density and increase the productivity of late sown wheat (Chaudhry *et. al*., 2013) [3]. Keeping in view the losses due to weed infestation, high cost of manual labour and hazardous effect of narrow spectrum herbicides a study was undertaken to test the efficacy and selectivity of different herbicides for weed control to improve the productivity of wheat.

Materials and Methods

The experiment was conducted during *rabi* season of 2015-16 and 2016-17 at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The experiment comprised of fifteen treatments *viz*. pendimethalin 0.75 kg ha^{-1}; sulfosulfuron 0.025 kg ha^{-1}; metribuzin 0.21 kg ha^{-1}; clodinafop 0.06 kg ha^{-1}; metsulfuron 0.004 kg ha^{-1}; pendimethalin + metribuzin 0.75 + 0.175 kg ha^{-1}; pendimethalin *fb* sulfosulfuron 0.75 + 0.02 kg ha^{-1}; pendimethalin *fb* clodinafop 0.75 + 0.05 kg ha^{-1}; pendimethalin *fb* metsulfuron 0.75 + 0.004 kg ha^{-1}; metsulfuron + sulfosulfuron 0.003 + 0.02 kg ha^{-1}; pinoxaden + metsulfuron 0.06 + 0.004 kg ha^{-1}; mesosulfuron + iodosulfuron 0.012 + 0.0024 kg ha^{-1}; clodinafop + metsulfuron 0.06 + 0.004 g ha^{-1}, two hand weeding at 30 & 45 DAS and unweeded control. All the treatments were replicated four times indiscriminately in Randomize Block Design. Wheat variety Raj.- 3765 was used as a test crop. The soil of the experimental site were clay loam in texture, non saline and slightly alkaline in reaction. They were low in available nitrogen, medium in organic carbon and phosphorus and high in available potassium. The crop was sown on 2nd week of December during *rabi* seasons with a recommended seed rate of 125 kg ha^{-1}. All crop management practices were performed as per recommendation. The crop was supplied with 90 kg N and 35 kg P_2O_5 ha^{-1} through Urea and DAP. Half dose of nitrogen and full dose of phosphorus were applied as basal at the time of sowing while remaining half dose of nitrogen was top dressed in two equal splits at the time of first and second irrigation. The observations were taken on weed count, weed dry matter accumulation and nutrient content by the weeds at different time intervals. The data on were density were recorded with 0.5 m x 0.5 m quadrants per plot at 60 DAS and were subjected to square root transformation $\sqrt{\mathbf{X+0.5}}$ before statistical analysis to normalize their distribution. The weed samples collected for recording weed density were utilized for dry matter accumulation and nutrient content. These samples were first sun-dried and then oven dried at 65ºC till constant weight achieved. Weed control efficiency (WCE) has been calculated with the formula: WCE= (x-y) 100/x, where; *x* = weed dry weight in unweeded control and *y* = weed dry weight in treated plot. Nitrogen was estimated by Kjeldhal's method (Jackson 1973) [6] from ground samples of grain and straw and weed samples. Phosphorus and potassium of samples were estimated following standard methods described by Jackson (1973) [6]. All the data were subjected to analysis of variance (ANOVA) for RBD using SAS 9.3 software packages.

Results and Discussion

Weed flora

The experimental field was full of the weeds comprised of both dicots and monocots. Among the total weeds, dicots weeds (91%) were more prominent as compared to monocots (9%). The weed flora under dicots includes many species like *Melilotus indica* (45%), *Fumaria parviflora* (15%), *Chenopodium album* (9%), *Chenopodium murale* (6%), *Convolvulus arvensis* (5%) and others dicots (11%) (*Anagallis arvensis*, *Spergulla arvensis* and *Coronopus didymus*) whereas *Phalaris minor* (9%) was only grassy weed under monocot (Fig. 1 & 2).

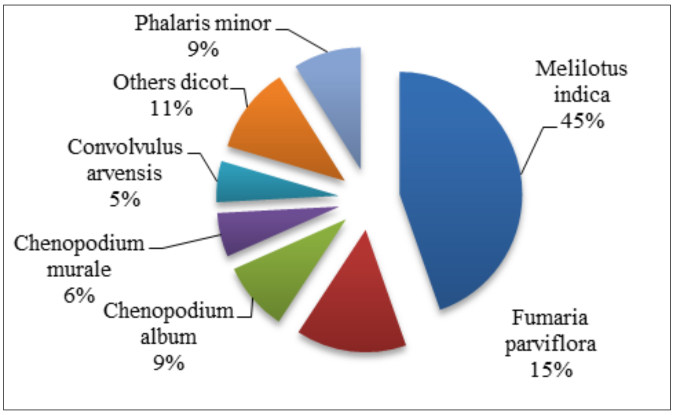

Fig 1: Weed flora in the experimental field

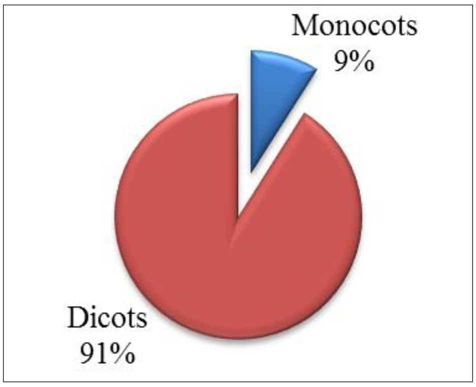

Fig 2: Density of monocot and dicot weeds in unweeded control

Effect of herbicide and their combinations on Weed density

Decline of significant margin was brought about by weed control through various means in comparison to a weedy wheat crop. Different weed control treatments significantly reduced the density of monocot, dicot and total weeds in comparison to unweeded control during both the years. Per cent variation in the pooled number of weeds varied from 16.6 to 87.7 % for monocot, 48.2 to 92.8 % for dicots and 42.5 to 91.9 % for total weeds among the treatments (Table 1). The least number of total weeds were observed under two hand weedings (19.0 m^{-2}) whereas unweeded control accounted for highest density of the same (234.2 m^{-2}). Among the herbicides, metsulfuron + sulfosulfuron retarded growth of weeds and reduced the density of total weeds to minimum followed by mesosulfuron + iodosulfuron, clodinafop + metsulfuron and pinoxaden + metsulfuron which recorded

90.0, 88.8, 88.0 and 87.4 per cent reduction and proved their superiority over rest of the treatments. The alone application of a single herbicide curtailed the density of weeds but not upto the satisfactory level.

Table 1: Effect of weed control treatments on density of monocot, dicot and total weeds at 60 DAS of wheat

Treatments	Weed density (no. m^{-2})								
	Monocot weeds			Dicot weeds			Total weeds		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Pendimethalin 0.75 k g ha^{-1}	5.85	6.09	5.97	9.83	10.16	9.99	11.41	11.82	11.62
	(33.69)	(36.55)	(35.12)	(96.04)	(102.74)	(99.39)	(129.73)	(139.29)	(134.51)
Sulfosulfuron 0.025 kg ha^{-1}	4.21	4.54	4.38	6.74	7.11	6.93	7.92	8.41	8.17
	(17.24)	(20.10)	(18.67)	(44.91)	(50.09)	(47.50)	(62.15)	(70.19)	(66.17)
Metribuzin 0.21 kg ha^{-1}	3.92	4.27	4.10	6.44	6.83	6.64	7.51	8.02	7.77
	(14.89)	(17.75)	(16.32)	(40.97)	(46.15)	(43.56)	(55.86)	(63.90)	(59.88)
Clodinafop 0.06 kg ha^{-1}	3.99	4.33	4.16	6.31	6.71	6.51	7.43	7.95	7.70
	(15.41)	(18.27)	(16.84)	(39.31)	(44.49)	(41.90)	(54.72)	(62.76)	(58.74)
Metsulfuron 0.004 kg ha^{-1}	3.62	4.00	3.82	5.87	6.29	6.08	6.86	7.42	7.15
	(12.64)	(15.50)	(14.07)	(33.91)	(39.09)	(36.50)	(46.55)	(54.59)	(50.57)
Pendimethalin + Metribuzin (0.75 + 0.175 kg ha^{-1}) TM	3.52	3.91	3.72	5.61	6.06	5.84	6.59	7.17	6.89
	(11.89)	(14.75)	(13.32)	(31.00)	(36.18)	(33.59)	(42.89)	(50.93)	(46.91)
Pendimethalin *fb* Sulfosulfuron (0.75 + 0.02 kg ha^{-1})	3.24	3.65	3.45	5.43	5.89	5.66	6.28	6.89	6.59
	(9.97)	(12.83)	(11.40)	(28.99)	(34.17)	(31.58)	(38.96)	(47.00)	(42.98)
Pendimethalin *fb* Clodinafop (0.75 + 0.05 kg ha^{-1})	2.91	3.36	3.14	4.99	5.49	5.25	5.73	6.40	6.07
	(7.95)	(10.81)	(9.38)	(24.43)	(29.61)	(27.02)	(32.38)	(40.42)	(36.40)
Pendimethalin *fb* Metsulfuron (0.75 + 0.004 kg ha^{-1})	2.87	3.33	3.10	4.68	5.21	4.95	5.44	6.14	5.80
	(7.71)	(10.57)	(9.14)	(21.43)	(26.61)	(24.02)	(29.14)	(37.18)	(33.16)
Metsulfuron + Sulfosulfuron (0.003 + 0.02 kg ha^{-1}) TM	2.33	2.88	2.62	3.85	4.48	4.18	4.45	5.27	4.88
	(4.91)	(7.77)	(6.34)	(14.36)	(19.54)	(16.95)	(19.27)	(27.31)	(23.29)
Pinoxaden + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	2.80	3.27	3.05	4.31	4.87	4.60	5.09	5.82	5.47
	(7.35)	(10.21)	(8.78)	(18.04)	(23.22)	(20.63)	(25.39)	(33.43)	(29.41)
Mesosulfuron + Iodosulfuron (0.012 + 0.0024 kg ha^{-1}) TM	2.57	3.07	2.83	4.09	4.68	4.39	4.78	5.55	5.18
	(6.09)	(8.95)	(7.52)	(16.22)	(21.40)	(18.81)	(22.31)	(30.35)	(26.33)
Clodinafop + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	2.63	3.13	2.89	4.24	4.81	4.54	4.94	5.70	5.33
	(6.41)	(9.27)	(7.84)	(17.49)	(22.67)	(20.08)	(23.90)	(31.94)	(27.92)
Two Hand Weedings at 30 and 45 DAS	2.06	2.67	2.38	3.43	4.12	3.79	3.94	4.85	4.42
	(3.75)	(6.61)	(5.18)	(11.26)	(16.44)	(13.85)	(15.01)	(23.05)	(19.03)
Unweeded control	6.42	6.64	6.53	13.76	13.99	13.88	15.16	15.47	15.32
	(40.71)	(43.57)	(42.14)	(188.71)	(195.33)	(192.02)	(229.42)	(238.90)	(234.16)
SEm±	0.52	0.48	0.50	1.21	1.17	1.19	1.32	1.26	1.29
CD (P=0.05)	1.50	1.38	1.43	3.46	3.34	3.40	3.77	3.35	3.68

*Data subjected to $\sqrt{X+0.5}$ transformation and figures in parenthesis are original weed count m^{-2}

Weed dry matter accumulation

Results shows significant drop down in dry matter accumulation of monocot, dicot and total weeds over unweeded control during investigation period. All the herbicide mixtures and sequential applications were significantly superior over signally applied herbicides in reducing dry matter. The per cent reduction in pooled dry matter of monocot, dicot and total weeds varies from 8.1 to 92.8, 57.5 to 97.0 and 49.4 to 96.3 per cent over unweeded control (Table 2). Among different weed control treatments, two hand weedings brought about greatest reduction in pooled dry matter accumulation by total weeds (96.3%). However, variations were at par with metsulfuron + sulfosulfuron, mesosulfuron + iodosulfuron, clodinafop + metsulfuron and pinoxaden + metsulfuron which declined pooled dry matter to 95.3, 94.7, 94.4 and 94.2 per cent, respectively. The performance of single herbicides alone was not up to the satisfactory level. However, results were significant to the unweeded control. The superiority of tank mix application of broad leaf weed and grassy weed suppressing herbicides over their individual applications in reducing total weed density and dry matter has also been reported by Meena *et al*., (2017) [10], Chaudhari *et al*., (2017) [2], Singh *et al*., (2017) [12], Punia *et al*., (2017) [11] and Barla *et al*., (2017) [1].

Table 2: Effect of weed control treatments on weed dry matter accumulation at 60 DAS of wheat

Treatments	Weed dry matter accumulation (g m^{-2})								
	Monocot weeds			Dicot weeds			Total weeds		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Pendimethalin 0.75 k g ha^{-1}	25.11	27.57	26.34	61.13	63.39	62.26	86.24	90.96	88.60
Sulfosulfuron 0.025 kg ha^{-1}	8.74	10.10	9.42	18.45	20.71	19.58	27.19	30.81	29.00
Metribuzin 0.21 kg ha^{-1}	7.90	9.26	8.58	16.41	18.67	17.54	24.31	27.93	26.12
Clodinafop 0.06 kg ha^{-1}	7.95	9.31	8.63	15.63	17.89	16.76	23.58	27.20	25.39
Metsulfuron 0.004 kg ha^{-1}	7.50	8.86	8.18	15.55	17.81	16.68	23.05	26.67	24.86
Pendimethalin + Metribuzin (0.75 + 0.175 kg ha^{-1}) TM	15.55	16.91	16.23	42.11	44.37	43.24	57.66	61.28	59.47
Pendimethalin *fb* Sulfosulfuron (0.75 + 0.02 kg ha^{-1})	3.16	4.52	3.84	12.83	15.09	13.96	15.99	19.61	17.80
Pendimethalin *fb* Clodinafop (0.75 + 0.05 kg ha^{-1})	2.84	4.20	3.52	11.65	13.91	12.78	14.49	18.11	16.30

Pendimethalin *fb* Metsulfuron (0.75 + 0.004 kg ha^{-1})	2.80	4.16	3.48	10.49	12.75	11.62	13.29	16.91	15.10
Metsulfuron + Sulfosulfuron (0.003 + 0.02 kg ha^{-1}) TM	1.56	2.92	2.24	4.76	7.02	5.89	6.32	9.94	8.13
Pinoxaden + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	2.28	3.64	2.96	6.11	8.37	7.24	8.39	12.01	10.20
Mesosulfuron + Iodosulfuron (0.012 + 0.0024 kg ha^{-1}) TM	2.08	3.44	2.76	5.35	7.61	6.48	7.43	11.05	9.24
Clodinafop + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	2.14	3.50	2.82	5.81	8.07	6.94	7.95	11.57	9.76
Two Hand Weedings at 30 and 45 DAS	1.38	2.74	2.06	3.25	5.51	4.38	4.63	8.25	6.44
Unweeded control	27.65	29.71	28.68	145.29	147.55	146.42	172.94	177.26	175.10
SEm±	1.61	1.75	1.68	2.69	2.42	2.55	2.23	2.14	2.18
CD (P=0.05)	4.28	4.65	4.46	7.15	6.43	6.78	5.93	5.69	5.79

Weed control efficiency

All herbicide mixtures and sequential application attributed to greater weed control efficiency than singly applied herbicides. The pooled data on weed control efficiency (WCE) for monocot ranged from 8.2 to 92.8 per cent whereas 57.5 to 97.0 per cent for dicots. The array of total weed control efficiency at 60 DAS was between 49.4 to 96.3 per cent (Table 3). The highest pooled WCE was acquired by two hand weedings followed by mixed application of metsulfuron + sulfosulfuron, mesosulfuron + iodosulfuron, clodinafop + metsulfuron and pinoxaden + metsulfuron. It is because of the fact that metsulfuron control both monocot as well as dicot weeds and when sulfosulfuron ready mixture with metsulfuron which take care of narrow leaf weeds especially *Phalaris minor* enhance the efficacy of this combination and ultimately this treatment proved superior with respect to control of the different weed flora and achieved highest value of WCE (95.4 %) at 60 DAS. The solitary application of pendimethalin lagged behind herbicide mixtures and sequential application and hence responsible for lesser WCE among all the treatments. Mixtures comprising of such herbicides, result in greater overall weeds control, if their interaction is synergistic or additive. The results corroborate the findings of Meena *et al*. (2017) [10], Singh *et al*., (2017) [12], Kaur *et al*., (2017) [7], Chaudhari *et al*., (2017) [2] and Punia *et al*., (2017) [11].

Table 3: Effect of weed control treatments on weed control efficiency at 60 DAS of wheat

Treatments	**Weed control efficiency (%)**								
	Monocot weeds			**Dicot weeds**			**Total weeds**		
	2015-16	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
Pendimethalin 0.75 k g ha^{-1}	9.19	7.20	8.16	57.93	57.04	57.48	50.13	48.69	49.40
Sulfosulfuron 0.025 kg ha^{-1}	68.39	66.00	67.15	87.30	85.96	86.63	84.28	82.62	83.44
Metribuzin 0.21 kg ha^{-1}	71.43	68.83	70.08	88.71	87.35	88.02	85.94	84.24	85.08
Clodinafop 0.06 kg ha^{-1}	71.25	68.66	69.91	89.24	87.88	88.55	86.37	84.66	85.50
Metsulfuron 0.004 kg ha^{-1}	72.88	70.18	71.48	89.30	87.93	88.61	86.67	84.95	85.80
Pendimethalin + Metribuzin (0.75 + 0.175 kg ha^{-1}) TM	43.76	43.08	43.41	71.02	69.93	70.47	66.66	65.43	66.04
Pendimethalin *fb* Sulfosulfuron (0.75 + 0.02 kg ha^{-1})	88.57	84.79	86.61	91.17	89.77	90.47	90.75	88.94	89.83
Pendimethalin *fb* Clodinafop (0.75 + 0.05 kg ha^{-1})	89.73	85.86	87.73	91.98	90.57	91.27	91.62	89.78	90.69
Pendimethalin *fb* Metsulfuron (0.75 + 0.004 kg ha^{-1})	89.87	86.00	87.87	92.78	91.36	92.06	92.32	90.46	91.38
Metsulfuron + Sulfosulfuron (0.003 + 0.02 kg ha^{-1}) TM	94.36	90.17	92.19	96.72	95.24	95.98	96.35	94.39	95.36
Pinoxaden + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	91.75	87.75	89.68	95.79	94.33	95.06	95.15	93.22	94.17
Mesosulfuron + Iodosulfuron (0.012 + 0.0024 kg ha^{-1}) TM	92.48	88.42	90.38	96.32	94.84	95.57	95.70	93.77	94.72
Clodinafop + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	92.26	88.22	90.17	96.00	94.53	95.26	95.40	93.47	94.43
Two Hand Weedings at 30 and 45 DAS	95.01	90.78	92.82	97.76	96.27	97.01	97.32	95.35	96.32
Unweeded control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NPK content in monocot and dicot weeds

Data clearly indicate (Table 4-6) that highest NPK content was registered under unweeded control but the weed control treatments tended to reduce it significantly. Among herbicides, least pooled total NPK content in monocot and dicot was exhibited by metsulfuron + sulfosulfuron (1.163 & 1.378, 0.162 & 0.242 and 0.230 & 1.008) followed by mesosulfuron + iodosulfuron, clodinafop + metsulfuron and pinoxaden + metsulfuron. It might be because of the fact that reduced density and retarded growth of weeds were more due to these treatments. The NPK content in total (monocot & dicot) weeds varied among the treatment and it ranges from 2.53 to 2.57, 0.40 to 0.43, and 1.23 to 1.27, respectively. The other remaining treatments (pendimethalin *fb* metsulfuron, pendimethalin *fb* clodinafop and pendimethalin *fb* sulfosulfuron) were next in order of significance whereas solitary application of single herbicide recorded more NPK content in both monocot as well as dicot weeds. However, two hand weeding responsible for lesser NPK content by both monocot and dicot weeds among all the treatments. The similar types of results have also been reported by Kumar *et al*., (2017) [8] and Meena *et al*., (2017) [10].

Table 4: Effect of weed control treatments on nitogen content in weeds at 60 DAS of wheat

Treatments	**Nitrogen (%)**					
	Monocot weeds			**Dicot weeds**		
	2015-16	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
Pendimethalin 0.75 k g ha^{-1}	1.145	1.205	1.175	1.351	1.431	1.391
Sulfosulfuron 0.025 kg ha^{-1}	1.144	1.204	1.174	1.349	1.429	1.389
Metribuzin 0.21 kg ha^{-1}	1.142	1.202	1.172	1.347	1.427	1.387
Clodinafop 0.06 kg ha^{-1}	1.140	1.200	1.170	1.346	1.426	1.386
Metsulfuron 0.004 kg ha^{-1}	1.143	1.203	1.173	1.345	1.425	1.385
Pendimethalin + Metribuzin (0.75 + 0.175 kg ha^{-1}) TM	1.143	1.203	1.173	1.348	1.428	1.388

Pendimethalin *fb* Sulfosulfuron (0.75 + 0.02 kg ha^{-1})	1.142	1.202	1.172	1.341	1.421	1.381
Pendimethalin *fb* Clodinafop (0.75 + 0.05 kg ha^{-1})	1.138	1.198	1.168	1.339	1.419	1.379
Pendimethalin *fb* Metsulfuron (0.75 + 0.004 kg ha^{-1})	1.133	1.193	1.163	1.338	1.418	1.378
Metsulfuron + Sulfosulfuron (0.003 + 0.02 kg ha^{-1}) TM	1.123	1.183	1.153	1.332	1.412	1.372
Pinoxaden + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	1.131	1.191	1.161	1.336	1.416	1.376
Mesosulfuron + Iodosulfuron (0.012 + 0.0024 kg ha^{-1}) TM	1.127	1.187	1.157	1.334	1.414	1.374
Clodinafop + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	1.129	1.189	1.159	1.335	1.415	1.375
Two Hand Weedings at 30 and 45 DAS	1.128	1.188	1.158	1.330	1.410	1.370
Unweeded control	1.147	1.207	1.177	1.353	1.433	1.393
SEm±	0.050	0.052	0.049	0.030	0.031	0.028
CD (P=0.05)	0.015	0.017	0.016	0.070	0.072	0.065

Table 5: Effect of weed control treatments on nutrient content in weeds at 60 DAS of wheat

Treatments	Phosphorus (%)					
	Monocot weeds			Dicot weeds		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Pendimethalin 0.75 k g ha^{-1}	0.167	0.171	0.169	0.211	0.291	0.251
Sulfosulfuron 0.025 kg ha^{-1}	0.167	0.171	0.169	0.210	0.290	0.250
Metribuzin 0.21 kg ha^{-1}	0.166	0.170	0.168	0.208	0.288	0.248
Clodinafop 0.06 kg ha^{-1}	0.165	0.169	0.167	0.208	0.288	0.248
Metsulfuron 0.004 kg ha^{-1}	0.164	0.168	0.166	0.206	0.286	0.246
Pendimethalin + Metribuzin (0.75 + 0.175 kg ha^{-1}) TM	0.166	0.170	0.168	0.209	0.289	0.249
Pendimethalin *fb* Sulfosulfuron (0.75 + 0.02 kg ha^{-1})	0.163	0.167	0.165	0.208	0.288	0.248
Pendimethalin *fb* Clodinafop (0.75 + 0.05 kg ha^{-1})	0.162	0.166	0.164	0.207	0.287	0.247
Pendimethalin *fb* Metsulfuron (0.75 + 0.004 kg ha^{-1})	0.162	0.166	0.164	0.205	0.285	0.245
Metsulfuron + Sulfosulfuron (0.003 + 0.02 kg ha^{-1}) TM	0.160	0.164	0.162	0.202	0.282	0.242
Pinoxaden + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	0.164	0.168	0.166	0.206	0.286	0.246
Mesosulfuron + Iodosulfuron (0.012 + 0.0024 kg ha^{-1}) TM	0.162	0.166	0.164	0.204	0.284	0.244
Clodinafop + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	0.163	0.167	0.165	0.204	0.284	0.244
Two Hand Weedings at 30 and 45 DAS	0.159	0.163	0.161	0.201	0.281	0.241
Unweeded control	0.170	0.174	0.172	0.214	0.294	0.254
SEm±	0.001	0.002	0.002	0.001	0.002	0.001
CD (P=0.05)	0.002	0.004	0.003	0.002	0.003	0.002

Table 6: Effect of weed control treatments on potassium content in weeds at 60 DAS of wheat

Treatments	Potassium (%)					
	Monocot weeds			Dicot weeds		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Pendimethalin 0.75 k g ha^{-1}	0.228	0.254	0.241	1.005	1.033	1.019
Sulfosulfuron 0.025 kg ha^{-1}	0.227	0.253	0.240	1.004	1.032	1.018
Metribuzin 0.21 kg ha^{-1}	0.226	0.252	0.239	1.004	1.032	1.018
Clodinafop 0.06 kg ha^{-1}	0.225	0.251	0.238	1.002	1.03	1.016
Metsulfuron 0.004 kg ha^{-1}	0.223	0.249	0.236	1.000	1.028	1.014
Pendimethalin + Metribuzin (0.75 + 0.175 kg ha^{-1}) TM	0.226	0.252	0.239	1.004	1.032	1.018
Pendimethalin *fb* Sulfosulfuron (0.75 + 0.02 kg ha^{-1})	0.222	0.248	0.235	0.999	1.027	1.013
Pendimethalin *fb* Clodinafop (0.75 + 0.05 kg ha^{-1})	0.221	0.247	0.234	0.998	1.026	1.012
Pendimethalin *fb* Metsulfuron (0.75 + 0.004 kg ha^{-1})	0.221	0.247	0.234	0.997	1.025	1.011
Metsulfuron + Sulfosulfuron (0.003 + 0.02 kg ha^{-1}) TM	0.217	0.243	0.230	0.994	1.022	1.008
Pinoxaden + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	0.221	0.247	0.234	0.997	1.025	1.011
Mesosulfuron + Iodosulfuron (0.012 + 0.0024 kg ha^{-1}) TM	0.219	0.245	0.232	0.995	1.023	1.009
Clodinafop + Metsulfuron (0.06 + 0.004 kg ha^{-1}) RM	0.220	0.246	0.233	0.996	1.024	1.010
Two Hand Weedings at 30 and 45 DAS	0.215	0.241	0.228	0.991	1.019	1.005
Unweeded control	0.230	0.256	0.243	1.009	1.037	1.023
SEm±	0.001	0.002	0.001	0.002	0.003	0.002
CD (P=0.05)	0.003	0.005	0.002	0.004	0.007	0.003

Conclusion

On the basis of findings of two years investigation it can be concluded that in late sown wheat weed management with the pre mix application either of metsulfuron + sulfosulfuron (0.003 + 0.02 kg ha^{-1}) or mesosulfuron + iodosulfuron (0.012 + 0.0024 kg ha^{-1}) as post-emergence at 5 WAS should be used for the control of complex weed flora in wheat crop as these resulted in significantly greater reduction in weed density and dry matter with higher weed control efficiency which results in lesser removal of nutrients by weeds and ultimately crop might be benefited to boost up the productivity of wheat crop.

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