Indian Journal of Weed Science (2023) **55**(4): 453–460
http://dx.doi.org/10.5958/0974-8164.2023.00082.5

RESEARCH NOTE

Weed dynamics, productivity and profitability of wheat as influenced by tillage and weed management practices in Eastern Indo-Gangetic Plains

Parmeswar Dayal[1,2], Arun Kumar[1,3], Ravikesh Kumar Pal[1], Sumit Sow[4*], Shivani Ranjan[4], Shashank Tyagi[1] and Pradeep Kumar[5]

Received: 6 June 2023 | Revised: 31 July 2023 | Accepted: 5 August 2023

ABSTRACT

Wheat (*Triticum aestivum* L.) is infested with several grassy and broad-leaf weeds which create competitive stress resulting in yield losses varying from 10-70% depending upon their density. A field experiment was conducted during winter season of 2021-22 at the Research Farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India to assess the effect of tillage and weed management practices on weed dynamics, yield and economics of wheat. The experiment was carried out in a split plot design, replicated thrice. The main plot comprised of two tillage methods *i.e.*, conventional tillage and zero tillage while subplots consisted different herbicide combinations *i.e.*, weedy, weed free, pinoxaden 5.1% EC 20 g/ha, carfentrazone-ethyl 40% DF 20 g/ha, clodinafop-propargyl 15% WP EC 60 g/ha, carfentrazone-ethyl 20% DF 20 g/ha + pinoxaden 5.1% EC 20 g/ha, carfentrazone-ethyl 20% DF EC 20 g/ha + pinoxaden 5.1% EC 20 g/ha, metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha, metsulfuron-methyl 20% WP 4 g/ha + pinoxaden 5.1% EC 20 g/ha. The low weed density and biomass along with higher grain yield were recorded under zero tillage as compared to conventional tillage. Similarly, zero tillage recorded lower cost of cultivation (₹ 33702 /ha), higher net returns (₹ 69381 /ha) and B: C ratio (2.07). Among herbicide combinations, the treatment metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha followed by metsulfuron-methyl 20% WP 4 g/ha + pinoxaden 5.1% EC 20 g/ha resulted in higher weed control efficiency, yield, net returns and B:C ratio.

Keywords: Chemical control, Metsulfuron, Profitability, Tillage, Weed dynamics, Wheat

Wheat (*Triticum aestivum* L.) is one of the most important food crops in India and it plays an important role in crop production due to its adaptability to wide range of agro-climatic conditions. It is the second most important cereal crop of India after rice and accounts for 31.5% of the total food grain production of the country (Choudhary *et al.* 2017). In India, Bihar ranks 6th in wheat production after Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, and Rajasthan. Rice-wheat has emerged as major cropping system of Indo-Gangetic Plain (IGP). At present, the sustainability of rice-wheat system is in question either due to yield stagnation or decline of rice or wheat across rice-wheat system of IGP, soil degradation, declining groundwater level, and environmental pollution from stubble burning (Verma *et al.* 2017). Heavy infestation of the weed flora in wheat has become a serious problem thereby hindering productivity under rice-wheat cropping systems (Kushwaha *et al.* 2020). *Phalaris minor* and *Avena ludoviciana* are major problematic grassy weeds causing significant reduction in wheat grain yield (Mukherjee *et al.* 2016). Besides *P. minor*, herbicide resistance has also been found in *Rumex dentatus* against metsulfuron-methyl and *Avena ludoviciana* (Kaur *et al.* 2018). Herbicide combinations such as mesosulfuron + iodosulfuron, fenoxaprop + metribuzin, and clodinafop + metribuzin provided alternative option to deal with resistant *P. minor* (Singh *et al.* 2015, Punia *et al.* 2017).

Zero-tillage in wheat in rice –wheat system has been proved as the most resource-conserving technique in IGP. It leads to considerable benefits in terms of production (6-10%) and cost reductions (5-10%) (Shyam *et al.* 2014). The study was carried out to find the effect of tillage and weed management practices on weed dynamics and productivity and profitability of wheat in EIGP.

[1] Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

[2] Present address: Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi, India

[3] Present address: Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India

[4] Department of Agronomy, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, India

[5] Department of Agronomy, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

* Corresponding author email: sumitsow19@gmail.com

A field study was conducted during *Rabi* (winter) season of 2021-22 at Research Farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India. The geographical details of the site are 25°50' N latitude, 87°19' E longitude and 52.73 meter above mean sea level (MSL). The soil of the experimental field was loamy in texture and almost neutral in reaction having pH 7.35, organic carbon 0.58%, available nitrogen 173.45 kg, available phosphorus 22.43 kg and available potassium 148.82 kg/ha. The experiment was laid out in a split plot design with three replications. The treatment details of the experiment were 2 tillage practices namely conventional tillage zero tillage while under weed management practices, there were nine treatment which details are given in **Table 1**. The wheat variety '*HD 2967*' was sown on 23rd December with a seed rate of 125 kg/ha for both zero and conventional tilled plots. Sowing was done mechanically with the help of a national zero-till seed-cum-fertilizer- drill by maintaining a row-to-row spacing of 20 cm.

The number of individual weed species was counted at 30, 60, and 90 DAS and at harvest stage from two spots selected randomly in each plot through a quadrate of 50 x 50 cm and expressed as number per meter square area. The data on weed density was subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis to normalize their distribution (Gomez and Gomez 1984). For determining weed biomass (g/m^2), samples were chopped and filled in perforated paper bags separately and sun-dried for two days. Finally, these samples were kept in an oven at 70 °C to obtain a constant weight. These were weighed and expressed in g/m^2 of weed biomass. Weed control efficiency (WCE) is the efficiency of applied treatment for controlling the weeds in comparison of weedy check. The following formula was used to calculate the weed control efficiency of various treatments as suggested by Mani *et al.* (1973) as follows;

$$WCE\ (\%) = \frac{DWC - DWT}{DWC} \times 100$$

where, WCE = Weed control efficiency, DWC = Dry weight of weeds in control plot; DWT = Dry weight of weeds in treated plot.

The crop harvested from each net plot was threshed individually and cleaned grains were sun dried to reduce their moisture content to 12% before being weighed. Then, the grain as well as straw yield were calculated and expressed as t/ha. The proportion of grains recovered from the total harvested yield was used to estimate the harvest index. The harvest index for each experimental plot was calculated using the formula (Singh and Stoskopf 1971).

$$\text{H.I.}\ (\%) = \frac{\text{Grain yield (q/ha)}}{\text{Biological yields (q/ha)}}$$

Economic analysis was done as per the prevailing cost of inputs and selling price of output during the concerning year. Benefit: cost ratio (B: C) was obtained by dividing the gross income with the cost of cultivation. The experimental data were analyzed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of the overall difference among treatments by the F-test and conclusions were drawn at a 5% probability level (Gomez and Gomez 1984).

Effect on weed flora

In this study, the wheat crop was infested with heavy population of grassy and broad-leaf weeds, *viz. Polypogon monspeliensis*, *Cynodon dactylon*, *Phalaris minor*, *Cyperus rotundus*, *Rumex dentatus*, *Convolvulus arvensis*, *Anagallis arvensis*, *Chenopodium album*, *Polygonum plebeium* and *Melilotus indica.* The broad-leaf weeds were more dominant than grassy and sedge weeds.

Effect on weed density

The weed density of *Cynodon dactylon* was reduced significantly by tillage and weed management practices at all the stages except 30 DAS (**Table 1**). The lowest weed density 16.13 and 10.78/m^2 of *Cynodon dactylon* was recorded under zero tillage at 60 and 90 DAS, respectively. It was realized that the weed density decreased as the crop growth advanced except in weedy and carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha, where it enhanced at 60 DAS and thereafter it decreased. All the herbicidal treatments recorded significantly lower density of *Cynodon dactylon* than the weedy plot at 60 and 90 DAS. Among the tillage management practices, conventional tillage recorded 31.2 and 21.9% higher weed density of *Polypogon monspeliensis* at 30 and 60 DAS, respectively. The density of *P. monspeliensis* revealed that it decreased as the crop growth advanced except weedy, where it enhanced at 60 DAS and thereafter it decreased. The highest weed density 36.33 and 35.17/m^2 was recorded in the weedy plot at 60 and 90 DAS. Furthermore, similar trend was followed in the density of *Phalaris minor* among tillage management practices. The lowest density of *P. minor* under zero tillage might be due to less soil disturbance; as a result, seeds present in lower soil layers failed to germinate (Singh *et al.* 2015). Weed seeds remained in the subsurface under zero tillage due to puddling carried out during rice transplanting which failed to germinate in wheat because of unfavorable condition (Katara *et al.*

2015). These findings were in conformity with those reported by Shivran *et al*. (2020).

Zero tillage plot recorded lowest weed density 10.64 and 9.81/m^2 of *C. rotundus* at 60 and 90 DAS, respectively (**Table 1**). Weed density decreased as the crop growth advanced except in weedy, where it enhanced at 60 DAS and thereafter it decreased. Application of metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha significantly reduced the density of *C. rotundus* (7.50 /m^2), which was found at par with metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha, carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha and carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha. On the other hand, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha significantly reduced the density of *C. rotundus* (6.10 /m^2) at 90 DAS, which was found at par with carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha, metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ ha, carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha and was found significantly superior over rest of the treatments. Weedy plot recorded significantly highest density of 37.50 and 32.83/m^2 *C. rotundus* at 60 and 90 DAS, respectively. It might be due to the optimal dose of these herbicides which controlled the grassy weeds and sedges effectively (Mukherjee 2020 and Hossain and Begum 2015).

In case of tillage practices, the density of *Rumex dentatus* was lowest (11.96 and 9.80 /m^2) under zero tillage at 60 and 90 DAS, respectively (**Table 2**). The lower weed density 15.52 and 13.63 /m^2 of *Polygonum plebeium* was recorded under zero tillage as compared to conventional tillage at 60 and 90 DAS, respectively. The density of other broad-leaf weeds like *Melilotus indica* and *Anagallis* sp., 11.05 and 7.04 /m^2 was also low under zero tillage and it decreased as the crop growth advanced except weedy, where it enhanced at 60 DAS and thereafter it decreased. Herbicide combination of metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha significantly reduced the weed density of other broad-leaved weeds (6.48 and 4.48/m^2), which was found at par with metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha and 46.7, 45.2% at 60 DAS, and at 90 DAS, it was 45.5 and 48.9% lower as compared to the treatment carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha and carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha, respectively. The density of other broad-leaf weeds was found more under conventional tillage. This was largely due to vertical distribution of weed seeds and more soil disturbance under conventional tillage which came up to the soil surface and germinated (Karunakaran and Behera 2013, Makhan *et al*. 2016). However, the density of *Rumex dentatus* was found more under

Table 1. Effect of tillage methods and weed management practices on weed density (no/m^2) of grassy weeds and sedge

Treatment	*Cynodon dactylon*			*Polypogon monspeliensis*			*Phalaris minor*			*Cyperus rotundus*		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Tillage practice												
Conventional tillage	3.63 (14.61)	4.03 (18.26)	3.69 (15.41)	3.94 (17.17)	3.66 (15.00)	3.28 (12.11)	4.21 (20.34)	3.84 (16.56)	3.61 (14.48)	3.74 (16.42)	3.60 (14.56)	3.25 (11.58)
Zero tillage	3.98 (18.04)	3.79 (16.13)	3.11 (10.78)	3.71 (15.74)	3.22 (11.37)	2.95 (9.93)	3.96 (17.74)	3.40 (12.96)	3.03 (10.41)	3.50 (13.68)	3.09 (10.64)	2.91 (9.81)
LSD (p=0.05)	NS	0.04	0.19	NS	0.21	0.16	NS	0.27	0.06	NS	0.11	0.13
Weed management practice												
Weedy	4.12 (17.33)	6.78 (46.10)	6.19 (38.17)	4.12 (17.17)	6.04 (36.33)	5.94 (35.17)	4.17 (18.83)	6.47 (41.67)	6.24 (38.67)	3.76 (15.60)	6.13 (37.50)	5.71 (32.83)
Weed free	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)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Pinoxaden 20 g/ha	4.90 (24.17)	4.53 (20.33)	4.09 (16.30)	4.61 (21.10)	3.92 (15.17)	3.57 (12.33)	4.70 (23.00)	4.20 (17.17)	3.56 (12.33)	4.48 (21.22)	3.91 (15.00)	3.50 (12.00)
Carfentrazone-ethyl 20 g/ha	4.57 (21.83)	4.40 (19.05)	3.84 (14.50)	4.50 (20.50)	3.70 (13.33)	3.26 (10.33)	4.62 (23.42)	4.33 (18.50)	3.85 (14.50)	4.18 (17.57)	3.67 (13.17)	3.22 (10.17)
Clodinafop-propargyl 60 g/ha	4.24 (18.20)	4.24 (17.67)	3.64 (13.20)	4.06 (17.67)	3.79 (14.00)	3.42 (11.50)	4.43 (19.93)	3.70 (13.33)	3.38 (11.17)	4.52 (21.83)	3.51 (12.05)	3.14 (9.50)
Carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha	3.99 (16.70)	3.82 (14.20)	3.34 (10.83)	4.03 (18.62)	3.62 (12.83)	3.12 (9.50)	4.51 (20.83)	3.58 (12.50)	3.23 (10.17)	3.94 (16.33)	3.22 (10.13)	3.13 (9.67)
Carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha	3.50 (12.97)	3.83 (14.17)	3.16 (9.67)	4.01 (16.70)	3.32 (10.67)	2.99 (8.50)	4.69 (22.50)	3.36 (10.83)	3.20 (9.83)	3.87 (15.50)	3.09 (9.20)	2.86 (7.83)
Metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha	4.02 (16.70)	3.31 (10.67)	2.73 (7.00)	3.89 (16.20)	2.82 (7.50)	2.40 (5.53)	3.99 (17.50)	3.01 (8.67)	2.74 (7.17)	3.70 (14.72)	2.81 (7.50)	2.55 (6.10)
Metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha	4.18 (19.00)	3.60 (12.55)	2.92 (8.17)	4.48 (20.17)	3.04 (8.83)	2.63 (6.50)	4.98 (25.33)	3.24 (10.17)	2.89 (8.17)	3.44 (12.67)	3.04 (8.83)	2.92 (8.17)
LSD (p=0.05)	NS	0.54	0.41	NS	0.46	0.44	NS	0.38	0.40	NS	0.48	0.63

*Original values given in parentheses was subjected to square root transformation ($\sqrt{x+0.5}$) before analysis; DAS: days after sowing, NS: Non-significant

zero tillage. This might be due to the concentration of *Rumex dentatus* seeds on the upper soil layer particularly on the surface, under zero tillage (Chhokar *et al.* 2007).

Effect on weed biomass

The biomass of *C. dactylon* was significantly affected by tillage and weed management practices at all the stages except 30 DAS (**Table 3**). Significantly lower weed biomass (18.41 and 14.93 g/m^2) of *C. dactylon* was found under zero tillage as compared to conventional tillage at 60 and 90 DAS, respectively. Metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha significantly reduced the biomass of *Cynodon dactylon* (14.98 g/m^2) which was at par with metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha, carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha and carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha. At 90 DAS, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha significantly reduced the weed biomass (9.73 g/m^2) of *Cynodon dactylon* which was 37.4, 31.1, 27.2% lower as compared to treatment Carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha, carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha and metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha. The weedy plot recorded highest weed biomass (56.60 and 50.38 g/m^2) at 60 and 90 DAS. Similarly in *Polypogon monspeliensis*, lower weed biomass (20.65 and 18.30 g/m^2) was recorded under zero tillage at 60 and 90 DAS, respectively. Application of carfentrazone-ethyl 40% DF 20 g/ha + clodinafop-propargyl 15% WP 60 g/ha significantly reduced the biomass of *Polypogon monspeliensis* (17.50 g/m^2), which was at par with metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha and carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha. However, at 90 DAS, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha significantly reduced the biomass of *Polypogon monspeliensis* (6.97 g/m^2). In case of *Phalaris minor*, lower biomass 20.53 and 17.57 g/m^2 was found under zero tillage at 60 and 90 DAS, respectively. At 60 DAS, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha significantly reduced the biomass of *Phalaris minor* (12.44 g/m^2), which was at par with metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha. Similarly at 90 DAS, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha significantly reduced the dry weight of *Phalaris minor* (7.66 /m^2). The weedy plot recorded highest weed biomass (77.67 and 87.17 g/m^2) at 60 and 90 DAS. The use of broad-spectrum herbicidal combinations proved more effective as it gave complete control of grassy weeds associated with wheat as reported earlier by Singh *et al.* (2015) and Bharat *et al.* (2012).

Table 2. Effect of tillage and weed management practices on weed density (no./m^2) of broad-leaved weeds

Treatment	*Rumex dentatus*			*Polygonum plebeium*			Other broad-leaf weeds		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Tillage practice									
Conventional tillage	3.79 (15.93)	3.78 (16.85)	3.38 (13.06)	4.28 (20.63)	4.30 (20.75)	3.87 (16.66)	3.87 (16.76)	3.49 (13.29)	3.14 (10.77)
Zero tillage	3.78 (16.09)	3.25 (11.96)	2.91 (9.80)	3.91 (17.54)	3.73 (15.52)	3.55 (13.63)	3.54 (14.34)	3.19 (11.05)	2.59 (7.04)
LSD (p=0.05)	NS	0.25	0.10	NS	0.40	0.17	NS	0.04	0.36
Weed management practice									
Weedy	4.06 (16.73)	6.79 (46.05)	6.22 (38.37)	4.48 (19.83)	6.80 (46.25)	6.08 (37.10)	3.44 (11.55)	4.90 (23.72)	4.21 (17.73)
Weed free	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)	0.71 (0.00)
Pinoxaden 20 g/ha	4.35 (18.88)	4.16 (17.83)	3.75 (13.62)	4.46 (21.70)	4.79 (22.73)	4.24 (17.72)	4.64 (23.05)	4.19 (17.58)	3.89 (14.78)
Carfentrazone-ethyl 20 g/ha	4.07 (16.42)	3.96 (15.47)	3.34 (10.75)	4.49 (20.77)	4.52 (20.25)	3.94 (15.50)	4.50 (21.23)	3.88 (14.72)	3.19 (10.03)
Clodinafop-propargyl 60 g/ha	4.05 (16.92)	3.85 (14.43)	3.45 (11.83)	4.71 (22.35)	4.36 (18.93)	4.08 (16.22)	4.08 (18.20)	3.64 (13.25)	3.15 (9.50)
Carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha	4.28 (18.77)	3.44 (11.54)	3.13 (9.40)	4.84 (24.75)	4.04 (16.37)	3.91 (14.93)	4.45 (20.57)	3.50 (12.17)	2.88 (8.23)
Carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha	4.01 (17.83)	3.23 (10.00)	2.85 (7.80)	4.66 (22.50)	3.83 (14.50)	3.70 (13.27)	4.30 (19.40)	3.49 (11.83)	3.00 (8.77)
Metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha	4.53 (20.17)	2.64 (6.52)	2.27 (4.72)	4.10 (19.03)	3.42 (11.27)	3.18 (9.65)	3.70 (13.68)	2.61 (6.48)	2.16 (4.48)
Metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha	4.02 (18.37)	2.88 (7.90)	2.59 (6.38)	4.41 (20.83)	3.64 (12.92)	3.51 (11.90)	3.52 (12.27)	3.15 (9.78)	2.62 (6.62)
LSD (p=0.05)	NS	0.47	0.38	NS	0.64	0.55	NS	0.70	0.58

*Original values given in parentheses was subjected to square root transformation ($\sqrt{x+0.5}$) before analysis; DAS: days after sowing, NS: Non-significant

The minimum weed biomass of *Cyperus rotundus i.e.* 20.67 and 15.04 g/m^2 at 60 and 90 DAS respectively was recorded under zero tillage (**Table 3**). Amongst weed management practices, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha recorded lowest biomass (11.83 g/m^2) at 60 DAS. Moreover, at 90 DAS, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha significantly reduced the weed biomass (8.15 g/m^2) of *Cyperus rotundus* which was found at par with metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha and 86.6% lower than the weedy. The effective weed control by sequentially applied herbicides resulted in the least crop weed competition due to lower weed biomass (Soni *et al.* 2022).

Biomass of *Rumex dentatus* was lower under zero tillage at 60 and 90 DAS, respectively (**Table 4**). Weedy plot recorded significantly highest biomass (97.50 and 55.67 g/m^2) of this weed at 60 and 90 DAS, respectively. In case of *Polygonum plebeium,* a similar trend was followed and lower biomass (23.68 and 16.63 g/m^2) was observed under zero tillage at 60 and 90 DAS, respectively. At 60 DAS, application of carfentrazone-ethyl 40% DF 20 g/ha + pinoxaden 5.1% EC 20 g/ha) significantly reduced the biomass of *Polygonum plebeium* (16.38 g/m^2). However, at 90 DAS, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha significantly reduced the biomass of *Polygonum plebeium* (9.83 g/m^2). Weedy plot recorded significantly highest dry weight (92.75 and 66.93 g/m^2) of this weed at 60 and 90 DAS, respectively. The results revealed that dry weight of other broad-leaved weeds was significantly affected by tillage methods and weed management practices at all the stages except 30 DAS. Among weed management practices, biomass of other broad-leaf weeds at 60 DAS was minimum with metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha. However, at 90 DAS, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha recorded minimum biomass of other broad-leaf weeds (8.54 g/m^2). Higher weed biomass was observed under conventional tillage in wheat because of soil disturbance caused by tillage that could have brought the deep buried weed seeds near to soil surface, where favourable environment, in terms of better availability of light, oxygen and moisture facilitated the germination and emergence of weed seeds (Arora *et al.* 2013). Besides, tillage caused abrasion/rapture of seed coat of weed seeds and thus facilitated germination of weed seeds and in turns had more density and biomass of former weeds (Punia *et al.* 2017).

Effect on yield

The maximum grain yield of 4.01 t/ha and 4.78 t/ha was recorded under zero tillage and weed free (weed free treatment), respectively which was found significantly superior over rest of the treatments

Table 3. Effect of tillage and weed management practices on weed biomass (g/m^2) of grassy weeds and sedge at various crop growth stages

Treatment	*Cynodon dactylon*			*Polypogon monspeliensis*			*Phalaris minor*			*Cyperus rotundus*		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Tillage practice												
Conventional tillage	3.18 (12.03)	4.63 (23.95)	4.21 (19.89)	3.88 (11.04)	4.41 (24.30)	3.68 (20.36)	2.85 (8.33)	4.28 (23.06)	4.06 (21.71)	3.42 (13.38)	4.56 (23.48)	4.18 (20.27)
Zero tillage	2.97 (10.57)	4.02 (18.41)	3.60 (14.93)	2.83 (10.27)	3.99 (20.65)	3.88 (18.30)	2.93 (7.64)	4.03 (20.53)	3.72 (17.57)	3.16 (11.00)	4.23 (20.67)	3.56 (15.04)
LSD (p=0.05)	NS	0.04	0.03	NS	0.16	0.17	NS	0.26	0.028	NS	0.18	0.17
Weed management practice												
Weedy	3.62 (13.42)	7.54 (56.60)	7.12 (50.38)	4.27 (13.31)	9.92 (98.00)	9.85 (96.83)	2.80 (8.16)	8.50 (77.67)	8.18 (87.17)	3.84 (15.43)	7.94 (62.55)	7.81 (60.72)
Weed free	0.71 (0.00)	0.71 (00.00)	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)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Pinoxaden 20 g/ha	3.69 (14.72)	5.06 (25.17)	4.53 (20.33)	2.24 (12.55)	4.29 (17.95)	3.99 (15.58)	2.79 (9.23)	4.97 (20.33)	4.51 (15.33)	3.76 (14.23)	5.16 (26.27)	4.24 (17.83)
Carfentrazone-ethyl 20 g/ha	3.42 (12.78)	4.77 (22.57)	4.12 (17.08)	4.12 (10.83)	4.03 (15.52)	3.67 (13.10)	3.59 (8.69)	4.46 (22.25)	4.07 (16.66)	3.36 (11.50)	4.91 (23.60)	4.38 (18.88)
Clodinafop-propargyl 60 g/ha	3.47 (13.13)	4.67 (21.58)	4.03 (16.10)	3.92 (11.60)	4.23 (17.78)	3.52 (11.98)	3.3 (9.13)	4.13 (17.96)	3.59 (14.08)	3.79 (15.38)	4.66 (21.53)	3.97 (15.50)
Carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha	3.05 (11.67)	4.12 (16.83)	3.97 (15.55)	3.98 (10.25)	3.45 (11.83)	3.44 (11.43)	2.77 (8.61)	3.96 (15.50)	4.06 (13.46)	3.61 (13.75)	4.39 (19.17)	3.86 (14.42)
Carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha	3.14 (10.53)	4.17 (17.32)	3.78 (14.12)	4.07 (12.05)	3.20 (17.50)	4.25 (10.23)	2.11 (7.26)	3.82 (14.86)	3.38 (12.21)	3.43 (12.83)	4.21 (11.45)	3.61 (12.67)
Metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha	3.33 (11.38)	3.91 (14.98)	3.18 (9.73)	4.08 (10.57)	3.31 (10.66)	2.72 (6.97)	3.10 (10.54)	3.27 (12.44)	2.86 (7.66)	3.90 (16.42)	3.50 (11.83)	2.92 (8.15)
Metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha	3.73 (14.05)	3.97 (15.55)	3.69 (13.37)	3.84 (12.52)	3.66 (13.02)	2.86 (7.85)	3.81 (10.21)	3.57 (15.17)	3.65 (10.21)	3.24 (10.15)	4.06 (16.27)	3.30 (10.63)
LSD (p=0.05)	NS	0.42	0.47	NS	0.43	0.48	NS	0.47	0.49	NS	0.42	0.41

*Original values given in parentheses was subjected to square root transformation ($\sqrt{x+0.5}$) before analysis; DAS: days after sowing, NS: Non-significant

(**Table 5**). Among herbicidal treatments, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha recorded significantly highest grain yield (4.36 t/ha) which was 9.0, 6.3 and 3.6% higher as compared to carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha, carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha and metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha respectively. Likewise, higher straw yield (5.58 t/ha) was recorded under zero tillage as compared to conventional tillage. Among herbicides, metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha exhibited significantly highest straw yield which was at par with metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha, carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha, carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha and clodinafop propargyl 60 g/ha. The reduced yield under conventional tillage might be due to more crop-weed competition and more dry matter accumulation by the weeds (Kumar *et al*. 2018). Among weed management practices, the highest grain and straw yield were obtained in weed-free treatment due to zero competition with the weeds. In contrast to this, the lowest grain and straw yield was obtained in weedy treatment due to season-long weed competition. Due to reduced weed infestation through these treatments might have helped the crop plants to accumulate more dry matter that might have provided more quantity of photosynthates to developing sink in crop plants produced more yield (Meena *et al*. 2019). The beneficial effects of herbicide mixture and their sequential application for weed management and higher grain and straw yield comparable to weed-free were also reported by Punia *et al*. (2020). This suggests that zero tillage should be accompanied with efficient herbicide combination for achieving higher wheat productivity.

Harvest index and weed control efficiency

Among the tillage management practices, zero tillage recorded highest harvest index (0.42%) **(Table 5)**. The maximum weed control efficiency (WCE) of 73.15% and 75.27% at 60 and 90 DAS respectively was achieved under zero tillage. The maximum weed control efficiency under zero tillage which might be due to better suppression of weed emergence with crop residue cover and less soil disturbance (Meena *et al*. 2016). On the contrary, WCE was less in conventional tillage. This may be attributed to the fact that tillage brought the deep buried weed seeds near to soil surface, where favourable conditions in soil could have facilitated germination and emergence of weed seeds (Mitra *et al*. 2014). In addition to this, no weed control measures were adopted in weedy check plots, which in turn had more dry matter of all weeds and finally lower weed control efficiency.

Table 4. Effect of tillage and weed management practices on weed biomass (g/m^2) of broad-leaved weeds at various crop growth stages

Treatment	*Rumex dentatus*			*Polygonum plebeium*			Other broad-leaf weeds		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Tillage practice									
Conventional tillage	3.11 (10.72)	4.85 (27.50)	3.86 (17.52)	3.73 (15.52)	4.78 (27.32)	4.09 (20.27)	2.93 (9.81)	4.28 (22.03)	4.06 (19.94)
Zero tillage	3.26 (11.48)	4.49 (25.39)	3.53 (14.45)	3.53 (13.77)	4.41 (23.68)	3.76 (16.63)	2.85 (8.78)	4.03 (19.30)	3.69 (16.5 5)
LSD (p=0.05)	NS	0.20	0.03	NS	0.34	0.06	NS	0.21	0.28
Weed management practice									
Weedy	3.53 (12.66)	9.87 (97.50)	7.48 (55.67)	4.07 (16.46)	9.65 (92.75)	8.17 (66.93)	2.80 (7.71)	8.50 (72.37)	8.08 (65.14)
Weed free	0.71 (0.0)	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)
Pinoxaden 20 g/ha	3.63 (13.63)	4.60 (20.73)	4.05 (15.99)	4.20 (18.21)	4.56 (20.36)	4.13 (16.77)	3.79 (16.38)	4.97 (24.55)	4.45 (19.59)
Carfentrazone-ethyl 20 g/ha	3.27 (10.89)	4.16 (17.07)	3.78 (13.89)	3.71 (13.76)	4.17 (17.15)	3.92 (15.03)	3.59 (13.72)	4.46 (19.56)	4.07 (16.70)
Clodinafop-propargyl 60 g/ha	3.68 (13.45)	5.04 (24.87)	4.07 (16.17)	4.46 (21.72)	4.94 (24.17)	4.22 (17.40)	3.33 (10.72)	4.13 (17.06)	3.59 (12.96)
Carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha	3.40 (12.25)	4.48 (19.82)	3.54 (12.20)	3.76 (13.83)	4.06 (16.38)	3.63 (12.98)	2.77 (7.91)	3.96 (15.37)	4.06 (16.80)
Carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha	3.41 (11.33)	4.51 (20.41)	3.66 (12.91)	4.27 (20.50)	4.73 (22.04)	4.11 (16.72)	3.11 (9.54)	3.82 (14.17)	3.38 (11.38)
Metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha	3.47 (12.22)	4.24 (17.93)	2.80 (7.41)	3.56 (12.38)	4.37 (19.16)	3.20 (9.83)	3.10 (9.24)	3.27 (10.50)	2.86 (8.54)
Metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha	3.58 (13.47)	4.45 (19.67)	3.18 (9.63)	3.92 (14.96)	4.17 (17.50)	3.28 (10.37)	2.83 (8.14)	3.57 (12.38)	3.65 (13.10)
LSD (p=0.05)	NS	0.57	0.31	NS	0.47	0.57	NS	0.47	0.77

*Original values given in parentheses was subjected to square root transformation ($\sqrt{x+0.5}$) before analysis; DAS: days after sowing, NS: Non-significant

Among herbicidal treatments, weed free recorded maximum harvest index of 0.45% followed by metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha, metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha, carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha and carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha. Highest weed control efficiency (82.45 and 86.91% respectively) was attained with metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha at 60 and 90 DAS. This might be attributed to the broad-spectrum activity and persistence of the herbicide which controlled the weeds more effectively than other herbicides (Sarita 2021, Chaudhari *et al.* 2017 and Chopra *et al.* 2015).

Economics

The minimum cost of cultivation (₹ 33702/ha) was incurred under zero tillage as compared to conventional tillage (₹ 37047/ha) (**Table 5**). This difference was due to cost involved for tillage operation in zero and conventional tillage. Among weed management practices, the maximum cost of cultivation (₹ 46427/ha) was incurred in weed free treatment which required more labor wages to keep the field free from weeds and minimum cost of cultivation (₹ 32045/ha) in weedy plot. Among herbicidal treatments, minimum cost of cultivation (₹ 33473/ha) was incurred in metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha. In case of gross returns, it was found maximum (₹ 120157/ha) in weed free treatment. Among herbicides, higher gross returns (₹ 110454/ha) were recorded under metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha followed by carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha, metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha and carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha. Although, minimum gross returns (₹ 69521/ha) was obtained in weedy plot. Zero tillage recorded highest net returns (₹ 69381/ha) whereas among weed management practices, the maximum net returns (₹ 76981/ha) was under metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha . Between tillage practices, the highest B:C ratio of 2.07 was obtained under zero tillage which was 40.8% higher as compared to conventional tillage. Whereas, application of metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha recorded the highest B:C ratio (2.32), which was 45.9% higher as compared to weed free.

The cost of cultivation was more under conventional tillage than zero tillage due to more number of tillage operations carried out under conventional tillage. The maximum cost was incurred on weed free treatment as it was kept weed free throughout the crop growth period. The combination of zero tillage and weedy treatment had the least cost of cultivation due to fewer tillage operations and less labour requirement and more cost incurred on the combination of conventional tillage and weed free treatment due to more tillage operations and more labour requirement for hand weeding. The gross and net returns were higher under zero tillage than conventional tillage due to more yield and less cost of cultivation (Fahad *et al.* 2015 and Kumar *et al.* 2018). This was also partly due to higher yield in this treatment as compared to the other herbicides. Among weed management practices, the higher B:C ratio was noted in metsulfuron-methyl 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha due to less cost of cultivation and higher returns (Khatri *et al.* 2020).

It was be concluded that zero tillage along with application of metsulfuron 20% WP 4 g/ha + clodinafop-propargyl 15% WP 60 g/ha should be practiced for minimizing weed density, weed biomass and to attain higher productivity and profitability of wheat.

REFERENCES

Arora A, Tomar SS and Sondhia S. 2013. Efficacy of herbicides on wheat and their terminal residues in soil, grain and straw. *Indian Journal of Weed Science* **45**(2): 109–112.

Bharat R, Kachroo D, Sharma R, Gupta M and Sharma AK. 2012. Effect of different herbicides on weed growth and yield performance of wheat. *Indian Journal of Weed Science* **44**(2): 106–109.

Chaudhari DD, Patel VJ, Patel HK, Mishra A, Patel BD and Patel RB. 2017. Assessment of pre-mix broad-spectrum herbicides for weed management in wheat. *Indian Journal of Weed Science* **49**(1): 33–35.

Chhokar RS, Sharma RK, Jat GR, Pundir AK and Gathala MK. 2007. Effect of tillage and herbicides on weeds and productivity of wheat under rice–wheat growing system. *Crop Protection* **26**(11): 1689–1696.

Chopra NK, Chopra N and Choudhary D. 2015. Bio-efficacy of sole and tank mix of pinoxaden and clodinafop with carfentrazone and metsulfuron for control of complex weed flora in wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **60**(1): 104–108.

Choudhary J, Nepalia V, Mali H and Sumeria HK. 2017. Alleviation of weed stress in wheat through herbicides and their combinations. *Indian Journal of Agronomy* **62**(2): 180–184.

Fahad S, Hussain S, Chauhan, BS, Saud S, Wu C, Hassan S, Tanveer M, Jan A and Huang J. 2015. Weed growth and crop yield loss in wheat as influenced by row spacing and weed emergence times. *Crop Protection* **71**: 101–108.

Gomez KA and Gomez AA. 1984. *Statistical Procedures for Agricultural Research* (2nd Ed.). John Wiley and Sons, New York, USA.

Hossain MM and Begum M. 2015. Soil weed seed bank: Importance and management for sustainable crop production - A Review. *Journal of Bangladesh Agriculture University* **13**(2): 221–228.

Table 5. Effect of tillage and weed management practices on yield, harvest index, weed control efficiency and economics of wheat

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Weed control efficiency (%)		Cost of cultivation (x10^3 ₹/ha)	Gross returns (x10^3 ₹/ha)	Net Net returns (x10^3 ₹/ha)	B:C ratio
				60 DAS	90 DAS				
Tillage practice									
Conventional tillage	3.53	5.14	0.40	69.33	72.52	37.05	91.63	54.59	1.47
Zero tillage	4.01	5.58	0.42	73.15	75.27	33.70	103.08	69.38	2.07
LSD (p=0.05)	0.13	0.17	0.04	2.67	4.13	-	2.00	2.00	0.07
Weed management practice									
Weedy	2.54	4.59	0.36	0.00	0.00	32.04	69.52	37.48	1.18
Weed free	4.78	5.98	0.45	100.00	100.00	46.43	120.16	73.73	1.59
Pinoxaden 20 g/ha	3.15	5.02	0.38	72.10	76.00	34.95	83.51	48.55	1.40
Carfentrazone-ethyl 20 g/ha	3.27	5.04	0.39	75.13	78.27	33.36	86.06	52.70	1.59
Clodinafop-propargyl 60 g/ha	3.50	5.12	0.40	73.93	78.54	33.32	91.08	57.76	1.76
Carfentrazone-ethyl 20 g/ha + pinoxaden 20 g/ha	4.00	5.59	0.42	79.43	80.11	35.66	102.94	67.28	1.90
Carfentrazone-ethyl 20 g/ha + clodinafop-propargyl 60 g/ha	4.10	5.62	0.42	77.76	81.40	34.03	105.18	71.15	2.11
Metsulfuron-methyl 4 g/ha + clodinafop-propargyl 60 g/ha	4.36	5.65	0.44	82.45	86.91	33.47	110.45	76.98	2.32
Metsulfuron-methyl 4 g/ha + pinoxaden 20 g/ha	4.21	5.62	0.43	80.33	83.82	35.10	107.32	72.22	2.07
LSD (p=0.05)	0.39	0.56	0.03	2.03	1.47	-	9.060	9.06	0.26

Karunakaran V and Behera UK. 2013. Effect of tillage, residue management and crop establishment techniques on energetics, water use-efficiency and economics in soybean–wheat cropping system. *Indian Journal of Agronomy* **58**(1): 42–47.

Katara P, Kumar S and Rana SS. 2015. Influence of pinoxaden in combination with other herbicides on nutrient depletion by weeds in wheat. *Indian Journal of Weed Science* **47**(4): 371–375.

Kaur E, Sharma R and Singh ND. 2018. evaluation of herbicides and their combinations for weed control in wheat (*Triticum aestivum* L.). *International Journal of Environment, Agriculture and Biotechnology* **3**(4): 1213–1215.

Khatri N, Pokhrel D, Pandey BP, Bista M, Marasini M, Paudel GP and Chaurasiya BP. 2020. Economics and yield of wheat as affected by pre- and post-emergence herbicides in western Terai Region of Nepal. *Journal of Research in Weed Science* **3**(2): 181–187.

Kumar M, Ghosh D and Singh R. 2018. Effect of crop establishment and weed management practices on growth and yield of wheat. *Indian Journal of Weed Science* **50**: 129–32.

Kushwaha SS, Kasana BS and Bhadauria SS. 2020. On-farm assessment of conservation tillage for wheat planting in rice-wheat cropping system. *Indian Journal of Weed Science* **52**(1): 89–92.

Makhan S, Bhullar SM, Pandey M, Kumar S and Gill G. 2016. Weed management in conservation agriculture in India. *Indian Journal of Weed Science* **48**(1): 1–12.

Mani VS, Malla ML, Gautam KC and Bhagwndas. 1973. Weed killing chemicals in potato cultivation. *Indian Farming* **22**: 17–18.

Meena OP, Nepalia V, Singh D, Verma A and Choudhary R. 2016. Herbicide combinations for broad spectrum weed control in wheat. *Indian Journal of Weed Science* **48**: 325–327.

Meena V, Kaushik MK, Dotaniya ML, Meena BP and Das H. 2019. Bio-efficacy of ready-mix herbicides on weeds and productivity in late-sown wheat. *Indian Journal of Weed Science* **51**(4): 344–351.

Mitra B, Mookherjee S and Das S. 2014. Performances of wheat *(Triticum aestivum)* under various tillage and nitrogen management in sub-Himalayan plains of West Bengal. *Journal of Cereal Research* **6**(2): 150–153.

Mukherjee D. 2020. Herbicide combinations effect on weeds and yield of wheat in North-Eastern plain. *Indian Journal of Weed Science* **52**(2): 116–122.

Punia SS, Soni J, Manjeet, Singh SK and Kamboj P. 2020. Management of herbicide resistant Phalaris minor in wheat. *Indian Journal of Weed Science* **52**(3): 237–240.

Punia SS, Yadav DB, Kaur M and Sindhu VK. 2017. Post-emergence herbicides for the control of resistant little seed canary grass in wheat. *Indian Journal of Weed Science* **49**(1): 15–19.

Sarita, Singh I, Mehriya ML, Shukla UN, Kumar M, Parewa HP and Raiger PR. 2021. Effect of different fertiliser levels and herbicide treatments on weeds and wheat. *Indian Journal of Weed Science* **53**(4): 367–373.

Shivran H, Yadav RS, Singh SP, Godara AS, Bijarniya AL and Samota SR. 2020. Tillage and weed management effect on productivity of wheat in North-West Rajasthan. *Indian Journal of Weed Science* **52**(2): 127–131.

Shyam R, Singh R, Singh VK. 2014. Effect of tillage and weed management practices on weed dynamics weed seed bank and grain yield of wheat in the rice-wheat system. *Indian Journal of Weed Science* **46**(4): 322–325.

Singh LD and Stoskopf NC. 1971. Harvest index in cereals. *Agronomy Journal* **63**: 224–226.

Singh M, Singh MK, Singh SP and Sahu R. 2015. Herbicide and nitrogen application effects on weeds and yield of wheat. *Indian Journal of Weed Science* **47**(2): 125–130.

Soni JK, Nibhoria A, Punia SS, Kamboj P and Choudhary, VK. 2022. Wheat growth and physiological response and management of herbicide resistant Phalaris minor Retz. as affected by selective herbicides. *Indian Journal of Weed Science* **54**(2): 151–156.

Verma SK, Singh RP and Kumar S. 2017 Effects of irrigation and herbicides on the growth yield and yield attributes of wheat. *Bangladesh Journal Botany* **46**(3): 839–845.