International Journal of Environment and Climate Change

Volume 13, Issue 4, Page 48-55, 2023; Article no.IJECC.89807
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Herbicides and Nitrogen Levels on *Phalaris minor* and Its Impact on Nutrient Uptake in Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i41711

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/89807

Original Research Article

Received: 28/05/2022
Accepted: 30/07/2022
Published: 09/03/2023

ABSTRACT

In the agricultural research farm of Banaras Hindu University, Varanasi, a field research study was carried out during the winter (Rabi) season of 2018–19 to examine the impact of levels of nitrogen and herbicides on associated weeds and wheat production. Nine weed species, including *Phalaris minor, Anagallis arvensis, Cynodon dactylon, Melilotus indicus, Chenopodium album, Vicia sativa, Medicago denticulata, Solanum nigrum, and Cyperus rotundus*, were frequently seen infesting wheat fields. Among these, *Phalaris minor* was the major weed. Application of Sulfosulfuron (25 g ha^{-1}) + 2, 4-DEE (750 ml ha^{-1}) significantly recorded the lowest weed density and biomass and higher weed control efficiency. HW twice (30&60 DAS) in combination with 180 kg N ha^{-1} followed by application of Sulfosulfuron (25 g ha^{-1}) + 2, 4-DEE (750 ml ha^{-1}) in combination with 180 kg N ha^{-1} performed significantly with respect to reduction in density, the biomass of Phalaris minor, as

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well as increased weed control effectiveness. Nutrient uptake was significantly highest under HW twice plot (30&60 DAS) followed by application of sulfosulfuron (25 g ha^{-1}) + 2, 4-DEE (750 ml ha^{-1}). The overall intake of N, P, and K in wheat grain and straw increased when nitrogen levels were high (180 kg ha^{-1}), but uptake of these nutrients was low when nitrogen levels were low, which was ascribed to reduced plant biomass (grain and straw) and a low proportion of these nutrients in the plant.

Keywords: Nitrogen levels; sulfosulfuron; 2, 4-DEE; weeds; wheat.

1. INTRODUCTION

A primary biotic barrier to attaining the potential wheat yield is considered to be weeds, which are typically the most expensive inhibitory factor. This situation contributes to increased poverty and food insecurity. It takes a comprehensive approach combining chemical and non-chemical weed control methods to efficiently manage weed infestations of both grassy and broad-leaved species [1]. To manage complex weed flora, many herbicides must be used in conjunction with one another. Combinations of herbicides not only increase the effectiveness of weed management against hard-to-control weed flora but also delay the emergence of herbicide resistance [2]. Wide leaved weeds and grassy weeds both have the potential to diminish wheat grain production by up to 52.2 percent and 55.7 percent, respectively revealed by [3]. [4] reported that Weeds in the weedy check decreased the wheat grain production by 47.5% as compared to other treatments. The management of complex weed flora necessitates the use of several herbicides; this combination not only increases the efficacy of weed control against composite weed flora but also postpones the emergence of herbicide resistance [5]. [6] revealed that increasing the level of nitrogen from 0 to 45, 45 to 90 and 90 to 135 kg ha^{-1} increased the nitrogen uptake by 28.2, 14.9, 7.7%, phosphorus by 26.2, 13.6, 8.5 % over the preceding levels. Yet, it was discovered that the amounts of inputs and the timing of their application had a substantial impact on the existence and density of weeds in the field. The grain production and straw yield improved as a result of increasing nitrogen fertilization from 120 to 150 kg N ha^{-1} by increasing the dry matter buildup, the number of tillers, and nutrient uptake [7].

2. MATERIALS AND METHODS

The fieldwork was conducted at the Banaras Hindu University's Agricultural Research Farm in Varanasi during the winter (rabi) of 2018–19, Uttar Pradesh, in the subtropical Indo-gangetic Plains at 25^{0}18' North Latitude and 83^{0} 03' East Longitude, which is located in the left bank of the River Ganga at an altitude of 75.70 metre above mean sea level. A sandy clay loam with a pH of 7, low organic carbon (0.21 percent), accessible nitrogen (152 kg ha-1), medium phosphorus (23.5 kg ha-1), and readily available potassium were present in the soil (188 kg ha-1). The experiment was set up using a split plot design with three replications.

The treatments comprised of 3 nitrogen levels and 5 weed control methods, viz., nitrogen levels: 120 kg ha^{-1}, 150 kg ha^{-1}, 180 kg ha^{-1}, weed control treatments: Weedy check, Hand weeding at 30 DAS and 60 DAS, Pinoxaden 5.1% EC (40 ml a.i ha^{-1}) + 2,4-DEE 38% EC (750 ml a.i ha^{-1}), Pendimethalin 30% EC at 1000 ml a.i ha^{-1} and 2,4-DEE 38% EC (750 ml a.i ha^{-1} at 30-35 DAS), Sulfosulfuron 75% WG (25 g a.i ha^{-1})+ 2,4-DEE 38% EC at 750 ml a.i ha^{-1}. On December 9th, 2018, 100 kg ha-1 of the wheat variety "HD-2967" were sowed, and irrigation was given during crucial crop growth phases. At rates of 60 kg ha-1 for single super phosphate (SSP) and 60 kg ha-1 for muriate of potash (MOP), respectively, the necessary doses of phosphorous and potassium were applied. Urea is used to apply nitrogen in accordance with the therapy. The remaining half of the nitrogen was administered as a top-dressing in two equal portions after the first and second irrigations, along with the full doses of phosphorus, potassium, and the remaining half of the nitrogen at the time of sowing. In terms of weed population, weed dry matter buildup, nutritional content, depletion (N, P, and K), and efficiency of various treatments. Each plot had a 25 × 25 cm quadrant where weeds were gathered at random and sun-dried. Samples were dried in an electric oven at a temperature of 60 to 65°C for 48 hours after being exposed to the sun. The dry weight resulting from this process was given in g m-2. At 15, 30, 60, and 90 days after treatment application (DAA), weed dry weight, weed control effectiveness, and weed population (pre-treatment) were all recorded. After 90 DAA, nutrient content and weed depletion of it were recorded. several agricultural growth metrics, including plant height (cm), the quantity of tillers per running metre, and the amount of dry matter accumulated by plants at 30, 60, and 90 days before harvest (DAA). Data related to weed components were analyzed using various statistical methods and square root transformation (√x+0.5) was undergone for uniformity. In order to conduct research on the crop's intake of several nutrients (nitrogen, phosphorus, and potassium), wheat grain and straw were measured at maturity. At the time of harvest, the plant samples (straw and grain) from wheat were collected independently according to treatment. These samples were grinded in the grinder after oven dried at 75˚C for 72 hours. As a result, the materials from the grinding facility were put through a 30-mesh sieve before being collected for analysis of their nitrogen, phosphorus, and potassium contents. These items' nutritional contents were chemically evaluated in a lab setting using the standardised techniques. Nutrient content of the grain and straw were multiplied by their respective dry weight/yields to determine the amount of nutrients absorbed (kg/ha).

Nitrogen content (%): By using a modified Kjeldahl technique, the nitrogen content of grain, straw, and weeds was measured as per procedure described by [8].

Phosphorous content (%): The Vanadomolybdo phosphoric yellow colour technique was used to determine the amount of phosphorus in grain, straw, and weeds as per procedure described by [8].

Potassium content (%): Using a flame photometer, the potassium concentration was calculated in accordance with method, described by [8].

Nutrient uptake by crop (kg ha^{-1}): The amount of nutrients absorbed by the crops' grain and straw was determined in kg ha^{-1} in relation to yield per ha by using the following formula.

Nutrient uptake (kg/ha) = (Nutrient content (%) × Yield (grain/straw in kg ha^{-1}) / 100)

Weed control efficiency: Weed control efficiency (W.C.E.) can be calculated on the basis of dates of observation by using the formula suggested by [9].

Weed control efficiency = [(DWC – DWT)/DWC]*100

Where DWC = dry weight of weeds in control (unweeded) plot
DWT = dry weight of weeds in the treated plot

3. RESULTS AND DISCUSSION

3.1 Weed Flora

The following common weed species were discovered to be present in the experimental field during the field investigation. Phalaris minor, *Cynodon dactylon*, and broad-leaved weeds including *Medicago denticulata, Anagallis arvensis, Melilotus indicus, Vicia sativa*, *Chenopodium album, Solanum nigrum,* and the only sedge was *Cyperus rotundus*. Here, it was demonstrated how nitrogen levels and pesticides affect *Phalaris minor*, a significant weed, and how this affects growth characteristics.

3.2 Effect of Density and Dry Weight of Weeds

The population of Phalaris minor was strongly impacted by the various treatments, as shown in Tables 01 and 02, according to a critical review of the data. The treatment of sulfosulfuron (25 g ha-1) + 2,4-DEE (750 ml ha^{-1}) during 60, 90 DAA greatly decreased the drymatter of grassy weeds like Phalaris minor. Several scholars, including [3] and [10], found that the results above were closely congruent. The herbicidal effect's diminished influence on grassy weed populations may have contributed to the application of pinoxaden (40 ml ha^{-1}) + 2,4-DEE (750 ml ha^{-1}) causing the lowest weed dry matter accumulation in grasses like *Phalaris minor* and minimum dry weight at 15 and 30 DAA. Similar findings has been also reported by [11] and [12]. The data on weed density and drymatter of different weeds (Table 01 & 02) as affected by different nitrogen levels envisaged non-significant differences in weed density of *Phalaris minor* at all the dates of observation. *Phalaris minor* density analysis revealed that increasing nitrogen treatment from 120 to 180 kg ha^{-1} enhanced weed population and dry matter. These results were in close conformity with findings of [13], [10] and [6].

3.3 Effect of Herbicides on Weed Control Efficiency

Meticulous examination of the data indicated that different treatments had an impact on the weed control effectiveness (WCE) of Phalaris minor, as shown in Table 3. Pinoxaden (40 ml ha-1) + 2, 4-DEE (750 ml ha-1) had the highest weed control

Table 1. Effect of herbicides and nitrogen levels on density (No. m^{-2}) of *Phalaris minor* in wheat

Treatments	Weed density (No. m^{-2})				
	Pre-treatment	15 DAA	30 DAA	60 DAA	90 DAA
Nitrogen levels (kg ha^{-1})	***Phalaris minor***				
N1 -120	0.71 (0.00)	0.88 (0.33)	0.88 (0.33)	1.43 (1.87)	1.20 (1.00)
N2 -150	0.71 (0.00)	0.82 (0.33)	1.19 (1.00)	1.25 (1.33)	1.25 (1.33)
N3 -180	0.71 (0.00)	1.10 (0.67)	1.10 (0.67)	1.25 (1.33)	1.31 (1.67)
SEm ±	0.00	0.089	0.13	0.060	0.038
CD (P=0.05)	NS	NS	NS	NS	NS
Herbicides					
H1-Weedy check	0.71 (0.00)	1.22 (1.00)	1.22 (1.00)	1.82 (2.89)	1.94 (3.33)
H2-HW twice (30&60 DAS)	0.71 (0.00)	1.10 (0.67)	1.10 (0.67)	0.71 (0.00)	0.71 (0.00)
H3-Pinoxaden 5.1% EC (40 ml) + 2,4-DEE* 38% EC (750 ml ha^{-1})	0.71 (0.00)	0.71 (0.00)	1.10 (0.67)	1.29 (1.33)	1.19 (1.00)
H4-Pendimethalin 30% EC (1000 ml) *fb* 2,4-DEE 38% EC (750 ml ha^{-1})	0.71 (0.00)	1.10 (0.67)	1.22 (1.00)	1.69 (2.67)	1.29 (1.33)
H5-Sulfosulfuron 75% WG (25 g) + 2,4-DEE 38% EC (750 ml ha^{-1})	0.71 (0.00)	0.71 (0.00)	1.10 (0.67)	1.10 (0.67)	1.10 (0.67)
SEm ±	0.00	0.104	0.16	0.151	0.126
CD (P=0.05)	NS	0.304	NS	0.442	0.367

**Ethyl ester, DAA- Days after treatment application, NS- Non-significant; Precise data subjected to square root ($\sqrt{x}+0.5$) transformation and original data shown in parenthesis*

Table 2. Effect of herbicides and nitrogen levels on drymatter (g. m^{-2}) of *Phalaris minor* in wheat

Treatments	Weed drymatter (g. m^{-2})				
	Pre-treatment	15 DAA	30 DAA	60 DAA	90 DAA
Nitrogen levels (kg ha^{-1})	***Phalaris minor***				
N1-120	0.88 (0.31)	0.92 (0.43)	1.12 (0.87)	1.04 (0.71)	0.88 (0.31)
N2-150	0.94 (0.44)	0.95 (0.46)	1.13 (0.93)	1.05 (0.73)	0.94 (0.44)
N3-180	0.93 (0.43)	0.98 (0.56)	1.23 (1.28)	1.19 (1.06)	0.93 (0.43)
SEm ±	0.019	0.015	0.051	0.045	0.019
CD (P=0.05)	NS	NS	NS	NS	NS
Herbicides					
H1-Weedy check	1.26 (1.08)	1.44 (1.58)	1.69 (2.38)	1.62 (2.16)	1.26 (1.08)
H2-HW twice (30&60 DAS)	0.85 (0.31)	0.88 (0.33)	0.71 (0.00)	0.71 (0.00)	0.85 (0.31)
H3-Pinoxaden 5.1% EC at 40 ml + 2,4-DEE* 38% EC at 750 ml ha^{-1}	0.77 (0.10)	0.76 (0.09)	1.16 (0.97)	1.07 (0.71)	0.77 (0.10)
H4-Pendimethalin 30% EC at 1000 ml *fb* 2,4-DEE 38% EC at 750 ml ha^{-1}	0.88 (0.31)	0.85 (0.24)	1.26 (1.22)	1.14 (0.90)	0.88 (0.31)
H5-Sulfosulfuron 75% WG at 25 g + 2,4-DEE 38% EC at 750 ml ha^{-1}	0.82 (0.18)	0.82 (0.18)	0.98 (0.57)	0.91 (0.39)	0.82 (0.18)
SEm ±	0.051	0.056	0.108	0.081	0.051
CD (P=0.05)	0.149	0.163	0.314	0.236	0.149

**Ethyl ester, DAA- Days after treatment application, NS- Non-significant; Precise data subjected to square root ($\sqrt{x}+0.5$) transformation and original data shown in parenthesis*

Table 3. Effect of herbicides and nitrogen levels on weed control efficiency (%) of wheat

Treatments	Weed control efficiency (%)			
	15 DAA	**30 DAA**	**60 DAA**	**90 DAA**
Nitrogen levels (kg ha^{-1})				
N1-120	68.67	69.78	54.55	64.62
N2-150	61.09	66.61	54.70	59.47
N3-180	62.11	69.00	59.34	56.92
Herbicides				
H1-Weedy check	0.00	0.00	0.00	0.00
H2-HW twice (30&60 DAS)	73.33	77.93	100.00	100.00
H3-Pinoxaden 5.1% EC at 40 ml + 2,4-DEE* 38% EC at 750 ml ha^{-1}	91.65	92.71	56.54	68.10
H4-Pendimethalin 30% EC at 1000 ml *fb* 2,4-DEE 38% EC at 750 ml ha^{-1}	71.65	83.77	50.12	53.85
H5-Sulfosulfuron 75% WG at 25 g + 2,4-DEE 38% EC at 750 ml ha^{-1}	83.15	87.90	74.34	79.72

EE-Ethyl ester, DAA- Days after treatment application, NS- Non-significant; Data subjected to square root ($\sqrt{x}$ + 0.5) transformation and original data presented in parenthesis

Table 4. Effect of herbicides and nitrogen levels on nutrient content in grain and straw

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
Nitrogen levels						
N1-120 kg ha^{-1}	1.73	0.54	0.37	0.075	0.41	1.37
N2-150 kg ha^{-1}	1.78	0.57	0.38	0.074	0.43	1.42
N3-180 kg ha^{-1}	1.81	0.58	0.35	0.078	0.45	1.45
SEm ±	0.007	0.011	0.014	0.0005	0.010	0.022
CD (P=0.05)	0.029	NS	NS	0.002	NS	NS
Herbicides						
H1-Weedy check	1.74	0.55	0.37	0.069	0.43	1.34
H2-HW twice (30 & 60 DAS)	1.80	0.58	0.38	0.075	0.44	1.44
H3- Pinoxaden 5.1% EC at 40 ml + 2,4-DEE* 38% EC at 750 ml ha^{-1}	1.77	0.54	0.36	0.075	0.40	1.41
H4- Pendimethalin 30% EC at 1000 ml *fb* 2,4-DEE 38% EC at 750 ml ha^{-1})	1.76	0.57	0.37	0.079	0.43	1.44
H5- Sulfosulfuron 75% WG at 25 g + 2,4-DEE 38% EC at 750 ml ha^{-1}	1.79	0.58	0.36	0.080	0.45	1.43
SEm ±	0.011	0.012	0.011	0.002	0.013	0.022
CD (P=0.05)	0.033	NS	NS	0.007	NS	0.064

EE-Ethyl ester, DAA- Days after treatment application, NS- Non-significant; Precise data subjected to square root ($\sqrt{x}$ + 0.5) transformation and original data shown in parenthesis

Table 5. Effect of herbicides and nitrogen levels on nutrient uptake in grain and straw

Treatments	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
Nitrogen levels						
N1-120 kg ha^{-1}	76.36	36.35	16.55	5.08	18.25	92.23
N2-150 kg ha^{-1}	83.56	41.28	18.18	5.34	20.06	102.28
N3-180 kg ha^{-1}	87.70	43.30	17.35	5.83	21.91	109.02
SEm ±	0.469	1.133	0.570	0.036	0.601	2.116
CD (P=0.05)	1.842	4.447	NS	0.141	2.362	8.310
Herbicides						
H1-Weedy check	70.75	37.72	15.11	4.74	17.53	92.20
H2-HW twice (30 & 60 DAS)	87.92	42.70	18.77	5.57	21.55	106.63
H3- Pinoxaden 5.1% EC at 40 ml + 2,4-DEE* 38% EC at 750 ml ha^{-1}	81.93	37.64	17.20	5.25	18.79	98.60
H4- Pendimethalin 30% EC at 1000 ml *fb* 2,4-DEE 38% EC at 750 ml ha^{-1})	84.02	41.26	17.60	5.64	20.62	103.74
H5- Sulfosulfuron 75% WG at 25 g + 2,4-DEE 38% EC at 750 ml ha^{-1}	88.07	42.24	18.10	5.89	21.89	104.70
SEm ±	0.852	1.058	0.523	0.168	0.661	1.823
CD (P=0.05)	2.486	3.089	1.527	0.489	1.928	5.321

EE- Ethyl ester, DAA-Days after treatment application, NS- Non-significant; Precise data subjected to square root ($\sqrt{x}$ + 0.5) transformation and original data shown in parenthesis effectiveness at 15 and 30 DAA, followed by sulfosulfuron (25 g ha-1) + 2, 4-DEE (750 ml ha-1); pendimethalin (1000 ml ha-1) fb 2, 4-DEE (750 ml ha-1) had the lowest weed control efficiency at 30 DAA. Whereas pendimethalin (1000 ml ha-1) fb 2, 4-DEE had a reduced weed control efficacy at 60 and 90 DAA, sulfosulfuron (25 g ha-1) + 2, 4-DEE (750 ml ha-1) had a greater weed control efficiency at each of those DAAs (750 ml ha-1). However, the HW twice (30&60 DAS) plot recorded 100% control in *Phalaris minor* at 60, 90DAA. Close examination of data revealed that application of 180 kg N ha^{-1} recorded higher weed control efficiency at 60 and 90 DAA. However, higher weed control efficiency was observed under application of 120 kg N ha^{-1} at 15 and 30 DAA. These results were in close conformity with the findings reported by [14], [15], and [12].

3.4 Effect of Nutrient Content and its Uptake by Crop and Weeds

The information in tables 04 and 05 explains how weeds used up all available nutrients at the time of harvest; dry matter buildup in weeds is a result of N, P, and K. Increased weed dry weight results in increased nutrient loss by weeds. As comparison to other weed control methods, the HW twice plot treated with sulfosulfuron (25 g ha^{-1}) + 2,4-DEE (750 ml ha^{-1}) reported less nutrient loss by weeds. Weed density and dry weight were noticeably lower under the aforementioned treatments, which led to a decrease in the quantity of nutrients that weeds were able to extract. Weed infestation levels and weeds' increased buildup of dry matter may be accountable for the untreated plot's greater nutrient loss and these findings were in close conformity with findings of [6].

The information in tables 04 and 05 explains how different treatments affect nutrient content and plant absorption. Due to weed control measures, grain and straw were found to have considerably higher N, P, and K contents. The N, P, and K content of crop grain and straw affects nutrient absorption. The HW twice plot (30&60 DAS) and the application of sulfosulfuron (25 g ha^{-1}) + 2, 4-DEE had the greatest levels, respectively (750 ml ha^{-1}). The reduction of weed growth under this treatment increases the availability of N, P, and K, which may be the primary factor in the greater dry matter production and nutrient uptake by the wheat crop. However, weedy check showed the lowest nutrition intake. and similar findings observed by [4] and [12]. The percentage of nitrogen increased with the quantity of nitrogen from 120 kg N to 180 kg N ha^{-1}, and this may be ascribed to more N being absorbed and transported to different plant components, including grains, than crop supplied with N. This percentage of nitrogen increased in both grain and straw. The overall intake of N, P, and K in wheat grain and straw rose when nitrogen levels were high (180 kg ha^{-1}), but uptake of these nutrients was low when nitrogen levels were low, which was ascribed to reduced plant biomass (grain and straw) and a low proportion of these nutrients in the plant. These findings were in close conformity with the findings of [16] and [5].

4. CONCLUSION

On the grounds of the above-summarized results, the following conclusions have been drawn: Due to better weed control effectiveness, the application of sulfosulfuron (25 g ha^{-1}) + 2,4-DEE (750 ml ha^{-1}) resulted in lower weed density and weed drymatter. Higher nutrient content and nutrient absorption were seen in wheat grain and straw following the application of 180 kg N ha-1 together with sulfosulfuron (25 g ha^{-1}) + 2,4-DEE (750 ml ha^{-1}).

ACKNOWLEDGEMENT

The Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, and Indian Council of Agricultural Research provided financial support (ICAR).

COMPETING INTERESTS

The authors have affirmed that there are no conflicting interests.

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Peer-review history:
The peer review history for this paper can be accessed here:
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