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Performance of Wheat (*Triticum aestivum* L.) as Affected by Different Densities of *Ranunculus spp*. under Temperate Conditions of Kashmir Valley, India

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Authors' contributions

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

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ABSTRACT

A field study was carried out at the Agronomy research farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2021-22 and 2022-23. The experiment was conducted in RCBD comprising of six weed densities viz., D_0 (0), D_1 (25), D_2 (50), D_3 (75), D_4 (100), and D_5 (125) plants m^{-2}. The results revealed that wheat growth and yield was significantly influenced by *Ranunculus* spp. densities, and increasing densities showed a corresponding decrease in yield. *Ranunculus* produced higher biomass at its higher densities of 100 and 125 plants m^{-2} as compared to the lowest densities of 25 plants m^{-2} which significantly affected the growth and yield of crop. The wheat yield and yield attributes were negatively affected by an increase in the *Ranunculus* weed density. The data revealed that during both the years of study, maximum reductions in the number of effective tillers m^{-2} (23-24%), grains per ear (23-23.7%), ear weight (32-33%), 1000-grain (7-7.8%) weight, and grain yield (41- 45%) were recorded at the highest *Ranunculus* spp. density (125 plants m^{-2}). However, the lowest density of 25 plants m^{-2} also caused only 8% and 6.3% losses in wheat yield during the years 2021-22 and 2022-23 respectively. Moreover, the yield losses were higher during the year 2021-22 because of the more competitive nature of the weed during the year. Thus, the study suggested that the weed is highly competitive in wheat-*Ranunculus* mixtures during early stages of the crop growth and pre-emergence herbicide (pendimethalin) after sowing of wheat and post-emergence herbicide (sulfosulfuron) in the 2nd week of March have been found effective in curbing the weed (*Ranunculus* spp.) and attaining higher wheat yield in Kashmir valley.

Keywords: Wheat; Ranunculus spp. weed density; herbicide; yield.

1. INTRODUCTION

Wheat is one of the important cereal crops in the world and is a staple food of over one-third of the world population. Globally it ranks first among the cereal crops in terms of both area (219.51 million ha) and production (758.02 million metric tons) (USDA, report 2017-18). The crop is used both as human food as well as livestock feed thus serving as a dominant crop in temperate countries. In India, it is one of the important crops covering over 31.5 M ha with an annual production of 108.7 MMT and productivity of 3424 kg ha^{-1} (Progress Report, 2021). The production has increased from a mere 11.0 MT during 1960-61 to 112.7 MT during 2022-23 (Sharma et al., 2024). This more than eight-fold increase in production was mainly due to the adoption of short stature high yielding varieties, increased fertilizer use, irrigation, and herbicides (Banjara et al., 2021). The crop provides around 21% of the per capita food energy and 18% of dietary protein in the country (Balasubramanian et al., 2012), thus playing a crucial role in ensuring food security (Chhokar et al., 2006). In the valley of Kashmir, it is grown mostly in winter as a rabi crop except in higher elevations where it is cultivated as a single summer crop. The crop is ecologically adapted to various growing environments but faces numerous challenges due to various biotic and abiotic factors. Among biotic factors, weeds are the most problematic competing for the essential growth factors (Singh et al., 2018). In addition to resource competition, these also exhibit allelopathic effects, serve as reservoirs for pathogens, act as alternate hosts for insects and fungi, and contribute to increased harvest costs (Singh et al., 2020). Substantial yield reductions have been observed due to increased pressure of the weed population (Mehra & Gill, 1988). Global studies suggest that crop losses due to weed competition exceed the combined losses caused by diseases and insect pests (Sharma et al., 2007). The extent of these losses due to weed infestations is influenced by factors like specific weed species, their density, emergence timing, and the duration of their competition with the crop (Hussain et al., 2015; Fahad et al., 2015). Typically, the yield losses are greater as the weed density and the duration of interference increase, with losses being particularly severe when weeds and crops emerge simultaneously and the resources are scarce (Zimdahl, 2007). Thus, understanding the dynamics of weed interference is critical for predicting yield losses caused by weed infestations and for developing sustainable weed management strategies (Fahad et al., 2014). In India, yield losses due to weed infestation are approximately 18.6% resulting in huge economic that account for about USD 3,376 million (Gharde et al., 2018). Infestation by broad-leaved weeds alone in wheat can reduce grain yields by 20-30% (Wilson & Cussans, 1984). *Ranunculus*

spp. (L.), one of the important broad-leaf weeds of wheat in temperate environments poses a significant challenge to its cultivation. Four species of this weed namely, *Ranunculus arvensis*, *R. muricatus*, *R. diffusus*, and *R leutus* have been documented infesting various field crops, especially winter wheat, of which *R. arvensis* is the most prevalent (Singh, 2012). Prolonged infestation by this species alone can lead to a grain yield reduction of 20-40%, along with substantial depletion of soil nutrients (Kumar et al., 2010). The leaves of these plants contain protoanemonin (ranunculin), an acrid compound that renders them unpalatable to livestock (Connor, 1977). This weed once established, developed a robust, deep-rooted corm system, making its manual control difficult. High weed infestation and their competition with wheat crops for the long term is responsible for serious yield reduction (Reddy et al., 2004). It is therefore important to study the effect of different densities of a particular weed species on crop yields to determine the economic thresholds to control that weed species (Bajwa et al., 2019). Keeping the above points in view this study was conducted to analyse the impact of different densities of *Ranunculus* spp. on the performance of wheat crop under temperate conditions of Kashmir valley.

2. MATERIALS AND METHODS

The present field experiment was carried out at Agronomic Research Farm of Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Wadura, Sopore, Baramulla during *Rabi* seasons of 2021-22 and 2022-23. The experiment was sited at 34° 21' N latitude, 74° 23' E longitude and 1590 m altitude above mean sea level in the temperate zone. The region experiences a temperate climate, characterized by very severe winters and moderately hot summers. Throughout the growing period, rainfall was 675.3 mm in the year 2021-22 and 736.2 mm in the year 2022-23. The experiment was carried in RCBD with three replications. The treatments consisted of six different densities of *Ranunculus* spp. viz., 0, 25, 50, 75, 100 and 125 plants m^{-2} that were established within 3-4 weeks after its emergence. The seeds (achenes) of *Ranunculus* spp. were collected from its naturally occurring local weed populations. The seeds were mixed with fine soil and broadcasted uniformly on the soil surface in each experimental plot except in the control treatment (0 weeds m^{-2}). After uniform emergence of the *Ranunculus* weed (approximately three weeks post-crop emergence), the required densities were maintained by removing the excess seedlings. Throughout the crop growing season weed densities were maintained by regularly removing any additional emerging *Ranunculus* seedlings. Other weed species were manually removed from all treatments. Moreover, herbicides pendimethalin and sulfosulfuron were used as pre and post emergence in the treatment with zero density of weeds (*Ranunculus* ssp.) for weed management.

3. RESULTS AND DISCUSSION

3.1 Weed (*Ranunculus* spp.) Biomass

The biomass of *Ranunculus* spp. was significantly influenced by its different densities during both years of the study (Fig. 1). Weed biomass increased hyperbolically with increasing weed densities. At lower densities the increment was rapid but as densities increased there was a marginal increase in weed biomass which could be because individual weeds acquired more biomass due to less intraspecific competition at lower weed densities. However as weed populations grew denser, there was more competition among them, which limited the amount of biomass that each plant could accumulate. significantly higher weed biomass was observed in D_5 (125 plants m^{-2}) than in other densities during both years and lower weed biomass was found in D_1 (25 plants m^{-2}). The increase in weed biomass per square meter with increased density could be because of the higher number of weeds per square meter. Higher weed biomass at higher weed density was also reported by Mamolos and Kalburtji (2001). Sharma et al. (2018) and Tiwari and Singh (2024) also observed the similar results.

3.2 Yield Attributes and Yield of Wheat

Effect of different *Ranunculus* spp. densities on effective tillers per square meter was significant. Maximum number of tillers (356) and (368) during the year 2021-22 and 2022-23 respectively were recorded in the control (D_0) treatment. The number of effective tillers decreased with increase in weed densities (Table 1). This is probably because of higher number of total tillers m^{-2} in D_0 and reduction in the number of total tillers m^{-2} with increased density of weed species. Bertholdsson (2004) also observed the negative effect on effective tillers due to severe weed infestation. Moreover, Similar results were reported by Bhat et al. (2006a), Kaur et al.

(2013), Jaidka and Kaur (2014) and Raj et al. (2020). Treatment D_5 resulted in minimum number of effective tillers during both the years of study. Similar effect was observed for grains per ear and ear weight which decreased successively and significantly with the increase in *Ranunculus* spp. densities from D_0 (0 plants m^{-2}) to D_5 (125 m^{-2}). Significantly higher grains ear^{-1} and ear weight was observed in D_0 as compared to all other densities during both the years. The lowest grains ear^{-1} and ear weight was observed in D_5 during the two years. Decrease in ear weight and grains per ear with increased density of weeds may be because of limiting resource availability, impeding photosynthesis and diverting of assimilates due to weed competition (Bhat et al., 2006 b). Similar results were also observed by Bertholdsson (2004) and Kaur et al. (2013). Results also depicted that 1000 grain weight was significantly influenced by different *Ranunculus* spp. densities, however all the treatments were statistically at par with each. Numerically higher 1000-grain weight was recorded in D_0 (41.2 g) in 2021-22 and 42.8 g in 2022-23, respectively. The reduction in test weight with increased weed densities was also reported by Kaur et al. (2013), Jaidka and Kaur (2014) and Kulsoom et al. (2018).

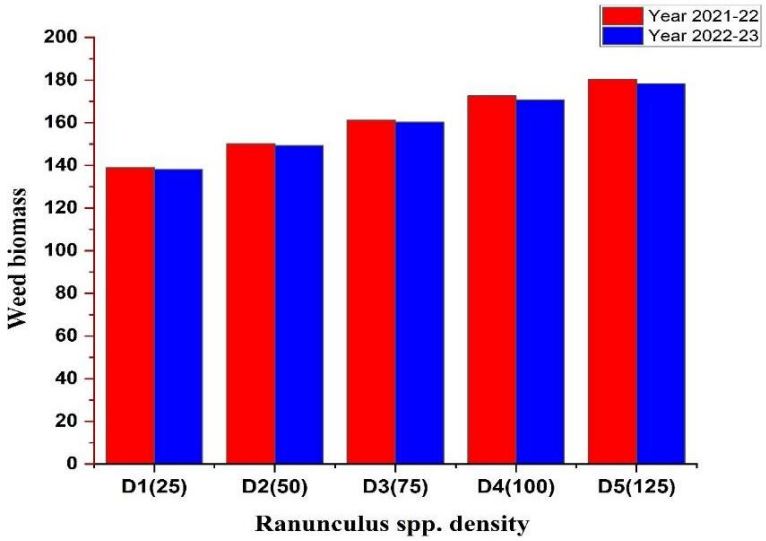

Fig. 1. Effect of different densities of *Ranunculus* spp. on its biomass

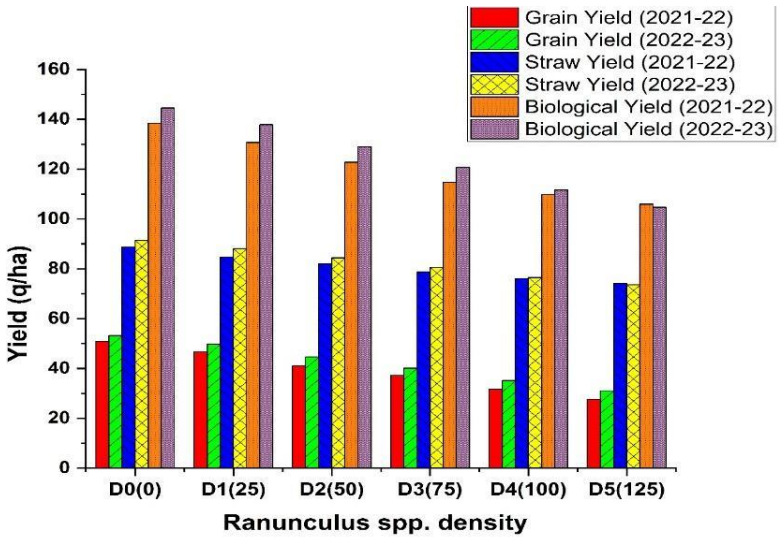

Fig. 2. Effect of different densities of *Ranunculus* spp. on grain yield, straw yield and biological yield of wheat

Table 1. Effect of different weed (*Ranunculus* spp.) densities on yield attributes of wheat

Treatment *Ranunculus* density (m^{-2})	Yield attributes of Wheat							
	Effective tillers (m^{-2})		Ear Weight (g)		Grains per Ear		Test Weight (g)	
	Year 2021-22	Year 2022-23	Year 2021-22	Year 2022-23	Year 2021-22	Year 2022-23	Year 2021-22	Year 2022-23
D_0	356	368	3.2	3.3	41.9	43.0	41.2	42.8
D_1	336	346	3.0	3.1	40.0	41.0	40.9	42.4
D_2	313	326	2.8	2.9	38.0	39.0	40.2	41.7
D_3	294	312	2.6	2.7	36.2	36.9	39.4	40.9
D_4	282	295	2.4	2.5	34.2	34.9	38.6	40.2
D_5	269	283	2.2	2.2	32.2	32.8	38.1	39.8
SEm (±)	5.6	5.2	0.06	0.06	0.63	0.7	0.35	0.44
CD ($P \leq 0.05$)	16.0	14.8	0.16	0.19	1.80	1.9	1.02	1.27

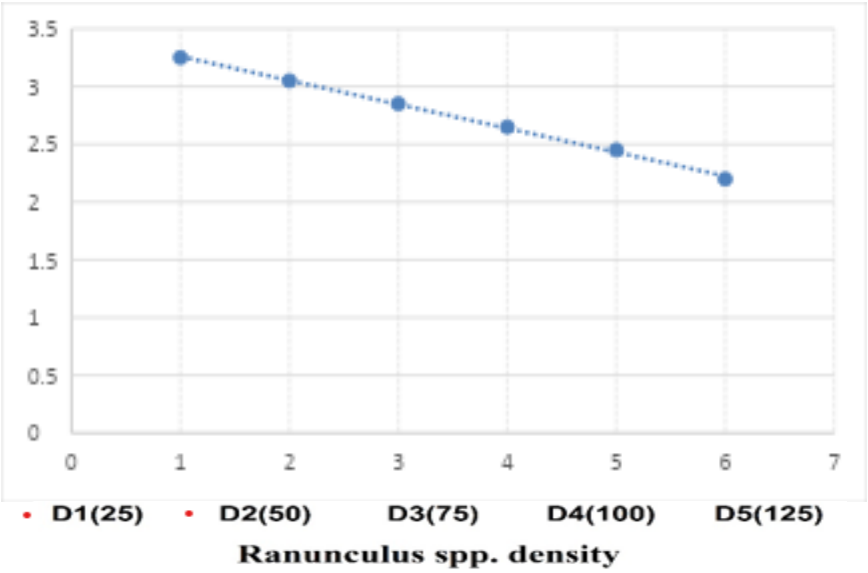

Fig. 3. Correlation between weed density and mean ear weight

The results also showed significant effect of *Ranunculus* spp. densities on grain yield of wheat during both the years (Fig. 2). Highest grain yields (5.1 t ha^{-1}) and (5.3 t ha^{-1}) during the years 2021-22 and 2022-23 respectively was obtained with zero density of *Ranunculus* spp. m^{-2}. The grain yield decreased by 45 % & 41.5 % from D_0 to D_5 during 2021-22 and 2022-23 respectively. The decline in grain yield with increased density of weeds may be because of the influence on crop growth and development throughout the season and by directly competing with the crop for limiting resources like sunlight, water and nutrients (Singh et al. 2022). Comparable outcomes were noted by Negewo et al. (2006) in barley where significant yield reductions were observed as the total weed population increased per unit area. Moreover, the yield attributes like effective tillers, ear weight, grains per ear and test weight were reduced in higher densities which may be responsible for lower yields in higher densities. Similar results of decreased yield with increased densities were also reported by Walia et al. (2004), Kolb et al. (2012), Kaur et al. (2013) and Kulsoom et al. (2018). Both straw yield and biological yield were significantly influenced by weed (*Ranunculus* spp.) density. Among weed densities D_0 resulted in significantly higher straw yield and biological yield during both the years (Fig. 2). However, the straw yield in D_4 was statistically at par with D_5 during the two years. Higher straw yield and biological yield in D_0 was because of higher plant height, Leaf area, dry matter and maximum tillers in the treatment. Armin et al. (2011) also observed the reduction in biological yield of

wheat with increased population of weeds. Similar observations were reported by Kolb et al. (2012), Hussain et al. (2016) and Deepak and Reema (2024).

4. CONCLUSION

Based on the generalisation of results obtained from the current study, it could be concluded that co-existing plant species interact with each other for limited growth resources. The weed (*Ranunculus* spp.) has been found potential competent in wheat cultivation and increasing the density of this weed caused huge yield reductions due to competition for different resources. The magnitude of yield loss due to the weed ranged from 7.6 % (D_1) to 43.2% (D_5) as observed from the pooled data of the two years. Therefore, curbing the *Ranunculus* before critical period of weed control is highly desirable. Moreover, preemergence herbicide (pendimethalin) after sowing of wheat and post emergence herbicide (sulfosulfuron) in the 2nd week of march have been found effective in attaining higher wheat yield in Kashmir valley.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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