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Response of wheat to non-chemical weed control approaches

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Abstract

The present study was conducted during *rabi* season of 2019-20 and investigated the response of wheat to non-chemical weed control approaches. Also, it estimated the correlation between growth and yield attributes of wheat and weed dry matter. A randomized block design with three replications was used and included seven treatments of weed control: weedy check, weed-free, Furrow Irrigated Raised Beds System (FIRBs) (67.5 cm), eucalyptus leaves mulching (6.0 t ha⁻¹), stale seedbed technique, stale seedbed technique followed by rice straw mulching (4.0 t ha⁻¹) and stale seedbed technique followed by two hoeings (wheel hand hoe). The results indicated that the most effective non-chemical weed control methods were the stale seedbed technique followed by straw mulching or two hoeings. These treatments resulted in the lowest weed dry matter and the highest grain yield. Additionally, a strong positive correlation was found between wheat growth and yield attributes, while a strong negative correlation was observed between the weed dry matter and grain yield. These findings demonstrate that non-chemical weed control approaches can significantly improve wheat productivity by reducing weed competition, offering a sustainable alternative to chemical herbicides.

Keywords: Wheat, non-chemical, weed control, stale seedbed, correlation

Introduction

Weeds interference in wheat crop causes heavy yield losses. They compete for moisture, nutrients, space, light, etc., and weeds are responsible for around one-third of the overall losses from wheat pests (Chand *et al* 2019) [3]. The problem of *Phalaris minor*, *Avena ludoviciana*, *Chenopodium album*, and *Melilotus alba* is critical in the state of Punjab, Haryana, Western Uttar Pradesh, and parts of Madhya Pradesh (Anonymous 2014) [1]. Gharde and Singh (2018) [5] reported that weeds cause potential yield losses of 10-60 percent in wheat crop. The effective weed control approach is herbicides and the use of herbicides increases with time. However, the continuous use of the same herbicides creates resistance in many weed species on which herbicide application may no longer be effective. *Phalaris minor*, a major wheat weed, has resistance to isoproturon (Kaur *et al* 2020) [8]. Moreover, further residual effects badly influence human health as well as the environment (Polyxeni *et al* 2016) [11]. Non-chemical approaches for weed control such as mulching, zero-tillage, live mulching, stale seedbed techniques, etc. can reduce the consumption of herbicides. The study was planned with the objective of non-herbicidal weed management methods and their efficacy on crop performance.

Materials and Methods

The field experiment was conducted at Student's Research Farm, Khalsa College, Amritsar (latitude 31.63° N and longitude 74.84° E, at an average elevation of 229 meters above the mean sea level) during *rabi* season 2019-20. The soil has a sandy loam texture, low in organic carbon and available nitrogen (0.48% and 179 kg ha⁻¹, respectively), medium available phosphorus (24 kg ha⁻¹), and high available potassium (360 kg ha⁻¹). The values of pH (8.4) and electrical conductivity (0.21 EC dS m⁻¹) were within the normal range. The study was conducted using seven weed control treatments such as weedy check, weed free, Furrow Irrigated Raised Beds System (FIRBs) (67.5 cm), eucalyptus leaves mulching (6.0 t ha⁻¹), stale seedbed technique, stale seedbed technique followed by straw mulching (rice) (4.0 t ha⁻¹) and stale seedbed

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technique followed by two hoeings (wheel hand hoe) were laid out in randomized block design with three replications. For the stale seedbed technique, shallow ploughing was done. The rice straw mulch was spread one day after the sowing. The wheat variety PBW 1 Zn was sown for this study. The seed rate used was 100 kg ha⁻¹ and for the furrow irrigated raised beds system was 75 kg ha⁻¹ with 20 cm spacing. The fertilizer was provided at the rate of 120 kg ha⁻¹ N and 60 kg ha⁻¹ P₂O₅. The plant height was taken above the soil surface to the base of the ear. At harvest, the effective tiller count was taken with a meter rod and expressed in 1 m². For the dry matter of crop and weeds, plants were sun-dried for two days, then kept in a hot air oven at 65 ± 1 °C until they achieved constant weight. For grain yield, after harvesting weigh each bundle separately and collect grains in separate bags, then expressed in q ha⁻¹. R-software was used for statistical examination (R Core Team 2020) [12].

Results and Discussion

Effect of different non-chemical weed control methods on growth attributes of wheat

The maximum plant height resulted in weed-free and the lowest plant height in the weedy check (Table 1). The stale seedbed technique followed by straw mulching, stale seedbed technique followed by two hoeings, and furrow-irrigated raised beds were resulted in the statistically similar plant heights as that of weed-free. The treatments stale seedbed techniques and eucalyptus leaves mulching were found significantly differed and superior to the weedy check treatment. According to Saquib *et al* (2012) [14], the weed-free treatment allowed plants to reach their full height.

As depicted in Table 1, the treatment weed-free had the highest dry matter accumulation during the crop growth period when compared to all other treatments. The treatment weedy check has the least amount of dry matter build-up. The treatments stale seedbed technique, furrow irrigated raised beds and eucalyptus leaves mulching were significant to each other. The treatments of stale seedbed technique followed by straw mulching and stale seedbed technique followed by two hoeings resulted statistically similarly with weed-free. The crop can reach its full yield

potential when it accumulates dry matter at the ideal rate and assimilates into the growing sink in an appropriate amount. The deposition of dry matter increased with the increase in the crop age. Increased dry matter accumulation is a result of hoeing that improves root development, decreases weed competition, and increases aeration. According to Kumari *et al* (2019) [10], manual hoeing produced the highest dry matter accumulation at various phases of the plant's growth.

Effect of non-chemical weed control methods on yield attributes of wheat

The treatment weed-free resulted in the highest number of effective tillers, which was at par with the stale seedbed technique followed by straw mulching and stale seedbed technique followed by two hoeings (Table 1). The treatments of stale seedbed technique, eucalyptus leaves mulching, and furrow irrigated raised beds system differed significantly. The treatment weedy check had the lowest effective tiller count. Among the yield characteristics, the number of tillers per unit area not only shows appropriate crop establishment but also significantly influences grain yield by contributing to a higher grain yield in the wheat crop. According to Terefe *et al* (2016) [16], varying the timing of weeding has an impact on the weed population as well as the tillering of crops.

Effect of non-chemical weed control methods on grain yield of wheat

There was a significant difference in the grain yield between different weed control methods. The highest grain yield was recorded in treatment weed-free. The statistically similar grain yield was recorded from the treatments stale seedbed technique followed by straw mulch as well as the two hoeings. The treatments stale seedbed technique, eucalyptus leaves mulching, and FIRBs (Table 1) showed significant differences from one another. The treatment weedy check had the lowest grain yield and showed a statistically significant difference from all the treatments. The stale seedbed approach resulted in favourable grain production, as reported by Senthilkumar *et al* (2019) [15].

Table 1: Effect of different weed control treatments on growth parameters and yield attributes of wheat (*Triticum aestivum* L.) and total dry matter accumulation of weeds (g m⁻²).

Treatment	Plant height at 120 DAS (cm)	Dry matter accumulation of wheat at 120 DAS (g m ⁻²)	Dry matter accumulation of weeds at 120 DAS (g m ⁻²)	Effective tiller count (m ⁻²)	Grain yield (t ha ⁻¹)	Yield losses due to weeds (%)
Weedy check	73.1	72.07	9.36 (86.63)	216.90	2.20	54.27
Weed free	89.0	121.40	1.00 (0.00)	348.30	4.80	0.00
Furrow irrigated raised beds (FIRBs)	86.8	106.22	6.05 (35.67)	310.50	4.06	15.52
Eucalyptus leaves mulching	77.0	82.12	7.33 (66.07)	245.20	2.79	41.98
Stale seedbed technique	80.4	93.94	7.04 (48.54)	278.10	3.42	28.85
Stale seedbed technique followed by straw mulching	88.2	117.60	4.65 (20.61)	338.40	4.69	2.40
Stale seedbed technique followed by two hoeings (wheel hand hoe)	88.6	118.43	4.52 (19.43)	341.90	4.73	1.56
CD (p=0.05)	2.6	6.74	0.24	20.18	0.05	
Original values given in parenthesis were subjected to square root transformation ($\sqrt{x+1}$) Significance at a 5% level of probability.						

Effect of different non-chemical weed control methods on weeds dry matter

The different weed control methods had a significant impact on the weed dry weight over the entire observation period. Weed species recorded such as *Phalaris minor*, *Anagallis arvensis*, *Sonchus arvensis*, *Melilotus alba*, *Rumex spp.*, *Coronopus didymus*, *Fumaria parviflora*, *Euphorbia helioscopia*, and

Chenopodium album. Weed dry matter accumulation increased under weedy check and decreased under weed-free over the crop period (Table 1). The stale seedbed technique followed by two hoeings and stale seedbed technique followed by straw mulching proved to be highly successful in controlling weeds. Under all the treatments, the dry matter accumulation of weeds was found to be much lower than that of the weedy check. A significant

relationship existed between the dry matter of weeds recorded under the stale seedbed technique, and mulching with eucalyptus and furrow irrigated raised beds. Mulching with eucalyptus leaves had no appreciable impact on grain yield. Pandey *et al* (2013) gave the results that *Phalaris minor* was less prolific on dry tops of raised beds and easy to control weeds mechanically between the beds. Dry matter accumulation by weeds reflects the competing ability of weeds. Accumulation of biomass by weeds increased progressively with the advancement of crop age. The result of the weed dry matter accumulation was in close agreement with the findings of Inamullah *et al* (2005)^[6].

Yield losses in wheat due to wheat infestation under non-chemical control methods

Weed competition is a major factor affecting wheat yield, and its impact varies depending on the weed management strategy employed. The present study assessed yield losses due to different non-chemical weed control approaches, with the results summarized in Table 1. The highest loss was recorded in the weedy check treatment (54.27%), indicating severe yield reduction in the absence of any weed control measures. Conversely, the weed-free treatment yield losses achieved maximum productivity, emphasizing the importance of effective weed control. Among the non-chemical weed control methods, furrow irrigated raised beds (FIRBs) treatment recorded a yield loss of 15.52%, which was considerably less than the stale seedbed technique. This could be due to the improved crop stand establishment and reduced weed emergence (Razaq *et al* 2015)^[13]. The stale seedbed technique resulted in a yield loss of 28.85%, which, although lower than the weedy check, still

showed considerable weed interference. The effectiveness of this method depends on the pre-sowing weed control period and the residual weed seed bank (Senthilkumar *et al* 2019)^[15]. Mulching practices exhibited varied responses. The treatment of the stale seedbed technique followed by straw mulching showed the lowest yield loss (2.40%) demonstrating its effectiveness in suppressing weeds by reducing light availability and altering soil microclimate as compared to eucalyptus leaves mulching (41.98%). The stale seedbed technique followed by two hoeings (wheel hand hoe) (1.56%) was highly effective, reducing weed pressure and yield loss (Kaur and Chopra 2024)^[9]. This highlights the significant competition exerted by weeds for nutrition, water, and light, ultimately reducing wheat productivity. The results of the present study, the highest grain yield loss under weedy check and the lowest under weed-free treatment in line with Chandra *et al* (2018)^[4].

Correlation analysis

The crop growth and yield parameters – plant height, dry matter accumulation, effective tiller count had a significantly highly positive correlation with grain yield but weeds dry matter was highly negatively correlated (Table 2). The correlation between plant height (0.900), crop dry matter accumulation (0.825), and tillers count (0.885) was highly positive with grain yield. The correlation of weed dry matter was highly negative with grain yield (-0.922), tiller count (-0.831), and crop dry matter (-0.760). Kaur and Singh (2019)^[7] reported a negative association between grain yield and weed dry matter and a positive correlation between grain yield and growth qualities.

Table 2: Correlation coefficient between different growth and yield attributes of wheat and weeds

Parameter	Plant height (cm)	Dry matter accumulation at 120 DAS (g m ⁻²)	Effective tiller count (m ⁻²)	Grain yield (q ha ⁻¹)	Weed dry matter (g m ⁻²)
Plant height (cm)	1	.848**	.909**	.900**	-.892**
Dry matter accumulation (g m ⁻²)	.848**	1	.946**	.825**	-.760**
Effective tiller count (m ⁻²)	.909**	.946**	1	.888**	-.831**
Grain yield (q ha ⁻¹)	.900**	.825**	.888**	1	-.922**
Weed dry matter (g m ⁻²)	-.892**	-.760**	-.831**	-.922**	1

*, Correlation is significant at the 0.01 level (2-tailed).

Conclusion

The study highlights the significant impact of weed competition on wheat yield and the effectiveness of different non-chemical weed control approaches in minimizing yield loss. The present study concludes that a combination of stale seedbed techniques with two hoeings or straw mulching due to effective weed control resulted in higher grain yield. These methods can serve as viable alternatives to chemical herbicides, contributing to sustainable wheat production by reducing weed pressure while maintaining high yield potential.

Conflict of Interest

There is no conflict of interest.

Authors' contribution

Conceptualization of research work and designing of experiments by Gurbax Singh Chhina and Sharandeep Kaur; Execution of field/lab experiments and data collection by Sharandeep Kaur and Gurbax Singh Chhina; Analysis of data and interpretation by Sharandeep Kaur and Gurbax Singh Chhina; Preparation of manuscript Sharandeep Kaur and Gurbax Singh Chhina.

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