Integrated weed management in wheat by using sowing time, seed rate and herbicides

Muhammad Najeeb Khasraw[a], Shadia Hama Salih Kareem[a], Kamil Mahmood Mustafa[a], Omar Karim Aziz[a], Muhammad Arif[b], Adeel Anwar[c], Mubshar Hussain[d,e*]

[a] Department of Biotechnology and Crop Science, College of Agricultural Engineering Sciences, University of Sulaimani, Sulaimani, Iraq. [b] Water Resources Zone, Irrigation Department Punjab, Pakistan. [c] Department of Agronomy, PMAS-Arid Agriculture University, Rawalpindi 46300, Pakistan. [d] Department of Agronomy, Bahauddin Zakariya University Multan, 60800, Pakistan. [e] School of Veterinary and Life Science, Murdoch University, Murdoch, WA 6150, Australia.

Abstract: **Background:** Appropriate agronomic practices are required to ensure high and sustainable crop yields. Timely sowing of wheat at an optimum seeding rate plays an important role in weed management and obtaining higher crop yields. **Objective:** This study assessed the impact of agronomic practices, i.e., herbicide application, sowing dates and seeding rates on weed management and productivity of wheat. **Methods:** Experimental treatments comprised of three sowing dates (20 November, 5 December, and 30 December), three seeding rates (120, 160, and 200 kg ha^{-1}) and application of herbicides (tribenuron methyl + clodinafop-propargyl). **Results:** Sowing dates, seeding rates and herbicide application significantly affected dry weight of weeds, yield, and yield components of wheat. High seed rate and herbicide application in late-planted wheat (30 December) reduced the weed dry weight. Early-planted wheat (20 November) with 120 kg ha^{-1} seed rate resulted in a higher number of seeds/spike and 1,000-grain weight. Early-planted wheat (20th November) with high seed rate resulted in a higher tiller population and total biomass, which ultimately increased the final grain yield and net profit. **Conclusions:** Grass + broad leaf herbicide application on early-planted wheat with higher seed rates (160 and 200 kg ha^{-1}) suppressed weed growth and helped to improve yield and yield-related attributes, and net returns of wheat in Iraqi Kurdistan region.

Keywords: Grain yield; Herbicide; Planting density; Sowing dates; Weed dry weight

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* Corresponding author:
<mubashir.hussain@bzu.edu.pk>, <mubashiragr@gmail.com>

1. Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal produced in Iraq, accounting for ~70% of total cereal production. Wheat production is restricted by several factors in which severe weed interference is the most restrictive factor (Hussain et al., 2021). Weeds affect crop production by significantly decreasing crop yield through competition for nutrients, moisture, and light. The competition of weeds for nutrients may result in dwarfing of plants, nutrient starved conditions, wilting and dying out of plants (Minhas et al., 2023). Weeds are yield reducers that are, in many situations, economically more important than insects, fungi or other pest organisms (Shahzad et al., 2021). Weeds reduced grain productivity by 29.5% in the Iraqi Kurdistan region (Nadir, 2013). Herbicides are the most widely used weed management tool in modern agriculture. Herbicide application on wheat fields has frequently proven profitable under moderate to severe weed competition (Ansar et al., 2010). The most common method is to use a combination of broadleaf herbicide (tribenuron-methyl) mixed with a grass weed herbicide (clodinafop-propargyl) for wheat (Hussain et al., 2018; Minhas et al., 2023). Herbicide usage for broadleaf and grass weed management also significantly reduced weed dry biomass by 97.2% and 63.5%, respectively (Mazhar et al., 2021). However, sole dependence on herbicides increases weed resistance, soil, and irrigation water contamination, and killing of non-target organisms which might alter the natural balance (Buddenhagen et al., 2021).

The ability of a crop to capture resources and produce yield is determined by plant density, which is achieved through the optimum seeding rate. As plants compete for available resources at high plant densities, extremely low plant densities may allow weed invasion. Wheat yield loss due to weed-infested fields was reduced using higher than recommended seeding rates (Haile, Girma, 2010). High plant density due to a high seeding rate results in greater intraspecific competition for moisture, sunlight, and essential nutrients (Iqbal et al., 2020). High seeding rates increased total biomass, and grain yield (Iqbal et al., 2012) but the 1,000-grain weight decreased significantly (Nadir, 2013).

Sowing date is another crop management practice that is frequently manipulated to adjust the timing and occurrence of crop phenological phases based on environmental conditions. Adjusting the sowing date can increase wheat grain yield in arid and semiarid areas, while late sowing can decrease wheat grain yield (Hussain et al., 2012a; 2012b; Khan et al., 2017). Integrated weed management has gained popularity worldwide to minimize the issues of herbicide-resistant weeds, and environmental pollution caused by herbicides.

It was hypothesized that integrated weed management would result in better weed control and increase economic returns in wheat in Iraq. Therefore, the major aim of this study was to assess the impact of sowing time, seeding rate and herbicide application on weed suppression and wheat productivity.

2. Materials and Methods

2.1 Experimental design

The experiment was conducted during winter 2016-17 and 2017-18 at the Qlyasan Agricultural Research Station (35°34′ N, 45°22′ E), University of Sulaimani, in the Kurdistan Region of Iraq. The experiment was conducted according to a randomized complete block design with split-split plot arrangements. Three sowing dates (20^{h} November, 5 December, and 30 December) were in the main plots, three seeding rates (120, 160, and 200 kg ha^{-1}) were randomized in sub-plots and herbicide application (t+ clodinafop-propargyl) and a nontreated control were placed in sub-sub plots with three replicates. Each sub-plot consisted of five rows of wheat crop (20 cm row to row distance) with a row length of 5.0 meters. The bread wheat variety "Aras" was used in the study.

Composite soil samples were collected from 0 to 30 cm soil depth in the study area before sowing and examined for physico–chemical features. The soil texture was silty-clay, having 5.92% and 7.11% sand, 43.28 and 45.33% silt, 50.08 and 47.20% clay, 7.2 and 7.1 pH, 5.2 and 7.6 mg kg^{-1} available phosphorus and 0.17 and 0.15 mg kg^{-1} available potassium during 2016-17 and 2017-18, respectively.

The weather data from wheat sowing to harvesting were recorded from the observatory of Qlyasan Agricultural Research Station, University of Sulaimani, Iraq. A total of 697.0 mm rainfall was recorded during 2016-17 crop period of and 604.2 mm during 2017-18. Most of the rainfall was received during November, December, and March. The maximum (25.5 and 24.6 °C) and minimum (7.6 and 6.8 °C) temperatures were recorded, respectively during 1st and 2nd year growing seasons.

2.2 Fertilizer and herbicide application

The seedbed was prepared by cultivating the field area three times with a tractor-mounted cultivator followed by planking to level the soils. Fertilizer was applied at the rate of 120-90-60 NPK kg ha^{-1}. For chemical weed control, tribenuron, methyl (20 g ha^{-1} a.i) (Granstar 75% DF) was applied in combination with clodinafob-propargyl (240 g a.i. ha^{-1}) (Topik 240 EC) to control broadleaf and grass weeds at the early tillering crop stage. Herbicide treatments were applied with a battery sprayer series knapsack equipped with a flat-fan nozzle calibrated to deliver 250 L ha^{-1} at a speed of 3.2 km h^{-1}. The treatments were applied at the two- to four-leaf stage of weeds.

2.3 Weed sampling and agronomic traits

In both study years, weeds density and dry biomass were determined at harvest time, i.e., 10 and 15 June, randomly from each treated and untreated plot by collecting all weeds from 1 m^{2} area in each plot. Three rows were harvested from each sub-sub plot and the data were recorded for the number of spikes m^{-2}, number of grain spike^{-1}, 1,000-grain weight, total biomass, and grain yield.

2.4 Statistical and economic analyses

Three-way analysis of variance (ANOVA) was used to analyze the data on weed and yield-related traits using SPSS statistical software. Three-way interaction between sowing date, seeding rate and herbicide application was significant; therefore, interactions were considered for data interpretation. The differences between treatment means were assessed by Duncan's multiple range test at 5% probability levels (Steel et al., 1997). Moreover, economic analysis was conducted to validate the economic feasibility of applied treatments. The total cost of production included the expenses on land rent, land preparation, irrigation, fertilizers, herbicides, harvesting and labour charges. However, gross income was calculated according to the local market rate of wheat grain and straw. Net income was calculated by subtracting the total cost of production to gross income, and benefit cost ratio was calculated by dividing the gross income with the total cost of production.

3. Results and Discussion

The most prominent grass weed species found were *Cynodon dactylon* L., *Lolium rigidum* L., *Sinapis arvensis* L., *Vicia narbonensis* L. and broadleaf weeds were *Cichorium intybus* L., *Carthamus oxycathus* L., *Convolvulus arvensis* L., and *Melilotus indicus* L. (Table 1). Interaction between sowing date, seeding rate and herbicides had a significant effect on weed dry weight. Early planted wheat (20 November) using seed rate of 160 kg ha^{-1} in weedy-check plots had higher weed dry weight, while combined application of herbicides in late planted wheat (30 December) with seed rate of 160 and 200 kg ha^{-1} had the lowest weed dry weight during the first and second growing season, respectively (Table 2).

The experimental treatments had significant effect on plant height. Combined herbicide application in early-planted wheat (20 November) with 200 kg ha^{-1} seed rate produced taller plants during both growing seasons (Table 2). Late planted (30 December) wheat with higher seed rate (200 kg ha^{-1}) from control plots produced the shortest plants during both growing seasons.

Interaction between sowing date, seeding rate and application of herbicides affected the productive tillers. Application of herbicide on wheat planted on 20 November using a seeding rate of 200 kg ha^{-1} resulted in higher tiller population during both growing seasons. Late-planted wheat with the low seed rate (120 kg ha^{-1}) in weedy check plots had the fewest productive tillers in both growing seasons (Table 2).

Results showed that three-way interaction of applied treatments had a significant effect on number of seeds/ spike. Combined herbicide application in early-planted wheat (20 November) with 120 kg ha^{-1} seed rate resulted in higher number of seeds/spikes in both growing seasons. Late-planted wheat (30 December) using a seeding rate of 200 and 160 kg ha^{-1} in weedy-check plots produced the lowest number of seeds/spike during first and second growing season, respectively (Table 3).

The interactive effect of applied treatments had a significant effect on 1,000-seed weight. Combined herbicide application in early-planted wheat (20 November) using 120 kg ha^{-1} seeding rate produced higher 1,000-seed weight during both growing seasons (Table 3). Late-planted wheat using a maximum seeding rate of 200 kg ha^{-1} in weedy-check plots had the minimum 1,000-seed weight in both years.

Interaction between sowing date, seeding rate and herbicide application significantly affected grain yield. Wheat grain yield increased in the plots treated with herbicide compared with untreated control during both growing seasons. The combined application of herbicide on early planted wheat using 200 and 160 kg ha^{-1} seeding rate produced higher grain and total biomass in both growing seasons, respectively (Table 3). However, the late-planted wheat using higher and lower seeding rates (200 and 120 kg ha^{-1}) without herbicide application harvested the lowest grain yield and total biomass during first and second growing seasons, respectively (Table 3).

Economic analysis showed that combined application of herbicide on wheat planted on 20 November using a seeding rate of 200 and 160 kg ha^{-1} produced higher grain

Table 1 - Weed species observed in wheat fields during the study

Type of weeds	Scientific name	Family
Grass-leaf weeds	*Avena fatua* L.	Poaceae
	Bermuda grass L.	Poaceae
	Lolium rigidum L.	Poaceae
	Cynodon dactylon L.	Poaceae
Broad-leaf weeds	*Sinapis arvensis* L.	Brassicaceae
	Vicia narbonensis L.	Fabaceae
	Cichorium intybus L.	Asteraceae
	Carthamus oxycathus	Asteraceae
	Convolvulus arvensis	Convolvulaceae
	Melilotus indicus	Fabaceae

Table 2 - The effect of sowing date, seeding rate and herbicide on weeds dry weight, plant height and number of productive tillers

Sowing time	Seeding rate	Herbicide application	Weeds dry weight (g m^{-2})		Plant height (cm)		Number of productive tillers (m^{-2})	
			2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
20 November	120 kg ha^{-1}	Weedy-check	193 a	117 b	105 b	92 cd	307 eg	203 d
		Herbicide application	23 f	17 e	95 fg	101 a	347 cd	232 b
	160 kg ha^{-1}	Weedy-check	194 a	139 a	101 cd	97 b	323 de	201 d
		Herbicide application	28 f	17 e	102 c	101 a	426 b	230 bc
	200 kg ha^{-1}	Weedy-check	179 ab	113 b	95 f	93 c	304 eg	237 b
		Herbicide application	33 ef	17 e	113 a	102 a	462 a	248 a
5 December	120 kg ha^{-1}	Weedy-check	118 c	82 c	93 gh	87 ef	283 gi	162 i
		Herbicide application	28 f	13 e	101 cd	83 g	317 ef	173 h
	160 kg ha^{-1}	Weedy-check	56 de	78 c	100 d	92 cd	265 ij	184 fg
		Herbicide application	19 f	17 e	102 c	86 f	357 c	198 de
	200 kg ha^{-1}	Weedy-check	80 d	73 c	81 k	91 d	293 fh	194 de
		Herbicide application	19 f	21 e	97 e	92 cd	404 b	222 c
30 December	120 kg ha^{-1}	Weedy-check	184 ab	130 ab	92 h	88 e	236 k	116 k
		Herbicide application	19 f	17 e	92 h	78 i	311 ef	119 jk
	160 kg ha^{-1}	Weedy-check	66 d	47 d	83 j	91 d	251 jk	174 gh
		Herbicide application	14 f	17 e	86 i	83 g	283 gi	188 ef
	200 kg ha^{-1}	Weedy-check	165 b	126 ab	65 l	77 i	271 hj	127 j
		Herbicide application	23 f	13 e	86 i	80 h	256 ik	154 i
LSD (5%)			24.06	18.10	1.78	1.80	27.66	9.53

Means with different letters, within a column, are statistically different from each other at 5% probability level

Table 3 - The effect of sowing date, seeding rate and herbicide on number of seeds/pikes,1000-seeds weight, total biomass and grain yield

Sowing time	Seeding rate	Herbicide application	Number of seeds/ spike		1000-seed weight (g)		Total biomass (t ha^{-1})		Grain yield (t ha^{-1})	
			2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
20 November	120 kg ha^{-1}	Weedy-check	52 c	50 b	38.4 ce	40.5 c	11.7 bc	8.2 b	3.4 ei	2.1 e
		Herbicide application	60 a	60 a	40.9 a	42.8 a	10.3 de	8.0 b	3.8 ce	2.8 b
	160 kg ha^{-1}	Weedy-check	49 d	39 e	38.0 df	39.7 cd	12.1 b	6.0 de	3.5 dg	2.1 e
		Herbicide application	57 b	46 cd	40.5 a	40.3 c	12.1 b	9.9 a	4.4 b	3.4 a
	200 kg ha^{-1}	Weedy-check	45 ef	37 ef	36.6 gi	39.3 de	14.8 a	6.1 de	3.7 cf	2.3 d
		Herbicide application	49 d	36 ef	38.0 df	39.8 cd	15.2 a	9.8 a	6.0 a	2.9 b
5 December	120 kg ha^{-1}	Weedy-check	41 gh	38 ef	38.7 bd	36.5 h	10.7 ce	5.9 df	3.6 cg	1.8 f
		Herbicide application	52 c	39 e	40.5 a	41.7 b	8.6 g	5.4 g	3.6 cf	2.1 e
	160 kg ha^{-1}	Weedy-check	43 f	36 ef	36.5 gi	37.9 g	10.9 cd	5.5 fg	3.0 hj	1.9 f
		Herbicide application	50 d	49 bc	39.2 bc	38.9 ef	10.6 de	6.9 c	3.9 bd	2.5 c
	200 kg ha^{-1}	Weedy-check	41g	36 f	37.9 bc	34.8 i	8.4 g	6.2 d	3.7 cf	2.2 de
		Herbicide application	39 i	38 ef	37.6 ef	38.9 ef	9.7 ef	5.7 eg	4.0 bc	2.1 e
30 December	120 kg ha^{-1}	Weedy-check	45 e	36 f	39.4 b	37.0 h	9.77 ef	4.1 i	3.5 dh	1.2 i
		Herbicide application	45 ef	43 d	37.8 df	38.3 fg	9.9 de	4.1 i	3.6 cg	1.3 h
	160 kg ha^{-1}	Weedy-check	45 e	24 h	36.4 hi	35.4 i	10.5 de	3.4 j	3.0 ij	1.2 hi
		Herbicide application	46 e	30 g	37.4 fg	36.3 h	10.5 de	5.6 fg	3.3 fj	1.4 h
	200 kg ha^{-1}	Weedy-check	38 i	27 gh	36.3 i	33.9 j	8.3 g	4.6 h	2.8 j	1.2 i
		Herbicide application	39 hi	28 g	37.3 fh	34.8 i	8.8 fg	4.2 i	3.2 gj	1.6 g
LSD (5%)			1.7	3.3	0.9	0.7	1.0	0.3	0.4	0.1

Means with different letters, within a column, are statistically different from each other at 5% probability level

Table 4. The effect of sowing date, seeding rate and herbicide on economic analysis of wheat

Treatments	2016-17					2017-18				
	Variable cost (US$)	Total cost (US$)	Gross income (US$)	Net income (US$)	BenefitCost Ratio	Variable cost (US$)	Total cost (US$)	Gross income (US$)	Net income (US$)	BenefitCost Ratio
$D_1S_1H_0$	64.08	367.48	1590.47	1222.99	4.33	64.08	367.48	982.80	615.32	2.67
$D_1S_1H_1$	82.92	386.32	1751.90	1365.58	4.53	82.92	386.32	1313.62	927.29	3.40
$D_1S_2H_0$	85.44	388.84	1630.89	1242.05	4.19	85.44	388.84	1003.21	614.37	2.58
$D_1S_2H_1$	104.28	407.68	2019.42	1611.74	4.95	104.28	407.68	1594.13	1186.45	3.91
$D_1S_3H_0$	106.79	410.20	1698.26	1288.06	4.14	106.79	410.20	1068.75	658.55	2.61
$D_1S_3H_1$	125.64	429.04	2761.84	2332.80	6.44	125.64	429.04	1358.97	929.93	3.17
$D_2S_1H_0$	64.08	367.48	1668.51	1301.03	4.54	64.08	429.04	860.46	492.97	2.34
$D_2S_1H_1$	82.92	386.32	1689.43	1303.10	4.37	82.92	386.32	989.75	603.43	2.56
$D_2S_2H_0$	85.44	388.84	1399.62	1010.77	3.60	85.44	388.84	871.12	482.28	2.24
$D_2S_2H_1$	104.28	407.68	1814.51	1406.83	4.45	104.28	407.68	1160.56	752.88	2.85
$D_2S_3H_0$	106.79	410.20	1702.33	1292.13	4.15	106.79	410.20	1017.44	607.24	2.48
$D_2S_3H_1$	125.64	429.04	1865.82	1436.78	4.35	125.64	429.04	1002.25	573.21	2.34
$D_3S_1H_0$	64.08	367.48	1609.47	1241.98	4.38	64.08	367.48	553.21	185.73	1.51
$D_3S_1H_1$	82.92	386.32	1664.12	1277.79	4.31	82.92	386.32	616.55	230.23	1.60
$D_3S_2H_0$	85.44	388.84	1385.66	996.82	3.56	85.44	388.84	591.52	202.68	1.52
$D_3S_2H_1$	104.28	407.68	1510.65	1102.7	3.71	104.28	407.68	644.47	236.79	1.58
$D_3S_3H_0$	106.79	410.20	1300.11	889.91	3.17	106.79	410.20	562.00	151.80	1.37
$D_3S_3H_1$	125.64	429.04	1470.74	1041.70	3.43	125.64	429.04	742.83	313.79	1.73

Here, D_1= 20 November; D_2= 5 December; D_3= 30 December; S_1= 120 kg ha^{-1}; S_2= 160 kg ha^{-1}; S_3= 200 kg ha^{-1}; H_0= Weedy check (control); H_1= Herbicide application BCR; benefit-cost ratio yield during 2016-17 and 2017-18, respectively recorded maximum gross income, net income, and benefit-cost ratio (BCR). However, cultivation of wheat on 30 December using a maximum and minimum seeding rate of 200 and 120 kg ha^{-1} from control plots recorded the minimum net income and BCR during both growing seasons (Table 4).

Weed management in wheat crop has been based on herbicides application for the last few decades. However, frequent use of herbicides with the same mode of action is increasing the number of herbicide-resistant weed species. Adjustment in the sowing date and seeding rate are agronomic practices that play an important role in weed management (Ingraffia et al., 2022). Results of the current study showed that the highest weed dry matter was observed from early sowing of wheat using a seeding rate of 160 kg ha^{-1}. The total weed dry matter was reduced by delaying seeding until 30[a] December using a seeding rate of 200 kg ha^{-1}. a greater number of wheat plants emerged with increasing seeding rate which decreased weed dry biomass. Hence, enhanced interspecific competition in favour of wheat plants is negatively reflected in the total weight of weeds per unit area. These results are in line with the Bulut et al. (2010) and Haile and Girma (2010) who suggested that crop density would be naturally less under low seeding rate, leaving many resources available for weeds and enabling them to establish quickly.

Combined application of grass + broadleaf herbicide on early-planted wheat (20 November) with a seeding rate of 200 kg ha^{-1} produced taller wheat plants during both growing seasons. While late-planted (30 December) wheat from control plots produced smaller wheat plants during both growing seasons. This might be because early sowing of wheat produced significantly taller plants primarily because of longer vegetative phase (Hussain et al., 2012b). Plant height decreased in late planting due to high temperature and photoperiod which reduce the growth cycle (Hussain et al., 2012b). Plant height increased with higher planting density, due to minimum space for horizontal expansion of the plant and increased competition for light interception which increased upward growth.

Application of herbicide on early planted wheat using a seeding rate of 200 kg ha^{-1} produced higher number of spikes per m^{-2}. The minimum number of spikes m^{-2} was observed from cultivation of late planted wheat with a seeding rate of 120 kg ha^{-1} from control plots during both growing seasons. Number of spikes per unit area increased as higher seeding rate produced more spike-bearing tillers (Arduini et al., 2006). These findings could also be attributed primarily with the application of herbicides that improved wheat crop growth because of less weed competition with lower dry weed biomass compared to the control plots (Haile, Girma, 2010; Naseer-ud-Din et al., 2011). Moreover, it was also observed that delayed sowing reduced spike per unit area (Arduini et al., 2009; Alam et al., 2013).

Combined application of herbicide on early-planted wheat with a seeding rate of 120 kg ha^{-1} produced higher number of seeds/spike and 1,000-seed weight and the lowest was observed from late planted wheat using a seeding rate of 200 and 160 kg ha^{-1} from control plots. The highest number of seeds/spike and 1,000-seed weight value for herbicide treatment was possibly due to its superior weed elimination. In these plots, nutrient and water supply might be increased due to low weed-crop competition (Shahzad et al., 2021). In other studies, Naseer-ud-Din et al. (2011) and Calado et al. (2013) found that applying post-emergence herbicides increased the number of seeds/spike and 1,000-seed weight over weedy control. Competition between grass weeds and wheat plants also had an impact on crop grain formation and heading. Higher grain count and size of early sowing date (20 November) may have benefited from better environmental conditions, particularly temperature and solar radiation; this may help in wheat plant canopy establishment (Malik et al., 2009; Hussain et al., 2012b). These findings were consistent with the findings of Hussain et al. (2012b), who reported that early sowing dates enhanced 1,000-seed weight, which could be attributed to a longer grain filling period. Higher seeding rate reduced the 1,000-grain weight and number of seeds/spike in both study years.

Combined application of herbicide on early planted wheat using seeding rates of 200 and 160 kg ha^{-1} produced higher total biomass and grain yield and the lowest values were observed from late planted wheat. This higher yield might be attributed to efficient weed control achieved in herbicide treatment along with optimum growing conditions, which enabled the wheat plants to accumulate more photo-assimilates and ultimately higher yield. Nonetheless, the higher grain yield in above-mentioned combination of treatments was due to lower weeds infestation along with a greater number of productive tillers, number of seeds/spike and 1,000-seed weight (Tables 1-2).

Economic analysis was conducted to elucidate the adoption of any technique or practice on commercial basis (Shahzad et al., 2017). Results of this two-year field study indicated that early planted wheat using a seeding rate of 160 kg ha^{-1} along with herbicide application was more economical compared with the rest of treatments combinations as indicated by the higher values of net income and benefit cost ratio (Table 3).

4. Conclusions

Most of the wheat producers depend on herbicides for weed management because of lower cost and effectiveness compared with manual weeding. However continuous use of herbicide with same mode and mechanism of action have resulted in herbicide-resistant weeds. Integration of herbicides with proper sowing time and optimum seed resulted in efficient weed control. Early-planted wheat (20 November) using a seeding rate of 120 kg ha^{-1} resulted in a significantly higher number of seed/spike and 1,000-seed weight. Early-planted wheat (20 November) with high seed rate resulted in a higher tiller population, grain yield and net profit. Therefore, it is concluded that application of combined herbicides (grass+ broadleaf) on early-planted wheat (20 November) with increasing seeding rate (160 and 200 kg ha^{-1}) suppressed the growth of weeds and helped to improve the yield of wheat.

Authors' contributions

All authors read and agreed to the published version of the manuscript. MK, KM, MH, SHSK, and OA: conceptualization of the manuscript and development of the methodology. MK, KM, MH, SHSK, and OA: data collection and curation. AA, MA, and SHSK: data analysis. AA, MA, and SHSK: data interpretation. MK, KM, and OA: funding acquisition and resources. KM and MH: supervision: KM, MH, NK and SHSK: writing the original draft of the manuscript. AA, MA, MH, and SHSK: writing, review, and editing.

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