



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(6): 944-947
Received: 08-04-2026
Accepted: 20-05-2026

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Effect of date of sowing and weed management practices on growth indices of wheat (*Triticum aestivum* L.)

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i6l.5812>

Abstract

A field experiment was conducted during two consecutive seasons of *Rabi* 2021–22 and 2022–23 at Rajasthan Agricultural Research Institute, Durgapura, Jaipur, to evaluate the effect of sowing dates and weed management practices on growth of wheat (*Triticum aestivum* L.) under semi-arid conditions. The experiment was laid out in split-plot design consisted with four sowing dates and six weed management practices replicated thrice. The crop Sown on 15th November recorded significantly higher crop growth rate, relative growth rate and leaf area index, which remained at par with 1st November sowing. Among weed management practices, after weed-free treatment, post emergence application of clodinafop-propargyl + metsulfuron methyl recorded highest values for all growth indices and was statistically at par with sulfosulfuron + metsulfuron methyl. Delayed sowing, particularly on 15th December adversely affected the physiological growth of crop. Timely sowing during the first fortnight of November, combined with effective weed management, found improved growth performance of wheat in the semi-arid conditions of Rajasthan.

Keywords: Wheat, sowing dates, weed management, growth indices, herbicides

Introduction

Wheat [*Triticum aestivum* (L.)] is the most widely cultivated staple food crop of the world, playing a crucial role in global food security by providing food to billions of people and half of the dietary protein and more than half of the calories. It is being grown from temperate humid to dry cold environments, which provides a remarkable adaptability to the crop, sowing date is a key agronomic factor influencing crop establishment, growth and phenological development. Timely sowing enables the crop to utilize favourable temperature and radiation conditions, whereas delayed sowing exposes it to terminal heat stress, resulting in reduced growth and productivity (Paudel *et al.*, 2025) [8]. Physiological growth indices such as crop growth rate (CGR), relative growth rate (RGR) and leaf area index (LAI) are important indicators of crop growth dynamics and resource use efficiency. These parameters are greatly affected by sowing time and environmental conditions. Weed infestation further limits wheat productivity by competing for nutrients, moisture, light and space, particularly during the initial growth period. Effective weed management is therefore essential to minimize crop–weed competition and sustain crop growth (Loura *et al.*, 2024) [5]. The combined effect of optimum sowing time and efficient weed management can improve canopy development, photosynthetic efficiency and dry matter accumulation. Therefore, the present study was undertaken to evaluate the effect of different sowing dates and weed management practices on CGR, RGR and LAI of wheat.

Materials and Methods

The experiment was conducted at Instructional farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (Rajasthan) during two consecutive *Rabi* seasons of 2021–22 and 2022–23. The experimental site is situated at 26°51' N latitude and 75°47' E longitude at an altitude of 390 m above mean sea level and falls under Agro-climatic Zone IIIa (Semi-arid Eastern Plain Zone) of Rajasthan. The soil of the experimental field was loamy sand in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen and high in available phosphorus and potassium. The experiment was laid out in a split-plot design with three replications, assigning

sowing dates to the main plots and weed management treatments to the sub-plots. Wheat variety Raj-4120 was used as test crop.

Crop growth rate (CGR)

Crop growth rate was calculated according to the method described by Radford (1967) ^[10] from periodic dry matter records at different stages. CGR is defined as the increase in dry weight of plant material from a unit area per unit time and was calculated using the following formula:

$$\text{CGR (g/m}^2\text{/day)} = \frac{W_2 - W_1}{(t_2 - t_1)} \times \frac{1}{A}$$

Where,

W_1 and W_2 = Total dry weight of plants (g) at times t_1 and t_2 , respectively.

A = Land area over which the dry weight was recorded in m^2

Relative growth rate (RGR)

Relative growth rate was calculated following the method proposed by Radford (1967) ^[10]. It is defined as the increase in dry weight of plant material per unit of material present per unit time and was computed as:

$$\text{RGR (g/g/day)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

W_1 = Total dry weight of plant at time t_1

W_2 = Total dry weight of plant at time t_2

t_1 = Time at first observation

t_2 = Time at second observation

Leaf area index (LAI)

Leaf area index (LAI) was recorded at 30, 60, 90 DAS and at harvest. Five plants were randomly selected from each plot, and leaf area was measured using a portable leaf area meter at the experimental site. LAI was calculated according to Watson (1958) ^[13] using the following formula:

$$\text{LAI} = \frac{\text{Total leaf area (cm}^2\text{)}}{\text{Total ground area (cm}^2\text{)}}$$

The experimental data were statistically analysed following the procedure described by Panse and Sukhatme (1985). The significance of treatment was tested by the F-test at 5% probability level, and critical difference was calculated wherever the treatment effects was found significant.

Results and Discussion

Crop Growth Rate (CGR)

Crop growth rate was significantly influenced by both sowing dates and weed management practices. Wheat sown on 15th November recorded the highest CGR during 30–60 DAS (1.756 $\text{g/m}^2\text{/day}$), 60–90 DAS (4.851 $\text{g/m}^2\text{/day}$) and 60 DAS – at harvest (2.624 $\text{g/m}^2\text{/day}$), which remained statistically at par with 1st November sown crop during 30-60, 60-90 DAS and 90 DAS- at harvest (1.735, 4.845 and 2.661 $\text{g/m}^2\text{/day}$, respectively). Delayed sowing after first fortnight of November, particularly on 15th December, resulted in significantly lower crop growth rate throughout the crop growth period. The higher growth rate of timely sown crop may be attributed to favourable temperature

regimes and longer vegetative growth period, which enhanced photosynthetic assimilation and increase biomass accumulation. In contrast, late sowing exposed the crop to terminal heat stress, shortening the grain filling period and reducing assimilate production. Among weed management practices, after weed-free treatment highest crop growth rate recorded under post emergence application of clodinafop-propargyl + metsulfuron-methyl during 30-60, 60-90 DAS and 90 DAS- at harvest, 1.653, 4.427 and 2.360 $\text{g/m}^2\text{/day}$, respectively and remained statistically at par with sulfosulfuron + metsulfuron-methyl. Effective weed control reduced crop-weed competition for nutrients, moisture and light, thereby improving vegetative growth and canopy development. These results are corroborated with Mukherjee (2012) ^[6], Kumar *et al.* (2016) ^[5], Verma *et al.* (2023) ^[12], Ali *et al.* (2024) ^[1] and Kaur *et al.* (2025) ^[3].

Relative Growth Rate (RGR)

Relative growth rate was significantly affected by sowing dates throughout the crop growth period. Wheat sown on 1st November recorded the highest RGR during 30–60 DAS (0.0477 g/g/day), 60–90 DAS (0.0379 g/g/day) and 90 DAS to harvest (0.0105 g/g/day), which was statistically comparable with 15th November sowing. Delayed sowing significantly reduced relative growth rate, with the lowest values observed under 15th December sowing. Higher relative growth rate under optimum sowing dates was associated with efficient utilization of available resources and prolonged photosynthetically active periods. Delayed sowing shortened the crop growth duration and accelerated maturity due to exposure to elevated temperatures during reproductive stages, resulting in reduced photosynthetic assimilation. Similar findings were reported by Shahzad *et al.* (2007), Verma *et al.* (2023) ^[12] and Ali *et al.* (2024) ^[1]. Among weed management treatments, after weed-free, recorded maximum relative growth rate and it was at par with clodinafop-propargyl + metsulfuron-methyl and sulfosulfuron + metsulfuron-methyl. Weed control improved efficient use of resource availability and maintained uninterrupted crop growth, thereby enhancing biomass accumulation per unit dry matter.

Leaf Area Index (LAI)

Leaf area index was significantly influenced by both sowing dates and weed management practices. Wheat sown on 15th November recorded the highest LAI, 0.236, 2.125 and 4.501 during 30-60 DAS, 60-90 DAS and 90 DAS- at harvest, respectively and remained at par with 1st November sown crop. Timely sowing provided congenial environmental conditions, enabling greater leaf expansion and improved canopy development. Conversely, delayed sowing reduced leaf area development because of shortened vegetative duration and exposure to terminal heat stress during vegetative growth period. Among weed management practices, after weed-free treatment, highest leaf area index under clodinafop-propargyl + metsulfuron-methyl during 30-60 DAS, 60-90 DAS and 90 DAS- at harvest recorded 0.221, 2.049 and 4.343, respectively, which was statistically at par with sulfosulfuron + metsulfuron-methyl. Effective weed management minimized competition for light, moisture and nutrients, resulting in enhanced leaf production and better canopy architecture. Greater leaf area index contributed to improved interception of solar radiation and increased photosynthetic efficiency, ultimately leading to higher dry matter accumulation and crop growth. These findings corroborate the results of Mukherjee (2012) ^[6], Singh *et al.* (2012), Kumar *et al.* (2016) ^[5], Gupta *et al.* (2017), Verma *et al.* (2023) ^[12], Ali *et al.* (2024) ^[1] and Kaur *et al.* (2025) ^[3].

Table 1: Effect of date of sowing and weed management practices on Crop growth rate (g/m²/day) in wheat

Treatments	Crop growth rate (g/m ² /day)								
	30-60 DAS			60-90 DAS			90 DAS-At harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Date of sowing (D)									
D ₁	1.696	1.773	1.735	4.781	4.910	4.845	2.684	2.638	2.661
D ₂	1.712	1.800	1.756	4.842	4.859	4.851	2.713	2.536	2.624
D ₃	1.399	1.442	1.420	3.240	3.352	3.296	1.704	1.777	1.740
D ₄	1.280	1.304	1.292	3.018	3.130	3.074	1.079	1.108	1.094
SEm _±	0.042	0.057	0.031	0.108	0.107	0.066	0.205	0.196	0.123
CD (<i>P</i> = 0.05)	0.144	0.198	0.095	0.373	0.372	0.203	0.710	0.679	0.379
Weed management practices (W)									
W ₁	1.290	1.333	1.312	3.064	3.207	3.136	1.244	1.146	1.195
W ₂	1.449	1.472	1.460	3.712	3.776	3.744	1.661	1.667	1.664
W ₃	1.622	1.686	1.654	4.320	4.336	4.328	2.392	2.496	2.444
W ₄	1.538	1.612	1.575	4.075	4.171	4.123	2.045	1.995	2.020
W ₅	1.616	1.690	1.653	4.371	4.483	4.427	2.476	2.245	2.360
W ₆	1.616	1.687	1.651	4.282	4.404	4.343	2.452	2.540	2.496
SEm _±	0.049	0.055	0.037	0.136	0.125	0.092	0.163	0.201	0.130
CD (<i>P</i> = 0.05)	0.140	0.157	0.103	0.388	0.357	0.260	0.467	0.575	0.365

Table 2: Effect of date of sowing and weed management practices on Relative growth rate (g/g/day) in wheat

Treatments	Relative growth rate (g/g/day)								
	30-60 DAS			60-90 DAS			90 DAS-At harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Date of sowing (D)									
D ₁	0.0471	0.0482	0.0477	0.0379	0.0379	0.0379	0.0107	0.0102	0.0105
D ₂	0.0468	0.0475	0.0472	0.0379	0.0371	0.0375	0.0107	0.0099	0.0103
D ₃	0.0436	0.0443	0.0439	0.0330	0.0332	0.0331	0.0092	0.0095	0.0093
D ₄	0.0424	0.0424	0.0424	0.0331	0.0335	0.0333	0.0066	0.0064	0.0065
SEm _±	0.0005	0.0011	0.0005	0.0008	0.0007	0.0005	0.0007	0.0008	0.0005
CD (<i>P</i> = 0.05)	0.0017	0.0038	0.0016	0.0029	0.0025	0.0015	0.0025	0.0027	0.0014
Weed management practices (W)									
W ₁	0.0413	0.0417	0.0415	0.0328	0.0332	0.0330	0.00701	0.00618	0.00659
W ₂	0.0434	0.0434	0.0434	0.0348	0.0350	0.0349	0.00819	0.00805	0.00812
W ₃	0.0468	0.0472	0.0470	0.0364	0.0358	0.0361	0.01029	0.01066	0.01047
W ₄	0.0453	0.0464	0.0459	0.0360	0.0358	0.0359	0.00923	0.00883	0.00903
W ₅	0.0466	0.0476	0.0471	0.0367	0.0366	0.0366	0.01048	0.00957	0.01003
W ₆	0.0465	0.0474	0.0469	0.0361	0.0360	0.0360	0.01063	0.01072	0.01068
SEm _±	0.0009	0.0010	0.0007	0.0009	0.0009	0.0006	0.00079	0.00090	0.00060
CD (<i>P</i> = 0.05)	0.003	0.003	0.002	0.0025	0.0024	0.0018	0.00225	0.00257	0.00168

Table 3: Effect of date of sowing and weed management practices on Leaf area index in wheat

Treatments	0-30 DAS			30-60 DAS			60-90 DAS		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
	Date of sowing (D)								
D ₁	0.219	0.235	0.227	2.111	2.119	2.115	4.468	4.548	4.508
D ₂	0.233	0.239	0.236	2.113	2.137	2.125	4.503	4.498	4.501
D ₃	0.228	0.232	0.230	1.954	1.956	1.955	4.187	4.229	4.208
D ₄	0.192	0.198	0.195	1.860	1.805	1.832	3.612	3.644	3.628
SEm _±	0.005	0.005	0.003	0.042	0.048	0.028	0.087	0.072	0.049
CD (<i>P</i> = 0.05)	0.018	0.018	0.010	0.144	0.167	0.085	0.301	0.249	0.151
Weed management practices (W)									
W ₁	0.190	0.199	0.195	1.894	1.837	1.865	3.811	3.858	3.835
W ₂	0.230	0.238	0.234	1.948	1.953	1.950	4.028	4.069	4.049
W ₃	0.221	0.227	0.224	2.058	2.086	2.072	4.330	4.357	4.343
W ₄	0.215	0.222	0.218	1.954	2.008	1.981	4.128	4.154	4.141
W ₅	0.217	0.224	0.221	2.056	2.041	2.049	4.399	4.431	4.415
W ₆	0.235	0.246	0.240	2.149	2.101	2.125	4.459	4.509	4.484
SEm _±	0.006	0.006	0.004	0.049	0.058	0.038	0.102	0.078	0.064
CD (<i>P</i> = 0.05)	0.017	0.018	0.012	0.140	0.166	0.107	0.290	0.222	0.180

Conclusion

The study revealed that sowing date and weed management practices significantly affected the growth indices of wheat. Sowing on 15th November proved to be the most suitable,

recording a higher crop growth rate, relative growth rate and leaf area index, while 1st November date of sowing was remained at par with D₂. Among weed management practices, weed-free treatment performed best and remained comparable with

clodinafop-propargyl + metsulfuron methyl and sulfosulfuron + metsulfuron methyl. Delayed sowing, particularly on 15th December, and the weedy check adversely affected all growth indices. Therefore, timely sowing during the first fortnight of November, combined with effective weed management practice was found suitable.

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