Effect of sowing date and post-emergence herbicide application on growth of wheat (*Triticum aestivum* L.)

Abstract: Wheat (*Triticum aestivum* L.) is a major food grain crop around the world, including India. After rice, it is India's second-most important foodgrain crop, accounting for about half of all calories and protein. To improve wheat growth and output, it is crucial to seed at the right time and use effective weed control techniques. An Experiment was conducted at Pilikothi Farm of T. D. P. G. College, Jaunpur, U.P. during the *Rabi* season of 2018-19 and 2019-20. Experiment was laid out in split plot design replicated thrice with three sowing dates i.e. 15 November, 30 Nevember and 15 December as main plot treatment and six weed management practices i.e. weedy check, weed free, 2, 4 DEE @ 0.5 kg a.i./ha., Carfentrazone @ 0.025 kg a.i./ha., Metsulfuron methyl @ 0.004 kg a.i./ha., Arylex 20.85% + Florasulam @ 20% as sub plot treatment. Soil of the experimental field was sandy clay loam. Fertilizer dose of 150:60:40 kg N, P_2O_5 and K_2O per hectare were applied. The results of the two years of experiment clearly indicate that plant height, number of tillers, and leaf area index values were recorded higher under sowing on November 15th as compared to other dates of sowing, while Arylex 20.85% + Florasulam @ 20% recorded higher growth over the rest of the herbicide treatments, but the weed-free plot recorded the highest values of the aforementioned growth parameters. Based on the findings, it is possible to infer that planting wheat on time (15th November) with Arylex 20.85% + Florasulam 20% herbicide for weed control may result in increased crop growth in the agro-climatic conditions of eastern Uttar Pradesh.

Keywords:*post-emergence herbicide, wheat, time of sowing, weed control, wheat growth*

1. Introduction:

Wheat (*Triticum aestivum* L.) is an important food grain crop in the globe, including India. India produced around 96.16 million tonnes of wheat from 30.33 million hectares, with an average productivity of 3171 kg ha-1 (DES, 2020). Uttar Pradesh, one of the biggest wheat-growing states, produced 32.59 million tonnes of wheat on 9.50 million hectares (DES, 2020). India, which produces over 13.5% of the world's wheat (*Triticum aestivum* L.), is the second-largest wheat grower in the world, after China [1]. After rice, it is the second-most significant foodgrain crop in India, accounting for almost 50% of all calories and protein.

Planting dates significantly impact agronomic crop output. Planting date is determined by the presence of weeds, illnesses, and insect assaults, as well as the temperature of the soil and surroundings. The sowing date determines the crop's exposure to environmental conditions during important stages of growth, including yield and quality components.Abbas *et al.* (2019) found that optimum planting dates improve yield components and contribute to global food security. Proper sowing timing allows cultivars to fully express their development patterns in a variety of environments, including genotype-environment interaction. It also aids scientists in maximising production in certain areas (Shah *et al.*, 2006). According to Kumar *et al.* (2000) and Akhtar *et al.* (2006), wheat seeded between November 15th and 30th yields higher grain production. Different field crops yield more economically when seeded at the right time of year since it allows the kinds to reach their maximum

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growth potential. Due to regional variations in climate, the timing of the wheat crop's seeding is crucial, since a delay in sowing reduces wheat grain production by 58.2 percent (Ali *et al*., 2004). According to Ouda*et al.* (2005), there was a 16% decrease in grain yield when wheat was sown later in December. Wheat planted too late has inadequate tillering and a higher risk of winter damage (Joshi *et al*., 1992). A wheat crop that was seeded later than usual was subjected to low temperatures during germination, which postponed crop emergence. Higher temperatures during the reproductive phase caused forced maturity, which decreased yield and yield characteristics (Gupta *et al.*, 2017).

High yielding dwarf cultivars' susceptibility to weed infestation combined with their high fertiliser and water requirements made them vulnerable, which posed a significant threat to productive crop production. Due to their erectile leaf orientation and dwarf wheat cultivars, weeds are more competitive and allow more light to pass through their canopy (Bisen and Singh, 2008b). The quantity of weed plants, their species, the spacing and variety of wheat, as well as other soil and environmental conditions, all contribute to the yield loss (Malik and Singh, 1995). Chemical weed control is the most convenient and economical option when compared to manual weeding since conventional cultural and manual weed management (CCMWM) techniques need a lot of time and effort (Chokar*et al., 2002*; Das *et al*., 2017). A growing manpower scarcity in these underprivileged habitats as a result of rural-to-urban migration seeking better incomes has made chemical weed control even more crucial than CCMWM approaches in NWH (Choudhary, 2016). Therefore, a lack of manpower for the expensive human work needed for CCMWM methods is impeding wheat production, particularly in the intricate weed-flora-dominated parts of NWH. In NWH, *Phalaris minor*, *Avenaludoviciana*, *Loliumtemulentum* and *Poa annua* are the major grassy weeds; while *Vicia sativa*, *Anagallis arvensis*, *Ranunculus arvensis* and *Coronopusdidymus* are the main broad-leaved weeds that grow in association with wheat crop. These weeds germinate even before wheat germination and flourish luxuriously, taking advantage of its slow initial growth in NWH. Thus, weed competitionthroughout the crop season reduces wheat yield drastically if not managed scientifically.

2. Materials and method:

Experiment was conducted at Pilikothi Farm of T. D. P. G. College, Jaunpur, U.P. during the *Rabi* season of 2018-19 and 2019-20. Experiment was laid out in split plot design replicated thrice with three sowing dates i.e. D_1: 15 November, D_2: 30 Nevember and D_3: 15 December as main plot treatment and six weed management practices i.e. W_1: weedy check, W_2: weed free,W_3: 2, 4 DEE @ 0.5 kg a.i./ha., W_4: Carfentrazone @ 0.025 kg a.i./ha., W_5: Metsulfuron methyl @ 0.004 kg a.i./ha., W_6: Arylex 20.85% + Florasulam @ 20% as sub plot treatment.Jaunpur district has a climate consistent with that of the Northern Plain and Central Highlands including the Aravalli range, hot semi-arid eco-region 4.3 and hot dry ecoregion 9.2. The temperature varies between about 4 °C (39 °F) and 44 °C (111 °F).The annual normal rainfall is 1,098 millimetres (43.2 in). The monsoon season occurs from the third week of June to the first week of October. Normally, there are 46 rain days per year of which 31 occur in the monsoon season. The district regularly suffers drought and pestilence.Soil of the experimental field was sandy clay loam. Fertilizer dose of 150:60:40 kg N, P_2O_5 and K_2O per hectare were applied. Full dose of P_2O_5 and K_2O were applied as basal and N was

Comment [A1]: Inform when the herbicide treatments were applied, the variables and dates evaluated.

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applied in three splits: half dose was applied as basal and rest of the half dose was applied in two equal splits *i.e.* after first and second irrigation. Irrigation was done as per requirement. Field was tilled twice followed by planking and then seeding was done after a pre sowing irrigation with seed drill machine. Variety HD 2967 of wheat was sown in the field as per treatment requirement with a seed rate of 100 kg ha^{-1}.

Comment [A2]: Inform which statistical procedures were used

3. Result:

3.1 Plant height: Data presented in table 1 clearly indicates that there is a significant difference in plant height were recorded due to various sowing date and weed control measures. Wheat sown on 15 November has recorded maximum plant height at all the stages of observation but it was observed statistically at par with wheat sown on 30th November, while crop sown on 15th December has observed minimum plant height among the main plot treatments *i.e.* different dates of sowing. Among the sub plot treatments (Various weed control measures), treatment W_2: weed free (two hand weeding) recorded significantly maximum plant height over rest of the weed control measures. Among the rest of the herbicidal weed management options, Arylex 20.85% + Florasulam 20 % recorded maximum plant height but it was found statistically at par with treatment Carfentrazon @ 0.025 kg *a.i.*/ha atall the stages of observation and except at 30 DAS (days after sowing) in first year and at harvest in both the years where it was found at par with Carfentrazon @ 0.025 kg *a.i.*/ha and2,4 DEE @ 0.5 kg *a.i.*/ha. Weedy check treatment recorded minimum plant height among the sub plot treatments.

Table 1: Effect date of sowing and weed control measures on plant height (cm) of wheat at various crop growth stages

Comment [A3]: Improve the presentation of tables, eliminating all vertical lines and horizontal lines inside the table, only in the header and footer.
I believe it would make understanding easier if the tables were organized by year of experiment, instead of DAS.

Treatments	Plant height (cm)							
	30 DAS		60 DAS		90 DAS		At harvest	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Main Plot: Sowing dates (3)								
D_1: 1st date of sowing (15th Nov)	25.03	25.28	55.96	57.13	93.37	96.19	99.78	102.77
D_2: 2nd date of sowing (30th Nov)	24.16	24.35	53.80	55.01	90.16	92.31	96.16	98.94
D_3: 3rd date of sowing (15th Dec)	21.94	22.12	48.72	49.88	82.59	83.83	88.21	90.80
SEm ±	0.35	0.33	0.77	0.74	1.29	1.24	1.38	1.33
CD (*p=0.05*)	1.09	1.03	2.43	2.32	4.08	3.90	4.36	4.19
Sub Plot: Weed control measures (6)								
W_1: Weedy check	21.78	21.62	43.42	44.68	74.70	76.23	80.47	83.13
W_2: Weed free (Two hand weeding)	25.83	26.15	59.07	60.10	98.01	100.40	104.20	107.08
W_3: 2,4 DEE @ 0.5 kg *a.i.*/ha Post-em (28 DAS)	23.41	23.66	52.92	54.16	88.85	91.00	94.93	97.74
W_4: Carfentrazon @ 0.025 kg *a.i.*/ha Post-em (28	24.04	24.32	54.56	55.69	91.29	93.40	97.35	100.16

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DAS)								
W$_5$: Metsulfuron-methyl @ 0.004 kg *a.i.*/ha Post-em (28 DAS)	22.84	23.08	51.43	52.74	86.63	88.59	92.61	95.38
W$_6$: Arylex 20.85% + Florasulam 20 % Post-em (28 DAS)	24.38	24.68	55.56	56.71	92.79	94.75	98.77	101.54
SEm ±	0.31	0.30	0.70	0.67	1.17	1.13	1.25	1.21
CD (*p=0.05*)	0.97	0.93	2.16	2.11	3.63	3.54	3.87	3.80
Interaction (D×W)	NS	NS	NS	NS	NS	NS	NS	NS

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3.2 Number of tillers: A scrutiny of data presented in table number 2 clearly showed that various date of sowing and weed control measures has a significant effect on number of tillers at different stages of observation. Highest number of tillers was produce under the treatment D$_1$*i.e.* wheat sown at 15th November over the other date of sowing *i.e.* 30th November & 15th December. Weed free plot recorded with maximum number of tillers at all the stages of observation over rest of the sub plot treatments. It was obvious from the data that Arylex 20.85% + Florasulam 20 % recorded maximum number of tillers over rest of the post emergence herbicidal treatments but observed statistically at par with Carfentrazon @ 0.025 kg *a.i.*/haat 60, 90 DAS and at harvest, whereas at 30 DAS it was found at par with Carfentrazon @ 0.025 kg *a.i.*/ha & 2,4 DEE @ 0.5 kg *a.i.*/ha in first year of experimentation. Observation at 30 DAS in second year showed that all the herbicidal weed control found at par with each other.

Table 2: Effect date of sowing and weed control measures on number of tillers (No. m^2) of wheat at various crop growth stages

Treatments	number of tillers (No. m^2)							
	30 DAS		60 DAS		90 DAS		At harvest	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Main Plot: Sowing dates (3)								
D$_1$: 1st date of sowing (15th Nov)	145.6	147.0	341.8	348.6	335.0	338.2	324.2	329.6
D$_2$: 2nd date of sowing (30th Nov)	138.1	139.2	325.5	333.7	315.7	323.7	309.5	312.6
D$_3$: 3rd date of sowing (15th Dec)	126.5	127.5	297.7	304.5	285.8	295.3	282.7	284.3
SEm ±	2.08	2.01	4.69	4.66	4.55	4.52	4.33	4.28
CD (*p=0.05*)	6.29	6.21	14.48	14.41	14.05	13.98	13.38	13.2
Sub Plot: Weed control measures (6)								
W$_1$: Weedy check	128.9	129.3	260.5	272.1	252.3	263.9	250.1	251.1
W$_2$: Weed free (Two hand weeding)	153.6	155.2	360.5	366.0	350.2	355.0	341.1	345.7
W$_3$: 2,4 DEE @ 0.5 kg *a.i.*/ha Post-em (28 DAS)	133.9	135.3	323.1	329.8	313.5	319.9	306.5	310.0

W_4: Carfentrazon @ 0.025 kg *a.i.*/ha Post-em (28 DAS)	135.2	136.5	333.0	339.1	323.3	328.9	315.5	319.5
W_5: Metsulfuron-methyl @ 0.004 kg *a.i.*/ha Post-em (28 DAS)	131.3	132.6	313.9	321.2	304.6	311.5	298.2	301.4
W_6: Arylex 20.85% + Florasulam 20 % Post-em (28 DAS)	137.3	138.6	339.2	345.4	329.3	335.0	321.4	325.3
SEm ±	1.99	1.97	4.59	4.56	4.46	4.55	4.36	4.14
CD (*p=0.05*)	6.02	5.94	13.87	13.78	13.46	13.75	13.17	13.13
Interaction (D×W)	NS	NS	NS	NS	NS	NS	NS	NS

3.3 Leaf Area Index (LAI): The value of LAI was recorded significantly higher in D_1 plots *i.e.* wheat sown on 15th November over rest of the sowing dates at all the stages of observation as confirmed by data presented in table no. 3. Among the different herbicidal weed management options, higher LAI value was recorded under the Arylex 20.85% + Florasulam 20 % which observed statistically at par with Carfentrazon @ 0.025 kg *a.i.*/ha over rest of the herbicides at 60 & 90 DAS, whereas at 30 DAS all the herbicidal treatments recoded at par with each other. Although highest value of LAI was found under weed free plot whereas lowest value recorded in weedy check plot among the sub plot treatments.

Table 3: Effect date of sowing and weed control measures on Leaf Area Index (LAI) of wheat at various crop growth stages

Treatments	Leaf Area Index (LAI)					
	30 DAS		60 DAS		90 DAS	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Main Plot: Sowing dates (3)						
D_1: 1st date of sowing (15th Nov)	0.78	0.79	3.75	3.84	2.99	3.08
D_2: 2nd date of sowing (30th Nov)	0.74	0.75	3.60	3.67	2.89	2.95
D_3: 3rd date of sowing (15th Dec)	0.67	0.68	3.26	3.34	2.64	2.68
SEm ±	0.01	0.01	0.05	0.05	0.04	0.04
CD (*p=0.05*)	0.03	0.03	0.16	0.15	0.13	0.12
Sub Plot: Weed control measures (6)						
W_1: Weedy check	0.69	0.69	2.91	2.99	2.39	2.44
W_2: Weed free (Two hand weeding)	0.82	0.83	3.96	4.03	3.14	3.21
W_3: 2,4 DEE @ 0.5 kg *a.i.*/ha Post-em (28 DAS)	0.71	0.72	3.55	3.63	2.84	2.93
W_4: Carfentrazon @ 0.025 kg *a.i.*/ha Post-em (28 DAS)	0.72	0.73	3.66	3.73	2.92	2.99
W_5: Metsulfuron-methyl @ 0.004 kg *a.i.*/ha Post-em (28 DAS)	0.70	0.71	3.45	3.53	2.77	2.83
W_6: Arylex 20.85% + Florasulam 20 % Post-em (28 DAS)	0.73	0.74	3.72	3.80	2.97	3.03
SEm ±	0.01	0.01	0.05	0.05	0.04	0.04
CD (*p=0.05*)	0.03	0.03	0.16	0.14	0.12	0.12
Interaction (D×W)	NS	NS	NS	NS	NS	NS

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4. Discussion:

Higher values of different growth parameters *i.e.* plant height, number of tillers and leaf area index were recorded higher under the wheat sown on 15th November.This is explained by the fact that, in contrast to late planting, the 15th November crop had a shorter photoperiod and a maximum duration of low temperatures for vegetative development. The unfavourable climatic circumstances seem to alter the plants' height. The results of this study were comparable to those noted by Kumar (2016) and Tomar *et al.* (2014). The plant height and leaf-area index (LAI) were strongly impacted by the sowing date. Compared to the other sowing dates, the plant height and LAI at every stage of the observation days were noticeably greater on November 15. Better plant establishment can be attributed to good meteorological conditions, particularly the temperature that persisted during the growth season. The findings support the conclusions reached by Tahir *et al.* (2009). The shorter length of the vegetative development stage in the 30 November and 15 December sowings resulted in a decrease in plant height and the leaf-area index (LAI). This decrease may be the result of a lower temperature during the early stages of vegetative growth, which inhibits cell expansion and growth, and a rapid rise in temperature during the late stages of vegetative growth, which forces crop growth and development. In late-planted crops, this high warmth accelerated crop maturity and leaf senescence. These findings are consistent with what Ram *et al.* (2012) reported.

Among weed control measures, weed free plot recorded highest growth parameters followed by Arylex 20.85% + Florasulam 20 %. Effective weed control measures, including manual weeding at crucial times, led to increased crop growth by reducing competition for nutrients, moisture, and space. These findings highlight the significance of good weed control in improving crop performance and yield, consistent with earlier research (Sachin *et al.*, 2024; Jat *et al.*, 2019).

5. Conclusion:

Wheat is one of India's most important food crops, although it is currently facing certain production hurdles, including timing of planting and weeds, particularly broad-leaved weeds. So it is critical to seed the crop at the optimal time and with an appropriate weed management approach. Wheat sown on November 15th had higher plant height, number of tillers, and LAI value than delayed planting due to longer duration of growth and favourable temperature, whereas better weed control under Arylex 20.85% + Florasulam 20% resulted in higher values of the aforementioned growth parameters. It may be concluded that timely sowing of wheat (15th November) with Arylex 20.85% + Florasulam 20% herbicide for weed control may result in improved crop growth under the agro-climatic conditions of eastern Uttar Pradesh.

Comment [A4]: Perhaps the better development of wheat in the Arylex + Florasulam treatment is not due to better weed control. It may be due to the lower phytotoxic effect of this herbicide treatment, which allows rapid reestablishment of growth... Therefore, I would not use the phrase better weed control under arylex + Floransulam

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