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Effect of different Dates of Sowing, Irrigation Scheduling and Soil Amendments on Growth Attributes of Wheat

CH V L Kishore*, Sharad Pandey, Maneesh Bhatt, Mamta and BKM Patro
Department of Agriculture, School of Agriculture,
Forestry and Fisheries, Himgiri Zee University, Chakrata Road, Dehradun (Uttarakhand), India.

(Corresponding author: CH V L Kishore)*
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ABSTRACT: A two-year field experiment was conducted during the *rabi* season of 2020–21 and 2021–22 at the Agriculture Farm, Himgiri Zee University, P.O. Sherpur, Chakrata Rd., Dehradun, Uttarakhand, to study the effects of different dates of sowing, irrigation scheduling, and soil amendments on the growth attributes of wheat (*Triticum aestivum* L.). The study consists of three irrigation scheduling's:I_1 (irrigation at 40% depletion from ASM), I_2 (irrigation at 50% depletion from ASM), and I_3 (irrigation at growth stages) in the main plots, while the three soil amendments S_1 (FYM @ 10 t ha^{-1}), S_2 (urban compost @ 5 t ha^{-1}), and S_3 (vermicompost @ 5 t ha^{-1}) are in the sub-plots with two dates of sowing, *viz.* D_1 *(timely* sown) and D_2 (late sown) in the sub-sub plot with three replications. Among the different dates of sowing, irrigation scheduling, and soil amendment application, D_1 (timely sown), I_1 (irrigation at 40% depletion from ASM), and S_3 (vermicompost @ 5 t ha^{-1}) showed the highest growth attributes, *viz.*, plant height, spike length, peduncle length, number of tillers, and leaf area index, which were observed during both years of the experiment (2020–21 and 2021–22), respectively. Thus, it can be concluded that timely sown wheat crop along with 40% depletion of available soil moisture and vermicompost @ 5 t ha^{-1} showed the best agronomic practices and resulted in the highest grain yield and economic return under sandy loam soil conditions at Himgiri Zee University.

Keywords: Different dates of sowing, Irrigation scheduling and Soil amendments.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important crop among all cereals used as food grains in the world. It provides nearly 55% of the carbohydrate and 20% of the calories, which are consumed by two billion people (36% of the world population) as staple foods. It is more nutritious as compared to other cereals. It has a good nutrition profile with an average of 12.2% protein, 1.8% lipids, 1.8% ash, and 2.0% reducing sugars, and it also provides 314 kcal per 100 g of food. It ranks first in the world for cereal area and production. In the marketing year 2022–23, the global production volume of wheat amounted to over 781 million metric tons. This was an increase as compared to the previous marketing year. In India, wheat acreage was 34.1 million hectares, up from 34 million hectares the previous year **(**Ministry of Agriculture**)**. "The output is likely to increase, but not too much, as the sown area under wheat was largely steady", a trader in Delhi said. India's wheat production during the years 2022–23 has been estimated at a record high of 112.18 million metric tons (mt), 4 percent higher than 107.74 mt last crop year (Ministry of Agriculture). In the financial year 2022, India's production volume of wheat during the *rabi* season was estimated to be over 106 million metric tons. Wheat production across the South Asian countries has reflected steady growth over the years. Wheat is the second-most common food crop grown globally. India's 2023 wheat production is likely to rise 4.1% to a record 112.2 million metric tons, as higher prices prompted farmers to expand crop-growing areas with high-yielding varieties and the weather remained favourable. India's wheat output fell to 107.74 million metric tons in 2022 from 109.59 million metric tons a year earlier, according to the Ministry of Agriculture and Farmers Welfare. In Uttarakhand, the productivity of wheat was reported at 3.07 t/ha during the years 2021–22. In the financial year 2021, about 955 thousand metric tons of wheat were produced in the northern state of Uttarakhand in India. This was an increase from a production volume of over 600,000 metric tons in year 2015. The largest cultivable area in Uttarakhand is covered by the wheat crop, followed by the paddy crop. The net cultivable area in Uttarakhand is about 358.1 hectares, with a production of 858.2 tons. Uttarakhand consists of hilly tracts as well as tarai areas where wheat is an important crop during *rabi*. It has a contribution of 1.51% towards national production from 1.07% of the wheat-growing area of the country, with a productivity of 1.9 tons/ha. This is due to the fact that wheat in the hills is mainly rainfed as compared to irrigated crops in the tarai. The total area under wheat is 0.4 million ha, with a total production of 0.8 tons and productivity of 1.9 tons/ha over the last five years. The constraints are water scarcity in hills and *Tarai* areas, low soil organic carbon status, high nutrient mining, imbalanced fertilization, and infestations of powdery mildew and Karnal bunt diseases. There are many factors responsible for the low yield of the wheat crop, but inadequate irrigation and poor crop nutrition are the most important. Therefore, irrigation scheduling is one of the most important professional activities, and it aids in the efficient consumption of water by crops. It governs the process of deciding when to irrigate, how to irrigate, and how much water to apply to the crop. It optimizes agricultural production by minimizing yield loss due to water shortages and improving the performance and sustainability of any irrigation system by conserving water. Timely sowing of wheat crops has a longer growth duration, which consequently provides an opportunity to accumulate more biomass as compared to late sowing and hence manifests in higher grain and biological yield. Whereas in the case of delayed sowing, the wheat crop is exposed to sub-optimal temperatures at establishment and supra-optimal temperatures at reproductive phases, which leads to forced maturity and a reduction in grain yield. In India, the imbalanced use of chemical fertilizers by farmers has deteriorated soil health. Hence, there is a need to adopt the concept of integrated nutrient management, through which we may increase the productivity of the crop while also improving soil quality.

MATERIALS AND METHODS

A. Site of the experiment

The field experiments were conducted at the experimental farm of Himgiri Zee University, Dehradun, Uttarakhand, during the *rabi* season of 2020–2021 and 2021–2022.

B. Location

The experimental farm is situated at 30°19'N latitude, 78°04' longitude, and 650 meters above mean sea level.

C. Climate and Weather Conditions

The climate of Dehradun is moderate due to its location at the foot of the Himalayas. The climate of Dehradun is the same as any of the North Indian climates, *i.e.*, cool winters, warm summers, and rainy monsoons. During the summer, the maximum temperature is 360 °C and the minimum is 160°C. In winter, the maximum temperature is 230°C and the minimum is 50°C. Dehradun gets an average rainfall of 2073.3 mm annually. Dehradun receives rainfall between June and September, though in December and January it receives winter rainfall through western disturbances.

D. Treatment and Design of the Experiment

Field experiments were laid out in a split-split plot design consisting of irrigation scheduling under the main plot (I_1= irrigation applied at 40 DASM; I_2= irrigation applied at 50 DASM; I_3 = irrigation applied at critical plant growth stages); soil amendment under the sub-plot (S_1= FYM @ 10t ha^{-1}; S_2 = urban compost @ 5 t ha^{-1}; S_3= vermicompost @ 5 t ha^{-1}); and date of sowing under the sub-subplot (D_1 = timely sowing; D_2 = late sowing) with a total of 18 treatments with three replications.

RESULTS AND DISCUSSION

A. Growth attributes

Among different dates of sowing, the timely sowing of wheat recorded the highest plant height at maturity (101.34cm and 101.85cm) and the number of tillers per plant (7.71cm and 7.64cm) at 90 DAS during the years 2020–21 and 2021–22, respectively, whereas in the case of irrigation scheduling, irrigation at 40% DASM recorded the significant highest value of plant height (98.69 cm and 98.61 cm) and the number of tillers (6.68 cm and 6.97cm). However, among different soil amendments, application of vermicompost @ 5t ha^1 recorded the highest plant height (98.94cm and 100.95cm) and number of tillers (6.75cm and 6.96cm) during both years. The data shown in the table reported the significant effect of spike length, peduncle length, and LAI under different dates of sowing, irrigation scheduling, and soil amendments during the years 2020–21 and 2021–22, respectively. Among the different dates of sowing, the timely sowing of wheat recorded significantly maximum spike length (13.73cm and 13.82cm), peduncle length (19.47cm and 19.59 cm), and LAI (3.45 and 3.71). whereas in the case of irrigation scheduling, the irrigation applied at 40% DASM recorded significantly maximum spike length (13.24cm and 13.46cm), pedal length (18.09cm and 18.12 cm), and LAI (3.32 and 3.37 cm). However, among different soil amendments, application of vermicompost @ 5t ha^1 recorded significantly maximum spike length (13.28cm and 13.49cm), peduncle length (18.19cm and 18.57 cm), and LAI (3.34 cm and 3.39) during the years 2020–21 and 2021–22, respectively.

The maximum plant height of wheat under timely sown conditions might be due to the optimum temperature available for crop growth. Similar results were also recorded by Mumtaz *et al***.** (2015); Ma *et al.* (2018**).** This might be due to the fact that favourable soil water balance without wide fluctuations under 40% DASM might have stimulated increased activity of meristematic cells and cell elongation of internodes, resulting in a higher growth rate of stems, in turn promoting the increased plant height of wheat. Similar results were also reported by Meena *et al***.** (2015). The maximum plant height in the treatment where vermicompost was applied might be due to the highest nutrient contents in it, which increase the rate of cell elongation and differentiation as compared with other soil amendments. These results were in consonance with the findings of Kakraliya *et al.* (2017).

The timely sown crop resulted in better spike length development due to the longer growing period. These findings were in agreement with Meena *et al.* (2015); Bolach *et al***.** (2010). During both years of experimentation, I_3 (irrigation at critical stages) remained inferior to I_2 and I_1. The maximum spike length in the I_1 treatment (irrigation at 40 percent DASM) might be due to optimum soil moisture conditions at all stages of crop growth. These results were consistent with those of Meena *et al.* (2015). The maximum spike length was recorded in S_3 (vermicompost @ 5 t ha^{-1}) with values of 13.28 cm and 13.49 cm during 2020–21 and 2021–22, respectively, followed by S_1 (FYM @ 10 t ha^{-1}) with values of 12.79 cm and 12.74 cm, respectively.

The crop that was timely sown (D_1) recorded significantly higher peduncle lengths of 19.47 cm and 19.59 cm, followed by late sown (D_2) with peduncle lengths of 14.04 cm and 14.07 cm during 2020–21 and 2021–22, respectively. The timely sowing of the wheat crop provides the optimum amount of light for the crop to grow. These findings were in agreement with Paul *et al.* (2021); Mardalipour ***et al.*** (2014). The maximum peduncle length of wheat in the I_1 treatment might be due to more moisture available at 40 percent DASM for the wheat crop at different stages of crop growth. These results were in line with the findings of Agami *et al.* (2018). The maximum peduncle length of wheat recorded in the treatment where vermicompost was applied might be due to an increase in soil moisture storage with an increase in the number of micropores. These results are in consonance with the findings of Iqbal *et al.* (2021).

During 2020–21, the maximum leaf area index was recorded with early crop sown (D_1) with values of 2.33 cm, 3.30 cm, and 3.71 cm and 3.45cm and 2.32 cm, 3.31 cm, 3.71 cm, and 3.461cm, respectively, during 2021-22. Delay in sowing time decreases the growth attributes of the wheat crop due to the effect of photoperiodism during the growing period of the crop. These results were incongruous with the findings of Shah *et al.* (2020); Bashir *et al.* (2020). Crop irrigation scheduled at 40 percent DASM (I_1) recorded the maximum leaf area index, followed by 50 percent DASM (2.13cm, 3.09cm, 3.32 cm, and 3.13cm, respectively, during 2020–21) and (2.14 cm, 3.05 cm, 3.35 cm, and 3.146 cm, respectively, during 2021-22). This might be due to the fact that a favourable soil water balance without wide fluctuations under 40% DASM might have stimulated increased activity of meristematic (Greek word meristos, meaning divisible - cells are responsible for the root and shoot growth of plants) cells and cell elongation of internodes, resulting in a higher growth rate of stems, in turn promoting the increased leaf area of wheat. Similar results were reported by Jaleel and Llorente (2009); Meena *et al***.*** (2015); Brahma *et al***.*** (2007)**.** Among the soil amendments, the crop treated with vermicompost at 5 t ha^{-1} (S_3) recorded the maximum leaf area index with a value of 2.25 cm^2, 3.20cm, 3.56 cm, and 3.34cm during the years 2020–21 and 2.28cm, 3.21cm, 3.61 cm, and 3.389 cm during the years 2021–22, followed by FYM at 10 t ha^{-1} (S_1). Who revealed that the use of vermicompost in plant production has a vital role as a source of nutrients for plant growth and development. Similar results were also reported by Shekar *et al.* (2022).

Table 1: Effect of Dates of sowing, Irrigation scheduling and Soil amendments on plant height and number of tillers of wheat during *rabi* 2020-21 & 2021-22.

Sr. No.	Treatment details	Plant height (cm)							
		at 30 DAS		at 60 DAS		at 90 DAS		at 120 DAS	
A.	**Sowing Time**	**2020-21**	**2021-22**	**2020-21**	**2021-22**	**2020-21**	**2021-22**	**2020-21**	**2021-22**
D_1	Timely sowing	18.14	18.28	48.73	49.03	80.90	81.35	101.34	101.85
D_2	Late sowing	14.47	14.26	36.45	35.86	70.01	68.93	90.47	90.63
	S.E. ±	0.44	0.47	1.24	1.29	1.64	2.02	1.74	1.79
	CD at 5 %	2.76	2.93	7.68	7.95	5.16	6.14	5.44	6.27
B.	**Irrigation Scheduling**								
I_1	Irrigation at 40% depletion from ASM	16.72	16.23	45.61	45.28	78.08	79.54	98.79	99.61
I_2	Irrigation at 50% depletion from ASM	16.53	16.77	41.60	42.22	74.29	75.26	94.98	95.97
I_3	Irrigation at growth stages	15.67	15.80	40.56	40.84	73.99	74.62	94.04	94.14
	S.E. ±	0.44	0.49	1.27	1.24	0.12	0.21	0.31	0.28
	CD at 5 %	NS	1.53	3.15	3.84	0.38	0.67	1.02	0.91
C.	**Soil Amendments**								
S_1	FYM @10 t ha^{-1}	16.61	16.69	43.23	43.40	75.67	75.96	96.38	96.08
S_2	Urban compost @5t ha^{-1}	15.18	14.76	38.44	37.32	72.50	70.44	92.39	91.70
S_3	Vermicompost @5t ha^{-1}	17.12	17.35	46.09	46.62	78.19	79.02	98.94	100.95
	S.E. ±	0.36	0.39	0.99	1.05	0.30	0.44	0.10	0.35
	CD at 5 %	1.07	1.14	2.89	3.06	0.87	1.28	0.28	1.02
D.	**Interaction**								
	D × I								
	CD at 5 %	NS	NS	NS	NS	S*	S*	S*	S*
	I × S								
	CD at 5 %	NS	NS	NS	NS	S*	S*	S*	S*
	S × D								
	CD at 5 %	NS	NS	NS	NS	S*	S*	S*	S*
	D × I × S								
	CD at 5 %	NS	NS	NS	NS	S*	S*	S*	S*

Sr. No.	Treatment details	Number of tillers 2020-21			Number of tillers 2021-22		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
A.	**Sowing Time**						
D_1	timely sowing	6.78	7.63	7.71	6.67	7.57	7.64
D_2	Late sowing	3.61	4.47	4.54	3.72	4.58	4.66
	S.E. ±	0.16	0.16	0.16	0.14	0.21	0.17
	CD at 5 %	0.98	0.98	0.98	0.91	1.31	1.07
B.	**Irrigation Scheduling**						
I_1	Irrigation at 40% depletion from ASM	5.75	6.61	6.68	6.02	6.90	6.97
I_2	Irrigation at 50% depletion from ASM	5.18	6.03	6.11	4.99	5.92	5.99
I_3	Irrigation at growth stages	4.65	5.51	5.58	4.54	5.41	5.48
	S.E. ±	0.15	0.15	0.15	0.16	0.18	0.19
	CD at 5 %	0.48	0.48	0.48	0.54	0.59	0.62
C.	**Soil Amendments**						
S_1	FYM @10t ha^{-1}	5.48	6.34	6.41	5.37	6.22	6.29
S_2	Urban compost @5t ha^{-1}	4.28	5.13	5.21	4.29	5.12	5.19
S_3	Vermicompost @5t ha^{-1}	5.82	6.68	6.75	5.91	6.89	6.96
	S.E. ±	0.12	0.12	0.12	0.14	0.14	0.15
	CD at 5 %	0.36	0.36	0.36	0.41	0.42	0.44
D.	**Interaction**						
I.	D × I						
	CD at 5 %	NS	NS	NS	NS	NS	NS
II.	I × S						
	CD at 5 %	NS	NS	NS	NS	NS	NS
III.	S × D						
	CD at 5 %	NS	NS	NS	NS	NS	NS
IV	D × I × S						
	CD at 5 %	NS	NS	NS	NS	NS	NS

Table 2: Effect of Dates of sowing, Irrigation scheduling and Soil amendments on Spike length(cm) and Peduncle length(cm) and LAI of wheat during *rabi* 2020-21 & 2021-22.

	Treatment details	Spike length (cm)		Peduncle length (cm)		Leaf area index			
		2020-21	2021-22	2020-21	2021-22	30 DAS		60 DAS	
						2020-21	2021-22	2020-21	2021-22
A.	**Sowing Time**								
D_1	timely sowing	13.73	13.82	19.47	19.59	2.33	2.32	3.30	3.31
D_2	Late sowing	11.50	11.62	14.04	14.07	1.98	2.00	2.82	2.80
	S.E. ±	0.52	0.61	0.47	0.52	0.059	0.055	0.07	0.081
	CD at 5 %	1.97	2.02	2.95	3.20	NS	0.33	0.48	0.50
B.	**Irrigation Scheduling**								
I_1	Irrigation at 40% depletion from ASM	13.24	13.46	18.09	18.12	2.24	2.27	3.18	3.23
I_2	Irrigation at 50% depletion from ASM	12.48	12.53	16.41	16.60	2.13	2.14	3.09	3.05
I_3	Irrigation at growth stages	12.22	12.18	15.77	15.81	2.08	2.07	2.97	2.98
	S.E. ±	0.48	0.35	0.45	0.51	0.058	0.056	0.08	0.084
	CD at 5 %	1.06	1.14	1.49	1.66	NS	0.18	0.28	0.27
C.	**Soil Amendments**								
S_1	FYM @10 t ha^{-1}	12.79	12.74	17.09	17.05	2.17	2.16	3.09	3.10
S_2	Urban compost @5 t ha^{-1}	11.85	11.94	15.00	14.88	2.03	2.04	2.90	2.85
S_3	Vermicompost @5 t ha^{-1}	13.28	13.49	18.19	18.57	2.25	2.28	3.20	3.21
	S.E. ±	0.35	0.29	0.64	0.42	0.050	0.049	0.07	0.070
	CD at 5 %	0.81	0.87	1.10	1.23	NS	0.14	0.20	0.20
D.	**Interaction**								
I.	D × I								
	CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
II.	I ×S								
	CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
III.	S × D								
	CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
IV	D x I x S								
	CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSIONS

Based on the results presented above, it can be concluded that applying irrigation at 40% DASM (Depletion from Available Soil Moisture) created optimal conditions for wheat when sown in a timely manner. Additionally, the application of vermicompost @ of 5 t ha^{-1} improved soil fertility by adding more nutrients to the soil, resulting in better outcomes compared to the other treatment combinations.

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