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Foliar-Applied Sorghum Water Extract Improves the Productivity of Wheat Planted at Varying Dates

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ABSTRACT

Among the cereals, wheat is a key crop fulfilling the food demand of millions of masses around the globe. Late sowing in wheat is the most yield-limiting factor causing 35% yield losses. One approach to compensate for yield losses is boosting crop growth by the application of growth regulators. We checked the role of sorghum water extract that can act as plant-based growth regulators in wheat planted at various dates to cover a wide sowing window. A trial under controlled condition was conducted at the glass house facility of Bahauddin Zakariya University, Multan, Pakistan during 2021-2022. Wheat cultivar Akbar 2019 was sown with an interval of 7 days starting from October 29 to December 03. A pre-determined level of sorghum water extract at 3% concentration was foliar-applied at 30 days after sowing. For comparison, un-treated pots were applied with water spray. Collected data revealed that significantly higher grain yield was obtained from the pot that were sown on November 19 and treated with sorghum water extract followed by same sowing date but was untreated. Data further explained that grain yield and other yield related traits significantly reduced in late planted wheat when compared with timely plantation of wheat. Results concluded that sorghum water extract is a potential plant regulator and its foliar application can enhance the yield of timely as well late planted wheat but for getting maximum yield foliar application should done at timely plantation of wheat at November 19.

Keywords: Wheat sowing times, allelopathy, sorghum water extract.

INTRODUCTION

Among cereals, wheat *(Triticum aestivum L)* holds the unique distinction of being the primary cereal crop worldwide and most extensively grown crop within Poaceae family. Due to its extensive cultivation, commonly referred to as the King of Cereals and have substantial role in the international grain market (Ahmad *et al*., 2022; Bhanu *et al*., 2018). Wheat flour is widely used as a main diet source by humans worldwide. Approximately 36 % of the global population relies on wheat for food (Singh *et al*., 2020). China is the leading global grower of wheat, with India, Russia, United States, Canada, France, Germany, and Pakistan following behind (Biz Vibe, 2019).

Sowing time is a vital factor that have a decisive role on the vegetative and reproductive stages of the crop's growth, ultimately on the production of grains, especially on the small grain cereal crops (Fayed *et al*., 2015; Farooq, 2013). Sowing is delayed due to various reasons including delayed cotton picking, time required for land preparation after rice harvesting, late sowing of autumn maize in august, late maturing varieties of sugarcane, and delayed onset of rainfall in rainfed regions. Late planted wheat crops have less number of growing days, hence grain yield is negatively affected. In other sense, such crop has increased exposure to the high temperatures (Farooq *et al*., 2013; Haroun *et al*., 2012; Mostafa *et al*., 2009). Similarly, it has earlier been established that a delay of one day from the optimal wheat sowing yielded in a decline of 1% of grain yield (Ihsan *et al*., 2016). Late picking of cotton and maturation of certain rice cultivars are the dominant reasons in the sowing of wheat in cotton-wheat and rice-wheat cropping systems respectively (Shah *et al*., 2016; Hameed *et al*., 2003; Hussain *et al*., 2001). One of the approaches to improve crop performance of late-sown crops is manipulating allelopathic phenomenon in cropping systems.

Allelopathy is a biological phenomenon that mediates through the released chemicals from the living organisms and have either stimulatory or inhibitory effects (Khan *et al*., 2018), higher concentrations usually have negative impacts and used for weed control (Farooq *et al*., 2018) whereas lower concentrations have promotive effects (Farooq *et al*., 2021). Lower concentrations of allelopathic plant water extracts have resulted in enhanced seedling growth of different crop, furthermore, it is an eco-friendly and cost effective way to improve the growth and productivity of field crops (Bajwa *et al*., 2018; Bajwa and Farooq, 2017). Likewise, in an investigation wheat at its anthesis stage was foliar-sprayed with lower concentration of sorghum water extract (SWE) and results indicated that SWE improved the water relations, membrane stability, and other yield parameters (Munir, 2011*)*. Keeping this idea, an experiment was planned to check the efficacy of lower concentrations of SWE in late-planted wheat.

MATERIALS AND METHODS

This experiment was conducted under controlled conditions at Glass house, Institute of Agronomy, Bahauddin Zakariya University, Multan during the Rabi season-2021-22. Soil for the experiment was collected from the agronomic field and each pot was filled with 18 kg of soil. A soil sample for analysis was obtained and subject to laboratory for various properties (Table: 1). There were 6 sowing dates (as Factor 1) started from October 29 to December 02 with an interval of 1 week (D_1: Oct. 29, D_2: Nov. 03, D_3: Nov. 12, D_4: Nov. 19, D_5: Nov. 26, D_6: Dec. 02), while foliar application (as Factor 2) were as T_1: foliar application of SWE, T_2: Water spray. Sowings were done at their respective times in well-prepared and well-watered soil conditions. Wheat cultivar Akbar-2019 was obtained from Punjab Seed Corporation, Multan. To fulfill the nutritional requirement, each pot was supplied with calculated nutrient dose, following recommended dosage as nitrogen at 120 kg ha^{-1}, potassium 100 kg ha^{-1} and phosphorus 100 kg ha^{-1}. Total 10 wheat seeds were sown in each pot which after germination were thinned to 5 seedlings. All other standard production practices including irrigation and plant protection measures were followed. SWE at lower concentration (3%) was foliar sprayed at 30 DAS from each sowing date while for comparison other pots were sprayed with water. All the yield and yield related parameters were recorded at the onset of physiological maturity.

RESULTS

Interaction between different wheat sowing dates and SWE foliar application revealed that maximum wheat plant height, spike length and thousand grain weight was recorded where wheat was sown on November 19 and SWE was applied as foliar spray at 3% (D_4T_1). For plant height and spike length, while, statistically similar results were observed at November 12 planted wheat and SWE was foliar sprayed (D_3T_1) while for thousand grain weight it was followed by November 12 planted wheat and SWE was foliar sprayed (D_3T_1). Whereas, minimum plant height, spike length and thousand grain weight was recorded where wheat was late planted at December 3 and no SWE was foliar sprayed (D_6T_2) (Table 1).

Nearly similar results were obtained for the number of productive tillers, number of spikelets per spike and number of grains per spike, data presented in Table 2 is highly significant. Maximum productive tillers were counted at November 12 planted wheat with SWE application as foliar spray (D_3T_1) while it was followed by wheat planted at same date with no SWE spray (D_3T_2). Here, interestingly similar number of productive tillers were obtained at further delayed planting of wheat at November 19, November 26 and December 3 but with foliar application of SWE at these sowing dates (D_4T_1, D_5T_1 and D_6T_1). In case of number of spikelets per spike and number of grains per spike maximum value of these were recorded at November 19 planted wheat with either SWE application or no application (D_4T_1, D_4T_2), while, statistically similar number of spikelets per spike were recorded at November 12 planted wheat with SWE foliar spray and it was followed by November 12 and November 19 planted wheat with no SWE spray

(D_3T_2, D_4T_2). However, minimum values for these parameters were recorded in early planting of wheat at October 29 and November 5 with no SWE spray.

In case of biological and grain yield, again similar trend was observed (Table 3).

Table 1. Interactive effect of SWE foliar sprays and sowing dates on the plant height, spike length and thousand grain weight of wheat.

Treatment	Plant Height (cm)			Spike Length (cm)			Thousand grain weight (g)		
	Foliar Sprays		Means SD	Foliar Sprays		Means SD	Foliar Sprays		Means SD
Sowing dates	T_1	T_2		T_1	T_2		T_1	T_2	
D_1 - 29th Oct.	62.45 e*	60.50 ef	61.47 C	10.70 cde	8.58 gh	9.64 C	41.27 d	39.06 e	40.16 C
D_2 - 5th Nov.	67.58 cd	65.51 d	66.54 B	11.90 bc	9.65 efg	10.77 B	41.80 cd	39.30 e	40.54 C
D_3 – 12th Nov.	71.00 ab	69.25 bc	70.12 A	13.54 a	11.16 bcd	12.35 A	45.60 b	43.59 c	44.59 B
D_4 - 19th Nov.	71.78 a	69.40 bc	70.58 A	12.46 ab	12.46 ab	11.22 B	47.60 a	45.39 b	46.49 A
D_5 – 26th Nov.	59.30 f	56.92 g	58.12 D	10.72 cde	8.86 fgh	9.78 C	31.42 f	29.06 g	30.24 D
D_6 – 3rd Dec.	56.42 gh	54.20 h	55.31 E	10.30 def	8.28 h	9.28 C	27.64 g	25.68 h	26.67 E
Means FS	64.75 A	62.62 B		11.60 A	9.42 B		39.22 A	37.01 B	
LSD	FS = 1.84, SD = 1.16, Interaction FS*SD = 1.65			FS = 1.36, SD = 0.85, Interaction FS*SD = 1.21			FS = 1.30, SD = 1.09, Interaction FS*SD = 1.55		

SD = sowing date FS = foliar spray T_1 = SWE at 3 %, T_2 =No Spray
LSD = least significant difference at 5% probability level

Table 2. Interactive effect of SWE foliar sprays and sowing dates on the number of productive tillers, number of spikelets per spike and number of grains per spike of wheat.

Treatment	No. of Productive Tillers (pot^{-1})			No. of spikelets $spike^{-1}$			No. of grains $spike^{-1}$		
	Foliar Sprays		Means SD	Foliar Sprays		Means SD	Foliar Sprays		Means SD
Sowing dates	T_1	T_2		T_1	T_2		T_1	T_2	
D_1 - 29th Oct.	9.56 b	7.02 e	8.30 B	12.95 de	10.52 fg	11.74 C	31.60 f	29.30 g	30.45 E
D_2 - 5th Nov.	8.63 bcd	7.07 e	7.85 B	11.67 ef	9.91 g	10.80 CD	34.75 cd	32.23 ef	33.50 D
D_3 – 12th Nov.	11.26 a	9.52 b	10.40 A	16.33 a	14.68 bc	15.51 A	43.38 b	41.43 b	42.41 B
D_4 - 19th Nov.	9.20 bc	7.95 cde	8.57 B	17.17 a	15.63 ab	16.40 A	49.46 a	47.55 a	48.51 A
D_5 – 26th Nov.	9.59 b	7.25 de	8.42 B	13.88 cd	11.98 e	12.93 B	35.66 c	33.91 cde	34.78 C
D_6 – 3rd Dec.	8.72 bc	7.30 de	8.01 B	11.58 e	9.37 g	10.48 D	35.60 c	33.56 def	34.58 CD
Means FS	9.50 A	5.68 B		13.93 A	12.02 B		38.41 A	36.33 B	
LSD	FS = 0.81, SD = 0.92, Interaction FS*SD = 1.30			FS = 1.01, SD = 1.03, Interaction FS*SD = 1.45			FS = 1.42, SD = 1.21, Interaction FS*SD = 1.72		

SD = sowing date FS = foliar spray T_1 = SWE at 3 %, T_2 =No Spray
LSD = least significant difference at 5% probability level.

Maximum biological and grain yield was recorded in wheat planted at November 12 and November 19 with SWE applied as foliar spray (D_3T_1, D_4T_1) and this was followed by the earlier planting of wheat at November 5 with SWE foliar spray (D_2T_1). While minimum grain and biological yield was revealed at late planting of wheat at December 3 with no SWE spray (D_6T_2). Data regarding harvest index (HI) realized that maximum HI was obtained in earlier plantation of wheat at October 29 with no SWE spray (D_1T_2) and it was followed by the late plating of wheat at December 3 with SWE spray (D_6T_1), however, minimum HI was observed in late plating of wheat at December 3 with no SWE spray (D_6T_2).

Table 3. Interactive effect of foliar sprays and sowing dates on the biological yield, grain yield and harvest index of wheat.

Treatment	Biological Yield (g pot^{-1})			Grain Yield (g pot^{-1})			Harvest Index (%)		
Sowing dates	Foliar Sprays T_1	Foliar Sprays T_2	Means SD	Foliar Sprays T_1	Foliar Sprays T_2	Means SD	Foliar Sprays T_1	Foliar Sprays T_2	Means SD
D_1 - 29th Oct.	124.88 d	105.22 g	115.05 C	39.25 c	34.70 d	36.98 C	31.42 bc	32.97 a	32.20 A
D_2 - 5th Nov.	129.04 b	121.17 e	125.11 B	40.71 bc	35.33 d	38.02 C	31.55 bc	29.15 e	30.35 B
D_3 – 12th Nov.	138.76 a	126.71 c	132.74 A	45.03 a	39.70 c	42.36 B	32.45 ab	31.32 bcd	31.88 A
D_4 - 19th Nov.	139.29 a	128.66 b	133.98 A	45.84 a	41.63 b	43.74 A	32.90 a	32.35 ab	32.63 A
D_5 – 26th Nov.	115.47 f	98.22 h	106.85 D	34.85 d	23.34 f	29.10 D	30.19 de	23.76 f	26.97 C
D_6 – 3rd Dec.	106.80 g	94.06 i	100.43 E	33.10 e	18.73 g	25.74 E	30.99 cd	19.51 g	25.25 D
Means FS	125.71 A	112.34 B		39.80 A	32.18 B		31.58 A	28.17 B	
LSD	FS = 0.69, SD = 1.26, Interaction FS*SD = 1.70			FS = 1.18, SD = 0.58, Interaction FS*SD = 1.42			FS = 0.49, SD = 0.82, Interaction FS*SD = 1.20		

SD = sowing date FS = foliar spray T_1 = SWE at 3 %, T_2 =No Spray
LSD = least significant difference at 5% probability level

DISCUSSION

The findings of this investigation are very important pertaining to the effects of sowing dates and foliar application of sorghum water extract. Interaction between sowing dates and foliar applications was highly significant for all the recorded parameters of wheat, including growth, yield and yield contributing traits (Table 1, Table 2 and Table 3). This study aimed to check the role of lower concentration of foliar applied SWE in wheat planted at various dates, particularly late planted wheat. In Pakistan and India, wheat is usually cultivated in cotton-wheat and rice-wheat cropping systems that are the dominant system in South Asia (GOI, 2017; Shahzad *et al*., 2016). Wheat planted at November 12, November 19 followed by foliar application of SWE at 30 DAS yielded maximum grain yield (Table 3). Regarding planting time of wheat, many researchers has established that November 10 to November 20 is the most favorable time to get maximum grain yield (Sokoto and Singh. 2013; Baloch *et al*, 2012; Ali *et al*., 2004), furthermore, yield contributing parameters like spike length, number of spikelets per spike, number of grains per spike, productive tillers and thousand grain weight was also yielded highest at November 10 to November 20 planted wheat. Whereas, sowing of wheat too early or too late have resulted in loss of yield and yield parameters (Fateh, 2011), this also indicates the importance of sowing time in getting maximum returns. Delayed planting of wheat also experienced lesser plant height when sowing was delayed beyond the optimum time (Inamullah *et al*., 2011). Similarly in another investigation, Farooq and Cheema (2014) revealed that delay in sowing not only caused substantial reduction in crop yield but also resulted in least returns of your expenses. Allelopathy has been practiced since decades for improving production of field crops in over the globe (Cheema *et al*., 2013). Sorghum is a potent allelopathic crop possessing several allelochemicals that can play a vital role in uplifting productivity of agro-systems (Hussain *et al*., 2021). There are many other allelopathic crops having allelochemicals, their role is concentration dependent, at higher concentrations it shows killing effect while in lower concentrations it shows growth promotory effect (Bachheti *et al*., 2020), likewise to check the role of lower concentration of brassica water extract, study under control condition revealed that brassica water extract is a suitable plant growth regulator, when applied as foliar spray it enhanced the seedling growth of wheat and chickpea (Farooq *et al*., 2021). Furthermore, SWE has also been proved as an important agent to save the crops from various stresses and helps in improving the productivity of host crops (Bajwa *et al*., 2020; Waqas *et al*., 2017). Hormesis is a dose response phenomenon in which higher dose shows inhibitory or killing effect, while, low dose shows promotive effect. Similarly in present study, SWE applied in lower concentration (3%) shows hormesis action of allelochemicals present in SWE that improved the growth and yield of wheat planted at varying dates.

CONCLUSION

Wheat yield was significantly influenced by various sowing dates. Early and late planting both negatively affect the productivity of wheat. SWE is a natural growth regulator that enhance the wheat yield at all the sowing dates. Maximum grain yield was recorded when wheat was sown at November 12 and November19 followed by foliar application of SWE at 3% concentration.

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