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Mitigation of water stress through foliar spray of agrochemicals in wheat (*Triticum aestivum* L.) under late sown conditions

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Abstract
A field experiment was carried out during *rabi* 2020-21 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur to study the performance of winter wheat under water stress and agrochemicals foliar spray treatment. The results revealed that water stress at milking recorded significantly lower plant height, dry matter, number of tillers, total chlorophyll and relative water content of leaves and there was significant reduction in yield attributes with water stress at milking. Grain, straw and biological yield were significantly reduced with water stress at heading and milking stage over no water stress. Foliar spray of KCl 1% and CaCl2 0.2% proved effective in improving growth and yield attributes. Grain yield and biological yield were significantly higher with foliar spray of KCl 1% over water spray.

Keywords: Winter wheat, agrochemicals, KCl, yield

Introduction
Plant growth and development along with productivity are negatively affected by environmental stresses, because plants are delicate and sessile organisms that meet various of environmental stress all over the life cycle. (Khan and Singh, 2008) [6]. Every year countries lose a big amount of money from decrease in crop productivity caused by various abiotic stresses (Rengasamy, 2006) [8]. These environmental stresses will become more vigorous and frequent with these climatical changes, especially with the global warming. On the other hand, the world population is estimated to reach around 10 billion by 2050, which will face serious food scarcities. Therefore, tolerant and resistant crops should be developed to feed the hovering population. Maintaining crop yields under unfavourable enviourmental conditions is probably the major challenge for modern agriculture to face. Plants possess well-organized defence mechanisms to deal with the abiotic stresses, which includes UV radiation, drought, salinity and temperature (Fujita *et al*., 2006) [5].
Inadequate accessibility of water to crop is a solemn constraint to agricultural production of major crops (Shao *et al*., 2009) [9] because water is the most vital factor in plant growth and development. Reduced supply of water is known to hamper important biochemical and physiological mechanisms leading to reduction in plant growth. Substantial yield losses have been detected in different crops due to low supply of water even for a very short period of time (Pinheiro *et al.*, 2005). Drought stress affect stomatal conductance negatively resulting in decreased NPR (net photosynthetic rate). Degradation of chlorophyll due to drought stress also inhibits photosynthesis in wheat. Drought stress deteriorates plant cell membranes which adversely affects many metabolic reactions occurring within the cell (Ashraf, 2009) [2]. Many techniques were evolved to assess wheat tolerance such as seed priming and exogenous applications of agrochemicals during cultivation were efficiently used as methods of plant mitigation under heat and drought stress conditions. The application of agrochemicals is known to play an important role in plant response to stresses. Agrochemicals might act as modulators of plant responses and have potential to upsurge crop production through transmitting the metabolism and partitioning of assimilates. Nutritional status of the plant is the indicator of its response to environmental stress. Cakmake (2005) [3] reported that K boosted drought tolerance in plants by mitigating harmful effects by increasing translocation and maintaining water balance in plants. Crop can more easily take nutrients when applied foliarly and in return increases crop yield (Arif *et al.*, 2006) [1].

El-Ashry *et al.* (2005) [4] reported that the negative effect of drought on growth of wheat can be decreased which resulted in higher yield K plays a key role in osmoregulation, stomatal opening and closing, photosynthesis, transpiration, and protein synthesis (Cakmake, 2005) [3].

Materials and Methods

The experiment was conducted during *rabi* 2020-21 at Instructional Farm of Rajasthan College of Agriculture, MPUAT, Udaipur. The soil of the experimental site was clay loam in nature, with slightly alkaline reaction (pH 8.13) having bulk density 1.40 g cc-1 and electrical conductivity 0.78 dS m-1. The nutrient status of the soil showed organic carbon content (0.71%), available nitrogen content (284.6 kg ha-1), available phosphorus content (20.47 kg ha-1) and available potassium content (292.34 kg ha-1) depicting overall medium nutrient status of the soil. The treatments consisting of 3 water stress (no water stress, water stress at heading and water stress at milking) and four levels of foliar spray of agrochemicals [water spray, KCl 1%, Boric acid 0.2% and CaCl2 0.2%]. Wheat variety Raj-4238 was used as test crop were laid out in factorial randomized block design (FRBD) and replicated thrice. Crop was sown with late sowing with 125 kg ha-1 and sowing was done manually. Agrochemicals (water spray, KCl 1%, Boric acid 0.2% and CaCl2 0.2%) were sprayed with knapsack sprayer fitted with flat fan nozzle using 750 litres of water per hectare one day before water stress imposed. The crop was irrigated at critical growth stages *viz*., (i) crown root initiation, (ii) tillering, (iii) Booting/ late jointing, (iv) flowering / heading stage, (v) milking stage and (vi) dough stage during experimental duration. Irrigation was skipped at heading and milking stage in treatment plots.

Results and Discussion

Water stress: The results showed that water stress at different stages caused momentous decrease in several growth parameters *viz*., plant height at harvest, number of tillers at 90 DAS and at harvest, dry matter accumulation and flag leaf area in comparison to no water stress treatment. water stressed plants showed increased proline content accumulation, water stress at milking registered significantly higher proline content by 8.7 and 18.6% over water stress at heading and no water stress, respectively. A significant decrease in yield attributes recorded due to water stress conditions. The crop grown with no water stress recorded significantly higher yield attributes *viz*. effective tillers m-1 row, number of spikelets ear-1, ear length, number of grains ear-1 and 1000- grain weigh. The highest reductions in the yield attributing characters were recorded under water stress at milking. In terms of grain yield, it was found that water stress at milking and heading cause significant reduction of 13.7 and 9.3% in comparison to no water stress treatment (3724.7kg ha-1). Such differences in deleterious effects of water stress at these two stages are attributable to variations in yield attributes *viz*., number of effective tillers, number of spikelets, ear length, numbers of grains ear-1and 1000- grain weight which underwent more severe depression because of water stress at milking and heading. The result showed that relative water content and chlorophyll content reduced under water stress at milking stage over no water stress condition. Maximum reduction occurred at water stress at milking stage as compared to water stress at heading stage. No water stress recorded significantly higher net returns and B:C over water stress at heading and milking. This was due to higher grain and straw yield obtained with no water stress over water stress at heading and milking.

Agrochemicals foliar spray: In the present study, KCl 1% and CaCl20.2% significantly improved various growth parameters *viz*., dry matter accumulation, number of tillers and flag leaf area over water spray. Foliar spray of Boric acid 0.2% brought about significant increase in number of tillers 90 DAS and at harvest. Across the year, foliar sprays of KCl 1% and CaCl20.2% brought about significant improvement in yield attributes *viz*., number of effective tillers at 90 DAS and at harvest, number of spikelets, ear length, number of grains ear-1, ear length and 1000 grain weight over water spray. These improvements ultimately resulted in significantly higher grain yield under foliar spray of KCl 1% as compared to water spray. Maximum increase in grain yield over water spray was recorded due to KCl 1% followed by CaCl20.2%. Khan *et al.* (2006) [7] also reported that foliar application of KNO3 and KCl 1% are effective in increasing wheat yield and can be helpful in achieving maximum yield. Application of KCl 1% and CaCl20.2% brought about significant improvement in biochemical studies *viz*., proline content, chlorophyll content and RWC over water spray. These improvements ultimately resulted in significantly higher grain yield under foliar spray of KCl 1% and CaCl20.2% as compared to water spray. CaCl2 helpful in protecting chlorophyll content in plants in results there is significant difference in chlorophyll content with recorded with CaCl2 0.2% spray by 1.8% over water spray its because CaCl2 foliar spray, reduce the loss of chlorophyll under moisture stress, probably by lowering photo-oxidation *via* increasing antioxidant enzyme activities, and also improve net photosynthetic rate under stress by maintaining higher stomatal conductance (Tan *et al.*, 2011).

Table 1: Effect of water stress and foliar spray of agrochemicals on yield attributes of wheat

Treatment	Yield attributes					
	Effective tillers m^{-1} row length		Number of spikelets ear^{-1}	Ear length (cm)	Number of grains ear^{-1}	1000 grain weight (g)
Water stress	At 90 DAS	At harvest				
No water stress	129.4	138.4	16.4	8.5	41.1	36.1
Water stress at heading	115.3	127.1	15.8	8.1	39.3	35.1
Water stress at milking	112.7	124.9	15.3	7.7	37.3	34.1
SEm±	2.9	3.0	0.3	0.2	0.6	0.5
C.D.(P=0.05)	8.5	8.9	0.8	0.5	1.7	1.4
Foliar spray						
Water spray	113.8	124.3	15.2	7.5	38.1	34.1
KCl 1%	127.2	138.6	16.5	8.7	40.9	36.6
Boric acid 0.2%	114.9	125.0	15.3	7.9	38.7	34.7
$CaCl_2$ 0.2%	120.7	132.7	16.1	8.3	39.3	35.1

SEm±	3.3	3.5	0.3	0.2	0.6	0.6
C.D.(P=0.05)	9.8	10.3	0.9	0.6	1.9	1.7

Table 2: Effect of water stress and foliar spray of agrochemicals on yield and harvest index of wheat

	Yield (kg ha^{-1})			
Treatment	**Grain**	**Straw**	**Biological**	**Harvest index (%)**
Water stress				
No water stress	3724.7	5695.3	9420.0	39.5
Water stress at heading	3405.7	5225.6	8631.4	39.6
Water stress at milking	3275.0	5030.3	8305.3	39.5
SEm±	73.8	131.3	159.3	0.7
C.D.(P=0.05)	216.3	385.0	467.3	NS
Foliar spray				
Water spray	3324.2	4943.9	8268.1	40.3
KCl 1%	3673.6	5468.2	9141.7	40.2
Boric acid 0.2%	3393.2	5415.2	8808.4	38.5
$CaCl_2$ 0.2%	3482.9	5441.1	8924.0	39.1
SEm±	85.1	151.6	183.9	0.8
C.D.(P=0.05)	249.8	NS	539.6	NS

Table 3: Effect of water stress and foliar spray of agrochemicals on proline content and chlorophyll content of wheat

Treatment	**Proline content (µg g^{-1} fresh weight)**		**Chlorophyll content (mg g^{-1} fresh weight)**	
Water stress	**At heading**	**At milking**	**At heading**	**At milking**
No water stress	1.923	2.149	1.865	1.915
Water stress at heading	2.159	2.354	1.764	1.825
Water stress at milking	2.365	2.480	1.752	1.739
SEm±	0.021	0.018	0.009	0.010
C.D.(P=0.05)	0.062	0.053	0.025	0.029
Foliar spray				
Water spray	2.090	2.265	1.770	1.800
KCl 1%	2.190	2.369	1.817	1.850
Boric acid 0.2%	2.150	2.333	1.785	1.815
$CaCl_2$ 0.2%	2.166	2.344	1.803	1.839
SEm±	0.024	0.021	0.010	0.011
C.D.(P=0.05)	0.07	0.06	0.03	0.03

Conclusion

On the basis of results procured from the present investigation entitled "Mitigation of water stress through foliar spray of agrochemicals in wheat (*Triticum aestivum* L.) under late sown conditions" conducted during *Rabi* 2020-21, it is concluded that under prevailing agro-climatic conditions of Rajasthan, a significant reduction in growth, yield parameters as well as grain yield, and biochemical changes was recorded with water stress heading and milking stage under late sown conditions. To minimize the effect of water stress at milking stage, crop should be sprayed with KCl 1% under late sown conditions. The maximum grain yield of 3964 kg ha-1 obtained with foliar spray of KCl 1% which also fetched maximum net returns (63254 ha-1) and B: C (1.9) under no water stress.

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