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KM Singh
Senior Scientist & Head, Krishi Vigyan Kendra, Agwanpur, Saharsa, Bihar, India

Hemant Kumar Singh
Subject Matter Specialist, Krishi Vigyan Kendra, Kishanganj, Bihar, India

Correspondence
KM Singh
Senior Scientist & Head, Krishi Vigyan Kendra, Agwanpur, Saharsa, Bihar, India

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Effect of foliar application of potassium nitrate on late sown wheat (*Triticum aestivum* L.) in mitigating terminal heat stress

KM Singh and Hemant Kumar Singh

Abstract
An investigation of on farm trial (OFT) conducted on farmer's field during Rabi season 2016-17 & 2017-18 in Kishanganj district of Bihar for studies on 'Effect of foliar application of potassium nitrate on late sown wheat in mitigating terminal heat stress' revealed that the foliar application of 0.5 % KNO_3 at booting and 0.5 % KNO_3 at anthesis stage of wheat recorded higher grain yield (31.50 and 30.30 q/ha in 2016-17 and 2017-18 respectively) followed by foliar application of 1.0 % KNO_3 only at anthesis stage of wheat (29.75 and 28.50 q/ha in 2016-17 and 2017-18 respectively) in comparison to wheat yield obtained under farmer practice of without any foliar application (28.50 and 25.50 q/ha in 2016-17 and 2017-18 respectively).The two spray of KNO_3 0.5% at boot and anthesis stage on wheat showed the favorable effect on yield attributing characters(plant height, effective tillers/m^2,spike length, number of grains/spike and test weight). This treatment also recorded higher net return and B:C ratio (Rs. 28,250/ha, 2.49) during 2016-17 and that (Rs. 24,450/ha, 2.27) during 2017-18 respectively. The application of KNO_3 at the stage of booting and anthesis stage found effective in increasing the yield of late sown wheat variety HD-2985 in Kishanganj district of Bihar. Farmers were satisfied with the performance of the technology in mitigating heat stress in late sown wheat.

Keywords: wheat, potassium nitrate, heat stress, yield, growth, economics

Introduction
Wheat (*Triticum aestivum* L.) is an important crop of *Rabi* season covering an area of 30.79 million hectares with production of 98.51 million tones and productivity of 3200 kg/ha in India (Anonymous, 2018) [2]. Seasonal fluctuations in temperature have potential impact on the growth stages development and grain yield of crops. Wheat, being a winter cereal requires particular environmental condition for better emergence, growth and flowering and is more vulnerable if exposed to high temperatures during reproductive stages (Kalra *et al*., 2008) [10]. The level of self-sufficiency will not be achieved unless researchers and extension personnel manage to make better use of resources in new arena of climate change and appropriate location specific transfer of agricultural technology.
In India, terminal heat stress is a major reason of yield decline in wheat due to delay planting (Joshi *et al*., 2007) [9]. Late planted wheat suffers drastic yield losses which may exceed to 40-50%. The various abiotic stresses causing decrease in food productivity and minimizing these losses is a major concern to cope with the increasing food requirements (Mahajan and Tuteia, 2005) [11]. According to a report of the intergovernmental Panel on climate change, the global climate models predict an increase in mean ambient temperature between 1.8 and 5.8 ^oC by end of this century (IPCC, 2007) [8]. High temperature stress in wheat during reproductive development is a primary constraint to its production. Increased ethylene has been shown in mature wheat plants to shorten the grain filling period, decrease 1000 kernel weight, hasten maturity and trigger premature senescence (Beltrano *et al*., 1999) [5]. Hobbs and Morris (1996) [7] observed a 1% decrease for each day that wheat sowing was postponed after the optimum sowing date (15-20 November). Shriveled small grains are produced and different yield associated traits such as tillering, grain weight and grains numbers/spike are reduced.

Using this factor 3-4 % loss in yield per 10 ^{0}C above 15–20 ^{0}C), it can be calculated that most commercially sown wheat cultivars in India would lose approximately 50 % of their yield potential when exposed to 32–38 ^{0}C temperature at the crucial grain formation stage (Dwivedi *et al.*, 2015) [6].

Adequate nutrition is essential for integrity of plant structure and physiological processes to be completed. Nitrogen and magnesium is associated with chlorophyll for photosynthesis, phosphorus structural part of nucleic acid needed for energy production and storage. Potassium is needed for osmotic regulation and activation of enzymes (Waraich *et al.*, 2011) [13]. These shows minerals nutritional status of plant greatly affects their ability to adapt to adverse weather conditions. The efficient nutrient management practices in wheat, N P K, Mg, and Zn are particularly important. Proper nitrogen management is required for grain filling for final wheat grain size and weight. Phosphate is associated with supply of energy for plant processes to achieve good grain size of wheat. Potassium help in movement of nutrients in plants for redistribution of minerals to the ear potassium levels, extend the grain filling period leading to improvement in grain weight of wheat. Potassium deficient plants are found poor in regulating transpiration leading to heat stress and wilting (Anonymous, 2020) [4].

The farmers of Kishanganj district generally get delayed in sowing of wheat (10 Dec-10 Jan) mainly due to practice of growing long duration paddy varieties, late release of accumulated water and more time consumed for land preparation resulting into poor yield of the crop. Wheat has significant area of about 16670 ha in Kishanganj district of Bihar with an average productivity of 1693 kg/ha (Anonymous, 2016) [1]. Selection of suitable crop varieties according to the agro-climatic conditions as well as balanced nutrition on developmental stages may play crucial role in realizing the optimum production of any crop commodity (Singh *et al.*, 2008) [12]. Keeping in view of mitigating terminal heat stress to improve the productivity of wheat in late condition, this investigation was undertaken to study on effect of foliar application of Potassium nitrate on late sown wheat in mitigating terminal heat stress on farmer's field under irrigated late sown condition in Kishanganj district of Bihar during 2016-17 and 2017-18.

Materials and Methods

The present investigation was conducted on farmer's field during 2016-17& 2017-18 for mitigation of terminal heat stress in late sown wheat through foliar applied potassium nitrate (KNO_3), The experiment was laid out on farmer's field in randomized block design with 10 replications and plot size of 0.1 ha. The technological options consisted of three levels of foliar spray of KNO_3 at different developmental stages.

Farmers' practice: General cultivation of late sown wheat (during 2nd fortnight of December) without any foliar spray Foliar spray of 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage Foliar spray of 1.0% KNO3 only at anthesis stage.

HD-2985 was grown in both the year of experimentation having following characteristics. Pusa Basant (HD2985) is released by IARI, Pusa in 2010 for North eastern Plains Zone. It is Suitable for irrigated late sown condition. Average seed yield is 35-40 q/ ha. It has the lowest reduction in the 1000-grain weight under very late sown conditions. The variety possesses the usable and most practical type of disease resistance *viz.*, the adult plant resistance (APR) because of *Lr13*.

Potassium nitrate (KNO_3) is a soluble source of two major essential plant nutrients. It's commonly used as a fertilizer for high-value crops that benefit from nitrate (NO_3-) nutrition and a source of potassium (K+) free of chloride (Cl^-). Farmers opt the choice for fertilizing with KNO_3 especially in conditions where a highly soluble, chloride-free nutrient source is needed. In such soils, all of the N is immediately available for plant uptake as nitrate, requiring no additional microbial action and soil transformation. Potassium nitrate contains a relatively high proportion of K, with an N to K ratio of approximately one to three. Applications of KNO_3 to the soil are made before or during the growing season. A diluted solution is sometimes sprayed on plant foliage to stimulate physiological processes or to overcome nutrient deficiencies. Foliar application of K during seed development advantages crops, since this growth stage often coincides with high K demands during the time of declining root activity and nutrient uptake.(anonymous, 2019) [3]. Chemical Properties: Chemical Formula - KNO3, N Content - 13%, K_2O content-44 to 46%, Water solubility at 20^0-316g/L, Solution P^H 7-10

In all the three treatments, other than foliar spray of KNO3, general agronomic management practices were followed as, date of sowing: 2nd fortnight of December, Seed rate: 125 kg/ha, spacing: 20 cm row to row distance. Fertilizer: 120:60:40 kg N:P_2O_5:K_2O ha-1, irrigation: Two at CRI and Boot stages. Need based all the agronomic management practices and plant protection measures were adopted.

Kisangani falls in Agro-climatic Zone-II North East alluvial plain zone. The climate is sub-tropical and humid with extremes of temperature in summer 46 ^{0}C and in winter 4 ^{0}C and the area receives the annual precipitation of 1200 - 1400 mm. The maximum rainfall occurs during monsoon period. The soil of the districts generally light textured having alluvial properties. The soils of Kishanganj district are coarse texture, sandy loam to loam with p^H 5.8 to 8, organic carbon 0.54 per cent, available N, P_2O_5 and K_2O 238, 30 and 161 kg /ha, respectively. Soil is also deficient in Zinc, Sulphur & Boron. Plant samples were collected randomly to number of effective tillers/m^2, length of spike (cm), number of grain/spike, 1000-grain weight. (g), grain yield (q ha^{-1}) as per standard methodology.

Results and Discussion

There was significant difference in grain yield of wheat due to application of KNO_3 during 2016-17 and 2017-18.The foliar spray of 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage in wheat cultivar HD-2985 during 2016-17 recorded higher grain yield (31.0 q/ha) which was on par with the foliar spray of 1.0% KNO3 only at anthesis stage (29.75 q/ha) in comparison to farmers practice without any foliar spray (28.50q/ha). There was 10 per cent increase in grain yield of wheat produced in spray schedule 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis over farmer's practice. The yield attributing characters were also significantly higher due to foliar application at 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage with respect to others and poor expression of yield attributing characters under farmers practice. They produced the maximum number of effective tillers/m^2 (354), no. of grain per spike (45), spike length(10cm) and 1000-grain weight (42g) and minimum under farmer's practice (Table.1) similar results were observed during 2017-18. The observation of higher yield of wheat under late sown condition due to foliar spray of 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage might have contributed towards favourable expression of growth and yield attributing

characters like plant height, effective tillers, spike length, no of grains/spike and grain weight. The effect of efficient nutrient management practices in wheat particularly N and K at developmental stages are particularly important. Proper Nitrogen management is required for grain filling for final wheat grain size and weight. Potassium help in movement of nutrients in plants for redistribution of minerals to the ear potassium levels, extend the grain filling period leading to improvement in grain weight of wheat. Foliar application of K during seed development advantages crops, since this growth stage often coincides with high K demands during the time of declining root activity and nutrient uptake (Anonymous, 2020) [4]. High temperature affects the period of grain filling and fertilization process resulting in reduced development of grain ultimately decreasing the crop yield. The differential behavior of wheat genotypes with heat stress environment in eastern indo-gangetic plains of Bihar have been reported by Dwivedi *et al.*, 2015 [6]. Waraich *et al.*, 2012) [14] reviewed the works on heat stress and emphasized the positive role of adequate plant nutrition in alleviating the heat stresses.

Maximum net return with B:C ratio was obtained under foliar spray of 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage in wheat cultivar HD 2985 during 2016-17 (Rs.28250/ha with 2.49) followed by foliar spray of 1.0% KNO3 only at anthesis stage (Rs.25625/ha with 2.35), and minimum under farmers practice without any foliar spray (Rs. 24150/ha with 2.30). Similar result was observed during 2017-18(Table 2). Considering the economics of study particularly net return, benefit: cost ratio and the yield of wheat grain recorded, it could be stated that the technology of foliar application of 0.5 % KNO_3 at booting & 0.5% KNO_3 at anthesis stage in wheat cultivar HD 2985 performed well under late sown condition in rice-wheat cropping system to mitigate the terminal heat stress in late sown wheat in Kishanganj district of Bihar. The farmers under test were satisfied with the KNO technology of foliar application of KNO_3 in wheat cultivar HD-2985 for its cultivation in irrigated late sown condition (16-30 December) for obtaining higher yield and profit of wheat cultivation.

Table 1: Effect of foliar application of KNO_3 on yield attributes and yield of late sown wheat during 2016-17 and 2017-18

	Plant height (cm)		No. of effective tillers/m^2		Spike length (cm)		No. of grain/spike		Test wt (gm)		Grain yield (q/ha)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Farmers practice: without any foliar spray	79.4	75.4	284	253	8.2	8.0	41	30	40.7	38.50	28.50	25.50
TO_1: Foliar spray of 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage	81.8	84.8	354	303	10	9.2	45	41	42.0	42.24	31.50	30.30
TO_2: Foliar spray of 1.0% KNO3 only at anthesis stage.	84.6	82.4	315	282	9.8	8.6	43.66	39	41.7	40.25	29.75	28.50
CD at 5%	2.83	3.39	4.09	5.43	1.42	1.02	2.35	3.39	3.61	2.55	1.40	3.02

Table 2: Effect of foliar application of KNO_3 on Economics of late sown wheat during 2016-17 and 2017-18

Treatments	Cost of cultivation (Rs/ha)		Grass Return (Rs/ha)		Net return (Rs/ha)		B:C ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Farmers practice: without any foliar spray	18600	19000	42750	38,250	24150	19250	2.30	2.01
TO_1: Foliar spray of 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage	19000	20000	47250	45,450	28250	25450	2.49	2.27
TO_2: Foliar spray of 1.0% KNO3 only at anthesis stage.	19000	19500	44625	42,750	25625	23250	2.35	2.19

Conclusion

It is concluded from this study that wheat variety HD-2985 under foliar spray of 0.5% KNO_3 at booting & 0.5% KNO_3 at anthesis stage in wheat performed well under irrigated late sown condition under rice-wheat cropping system in Kishanganj district of Bihar.

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