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Effect of split plot application of potassium and nitrogen on wheat (*Triticum aestivum L.*) under Punjab condition

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Abstract
A field study was carried out at Student's Experimental Farm, Department of Agronomy, at research farm of Chandigarh University of Agricultural Sciences and Technology, Punjab to evaluate the "Effect of split plot application of Potassium and Nitrogen on Wheat (*Triticum aestivum L.*) Under Punjab condition" emend. The experiment was set up in a split-plot design replicated thrice, consisting of 15 treatment combinations, *viz*. of potassium @ 30 kg/ha [K_1: 100% as basal dose-(RFP); K_2: 50% as basal dose + 50% at active tillering; K_3: as basal dose + 75% at active tillering] and 5 treatments of nitrogen @ 120 kg/ha in split ratios of [N_1: 50% as basal + 25% at jointing + 25% at booting stage (REP); 25% as basal dose + 75% at active tillering; N_3: 25% as basal dose + 50% at active tillering + 25% at booting; N_4: 50% as basal + 50% at active tillering; N_5: 0% as basal + 75% at active tillering + 25% at booting]. The results revealed that growth parameters and yield increased with the application of potassium in two equal splits in the ratio of 50:50 as compared to the treatment where potassium was given in one split as 100% basal dose. Splitting of potassium in the ratio of 50:50 produced higher grain yield by 48.24%, 46.76% and 45.54%, straw yield by 80.42%, 78.54% and 76.85%, respectively over 100% as basal dose. Application of nitrogen in three splits with reduced basal dose in the ratio of 25: 50: 25 improved growth and yield as compared to recommended practice. The increase in grain yield and straw yield was 48.41% and 82.36% respectively over 100% as basal dose. Application of nitrogen in three splits with reduced basal dose in the ratio of 25: 50: 25 improved growth and yield as compared to recommended practice. The benefit cost ratio with the application of potassium in two equal splits in the ratio of 50: 50 with reduced basal dose of nitrogen (25:50:25). The increase in wheat production is possible by selecting adapted genotypes with improved.

Keywords: time of application, nitrogen splits, potassium splits, yield

Introduction

Wheat (*Triticum aestivum L.*) is crucial cereal crop which is the staple food is major part of country due to rich fibers and instant carbohydrates. Approximately 93.50 million tonnes of wheat is produce in India per year. India ranks 7th in exporting agriculture produce (Anonymous, 2018a). About 29.8 million-hectare land in India is under the cultivation of wheat. Therefore, India stands at 2nd position in wheat production in world. Due to the increase in population the country has to enhance the production of wheat to 105 million tons per annum (Anonymous 2017) [1]. Potassium is involved in achieving vigorous early growth, improving grain quality (fruit colour, flavour, size of fruit and tubers, etc.), improves stress tolerance, reduces incidence of pest and diseases, protect the plant against lodging, regulates the transport of water and nutrient, help in translocation and storage of photosynthates, promotes protein and starch synthesis. The plant uptake accounts for 93 % of total K output from the field (Alfaro *et al*., 2003) [3]. It is plays a vital role both during vegetative and reproductive phases of the crop. But the higher basal nitrogen dose (60 kg N/ha) is subjected to leaching losses and is prone to denitrification or immobilization before plant uptake thus is most frequently found deficient. So to reduce the fixation of potassium and leaching losses of nitrogen, split application of K and N according to the demand of a growing crop is the best agricultural technique. Split application of K during the growth period has proven to be beneficial in wheat as compared to single basal application www.IndianJournals.com Members Copy, Not for Commercial Sale Downloaded From IP - 14.139.224.82 on dated 30-May-2018 (Wani *et al*., 2014) [17, 18]. Response of wheat to nitrogen splits with reduced basal dose has been reported by several workers in India (Akram *et al*., 2014) [2]. The crop growth and yield, it is important to reduce the fixation of potassium and nitrogen losses. There for, split application of potassium and nitrogen in proper propositions as per crop demand is an effective tool. Thus, the present study was carried out to elucidate the effects of split application of potassium and nitrogen on the growth of wheat. Booting was laid out in a split-plot design with 3 replications. Sowing was done in the second week of December with row-to-row spacing of 23 cm. Recommended dose of nitrogen (120 kg/ha) and potassium (30 kg/ha) through urea and muriate of potash respectively, was uniformly applied to each subplot as per the treatments while full dose of phosphorus (60 kg P2O5/ha) through diammonium phosphate was applied as basal dose. In place of DAP, single superphosphate (375 kg/ha) was applied in those plots where 0% N was used as basal dose. Standard cultural practices were followed until the crop matured but the crop was not irrigated due to sufficient availability of water. Plant height, number of tillers/m row length, dry weight and the yield attributes were recorded from 5 random plants in each subplot. In the absence of a satisfactory supply of potash, plants will grow poorly and be stunted, especially in dry seasons. Physiological stress will be more damaging if potash nutrition is limiting, and frost damage will be more severe, waterlogged areas will take longer to recover and plants will wilt earlier and remain flaccid for longer under drought conditions. Crops will be more susceptible to diseases and pests, especially where N and potash availability are imbalanced, which will result in weaker growth (PDA, 2012) [12]. Reported that split application of N was effective in increasing wheat grain yield and especially grain protein was improved by the late application of Nitrogen Fisher *et al*.) Reported that N use efficiency of wheat was the maximum when nitrogen fertilizer was applied in three splits rather than two splits or applied as all basal in no-till condition However, still there are controversies in N fertilization to maximize wheat yield and that needed to elucidate for the benefit of wheat production. Therefore, the present study was undertaken to validate existing nitrogen application methods in order to optimize the dose of N fertilizer and recommend the most effective method of Nitrogen Rahman *et al.* (2002). And durther, crop requires N throughout the growth period, which calls for split application of nitrogen that avoids nitrogen losses as a result of leaching and volatilization (Subedi *et al*., 2007) [16]. To maintain the soil fertility, productivity and crop yields, it is important to reduce the fixation of potassium and nitrogen losses. Therefore, split application of potassium and nitrogen in proper propositions as per crop demand is an effective too. Thus, the present study entitled "Studies on the split application of Potassium and Nitrogen in Wheat (*Triticum aestivum L.)* Under Punjab"

Materials and Methods

A field experiment entitled "Assessing the Effect of split plot application of Potassium and Nitrogen on Wheat (*Triticum aestivum* L.) Under Punjab condition." was conducted at the experimental farm of the Division of Agronomy, Chandigarh University of Agricultural Science and Technology of Punjab. The details of the materials used, experimental procedures followed and techniques adopted have been described in this chapter. The Experimental site is investigation was conducted at the experimental farm of Chandigarh University Gharuan Mohali and Punjab that lies between 30.7691ºN latitude and 76.5759ºE longitude at an altitude of 296.86 meters above the mean sea level. The climate is sub tropical type characterized by very hot summers and severe winters. The average annual precipitation over past twenty five years in 792 mm and more than 80 percent of precipitation is received during south west monsoon. During crop growth period (6^{th} Dec 28^{th}April) wettest month was December. The mean maximum and minimum temperature for entire crop growth period of wheat crop was 38.83ºC and 3.59ºC, respectively.

The experiment comprised 2 factors *viz*. 3 treatments of potassium (K_1, 100% K basal dose-recommended fertilizer practice; K_2, 50% K as basal dose + 50% K at active tillering; K_3, 25% K as basal dose + 75% K at active tillering) and 5 treatments of nitrogen [N_1, 50% N as basal + 25% N at jointing + 25% N at booting stages (RFP); N_2, 25% N as basal dose + 75% N at active tillering; N_3, 25% N as basal dose + 50% N at active tillering + 25% N at booting; N_4, 50% N as basal + 50% N at active tillering; N_5, 0% N as basal + 75% N at active tillering+ 25% N at booting] was laid out in a split-plot design with 3 replications. Sowing was done in the second week of December with row-to-row spacing of 23 cm. Recommended dose of nitrogen (120 kg/ha) and potassium (30 kg/ha) through urea and muriate of potash respectively, was uniformly applied to each subplot as per the treatments while full dose of phosphorus (60 kg P_2 O5 /ha) through diammonium phosphate was applied as basal dose. In place of DAP, single superphosphate (375 kg/ha) was applied in those plots where 0% N was used as basal dose. Standard cultural practices were followed until the crop matured but the crop was not irrigated due to sufficient availability of water. Plant height, number of tillers/m row length, dry weight and the yield attributes were recorded from 5 random plants in each subplot. Leaf-area index and SPAD reading was measured with canopy analyser (Accupar L80) and chlorophyll metre (SPAD-502 Konica Minolta Sensing), respectively, in the fully expanded top leaf of the 5 tagged plants from each subplot and the average reading was presented during both the years. The straw yield was computed by deducting the grain yield from the total biological yield and the grain yield data were adjusted at 14% moisture content

Results and Discussion

Growth attributes

Significantly taller plants, higher number of tillers/m^2, dry-matter accumulation, leaf-area index and SPAD reading were recorded with the application of potassium in 2 equal splits in the ratio of 50:50 (basal + active tillering) as compared to the treatments where potassium was applied in 2 splits in the ratio of 25:75 (basal + active tillering) and the treatment where potassium was given in once split as 100% basal dose (recommended practice) (Table 1). As the application of K in 2 equal splits leads to greater availability of K and lower transformation of potassium into non-exchangeable pool, which regulated the continuous growth of cells and tissues, enhanced N uptake and protein synthesis, improved many physiological growth processes and delayed plant leaf senescence, hence increased the growth parameters of the crop. Mathukia *et al*. (2014) [9, 10]

The result of the present study indicated that the growth parameters of plant such as plant height, LAI and dry matter accumulation of wheat crop were significantly influenced by different tillage potassium and nitrogen scheduling positive correlation with yield. Among treatments, the maximum plant height, leaf area index, and dry matter accumulation were recorded with the application of nitrogen in 3 splits with reduced basal dose in the ratio of 25:50:25 (basal + active tillering + booting) as compared to the treatments where nitrogen was applied in the ratios of 50: 25: 25 (basal + jointing + booting), 25: 75 (basal + active tillering), 50: 50 (basal + active tillering) and 75: 25 (active tillering + booting) (Table 1). The data averaged over 2 years showed that plant height, number of tillers/m^2 and SPAD reading recorded with the application of nitrogen in three splits with reduced basal dose in the ratio of 25: 50: 25 (basal + active tillering + booting) and in the ratio of 50: 25: 25 (basal + jointing + booting) were found at par with each other but significantly exceeded the mean plant height as compared to the treatments where nitrogen was applied in 2 splits. It might be attributed to the less leaching losses, better and timely availability of nitrogen for their utilization during the peak crop requirement. As the nitrogen promotes growth and development and enhances synthesis and accumulation of proteins, amino acids and enzymes which are responsible for cell division, cell elongation that promotes the plant height, number of tillers/m^2, dry-matter accumulation, LAI and chlorophyll content (SPAD values) of the leaf. The results are in close conformity with Akram *et al*. (2014) [2].

Table 1: Growth characteristics and Plant height (cm), Number of tillers (m^{-2}), Dry matter qha^{-1} and Leaf area index of wheat as influenced by split application of potassium and nitrogen.

Treatment	Plant height (cm)	Number of tillers (m^2)	Dry matter qha^{-1}	Leaf area index
K_1	85.6	331.41	78.92	3.16
K_2	92.2	359.53	77.12	3.48
K_3	90.8	346.06	74.22	3.34
SEm±	0.45	5.68	0.55	0.026
CD (p=0.05)	1.92	17.94	1.76	0.071
N_1	93.2	353.63	86.78	3.45
N_2	91.3	339.30	85.83	3.32
N_3	94.5	356.60	88.14	3.49
N_4	84.6	334.25	85.11	3.21
N_5	85.7	339.21	85.23	3.25
SEm±	1.42	4.41	0.39	0.062
CD (p=0.05)	4.36	13.64	1.12	0.186

K_1, 100% as basal dose; K_2, 50% as basal dose + 50% at active tillering; K_3, 25 % as basal dose + 75% at active tillering; N_1, 50% as basal + 25% at jointing + 25% at booting stages; N_2, 25% as basal + 75% at active tillering; N_3, 25% as basal + 50% at active tillering + 25% at booting; N_4, 50% as basal + 50% at active tillering; N_5, 0% as basal + 75% at active tillering + 25% at booting.

Effect on Yield attributes of Crop

The various treatments were influenced significantly on yield attributing characters. Among the various treatments, the maximum number of effective tillers, spike length, number of grain spike^{-1}and 1000-gram test weight were recorded. The application of potassium in 2 equal splits increased the grain, straw and harvest index by 45.85 76.85 and 37.20%, respectively over the treatment where the whole potassium was applied once as 100% basal dose (recommended practice). The grain yield with the application of potassium in the ratio of 25: 75 (basal + active tillering) was at par with the recommended practice. The higher grain, straw and harvest index might be owing to the cumulative effect and positive contribution of yield-contributing characters and because of better plant and vegetative growth characters obtained with the application of potassium in 2 equal splits. These findings are in line with those of Lu *et al*. (2014) [7].

The split application of potassium did not affect harvest index significantly, Amal *et al*. (2011) also reported the non-significant effect of split application of potassium. Among the different nitrogen splits, application of nitrogen in 3 splits with reduced basal dose in the ratio of 25: 50: 25 (basal + active tillering + booting) registered higher grain, straw and harvest index. The grain yield was higher by, 48.41, 46.76, 45.28, 43.85, 41.12% over the treatments where nitrogen was applied in 3 splits in the ratio of 50: 25: 25 (basal + jointing + booting) and in 2 splits in the ratios of 25: 75 (basal + active tillering), 50: 50 (basal + active tillering) and 75: 25 (active tillering + booting) respectively (Table 2). Increased yield in 3 splits with reduced basal dose might be owing to efficient utilization and arresting the volatilization and leaching down of nitrogen due to which plants do not suffer any shortage in nitrogen throughout life-cycle which led to an increase in yield component and consequently grain, straw and harvest index. These findings are in line with those of Khan *et al*. (2009) [6]. Harvest index with the application of nitrogen in 3 splits with reduced basal dose in the ratio of 25: 50: 25 (basal + active tillering + booting) was at par with 50: 25: 25 (basal + jointing + booting) but significantly superior to the treatments where nitrogen was applied in 2 splits. Higher harvest index with 3 splits of nitrogen application might be owing to more mobilization of assimilates from source to sink formation. These findings are in line with those of Samsujjaman *et al*. (2009) [15].

Table 2: Yield attributes and Spike length (cm), No. of Spike m^{-2}, No. of grain spike^{-1}, 1000-gram weight, Grain yield, Straw yield and harvest index of wheat as influenced by split application of potassium and nitrogen

Treatment (cm)	Spike length (m^{-2})	No. of Spike Spike $^{-1}$	No. of grains eight	1000-graim	Grain yield	Straw yield	Harvest Index
K_1	10.85	331.31	39.86	43.72	45.85	76.85	37.20
K_2	11.75	363.57	43.24	45.56	48.24	80.42	37.49
K_3	11.21	347.49	41.32	44.60	46.76	78.54	37.31
SEm±	0.921	1.62	0.068	0.072			
CD (p=0.05)	0.278	5.24	0.187	0.213			
N_1	11.45	355.71	41.14	44.87	46.76	81.52	36.45
N_2	11.31	343.25	39.71	44.05	45.28	80.18	36.09
N_3	11.83	358.31	41.75	45.24	48.41	82.36	37.01
N_4	10.95	339.81	39.13	45.24	41.12	78.48	34.38
N_5	11.84	341.62	39.51	43.74	43.85	79.54	35.53
SEm±	0.077	2.52	0.067	0.057			
CD (p=0.05)	0.213	7.12	0.198	0.165			

K_1, 100% as basal dose; K_2, 50% as basal dose + 50% at active tillering; K_3, 25 % as basal dose + 75% at active tillering; N_1, 50% as basal + 25% at jointing + 25% at booting stages; N_2, 25% as basal + 75% at active tillering; N_3, 25% as basal + 50% at active tillering + 25% at booting; N_4, 50% as basal + 50% at active tillering; N_5, 0% as basal + 75% at active tillering + 25% at booting.

Discussion

The application of potassium in two splits proved to be better compared to recommended fertilizer practice in terms of growth, yield, nutrient uptake and relative economics. Thus, split application of potassium and reduced basal dose of nitrogen could help in synchronization of potassium and nitrogen requirements to its peak demand by the crop for increased nutrient uptake and yield in wheat. The application of 30 kg K ha^{-1} in two equal splits and nitrogen 120 kg ha^{-1} in three splits with reduced basal dose (25: 50: 25) were superior in terms of growth, grain and straw yield, nutrient content and uptake on account of applied potassium and nitrogen fertilizer. That Yield attributing characters are the resultant of vegetative growth of the plants. All the attributes *viz* number of ear bearing shoots running $meter^{-1}$ spike length, number of spikelets $spike^{-1}$ and no of grains spike- and 1000- grains weight were affected significantly due to different time of nitrogen application. Highest value of all the yield attributes except number of spikelet and grain $spike^{-1}$ was recorded in the higher net returns in 2 splits of potassium application with 3 splits of nitrogen application was due to steady supply of potassium and nitrogen which synchronized with the peak period of potassium and nitrogen requirement that had resulted in higher yield which fetched higher prices. Mathukia *et al*. (2014) [9, 10] also reported higher net returns and benefit: cost ratio with the application of nitrogen @ 120 kg/ha in 3 splits and potassium @ 30 kg/ha in 2 splits. It was concluded that a significant yield response was observed with the application of potassium in 2 equal splits (50: 50). Among the nitrogen treatments, application of nitrogen in 3 splits with reduced basal dose (25: 50: 25) seems to be economically viable and sustainable as compared to the recommended practice.

Conclusion

The application of potassium in two splits proved to be better compared to recommended fertilizer practice in terms of growth, yield, nutrient uptake and relative economics. The current recommendation of 100% K as basal dose and 50% N as basal dose is not adequate to synchronize K and N supply with actual crop K and N demand due to illitic type of clay minerals and adverse environmental conditions in temperate Kashmir during winter months, which affects the availability of K by fixing it in the interlayer and wedge sides of soil clay and higher basal nitrogen dose gets subjected to leaching losses before plant uptake. The increase in potassium and nitrogen uptake due to split application of potassium and nitrogen with reduced basal dose had proved that the wheat crop requires potassium in two equal splits 50: 50 (basal + active tillering) and lower dose of nitrogen at the early stages (25% N as basal dose) and more N during its grand growth period (50% N at active tillering + 25% N at booting). Thus, split application of potassium and reduced basal dose of nitrogen could help in synchronization of potassium and nitrogen requirements to its peak demand by the crop for increased nutrient uptake and yield in wheat. The application of 30 kg K ha^{-1} in two equal splits and nitrogen 120 kg ha^{-1} in three splits with reduced basal dose (25: 50: 25) were superior in terms of growth, grain and straw yield, nutrient content and uptake on account of applied potassium and nitrogen fertilizer. Moreover, the available K status of the soil was maintained with the splitting of K dose into two equal splits but the available N status of the soil decreased with the application of nitrogen in three splits with reduced basal dose. This suggests that there is need to increase the N dose in order to maintain the N status of the soil. The application of K @ 30 kg ha^{-1} and nitrogen @ 120 kg ha^{-1} in three splits with reduced basal dose (25: 50: 25) gave increased yield of 11.08 q ha^{-1} and 11.82 q ha^{-1}

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