Applied Biological Research 19 (3): 257-263; (2017)
DOI: 10.5958/0974-4517.2017.00038.6

UPTAKE AND AVAILABILITY OF POTASSIUM AND NITROGEN IN WHEAT AS INFLUENCED BY THEIR SPLIT APPLICATION UNDER TEMPERATE CONDITIONS OF KASHMIR

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(Received 20 January, 2017; accepted 29 August, 2017)

ABSTRACT

An experiment was conducted at University Research Farm, SKUAST-K, Shalimar, Srinagar (J&K) to evaluate the effect of split application of potassium and nitrogen on their uptake and availability in wheat. The experiment was laid in a split plot design with 15 treatment combinations, *viz*., 3 levels of potassium (K) @ 30 kg ha^{-1} [K_1: 100% K as basal dose – [recommended fertilizer dose (RFP)]; K_2: split 50:50; K_3: split 25:75] and 5 of nitrogen (N) @ 120 kg ha^{-1} [N_1: 50:25:25 (RFP); N_2: 25:75, N_3: 25:50:25, N_4: 50:50 and N_5: 0:75:25]. The application of K in equal splits (basal + active tillering) improved grain yield by 10.6 and 11.6%, straw yield by 11.6 and 13.4%, K uptake by 17.2 and 18.8% and N uptake by 16.4 and 17.2% during 2013-14 and 2014-15, respectively, over RFP. The available K decreased steadily with recommended application but maintained its status quo when applied in split dose. The available N in soil maintained status quo with RFP; however, it showed decline when K was applied in splits. The N application in 25:50:25 ratios (basal + active tillering + booting) enhanced grain yield, straw yield and total K and N uptake during both the years. Also, K and N content in soil decreased when N was applied in 3 splits as compared to 2 splits, where it maintained status quo after harvest of 2nd year crop. This indicates there may be need to increase N dose in order to maintain the N status of soil.

Key words: Available soil nutrient, nutrient uptake, split application, wheat, yield

INTRODUCTION

Wheat is the second most important cereal crop after rice in India. During 2013-2014 wheat was cultivated on an area of 30.5 million ha with production of 93.5 million tones and productivity of 31.45 q ha^{-1} (Mohanty *et al*., 2015). Wheat crop by virtue of its potentiality is emerging as an important field crop under temperate conditions of Kashmir. In Jammu and Kashmir state, the crop is cultivated on an area of 2.53 lakh ha with a total production of 51.98 lakh quintals and productivity of 22.23 q ha^{-1} (ESJK, 2013-14). Since the area under wheat is almost stagnant and there is little scope for horizontal expansion, therefore the development of suitable wheat agronomy is pre-requisite. Many factors are responsible for increasing growth, yield uptake and availability of nutrients in wheat. Among these proper and balanced application of fertilizers particularly potassium and nitrogen are one of the most important factors contributing towards higher yield, grain quality, productivity, uptake and availability of nutrients.

Potassium is a macronutrient element required in higher concentration for the growth of plants and its availability controls many biochemical and physiological processes in plants so it is often called as “the quality element” (Khan *et al*., 2014). The soils of Kashmir are dominated by illitic type of clay minerals which affect the availability of K by fixing in interlayers and wedge sides of soil clays and so renders it unavailable to the growing plants thereby affect the soil productivity in general and essential minerals in particular. Similarly, nitrogen is an important constituent of plant protoplasm, proteins, nucleic acids and chlorophyll and its availability at critical stages is of paramount importance. The N management plays a key role in improving crop growth, environmental safety and economics of crop production (Maqsood *et al*., 2012). It plays a vital role both during vegetative and reproductive phases of crop. The application of higher basal nitrogen dose (60 kg N ha^{-1}) is often subject to leaching losses and is prone to denitrification or immobilization before plant uptake so is mostly deficient. To reduce K-fixation and leaching losses of N, split application of K and N as per the needs of a growing crop is the best agricultural technique. Split application of K significantly increased the uptake efficiency, productive efficiency of N and K and also increased the grain yield and its protein and wet gluten contents in wheat grains to a greater extent than the basal application of K alone (Wu *et al*., 2008). Split application of K during the growth period has also proved beneficial by simultaneously lowering the loss of K by leaching and by raising the use efficiency of K fertilizers applied (Romheld and Kirkby, 2010). Higher basal nitrogen dose affects N use efficiency due to leaching losses, which necessitates the reduction of basal dose (Mathukia *et al*., 2014). Further, 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). Therefore, split application of K and N in proper propositions as per crop demand is an effective tool. Thus, the present study was aimed to assess the uptake and availability of K and N under the influence of split NK application in wheat (*Triticum aestivum* L.) grown in temperate conditions of Kashmir.

MATERIALS AND METHODS

A field experiment was conducted at campus of SKUAST-K, Shalimar, Srinagar (Kashmir). The experimental site is situated in temperate zone of Jammu and Kashmir between (34º-05′N and 74º-89′E) at an altitude of 1587 m amsl. The experiment was conducted during *rabi* seasons of 2013-14 and 2014-15 on silty clay-loam soil, neutral in pH (6.78), medium in nitrogen (330 kg ha^{-1}), available phosphorus (19.2 kg ha^{-1}) and potassium (140.1 kg ha^{-1}). The sowing of wheat cv. ‘Shalimar Wheat-1’ was done on 12th October and harvested on 28th June during both the years. The rainfall received during the crop-growing season extending from October to June in years 2013-14 and 2014-15 was 793.3 and 1120 mm, respectively.

The experiment comprised 2 factors *i.e.* 3 treatments of potassium (K_1: recommended fertilizer practice [RFP] *viz*., 100% K as basal dose; K_2: split 50:50 as basal dose and at active tillering stage; K_3: split 25:75 as basal dose and at active tillering stage) and 5 treatments of nitrogen [N_1 : RFP *viz*., 50% as basal + 25% at jointing stage + 25% at booting stage; N_2: 25% as basal dose + 75% N at active tillering stage; N_3: 25% N as basal dose + 50% N at active tillering stage+ 25% N at booting stage; N_4: 50% N as basal dose + 50% N at active tillering stage; N_5 : 75% N at active tillering stage + 25% N at booting stage] was laid out in a split plot design with 3 replications. Sowing was done in the 2nd week of October with row to row spacing of 23 cm. Recommended dose of N (120 kg ha^{-1}) and K (30 kg ha^{-1}) was uniformly applied in the form of urea and muriate of potash, respectively, to each sub-plot as per treatment while full dose of phosphorus (60 kg P_2O_5 ha^{-1}) was applied as basal dose in the form of diammonium phosphate. In place of DAP, single super phosphate (375 kg ha^{-1}) was applied in those plots where 0% N was used as basal dose. 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. N and K uptake of grain and straw at harvesting was calculated by multiplying N and K content with the respective grain and straw yield.

N or K uptake of grain (kg ha^{-1}) = N or K content of grain x grain yield (kg ha^{-1})/100

N or K uptake of straw (kg ha^{-1}) = N or K content of straw x straw yield (kg ha^{-1})/100

Total nitrogen/potassium uptake = N or K uptake of grain + N or K uptake of straw

Soil samples at 40 DAS, active tillering, booting and harvesting from 0-15 cm soil depth were collected from each subplot in all the three replications and were shade dried label wise while whole wheat plants from each treatment were taken from an area of about 1 m^2 at these stages. The soil and plant samples for analysis of available soil N and K at active tillering was done before application of treatment. The soil samples after drying were ground, sieved through 2 mm mesh and analyzed for available nitrogen and potassium through Modified Alkaline permanganate method (Subbiah and Asija, 1956) and neutral normal NH_4OAC using systronics flame photometer (Merwin and Peech, 1950), respectively. The oven dried plant samples were grinded with the help of Yarco grinder. Nitrogen content in plant tissue was determined by using Kjeldahl method after digesting the samples with concentrated sulfuric acid (Jackson, 1973) and K content was determined after digestion with tri-acid (HNO_3: H_2SO_4: $HClO_4$) by using flame photometer (Systronics). The statistical analysis of the data was performed using microsoft Excel and "Indostat" softwares. Statistical significance between mean differences among treatments for various parameters was analyzed using critical differences at 0.05 probability level.

RESULTS AND DISCUSSION

Grain, straw and biological yields

Application of potassium (K) in 2 equal splits increased grain yield by 10.57 and 11.48% and straw yield by 11.60 and 13.36% during 2013-14 and 2014-15, respectively, over RFP (Table 1). The higher grain, straw and biological yields might be owing to the cumulative effect and positive contribution of yield-contributing characters and because of better plant and vegetative growth

Table 1: Yield (q ha^{-1}) of wheat as influenced by split application of potassium and nitrogen

Treatments*	Grain yield		Straw yield		Biological yield	
	2013	2014	2013	2014	2013	2014
K_1	33.99	40.14	71.55	83.12	105.54	123.26
K_2	38.01	45.35	80.94	95.94	118.95	141.30
K_3	35.27	41.72	75.54	87.02	110.81	128.74
SEm±	0.70	0.40	0.34	0.71	0.70	0.98
$CD_{0.05}$	2.13	1.21	1.04	2.14	2.12	2.98
N_1	37.08	43.52	76.52	89.00	113.61	132.52
N_2	34.00	40.60	74.16	87.70	108.55	127.80
N_3	39.41	46.01	80.10	92.58	119.52	138.60
N_4	33.33	40.10	74.05	86.52	108.05	127.13
N_5	34.95	41.78	75.22	87.66	109.11	129.45
SEm±	0.70	0.68	0.87	0.11	1.14	1.34
$CD_{0.05}$	2.06	2.00	2.54	3.34	3.34	3.93

K_1: Recommended fertilizer practice [RFP] *i.e.*, 100% K as basal dose; K_2: split 50:50 as basal dose and at active tillering stage; K_3: split 25:75 as basal dose and at active tillering stage

N_1: RFP *i.e.*, 50% as basal + 25% at jointing stage + 25% at booting stage; N_2: 25% as basal dose + 75% N at active tillering stage; N_3: 25% N as basal dose + 50% N at active tillering stage + 25% N at booting stage; N_4: 50% N as basal + 50% N at active tillering stage; N_5: 75% N at active tillering stage + 25% N at booting stage characters obtained with the application of K in 2 equal splits. These findings are in line with those of Lu *et al.* (2014). Among the different nitrogen (N) splits, the application of N in 3 splits with reduced basal dose in the ratio of 25: 50: 25 (basal + active tillering + booting) registered higher grain, straw and biological yields. The grain yield was higher by 5.91 and 4.46% and straw yield by 5.41 and 3.86% during 2013-14 and 2014-15, respectively, as compared to the recommended practice. Increased yield in 3 splits with reduced basal dose might be owing to efficient utilization and arresting the volatilization and leaching down of N due to which plants do not suffer any shortage in N throughout life-cycle of the crop which led to an increase in yield component and consequently grain, straw and biological yields. The findings are in line with Khan *et al.* (2009).

K and N uptake

Total K uptake with the application of K in 50: 50 ratio (basal + active tillering) was enhanced by 17.2 and 18.8%, N uptake by 16.4 and 17.2% over 100% as basal dose during the years 2013-14 and 2014-15, respectively (Table 2). It might be attributed to higher availability of K and lower transformation of K into non-exchangeable pool due to split application of K into two equal splits which resulted in better utilization, higher dry matter accumulation and nutrient uptake by crop. Lu *et al*. (2014) and Wani *et al*. (2014) also registered maximum total nutrient uptake by wheat crop with two equal splits of K over single split of basal application. Application of N in 3 splits with reduced basal dose in the ratio of 25: 50: 25 (basal + active tillering + booting) enhanced total K uptake by 4.45 and 3.89 % and total N uptake by 6.73 and 7.31% during the years 2013-14 and 2014-15, respectively, as compared to 50: 25: 25 (basal + active tillering + booting). Splitting of N fertilizer with reduced basal dose increased the efficiency of fertilizers by decreasing leaching losses of NO_3 to a large extent and increased both yield and quality of crops. These results are in confirmation with Ali (2011) [Table 1].

Soil available K and N

From 40 DAS to boot stage the available soil potassium except the RFP was more as compared to the initial available soil potassium, it might be due to the application of potassium according to the

Table 2: Uptake of potassium and nitrogen (kg ha^{-1}) at harvest by wheat as influenced by split application of potassium and nitrogen

Treatments	K uptake at harvest				Total K uptake at harvest (grain + straw)		N uptake at harvest				Total N uptake at harvest (grain + straw)	
	2013-14		2014-15		2013-14	2014-15	2013-14		2014-15		2013-14	2014-15
	Grain	Straw	Grain	Straw			Grain	Straw	Grain	Straw		
K_1	10.94	92.30	13.07	108.39	103.25	121.46	53.30	27.71	63.32	32.73	81.02	96.05
K_2	13.09	111.55	15.81	133.74	124.65	149.55	63.34	33.61	75.97	40.03	96.95	116.01
K_3	11.52	98.47	13.78	114.75	110.00	128.54	57.83	30.89	68.83	35.81	88.73	104.64
SEm±	0.21	1.08	0.07	1.30	0.82	0.84	1.21	0.41	0.64	0.49	1.36	1.70
$CD_{0.05}$	0.64	3.28	0.26	5.11	3.22	3.29	3.65	1.24	1.94	1.53	4.16	3.22
N_1	12.57	105.37	15.14	123.91	118.12	139.04	62.74	32.09	73.41	37.56	94.84	110.98
N_2	10.63	96.07	12.95	113.35	106.70	126.31	52.44	29.74	63.48	34.88	82.19	98.36
N_3	13.54	110.08	15.99	128.68	123.63	144.68	67.78	33.90	80.30	39.43	101.69	119.74
N_4	10.72	94.08	12.98	111.30	104.80	124.28	51.14	28.19	61.71	33.72	79.60	95.49
N_5	11.62	98.27	14.04	117.55	109.89	131.60	56.42	28.75	67.90	35.35	86.18	103.26
SEm±	0.28	1.69	0.32	2.61	1.84	2.00	1.29	0.48	1.25	0.57	1.36	1.46
$CD_{0.05}$	0.83	4.95	0.94	7.64	5.37	6.01	3.78	1.40	3.66	1.68	3.97	4.27

K_1: Recommended fertilizer practice [RFP] *i.e.*, 100% K as basal dose; K_2: split 50:50 as basal dose and at active tillering stage; K_3: split 25:75 as basal dose and at active tillering stage

N_1: RFP *i.e.*, 50% as basal + 25% at jointing stage + 25% at booting stage; N_2: 25% as basal dose + 75% N at active tillering stage; N_3: 25% N as basal dose + 50% N at active tillering stage + 25% N at booting stage; N_4: 50% N as basal + 50% N at active tillering stage; N_5: 75% N at active tillering stage + 25% N at booting stage

Table 3: Available soil potassium (kg ha^{-1}) at different growth stages of wheat as influenced by split application of potassium and nitrogen

Treatments	40 DAS		Active tillering		Boot stage		Harvest	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
K_1	169.56	163.04	161.39	155.53	137.16	135.53	134.59	133.10
K_2	144.13	146.93	138.26	140.38	146.22	145.18	141.18	139.02
K_3	140.84	138.76	130.34	131.61	150.08	149.41	142.24	140.51
SEm±	2.76	2.98	2.45	2.86	1.05	1.41	0.70	0.58
$CD_{0.05}$	8.45	8.92	7.38	8.61	3.17	4.25	2.10	1.75
N_1	159.32	151.51	148.03	142.57	149.27	143.57	138.35	136.07
N_2	150.00	149.04	143.72	141.14	144.71	142.47	140.55	138.69
N_3	145.63	142.29	139.63	139.70	140.26	139.37	137.73	134.70
N_4	158.22	153.60	147.36	145.11	148.00	146.45	140.67	140.11
N_5	144.39	150.78	139.24	144.03	140.18	145.03	139.38	138.15
SEm±	4.34	2.62	1.93	2.72	0.94	1.36	1.01	0.94
$CD_{0.05}$	12.68	7.65	5.63	7.96	2.75	3.98	2.95	2.74

Initial available soil K = 140.1 kg ha^{-1}

K_1: Recommended fertilizer practice [RFP] *i.e.*, 100% K as basal dose; K_2: split 50:50 as basal dose and at active tillering stage; K_3: split 25:75 as basal dose and at active tillering stage

N_1: RFP *i.e.*, 50% as basal + 25% at jointing stage + 25% at booting stage; N_2: 25% as basal dose + 75% N at active tillering stage; N_3: 25% N as basal dose + 50% N at active tillering stage + 25% N at booting stage; N_4: 50% N as basal + 50% N at active tillering stage; N_5: 75% N at active tillering stage + 25% N at booting stage

treatments. From boot stage to harvest the available soil K depicted a decrease which might be attributed to its uptake and fixation (Nachimuthu *et al*. (2007). At harvest the available soil K was more in the soils applied with K in 2 splits in 25:75 and 50:50 ratios. The more available soil K might be attributed to lower transformation of K into non-exchangeable pool in case of split application (Table 3). These finding is in agreement with Bangroo *et al*. (2012) and Wani *et al.* (2014).

With respect to N splits, available soil K from 40 DAS to boot stage was more as compared to initial available soil K status, however at boot stage the available soil K was little bit more as compared to active tillering, it might be due to the application of K to the main plots at active tillering according to the treatments. However, available soil K at harvest with the application of N 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) and 0:75:25 (basal + active tillering + booting) but less as compared to the treatments where N was applied in 2 splits in 25:75 ratio (basal + active tillering) and 50:50 ratio (basal + active tillering) during both the years. It might be due to the efficient utilization and uptake of K in treatments where N was applied at critical stages. Jan *et al.* (2010) also reported increased nutrient uptake and lower available K status in soil when N @120 kg ha^{-1} was applied in three equal splits than two split applications of N.

The available soil N decreased continuously from 40 DAS to harvest period. At harvest the available soil N was less in soils applied with K in 2 splits in 25:75 and 50:50 ratios as compared to the treatment where K was given in single split as 100% basal dose (recommended practice) during both the years (Table 4). The less available soil N might be due to the increased biomass and more N uptake with 2 equal split application of K, which ultimately led to a proportional decline in soil available N. The results are in conformity with the findings of Nachimuthu *et al*. (2007).

With respect to N splits, the available N was less with the application of N in 3 splits as compared to the treatments where N was applied in 2 splits during both the years. It might be due to the efficient utilization and uptake of N in 3 splits as compared to 2 splits. Pasha *et al*. (2007) also reported lower amount of available N content at harvest in wheat with the application of N in 3 splits as compared to 2 splits.

Table 4: Available soil nitrogen (kg ha^{-1}) at different growth stages of wheat as influenced by split application of potassium and nitrogen

Treatments	40 DAS		Active tillering		Boot stage		Harvest	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
K_1	350.16	349.57	338.01	337.16	333.79	333.05	330.50	328.85
K_2	346.13	344.74	333.99	333.30	329.04	328.30	326.28	324.83
K_3	343.29	341.10	331.15	330.06	330.20	330.02	328.51	327.26
SEm±	0.49	0.41	0.37	0.46	0.85	0.81	0.92	1.13
$CD_{0.05}$	1.50	1.23	1.20	1.40	2.65	2.45	2.80	3.32
N_1	366.72	364.90	343.00	342.13	333.94	332.78	327.24	325.79
N_2	335.88	334.06	330.88	330.01	333.95	332.80	328.59	327.14
N_3	335.82	334.00	330.82	329.95	332.14	330.98	325.79	324.34
N_4	365.66	363.84	341.00	340.12	326.60	325.45	329.07	327.62
N_5	328.55	327.02	326.20	325.32	330.44	330.28	331.46	330.01
SEm±	1.61	1.60	1.61	1.44	1.92	1.90	1.20	1.70
$CD_{0.05}$	4.71	4.80	4.72	4.21	5.62	5.60	3.57	5.20

Initial available soil nitrogen= 330 kg ha^{-1}

K_1: Recommended fertilizer practice [RFP] *i.e.*, 100% K as basal dose; K_2: split 50:50 as basal dose and at active tillering stage; K_3: split 25:75 as basal dose and at active tillering stage;

N_1: RFP *i.e.*, 50% as basal + 25% at jointing stage + 25% at booting stage; N_2: 25% as basal dose + 75% N at active tillering stage; N_3: 25% N as basal dose + 50% N at active tillering stage + 25% N at booting stage; N_4: 50% N as basal + 50% N at active tillering stage; N_5: 75% N at active tillering stage + 25% N at booting stage

Conclusion: From the study it may be concluded that a significant response in terms of yield, uptake and availability of K and N at harvest was obtained with the application of K in 2 equal splits (50:50) and with the application of N in 3 splits with reduced basal dose (25:50:25) as compared to the recommended practice. However, K and N status of soil decreased where N was applied in 3 splits as compared to 2 splits, where it maintained its status quo position after the harvest of 2nd year crop. This suggests that there is the need to increase the N dose in order to maintain the N status of the soil.

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