



Impact of Split Nitrogen and Potassium Applications on Nutrient Content and Uptake in Wheat (*Triticum aestivum* L.)

Sabia Akhter ^{a++}, Ambreen Nabi ^{a#*}, Bilal Ahmad Lone ^{a†},
Shazia Ramzan ^{a‡}, Vaseem Yousuf ^{a^}, Bhinish Shakeel ^{a##},
K. A. Zargar ^{a#^}, Iram Farooq ^{a§} and Himayat Gulzar ^{b^^}

^a KVK Budgam, SKUAST K, Shalimar Srinagar, India.

^b FOA, SKUAST -K, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted during the winter (*rabi*) seasons of 2020-21 and 2021-22 at Krishi Vigyan Kendra, Budgam- Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir, to evaluate the Nutrient Content (Nitrogen and Potassium) and their uptake by Wheat

⁺⁺Scientist Agronomy;

[#] Scientist Vegetable Science;

[†] Sr. Scientist and Head;

[‡] Scientist Soil Science;

[^] Scientist Plant Protection;

^{##} Scientist Home Science;

^{#^} Programme Assistant Horticulture;

[§] Programme Assistant Fisheries;

^{^^} MSc Scholar;

*Corresponding author: E-mail: ambre_nabi@yahoo.co.in;

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(*Triticum aestivum* L.) as influenced by split application of Potassium and Nitrogen. The experiment was set up in a split-plot design replicated thrice with Potassium splits as main plot factor and nitrogen splits as sub plot factor which resulted in 15 treatment combinations, viz. of potassium @ 30 kg/ha [K₁: 100% as basal dose-(RFP); K₂: 50% as basal dose + 50% at active tillering; K₃: 25 % as basal dose + 75% at active tillering] and 5 treatments of nitrogen @ 120 kg/ha in split ratios of [N₁ : 50% as basal + 25% at jointing + 25% at booting stage (RFP); N₂:25% as basal dose + 75% at active tillering; N₃ : 25% as basal dose +50% at active tillering + 25% at booting; N₄ : 50% as basal + 50% at active tillering; N₅ : 0% as basal + 75% at active tillering + 25% at booting]. The results of pooled data (2 yrs.) revealed that nutrient content and uptake (nitrogen and potassium) of wheat crop at various phenological stages were significantly more with the application of Potassium in two equal splits in the ratio of 50:50 as compared to the treatment where potassium was applied in one split as 100% basal dose. With the application of potassium in two equal splits (50:50), increase in Nitrogen, Potassium content(%) their uptake and dry matter accumulation by wheat crop was significantly higher as compared to recommended fertilizer application (K₁). Application of nitrogen in three splits with reduced basal dose in the ratio of 25:50:25 resulted in an increase of Nitrogen, Potassium content (%), their uptake and dry matter accumulation at all phenological stages by wheat crop and at physiological maturity there was an increase by 2.40%, 7.4%, 10.17 %, 8.83% in Nitrogen, Potassium content (%), their uptake and dry matter accumulation respectively, as compared to recommended practice.

Keywords: *Dry matter accumulation; nitrogen content and uptake; nitrogen and potassium splits; potassium content; wheat.*

1. INTRODUCTION

“Wheat crop by virtue of its potentiality is emerging as an important field crop under the Kashmir valley conditions. Globally wheat grain is grown on more land area than any other commercial food. It is the leading source of vegetable protein in human food, having a higher protein content (12-18%) than other major cereals, maize or rice and contains about 70% starch and is the source of approximately half of the food calories consumed worldwide” [1]. “Since the area under wheat is almost stagnating and there is little scope for horizontal expansion. Therefore, development of wheat agronomy is pre-requisite. Many factors are responsible for increasing growth, yield and quality of wheat. Among these proper and balanced application of fertilizers is one of the most important factor contributing towards higher grain quality and productivity” [2,3,4,5]. “Potassium and nitrogen plays a critical role for improving nutrient content and quality of wheat and potassium also improves water and nutrient use efficiency, improves stress tolerance, reduces incidence of pests 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” [6]. “As the soils of Kashmir are dominated by illitic type of clay minerals which affects the availability of K by fixing it in the interlayers and wedge sides of soil clays and reduces the availability of K to growing plants”

[7] that affects the soil productivity in general and particularly depletes the essential nutrients in the soil [8]. “So to reduce the fixation of potassium and to increase its availability, split application of K according to the demand of a growing crop is the best agricultural technique. Timing of N application at preplanting, stem elongation, heading and flowering or by increasing the number of split applications improves nutrient content and quality of wheat” [9,10]. Thus, the present study entitled “Nutrient Content and their Uptake (Nitrogen and Potassium) by Wheat (*Triticum aestivum* L.) as Influenced by Split Application of Potassium and Nitrogen” was carried out during *rabi* seasons of (2020-2021 and 2021-2022) at KVK Budgam, SKUAST-Kashmir, Shalimar.

2. MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) seasons of (2020–21 and 2021–22) at KVK Budgam, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Srinagar. The experiment was conducted on silty clay-loam soil, neutral in pH (7.08), medium in nitrogen (380 kg/ha), available phosphorus (18.2 kg/ha), and potassium (160.1 kg/ha). The experiment comprised 2 factors viz. 3 treatments of potassium (K₁ , 100% K basal dose-recommended fertilizer practice; K₂ , 50% K as basal dose + 50% K at active tillering; K₃, 25% K as basal dose + 75% K at active tillering) and 5

treatments of nitrogen [N1 , 50% N as basal + 25% N at jointing + 25% N at booting stages (RFP); N2 , 25% N as basal dose + 75% N at active tillering; N3 , 25% N as basal dose + 50% N at active tillering + 25% N at booting; N4 , 50% N as basal + 50% N at active tillering; N5 , 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 first week of October with row-to-row spacing of 30 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 P₂ O₅ /ha) through Di Ammonium 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. Sowing was done manually using seed rate of 120 kg ha⁻¹ and seeds were placed 3-4 cm deep in furrows. Pre emergence herbicide Pendimethalein (30 EC) was applied plot wise @1kg a.i ha⁻¹ three days after sowing and the first hand weeding was done after 35-40 DAS to flush out the autumn weeds and second hand weeding was done in the month of March to flush out the spring weeds. There was no requirement of irrigation due to sufficient availability of moisture during the crop growth. After removing two boundary rows in width from each side of the plot and half a meter in length from the other two, harvesting was completed at physiological maturity. After 48 hours of field drying, the harvested crop was heaped into bundles. Samples for the buildup of dry matter were taken in the penultimate rows from each side. At 40 DAS, active tillering, booting and at physiological maturity whole wheat plants from each treatment were taken from an area of about 1 m². These samples were put in an electric oven, dried for 36 hours at 60-65°C temperature. 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 [11] and K content was determined after digestion with tri-acid (HNO₃: H₂SO₄: HClO₄) by using Flame photometer. Prior to applying nitrogen and potassium, plant samples were taken in order to analyze the N and K levels during active tillering. N and K content were multiplied by the corresponding dry matter accumulation at 40 DAS, active tillering, booting, and physiological maturity to determine N and K uptake at these stages. The crop was grown as rainfed, although standard cultural procedures were maintained

until the crop reached maturity. The statistical analysis of the data was performed using Microsoft Excel and "Indostat" softwares. Critical differences (CD) at the 0.05 probability level were used to assess the statistical significance of mean differences among treatments for different parameters.

3. RESULTS AND DISCUSSION

3.1 Periodic Nutrient Content (%) (Nitrogen and Potassium), Dry Matter Accumulation (q/ha) and Uptake of Nutrients (kg/ha) by the Crop

Split application of potassium and nitrogen had a significant effect on periodic nitrogen and K content of wheat crop during the two growing seasons. The data indicated the decreasing trend of nutrient content (nitrogen and potassium) from 40 DAS to harvest, it is due to the dilution effect. During the early growth stages, the plant has a lower dry matter content, and the nitrogen is concentrated in fewer plant parts, leading to higher nitrogen content. As the plant grows, the dry matter content increases, and the nitrogen is distributed throughout the plant, leading to a decrease in nitrogen concentration [12]. At 40 DAS to active tillering nutrient content with the application of potassium in one split(100% basal dose)was maximum in plant sample as compared to other two treatments where potassium was given in two splits in the ratio of 50: 50 (basal + active tillering) and 25: 75 (basal + active tillering).It might be due to application of 100% recommended dose of K as basal that results in more available potassium in soil solution during the early growth stages that leads to more potassium content in plant samples. However from boot stage to physiological maturity nutrient content, dry matter accumulation and uptake of nitrogen and potassium recorded with the application of potassium in two equal splits in the ratio of 50: 50 (basal +active tillering) was at par with the application of potassium in two splits in the ratio of 25: 75 (basal + active tillering) but significantly higher than the treatment where potassium was given in one split as100%basal dose (Tables 1& 2).Application of 50 and 75 percent of recommended dose of potassium at active tillering might helped in maintaining the K availability in the root zone and thus enhanced the supply of potassium to the economical part of the crop [13,14]. Significant effect on potassium content of grains was also registered earlier [15] with the application of potassium

Table 1. Pooled Data (2 Yrs) of Nitrogen Content, Dry Matter Accumulation and Uptake of Nitrogen at Different Growth Stages of Wheat as Influenced By Split Application of Potassium and Nitrogen

Treatments	N Content (%)	Dry matter Accumulation (g/ha)	Uptake of N (Kg ha ⁻¹)	N Content (%)	Dry matter Accumulation (g/ha)	Uptake of N (Kg ha ⁻¹)	N Content (%)	Dry matter Accumulation (g/ha)	Uptake of N (Kg ha ⁻¹)	N Content (%)	Dry matter Accumulation (g/ha)	Uptake of N (Kg ha ⁻¹)
	40DAS			Active tillering			Boot stage			Physiological Maturity		
K1	2.94	1.68	4.94	2.58	5.50	14.15	2.03	36.52	74.13	1.95	88.54	172.64
K2	2.75	1.54	4.23	2.39	5.00	11.91	2.22	41.12	91.07	2.07	106.48	220.41
K3	2.70	1.35	3.64	2.30	4.45	10.21	2.16	39.39	85.08	2.04	96.69	197.24
SEm±	0.03	0.04	0.09	0.03	0.20	0.01	0.02	0.70	0.01	0.02	3.26	7.74
CD(p=0.05)	0.09	0.11	0.28	0.11	0.61	0.07	0.08	2.16	0.17	0.07	9.99	23.87
N1	2.84	1.63	4.63	2.49	5.42	13.46	2.18	39.77	86.49	2.08	102.91	214.05
N2	2.80	1.53	4.29	2.41	5.03	12.10	2.15	39.63	85.00	1.98	90.28	178.74
N3	2.81	1.49	4.18	2.45	4.90	11.97	2.13	39.90	84.78	2.13	110.72	235.82
N4	2.84	1.60	4.53	2.46	5.15	12.63	2.12	37.74	79.81	1.90	87.55	165.90
N5	2.70	1.38	3.72	2.31	4.42	10.18	2.14	38.03	81.18	2.01	94.72	190.39
SEm±	0.02	0.02	0.12	0.03	0.16	0.01	0.01	0.40	0.01	0.01	1.41	4.03
CD(p=0.05)	0.05	0.06	0.37	0.10	0.46	0.04	0.04	1.16	0.05	0.03	4.12	14.28
100% as basal dose				K ₁			50% as basal+25% at jointing+25% at booting stages			N ₁		
50% as basal dose+50% at active tillering				K ₂			25% as basal+75% at active tillering			N ₂		
25% as basal dose+ 75% at active tillering				K ₃			25% as basal+50% at active tillering+25% at booting			N ₃		
							50% as basal+50% at active tillering			N ₄		
							0% as basal +75% at active tillering+25% at booting			N ₅		

Table 2. Pooled Data (2 Yrs) Of Potassium Content, Dry Matter Accumulation and Uptake of Potassium at Different Growth Stages of Wheat as Influenced By Split Application of Potassium and Nitrogen

Treatments	K Content (%)	Dry matter Accumulation (q/ha)	Uptake of K (kg ha ⁻¹)	K Content (%)	Dry matter Accumulation	Uptake of K (kg ha ⁻¹)	K Content (%)	Dry matter Accumulation (q/ha)	Uptake of K (kg ha ⁻¹)	K Content (%)	Dry matter Accumulation (q/ha)	Uptake of K (kg ha ⁻¹)
	40DAS			Active tillering			Boot stage			Physiological Maturity		
K ₁	2.35	1.68	3.95	2.29	5.50	12.60	2.15	36.52	78.52	1.61	88.54	142.55
K ₂	2.31	1.54	3.56	2.26	5.00	11.30	2.24	41.12	92.11	1.73	106.48	183.68
K ₃	2.24	1.35	3.02	2.17	4.45	9.66	2.18	39.39	85.87	1.67	96.69	160.99
SEm±	0.02	0.04	0.00	0.02	0.20	0.00	0.02	0.70	0.01	0.02	1.53	0.03
CD(p=0.05)	0.06	0.11	0.01	0.07	0.61	0.04	0.06	2.16	0.13	0.06	3.69	0.23
N ₁	2.39	1.63	3.90	2.30	5.42	12.47	2.23	39.77	88.69	1.73	102.91	178.03
N ₂	2.28	1.53	3.49	2.23	5.03	11.22	2.19	39.63	86.79	1.60	90.28	144.45
N ₃	2.27	1.49	3.38	2.22	4.90	10.88	2.19	39.90	87.38	1.75	110.72	193.76
N ₄	2.35	1.60	3.76	2.28	5.15	11.74	2.19	37.74	82.65	1.59	87.55	139.20
N ₅	2.22	1.38	3.06	2.17	4.42	9.59	2.15	38.03	81.76	1.66	94.72	157.24
SEm±	0.02	0.02	0.00	0.02	0.16	0.00	0.02	0.40	0.01	0.02	1.41	0.03
CD(p=0.05)	0.05	0.06	0.00	0.06	0.46	0.03	0.05	1.16	0.06	0.07	4.12	0.29

sulphate at elongation stage and before heading time in bread wheat. Similarly, split application of nitrogen significantly influenced the nitrogen and potassium content during both the years. From 40 DAS to boot stage nitrogen and potassium content in plant samples recorded with the application of nitrogen in three splits in the ratio of 50:25:25 (basal+ jointing + booting) was higher as compared to other treatments. However at physiological maturity nutrient content, dry matter accumulation and uptake of nutrients recorded with the application of nitrogen in three splits in the ratios of 25:50:25 (basal + active tillering + booting) was found at par with 50: 25: 25 (basal + jointing +booting) but significantly superior as compared to the treatments where nitrogen was applied in two splits in the ratios of 25: 75 (basal + active tillering), 50:50 (basal+ active tillering) and 75: 25(active tillering + booting).

4. CONCLUSION

The application of potassium in two splits proved to be better compared to recommended fertilizer practice in terms of dry matter accumulation, nutrient content and uptake. 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 dry matter accumulation, nutrient content and uptake in wheat.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image

generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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