# Deterministic Parameters of Growth and Yield of Wheat (*Triticum aestivum L.*) as influenced by Fractional application of Nitrogen and Potassium.


## ABSTRACT

An experiment was conducted during the winter (*rabi*) seasons of 2020-21 and 2021-22 at Krishi Vigyan Kendra, Budgam-SherKashmir University of Agricultural Sciences and Technology, Kashmir, to evaluate the growth and yield variability of wheat as effected by split application of potassium (K) and nitrogen (N). The experiment was set up in a split-plot design replicated thrice with K splits as main plot factor and N splits as sub plot factor which resulted in 15 treatment combinations, viz. of K 30 kg/ha [$K_1$: 100% as basal dose-(RFP); $K_2$: 50% as basal dose + 50% at active tillering; $K_3$: 25 % as basal dose + 75% at active tillering] and 5 treatments of N:120 kg/ha in split ratios of [$N_1$ : 50% as basal + 25% at jointing + 25% at booting stage (RFP); $N_2$: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 like dry matter accumulation, leaf area index, SPAD reading at various phenological stages and quality parameters like Ncontent(%) of grain and straw,proteincontent of grain, yield andNuseefficiency were significantly more with the application of K in two equal splits in the ratio of 50:50 as compared to the treatment where K was applied in one split as 100% basal dose. There was the non-significant effect of split application of K and N on days taken to different phenological stages. Increase in Ncontent(%) of grain was 5.76 and 5.73% during the year 2020-21 and 2021-22, respectively. Average percent increase in grain yield, protein content of grain and N use efficiency (grain yield (kg)/kg Napplied) with the application of K in two equal splits in the ratio of 50:50 during both the years was 12.46, 5.81 and 12.46% that was significantly higher as compared to recommended fertilizer application ($K_1$).



**Keywords**: Grain yield, Nitrogen content, Nitrogen use efficiency, Nitrogen and potassium splits, Protein content, Wheat yield.


## Introduction

Wheat crop by virtue of its potentiality is emerging as an important fieldcrop under the Kashmir valley conditions. Globally, wheat grain is grown on moreland area than any other commercial food.It is the leading source of vegetableprotein in human food, having a higher protein content (12-18%) than other majorcereals, 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 andthere islittle scope for horizontal expansion. Therefore, development of wheat agronomyis pre-requisite.Many factors are responsible for increasing growth, yield andquality of wheat.Among these properand balanced application of fertilizers isone of the most important factor contributing towards higher grain quality andproductivity[2].Potassium(K) andnitrogen(N) playacriticalrolefor improving growth,yieldand qualityof wheat and K 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[3].As the soils of Kashmir are dominated by illitic type of clay mineralswhichaffectstheavailabilityofKbyfixingitintheinterlayersandwedgesides ofsoilclaysandreduces the availability of K togrowingplants[4]thataffectsthesoil ingeneral and particularly depletes the essential nutrients in the soil [5]. 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 bestagriculturaltechnique.TimingofNapplicationatpre-planting,stemelongation,headingandflowering or by increasing the number of split applications improves the growth, quality andgrainyieldofwheat[6,7]. Thus, the present study entitled "Deterministic Parameters of Growth and Yield of Wheat (*Triticumaestivum L.*) as influenced by Fractional application of Nitrogen and Potassium" wascarried out during *rabi*seasons of (2020- 2021and 2021-2022) at KVK Budgam, SKUAST-Kashmir, Shalimarwith thefollowingobjective:

- Tostudythe effectofsplitapplicationofpotassiumandnitrogenonGrowthandQuality ofwheat.

## 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 (N) (380 kg/ha), available phosphorus (P) (18.2 kg/ha), and potassium (K) (160.1 kg/ha). The experiment comprised 2 factors viz.3 treatments of K (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 N [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 N (120 kg/ha) and K (30 kg/ha) through urea and MOP respectively, was uniformly applied to each subplot as per the treatments while full dose of phosphorus (60 kg $P_2O_5$/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. Sowing was done manually at a distance of 23 cm apart from row to rowusingseedrate of 120kgha$^{-1}$ and seeds wereplaced 3-4 cmdeep 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 themonthof March to flushout thespringweeds. There was no requirement of irrigation due to sufficient availability ofmoistureduringthecropgrowth. Due to observance of sporadic attack of yellow rust during the first year ofexperiment, Propaconazole (25 EC) was sprayed on 26$^{th}$ March @ 1ml/lt. with thehelpof Knapsack sprayer. Harvesting was done at physiological maturity after excluding two borderrows breadth wise on each side of the plot and half of the meter length wise fromother two sides. The harvested crop was allowed to dry in field for 48 hours andwaspiled into bundles. For the purpose of recording non-destructive parameters, five plants wererandomly selected and tagged in each sub plot of replications and then the averagefor Leaf Area Index (AccuparL-80), SPAD reading (SPAD-502 Konica Minolta Sensing) was worked out and recorded at various phenological stages. Penultimate rows from each side were used to collect samples for dry matteraccumulation.Number of days taken by crop to reach various phenological stages *viz*.emergence,crownrootinitiation,activetillering,jointing,booting,heading,anthesis, milk, dough and maturity were recorded from each sub plot during boththe years. Thegrainandstrawsamples were oven dried, grinded and sieved through 1mm size sieve, the strawandgrainsampleswereanalyzedforNcontentfromeachsub-plotseparately. Theprotein contentof thegrainwasworkedoutas;

%protein =%Nx5.7(AACC, 2000)

Nitrogenuseefficiency(NUE)wascalculatedas;

NUE=Grainyield(kg)/kgNitrogenapplied[8]

Standard cultural practices were followed until the crop matured but the crop was cultivated as rainfed. The grain yield data was adjusted at 14% moisture content.

**Statistical analysis**

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 (CD) at 0.05 probability level.

## RESULTS AND DISCUSSION

### Growth Attributes and Grain Yield

Thedrymatteraccumulation, LAI and SPAD values weresignificantlyaffectedbysplitapplicationofboth potassiumandnitrogenatallthestagesofcropgrowth. Application of potassium in two equal splits in the ratio of 50: 50 (basal +activetillering)recordedsignificantlyhigherdrymatteraccumulationat maturity by2.51and 5.86% during the year 2020-21 and by 2.92 and 7.49% during the year 2021-22, respectively,over the treatment wherepotassium was givenin two splits in the ratio of 25: 75 (basal + active tillering) and the treatment wherepotassium was given in one split as 100% basal dose (recommended practice) (Table 1). The LAI and SPAD reading continued to increase upto anthesis and thereafterdeclinedtill harvest of thecrop in all thetreatments. It is because of the transition period fromvegetativeto reproductivephase as [9]. At anthesis the application of potassium in two splits in the ratios of 50: 50 (basal + active tillering) andin the ratio of 25: 75 (basal + active tillering)recorded significantly higher leaf area index (3.80; 3.78) and SPAD values (50.35 ; 47.91) during the year2020-21 while 3.90; 3.84 and 51.15; 48.68during the year 2021-22 as compared to the treatmentwherepotassiumwasgiveninonesplitas100%basaldosewhichrecordedLAI (3.54 and 3.61) and SPAD values (45.28 and 45.98) respectively during both the years (Table 2; Fig. 1a). The increased dry matter accumulation, LAI, SPAD values with application of K in 2 equal splits leads to greater availability of K and lower transformation of potassium into non-exchangeable pool, where its availability regulates numerous biochemical, phenological, and physiological responses in plants [10,11] such as water uptake [12]; nutrient translocation [13], enzyme activation [14], photosynthesis [15], protein synthesis [16], osmoregulation [17] resultingintaller plants,more number of tillers and hence more dry matter accumulation [18], betterfoliagegrowthandhencehigherleafareaindex[19] and delay in leaf senescence that leads to higher SPAD values. Similarresultswere reported withtheapplicationofpotassiumin two equal splits as compared to 60 kg$K_2O$/haas basal [20]. The days taken to different phenological stages by wheat are illustrated graphically in Fig. 2a and 2b and shows that split application of potassiumand nitrogen did not differ significantly. This is because days taken to different phenophases depends upon the twomostimportantfactorsthataffectrateofdevelopment in plants are photoperiod and temperature. These two factors wereuniformly experienced by wheat crop in different plots and thus the developmentin all plants was uniform and the days taken to different phenological stages werethesame. Similarfindings were reported earlier [21]. Nitrogen content (grain and straw) and proteincontentingrainwiththeapplicationofpotassiumintwo equal splits in the ratios of 50: 50(basal + active tillering)wasat par with25:75(basal+activetillering)butsignificantly higherascomparedtothetreatmentwherepotassiumwasgiveninonesplitas100%basaldose(recommendedpractice)duringboththeyears (Table 3). Greater availability of K in case of split application of K had the role in increasing translocation of photo assimilates fromleaves to the grains [22] and attributed to improved utilizationofN and hence higher protein content [23]**.**Theseresultsareinconfirmationwith earlier results [24, 25, 26].Potassiumin two equalsplitsin theratio of 50: 50 (basal + active tillering) recorded significantly maximum grainyieldof38.09qha$^{-1}$ and nitrogenuseefficiency of 31.68 (kg grain yield/kgN applied)during theyear2020-21 andof45.35qha$^{-1}$ and 37.79 (kg grain yield/kgNapplied)during theyear2021-22 ascomparedtothe treatments where potassiumwas appliedin,twosplitsintheratioof25:75(basal+activetillering)andthetreatment where potassiumwas applied in one split as100% basal dose (recommendedpractice).Thegrainyield and nitrogenuseefficiencywiththeapplicationofpotassiumintheratioof25:75(basal+activetillering)wasatparwiththerecommendedpractice (Table 3). Application of potassium in split doses enhanced the enzymatic activities, these reactions resulted in higher mobilization of nutrients in soil and plant and increased translocation of photosynthates in plant system, helps to produce large amounts of starch due to K-mediated carbohydrate metabolism leading to higher grain yield. Similar findings were reported earlier [3]. Maximum NUE in two equal splits of potassium might be due toprolonged availability of K in soil that promoted the absorption of top-dressed andsoil applied N by plant that resulted in higher yield from same amount of nitrogen applied (120kg/ha) and hence higher NUE. Earlier reports suggest thatsplitapplicationofKinwheatpromotedtheabsorptionoftop-dressedand soil applied N byplant [27, 38].

Further it is evident from the data, that the application of nitrogen in the ratio of 25: 50: 25 (basal + active tillering + booting) provedeffectiveinenhancing various growth parameters at all phenological stages like drymatterproduction,leaf area index (3.90 at anthesis) and SPAD values (48.92 at anthesis) during the year 2020-21 while 3.98 and 49.90 during the year 2021-22 respectively (Fig. 1b and Table 2), as compared to thetreatmentswherenitrogenwasappliedintheratiosof50:25:25(basal+jointing+booting),25:75(basal+activetillering),50:50(basal+activetillering)and 75: 25 (active tillering + booting). The increased drymatterproduction,leaf area index and SPAD values recorded withthe application of nitrogen inthree splitswithreduced basaldose inthe ratio of 25: 50: 25 might be attributed to the reduction in loss of nitrate by leaching during the wet growing season that results in adequate amount of nitrogen and its availability at critical growth stages of wheat improves photosynthetic activity by improving chlorophyll content which leads to increasing cell division and elongation ofcells that leads to higher dry matter production, increased leaf area and hence increased leaf area index [28] and also SPAD values. Similar results were reported with the application of nitrogen in splits who reported that nitrogen is considered as the prime nutrient and promote plant growth, and internode size result in increased plant height and hence dry matter accumulation [29]. These results are in confirmation with the earlier findings who also reported the increased leaf area index with the application of nitrogen in threesplitsas compared to twosplits [6]. At harvest nitrogen content (straw and grain), Proteincontent % (grain) grain yield (380.9 and 453.5kgha$^{-1}$) and highestNUEof31.74and37.79 (kggrain/kgNapplied) (Table 3) was recordedwiththreesplits of nitrogen intheratiosof25:50:25(basal+ active tillering + booting) was found at par with 50: 25: 25 (basal + jointing +booting) but significantly superior as compared to the treatments where nitrogenwas applied in two splits in the ratios of 25: 75 (basal + active tillering), 50: 50(basal+activetillering)and 75: 25(activetillering+booting). The possible reason of higher grain and strawnitrogen content at harvest might be due to the adequate availability of nitrogenthroughout the crop growth period in the plots received nitrogen in three splits that resulted in translocation of more nitrogen to grains and straw. Similar results were obtained by increased nitrogen content in grain and straw bythewheat crop when Nwasapplied in threesplits [30,31], further, splitting of Nfertilizer to many doses increasedthe efficiency of the fertilizers by decreasing leaching losses of $NO^-_3$ to a largeextent and increased both yield and quality of crops [32,33,34,35].These results are in confirmationwiththeearlier findings [36] who reported that N inthreesplitswithreducedbasaldoseresults in efficient utilization by arresting the volatilization or leaching down of nitrogendue to which plants don’t suffer any shortage in nitrogen throughout life cyclewhich led to an increase in yield component and consequently grain yield. Theseresultsregarding enhancedgrainyieldduetosplitapplicationofnitrogenareascertainedalsobyearlier experiments[37].

## Conclusions

Duetoilliticttypeofclaymineralsandadverseenvironmentalconditionsintemperate Kashmirduringwintermonths,which affects the availability of potassium (K) by fixing it in the interlayer and wedge sides of soilclay, and higher basal nitrogen (N) dose gets subjected to leaching losses before plantuptake. The current recommendation of 100% K as basal dose and50% N as basal dose is not adequate to synchronize K and N supply with actualcropKandNdemand. The increase in growth, yield, nitrogen content (grain and straw), protein content (grain) and N use efficiency with the split application of K and N with reduced basal dose had proved that the wheat croprequires K in two equal splits 50: 50 (basal + active tillering) and lowerdoseofNattheearlystages(25%Nasbasaldose)andmoreNduringits grand growth period (50% N at active tillering + 25% N at booting). Thus, splitapplicationofpotassium30 kg Kha$^{-1}$ in two equal splits andN 120 kg ha$^{-1}$ in three splits with reducedbasaldose(25: 50: 25) couldhelpinsynchronization of K and N requirements to its peak demand by the crop for increased nutrient, protein content and yield in wheat.

## References:


1. Khalid A, Hameed A and Tahir MF. 2023. Wheat quality: A review on chemical composition, nutritional attributes, grain anatomy, types, classification and function of seed storage proteins in bread making quality. *Frontiers in Nutrition*. **10**:1053196.
2. Wanjari, R. H., Dhiraj Kumar., Muneshwar Singh and Anil Nagwanshi. 2022. Balanced use of fertilizers: A key for sustaining crop productivity and soil quality. *Indian Farming*,**72** (04): 34-37.
3. Seema S and Singh J. 2020. Evaluation of split application of potassium for improving yield and potassium uptake in wheat**. I**nternational Journal of Chemical Studies. 8(3): 459-464.

4. Seema S and Singh J. 2021. Split application of potassium improves yield and potassium uptake of rice under deficient soils. Journal of Soil and Water Conservation 20(2): 213-220.
5. Akhter Sabia, R. Kotru and Wani JA. 2017. Uptake and Availability of Potassium and Nitrogen in Wheat as Influenced by Their Split Application under Temperate Conditions of Kashmir. *Applied Biological Research* 19 (3): 257-263.
6. Saeed, B., Gul, H., Ali, F., Khan, A. Z., Anwar, S., Nasrullah.,Alam, S., Khalid,S., Naz, A., Fayyaz, H. and Azra 2013. Contribution of soil and foliarfertilization of nitrogen and sulfur on physiological and quality assessmentofwheat(*Triticumaestivum*L.).*Natural Science* **5**(9): 1012-1018.

7. Akram, M., Iqbal, R. M. and Jamil, M. 2014. The response of wheat (*triticumTriticumaestivum*L.)tointegratingeffectsofdroughtstressandnitrogenmanagement.*BulgarianJournalof AgriculturalScience* **20**(2):275-286.
8. Sowers, K. E., Pan, W. L., Miller, B. C. and Smith, J. L. 1994. Nitrogen useefficiencyofsplitnitrogenapplicationinsoftwhitewinterwheat.*AgronomyJournal***86**: 942-948.
9. Alam, M. S., Nesa, M. N., Khan, S. K., Hossian, M. B. and Hoque, A. 2013.Varietal difference onyield and yield contributing characters of wheatunder different level of nitrogen and planting methods. *Journal of AppliedSciencesResearch***3**(11):1388-1392.
10. Hasanuzzaman M, MHMB B, Nahar K, Hossain MS, Mahmud JA, Hossen MS, Masud AAC, Moumita FM. 2018. Potassium: A vital regulator of plant responses and tolerance to abiotic stresses. Agronomy 8 (3):31.

11. Johnson, R., Vishwakarma, K., Hossen, M.S., Kumar, V., Shackira, A.M., Puthur, J.T., Sarraf, M., Hasanuzzaman, M. 2022. Potassium in plants: growth regulation, signaling, and environmental stress tolerance. Plant PhysiolBiochem **172**:56–69.
12. Sardans, J., Peñuelas, J. 2015. Potassium: a neglected nutrient in global change. Glob EcolBiogeogr
13. Xu, X., Du, X., Wang, F., Sha, J., Chen, Q., Tian, G., Zhu, Z., Ge, S., Jiang, Y. 2020. Effects of potassium levels on plant growth, accumulation and distribution of carbon, and nitrate metabolism in apple dwarf rootstock reedlings. **Front Plant Sci** 11:1–13.
14. Hasanuzzaman, M., Bhuyan, M.H.M.B., Zulfqar, F., Raza, A., Mohsin, S.M., A, l, Mahmud, J., Fujita, M., Fotopoulos, V. 2020. Reactive oxygen species and antioxidant defense in plants under abiotic stress: revisiting the crucial role of a universal defense regulator. Antioxidants **9**:1–52.
15. Siddiqui, M,H., Khan, M.N., Mukherjee., S, Alamri, S., Basahi, R, A., Al-Amri, A, A., Alsubaie, Q, D., Al-Munqedhi, B,M,A., Ali, H, M., Almohisen, I, A, A. 2021. Hydrogen sulfide (H2S) and potassium (K+) synergistically induce drought stress tolerance through regulation of H+-ATPase activity, sugar metabolism, and antioxidative defense in tomato seedlings. Plant Cell Rep 40:1543–1564.
16. Sahi N, Mostajeran A, Ghanadian M (2021) Altering amino acid profle in Catharanthusroseus (L.) G. Don using potassium and ascorbic acid treatments. Open Biochem J 15:53–60. https://doi.org/10.2174/ 1874091x02115010053.

17. Wang, Y., Wu, W-H. 2013. Potassium transport and signaling in higher plants. Annu Rev Plant Biol 64:451–476.
18. Wagnan, M. R., Oad, F. C. and Nenwani, K. S. 2002. Wheat growth and yield contributing characters under various sources and schedules

of nitrogenous fertilizer. *Pakistan Journal of Applied Sciences* **2**(11): 1013-1015.
19. Marschner, H. 1995. Mineral nutrition of higher plant. Second edition. AcademicPress,London,pp. 234.

20. Mathukia, R. K., Kapadiya, J. K. and Panara, D. M. 2014. Scheduling of nitrogenand potash application in irrigated wheat (*TriticumaestivumL.*) *Journal ofWheatResearch***2**: 171-172.
21. Nawab, K. A., Arif, M., Shah, P., Rab, A., Khan, M. Azim., Khan, M. A. andKhan, K. 2011. Effectof FYM, potassium and zinc on phenology andgrainyield of wheat in rainfed cropping systems.*Pakistan Journal ofBotany***43**(5): 2391-2396.
22. El-Abady,M.I.,Seadh,S.E.,El-Ward,Ibrahim,A.andEl-Emam,A.A.M.2009. Irrigation withholding and potassium foliar application effects onwheatyieldandquality.*InternationalJournalofSustainableCropProduction***4**(4): 33-39.
23. Bhati,A.S.andSingh,M.2015.Effectof splitapplicationof nitrogenandpotassiumonyield,nutrientuptakeandnutrientuseefficiencyinBtcotton.*Annals of Plant andSoil Research***17**(1): 71-73.
24. Fusheng, L. 2006. Potassium and water interaction. *International Workshop onSoilPotassiumandKFertilizerManagement,AgriculturalCollegeGuangxiUniversity*.
25. Zou, T. X., Dai, T. B., Jiang, D., Jing, Q. and Cao, W. X. 2006. Potassium supplyaffected plant nitrogen accumulation and translocation and grain proteinformation in winter wheat (In Chinese with English abstract). *Science ofAgriculturalSinetia***39**(4): 686-692.
26. El-Ashry.,Soad, M. and El-Kholy, M. A. 2005. Response of wheat cultivars tochemicaldesiccantsunderwaterstressconditions.*JournalofAppliedScienceResearch***1**(2): 253-262.

27.Yu, Z. W., Liang, X. F., Li, Y. Q. andWang, X. 2007. Effects of potassiumapplication rate and time on the uptake and utilization of nitrogen andpotassium bywinterwheat.*YingYong Sheng TaiXueBao***18**(1): 69-74.

28. Haile, D., Nigussie, D. and Ayana, A. 2012. Nitrogen use efficiency of breadwheat: Effects of nitrogen rate and time of application. *Journal of SoilSciencePlantNutrition* **12**(3): 389-410.
29. Khan, P., Yousuf, M., Memon, Imtiaz,M. and Aslam, M. 2009. Response ofwheat to foliar and soil application of urea at different growth stages.*PakistanJournal of Bot*any**41**(3): 1197-1204.

30.

Masaka,J.2006.TheeffectofNfertilizerplacementandtimingontheabovegroundbiometriccharacteristicsofspringwheat(*Triticumaestivum*L.cv.Spectrum)onleachedChernozem.*InternationalJournalofAgriculturalResearch***1**: 68-75.

31. Abedi, T., Alemzadeh, A., Kazemeini, S. A. 2011. Wheat yield and grain proteinresponsetonitrogenamountandtiming.*AustralianJournalofCropSciences***5**(3):330-336.
32. Gauer, L. E., Grant, C. A., Gehl, D. T. and Bailey, L. D. 1992. Effect of nitrogenfertilization on grain protein content, nitrogen uptake and nitrogenuseefficiency of sixspring wheat (*Triticumaestivum*L.) cultivars in relationto estimated moisture supply. *Canadian Journal of Plant Science* **72**: 235-241.
33. Patke, N. K., Dahatonde, B. N., Sarode, S. S. and Dahatonde, S. 2003. Studies ongrowth and yield of pre-monsoon hybrid cotton as influenced by nitrogenlevels, methods and split application under drip irrigation. *Research onCrops* **4**(1): 133-134.

American Association Cereal Chemists (AACC). 2000. Approved Methods of theAmerican Association Cereal Chemists. *American Association of CerealChemists*, Inc., St. Paul, Minnesota.

34. Shalaby, E. M., Teama, E. A. and Ali, E. A. 2006. Study the productivity andqualityofsomeEgyptianwheatvarietiesindesertbyusingnewsystemsofirrigationandfertilization.*The3rd InternationalConferencefor Development and the Environment in the Arab World*, March, 21-23, 2006AssuitUniversityCenter forEnvironmental Studies-Egypt.
35. Ali, E. A. 2010. Grain yield and nitrogen use efficiency of pearl millet as affectedbyplantdensity,nitrogenrateandsplittinginsandysoil.*American-Eurasian Journal of Agriculture and Environmental Science* **7**(3): 327-335.
36. Ali, E. A. 2011. Impact of nitrogen application time on grain and protein yields aswell as nitrogen use efficiency of some two-row barley cultivars in sandysoil. *American-Eurasian Journal of Agriculture & Environmental Sci*ence**10**(3):425-433.
37. Abedi, T., Alemzadeh, A., Kazemeini, S. A. 2011. Wheat yield and grain proteinresponsetonitrogenamountandtiming.*Australian JournalOfCropSciences***5**(3):330-336.
38. Tinghong Y, Jianglin Z, Jing li, Jianwei L, Tao R,Rihaun C, Zhifeng C, Zhifeng L and Xiaokun L.2021.Nitrogen/ Potassium interactions increase yield by improving canopy performance. Food and energy security. 10(3):1-13.

**Table1: Drymatteraccumulation(kgha$^{-1}$)atvariousgrowthstagesofwheatcropasinfluencedbysplitapplicationofpotassiumandnitrogen (Pooled data of 2 years)**

| Treatments | Active tillering | ointing | Boot stage | Anthesis | Milk stage | Dough | Maturity |
|---|---|---|---|---|---|---|---|
| K1 | 549.5 | 1491 | 3651.5 | 5739 | 9432 | 10711 | 11152 |
| K2 | 499.5 | 1639 | 4111.5 | 5981.5 | 9848 | 11437 | 11904 |
| K3 | 445 | 1530 | 3939 | 5873 | 9735 | 11143 | 11587 |
| SEm± | 20 | 23 | 69.5 | 35.5 | 55 | 108 | 68 |
| CD (p=0.05) | 61 | 70 | 215.5 | 107.5 | 176 | 327 | 208.5 |
| N1 | 541.5 | 1562 | 3976.5 | 5934 | 9778 | 11217 | 11597.5 |
| N2 | 503 | 1612 | 3962.5 | 5890 | 9733 | 11115 | 11537 |
| N3 | 489.5 | 1592.5 | 3989.5 | 5948 | 9814 | 11350 | 11789 |
| N4 | 514.5 | 1545.5 | 3773.5 | 5761 | 9511 | 10863 | 11438 |
| N5 | 441.5 | 1505.5 | 3802.5 | 5788.5 | 9523 | 10937 | 11376 |
| SEm± | 15.5 | 16.5 | 39.5 | 31 | 49 | 100 | 42.5 |
| CD (p=0.05) | 46 | 49 | 115.5 | 90.5 | 144 | 293 | 125.5 |

| | | | |
|---|---|---|---|
| 100%asbasaldose | $K_1$ | 50%asbasal+25%atjointing+25% atbootingstages | $N_1$ |
| 50%asbasaldose+50%atactivetillering | $K_2$ | 25%asbasal+75%atactivetillering | $N_2$ |
| 25%asbasaldose+ 75%atactivetillering | $K_3$ | 25%asbasal+50%atactivetillering+25%atbooting | $N_3$ |
| | | 50%asbasal+50%atactivetillering | $N_4$ |
| | | 0%asbasal+75%atactivetillering+25%atbooting | $N_5$ |

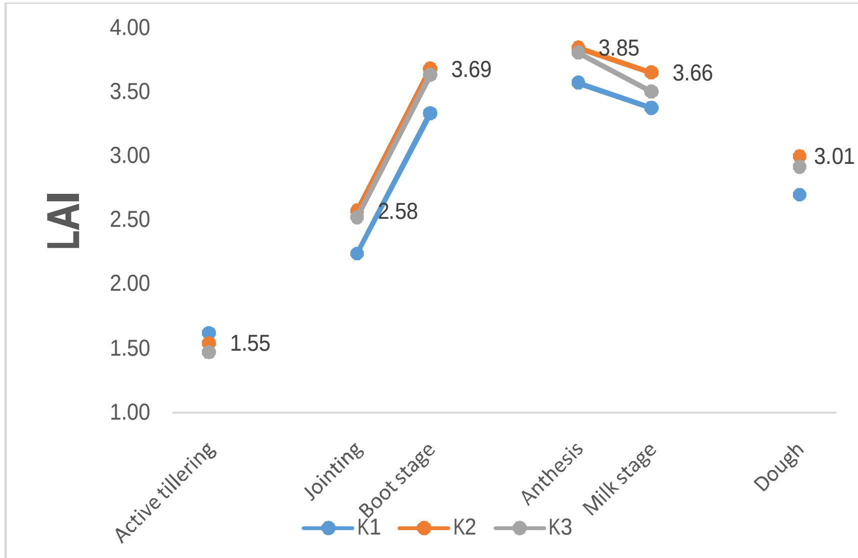


**Fig. 1a: Leafareaindexatvariousgrowthstagesofwheat Crop asInfluencedbysplitapplicationof** Potassium

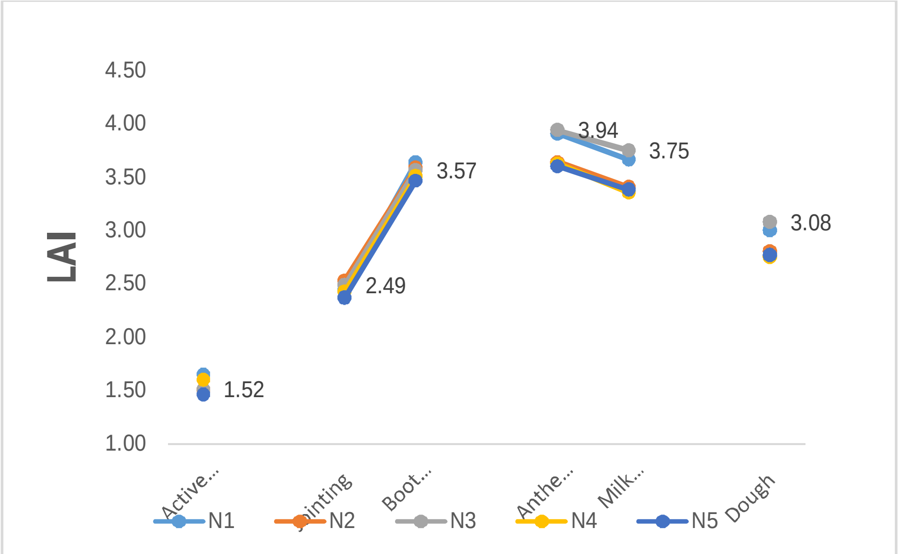


**Fig. 1b: Leafareaindexatvariousgrowthstagesofwheat Cropas Influencedbysplitapplication ofnitrogen**

**Table2:SPADreadingofwheatcropasinfluencedbysplitapplicationofpotassiumandnitrogen (Pooled data of 2 years)**

| Treatments | Active tillering | Jointing | Boot stage | Anthesis | Milk stage | Dough | Maturity |
|---|---|---|---|---|---|---|---|
| K1 | 40.4 | 44.0 | 44.8 | 45.6 | 40.0 | 35.7 | 26.2 |
| K2 | 36.8 | 49.3 | 50.2 | 50.8 | 44.6 | 39.4 | 32.1 |
| K3 | 33.6 | 45.8 | 47.7 | 48.3 | 41.7 | 37.8 | 28.6 |
| SEm± | 1.4 | 1.1 | 0.7 | 1.0 | 0.7 | 0.7 | 0.8 |
| CD (p=0.05) | 4.1 | 3.3 | 2.0 | 2.9 | 2.2 | 2.0 | 2.5 |
| N1 | 38.5 | 44.9 | 48.0 | 49.4 | 43.7 | 38.8 | 29.7 |
| N2 | 36.5 | 48.6 | 49.0 | 49.3 | 41.1 | 36.5 | 28.6 |
| N3 | 36.7 | 47.9 | 48.5 | 49.4 | 43.9 | 39.9 | 30.6 |
| N4 | 39.2 | 45.7 | 46.1 | 47.1 | 40.8 | 36.4 | 27.6 |
| N5 | 33.8 | 44.8 | 45.5 | 46.5 | 41.2 | 36.7 | 28.3 |
| SEm± | 0.9 | 0.9 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CD (p=0.05) | 2.7 | 2.7 | 2.1 | 2.1 | 1.9 | 2.2 | 2.4 |

| | | | |
|---|---|---|---|
| 100%asbasaldose | $K_1$ | 50%asbasal+25%atjointing+25% atbootingstages | $N_1$ |
| 50%asbasaldose+50%atactivetillering | $K_2$ | 25%asbasal+75%atactivetillering | $N_2$ |
| 25%asbasaldose+ 75%atactivetillering | $K_3$ | 25%asbasal+50%atactivetillering+25%atbooting | $N_3$ |
| | | 50%asbasal+50%atactivetillering | $N_4$ |
| | | 0%asbasal+75%atactivetillering+25%atbooting | $N_5$ |

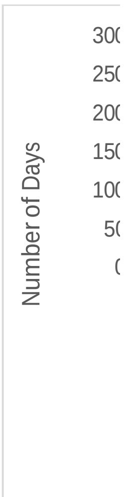


**Fig. 2a: Daystaken todifferent phenologicalstages as influenced bysplit applicationofpotassiumin wheat**

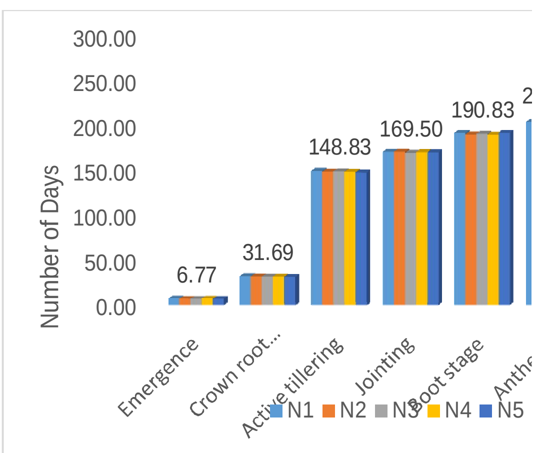

Fig. 2b: Daystaken todifferent phenologicalstages as influenced bysplit applicationofnitrogen in wheat

**Table3: Nitrogencontent(%) total,proteincontentandnutrientuseefficiency(kggrainyield/kgNappliedasinfluencedby split applicationofpotassiumand nitrogen (pooled data of 2 years)**

| | Nitrogencontent (%) GrainStraw | | Total | Protein content in grain (%) | GrainYield (q/ha) | Nitrogen useefficiency(kg grain yield/kgNapplied |
|---|---|---|---|---|---|---|
| $K_1$ | 1.56 | 0.38 | 1.94 | 1.96 | 37.075 | 30.895 |
| $K_2$ | 1.65 | 0.41 | 2.06 | 2.08 | 41.72 | 34.765 |
| $K_3$ | 1.63 | 0.40 | 2.03 | 2.05 | 38.645 | 32.205 |
| **SEm±** | **0.02** | **0.004** | 0.024 | 0.024 | 0.55 | 0.445 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **CD(p=0.05)** | **0.06** | **0.013** | 0.073 | 0.074 | 1.67 | 1.385 |
| $N_1$ | 1.66 | 0.41 | 2.07 | 2.09 | 40.35 | 33.625 |
| $N_2$ | 1.58 | 0.39 | 1.97 | 1.99 | 37.345 | 31.12 |
| $N_3$ | 1.71 | 0.42 | 2.13 | 2.13 | 42.755 | 35.63 |
| $N_4$ | 1.51 | 0.37 | 1.88 | 1.91 | 36.76 | 30.635 |
| $N_5$ | 1.60 | 0.40 | 2 | 2.02 | 38.41 | 32.005 |
| **SEm±** | **0.02** | **0.005** | 0.025 | 0.02 | 0.69 | 0.575 |
| **CD(p=0.05)** | **0.06** | **0.016** | 0. | 0.06 | 2.03 | 1.69 |

100%asbasaldose $K_1$

50%asbasaldose+50%atactivetillering $K_2$

25%asbasaldose+ 75%atactivetillering $K_3$

50%asbasal+25%atjointing+25% atbootingstages $N_1$

25%asbasal+75%atactivetillering $N_2$

25%asbasal+50%atactivetillering+25%atbooting $N_3$

50%asbasal+50%atactivetillering $N_4$

0%asbasal+75%atactivetillering+25%atbooting $N_5$