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NUTRIENT COMPOSITION OF WHEAT GRAIN WITH FERTILIZATION AND CUTTING TIMINGS

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ABSTRACT

The vital economic and nutritional contributions of wheat to both human and livestock diets are universally acknowledged. Dual purposes of wheat crop are responsible for improving grain productivity, nutrient content and provide green fodder in winter due to the shortages of animal feed. In recent years, cutting stages after sowing have emerged as a promising strategy for wheat cultivation to mitigate post-harvest losses. To investigate this approach, a trial was conducted during the 2022-2023 winter season at the Soil Fertility Research Institute Tandojam experimental field. The study comprised four treatments: T_1 No cutting, T_2 Cutting at 35 days after sowing (DAS), T_3 Cutting at 65 DAS, T_4 Cutting at 75 DAS. The experiment followed a statistical design (RCBD) Randomized Complete Block Design and replicate with four times. The data showed that the highest plant height, grain weight, and grain productivity were achieved in T_2 (cutting at 35 DAS). However, the wheat grain composition such as N, P, K, Fe, Zn, and protein content were observed maximum values in T_2 (cutting at 35 DAS). Minimum values were found at the treatment T_4 (Cutting 75 DAS) except for plant height. Maximum height was recorded in the control plot (T_1). The findings of the study suggested that there is a positive effect of early cutting schedule (35 DAS) in enhancing productivity and other components and further, noticed that lack of cutting plot showed similar grain productivity, 1000-grain weight and highest plant height. Additionally, cutting at 35 DAS enhances nutrient content in grain, statistically similar results to control plot, reduces lodging risk standards for domestic and export purposes. Hence, in timing of wheat cutting with balanced nutrition NPK is crucial to get higher nutritional values and simultaneously could minimize the lodging risk in the crop.

Keywords: grain content, grain element, nutrition, soil nutrient, wheat variety

INTRODUCTION

Bread wheat, (*Triticum aestivum* L.) in particular, holds significant importance in global agriculture, having played a central role in the inception of agricultural practices (Ahmed *et al.,* 2016). Concerns exist among farmers and researchers regarding the potential yield penalty when cutting wheat for green fodder. However, proper management can mitigate this issue (Zagonal *et al.,* 2002 and Chaudhary *et al.,* 2023). It is a major dietary staple, providing 72% of caloric intake, and contributes substantially to Pakistan's economy, accounting for 11.36% of value-added and 2.0% of gross domestic product (GoP, 2023). In Pakistan, wheat production has reached 25.482 million tons, with a cultivated area of 9.260 M ha and a yield of 2752 kg ha^{-1} (GoP, 2022). To achieve optimal regeneration, normal vegetative growth after cutting is essential, requiring timely and adequate nutrition. Stubble height is critical, yet research on this aspect is limited for tall wheat varieties. Recently, cutting method has gained popularity as a viable alternative for wheat cultivation. This approach involves harvesting wheat at an earlier growth stage, typically before full maturity, offering numerous benefits are contributing to reduce environmental hazards and minimizing losses (Adhikari *et al.,* 2020 and Chaudhary *et al.,* 2023). The quality of wheat grain is directly related its nutrient composition. The ability of crop to absorb nutrients from soil plays a major role in the nutrient composition of grain crop. Nutrients played an essential role for enhancing crop productivity and other life growing functions such as seed germination, root growth, photosynthesis and flower development (Kirkby *et al.,* 2023; Saleem *et al.,*

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2023 and Rajput *et al.,* 2024). According to the plant nutrients, nitrogen (N), crucial for protein and chlorophyll formation, growth and productivity of crop (Bhalerao *et al.,* 2009 and Rajput *et al.,* 2022). Phosphorus (P) serves for growth of healthy rhizomes and potassium (K) regulates stomata and enhanced grain quality (Bhalerao *et al.,* 2009; Rajput *et al.,* 2015). In Pakistan, 100% soils are deficient in N, 80-90% in P, 25-30% in K and 1.0% less than organic matter content (Akhtar *et al.,* 2003 and Abbas *et al.,* 2012 and Rajput *et al.* 2017). Mineral deficiency arises when plant lack essential nutrients necessary for their growth and development (Agrios, 2005). Nutrient availability also varies among species, so a deficiency in another crop does not necessarily mean the nutrient is deficient in wheat. Nutrients such as nitrogen, phosphorus and potassium are readily translocated from old leaves to new growth. So, deficiency symptoms occur in the older leaves. For many nutrients, the extent of retrains location is variable depending upon the degree of deficiency the plant species and the nitrogen status of the plant. N supply affects the movement of other nutrients from older leaves to new growth (Snowball *et al.,* 1991). N deficiency significantly affected the growth, grain filling, productivity, decrease chlorophyll ultimately impeding photosynthesis (Wei *et al.,* 2016 and Wang *et al.,* 2021). Similarly, low crop productivity, fail to storage energy rich compounds, less photosynthetic and phospho-protein is being reduced by P deficiency (Islam *et al.* 2017). Furthermore, the deficiency of K^+ in plant is resulting in reduced growth and productivity (Hafsi *et al.* 2014; Thornburg *et al.* 2020).

The previous studies have described that the effect of mineral fertilization and cutting stages on the response of wheat grain crop Islam *et al.* (2015); Tiwana *et al.* (2012); Raval *et al.* (2014); Meena *et al.* (2017) and Javed *et al.* (2023). Many research related of cutting with N application 75 kg ha^{-1} with cutting 55 DAS found highest grain yield and fodder for animal feed described by Ali *et al.* (2010); Kamboj (2011) and Sangwan *et al.* (2019). There are no studies concerning the balanced fertilization and cutting stages of particular this variety Akber. To address this knowledge gap, this experiment aimed to investigate cutting and NPK management strategies for enhanced quality and grain productivity. The analysis and nutrient composition of wheat grain is very common in Pakistan. There is no specific work carried out on wheat nutrition as a result of balanced fertilization and cutting stages. It is a new topic in research arena in Tandojam, Pakistan. Hence, this study was conducted by selecting this wheat variety in relation to its intake nutritional ability and evaluate the impact of various cutting timing of wheat for higher nutrient accumulation in wheat grain.

MATERIALS AND METHODS

Experimental details

A research trial was led during the 2022-23 Rabi period at the Soil Fertility Research Institute Tandojam experimental field. The study employed a randomized complete block design (RCBD). The experiment was replicated four times, evaluating four cutting treatments: no-cut (0), cuts at 35, 65, and 75 days after sowing (DAS), respectively. The variety was shown in Akbar. The biofortified wheat variety, Akbar-2019, released in 2019, has gained popularity among farmers due to its 8-10% higher yields, rust resistance and improved chapati quality. Cultivated on over 3.25 million hectares, Akbar-2019 highlights the demand for high-yielding, nutritious wheat. It is cultivated all over Sindh, mostly in Larkana district of kaccha area where 50-60% lodging was noticed. First time, it was cultivated in Tandojam under southern Sindh. Each plot measured 3 x 3 meters. Prior to sowing, the soil was prepared by ploughing using a cultivator, followed by planking to break clods. Wheat variety Akbar was sown in early November and harvested in mid-April. Seed was sown with 100 kg ha^{-1} seed rate by using a conventional seed drill. Phosphorus and potassium fertilizers were applied at sowing, while urea fertilizer was split into three equal applications: at sowing, with the second irrigation, and with the third. Wheat cutting was performed using a sickle at ground level at specified durations.

Physio-chemical analysis methods for soil and plant samples

Soil samples were taken from the experimental area and analyzed for physio-chemical parameters (Table 1). The analytical methods used were: Soil pH and electrical conductivity (EC) is determined by 1:2 ratio. The soil texture was determined by (Bouyoucos, 1962), whereas, organic matter (Jackson, 1958), total N (Bremner, 1965), Olsen P (Olsen *et al.* 1954), NH_4OAC-K and DTPA extractable micronutrient method (Estefan *et al.*, 2013).

Agronomic parameters and grain quality analysis

Agronomic parameters assessed included plant height (cm) which was measured from soil surface to spike tip, 1000-grain mass (g), productivity kg per hectare, and wheat grain productivity was noted. The grain quality analysis was conducted on wheat samples from the Akbar variety, collected from different experimental treatments. Wheat grain samples were also examined for total N, P, K and micronutrients (Fe and Zn) using AOAC methods (Lindsay and Norvell, 1978; Estefan *et al.,* 2013). Protein content was calculated by multiplying total N% in grain multiplying by a factor of 5.70.

Statistical analysis

Statistical analysis using MSTAT software (Michigan State University, USA), following the methods outlined by Gomez and Gomez (1984) with a probability level of < 0.05.

RESULTS

Soil physico-chemical properties

The soil had EC (0.39 dSm^{-1}), pH (0.38), $CaCO_3$ Content of 12.54%, total nitrogen in soil (0.05%) with value (0.03%), low organic matter (< 0.86%) with value (0.67%), medium level of AB-DTPA P (>7 ppm) with (7.48 ppm) and low in NH_4OAc extractable K (>120 ppm) with (122 ppm) in soil (Knudsen *et al.,* 1982) (Table 1.)

Table 1. Chemical properties of soil analysis before experiment

Parameters	Soil depth (0-15 cm)
Sand	25.5
Silt	35.0
Clay	45
Textural Class	Clay loam
EC dSm^{-1}	0.393
pH (1:1)	7.82
O M (%)	0.67
Total N (%)	0.029
Available P (ppm)	7.48
Available K (ppm)	122

Table 2. Analysis of variance for different parameters of Wheat as affected by fertilization and cutting stages of wheat

Parameters	F value	LSD (0.05)	S.E
Plant height (cm)	64.04	5.78	2.36
1000 grain weight (g)	24.17	4.63	1.89
Grain Yield (kg ha^{-1})	48.41	278.00	113.61
Nitrogen content (%) in grain	2.99	0.39	0.16
Phosphorus content (%) in grain	17.43	0.05	0.02
Potassium content (%) in grain	3.85	0.12	0.05
Iron content (%) in grain	8.03	65.006	26.56
Zinc content (%) in grain	75.84	2.54	1.04
Protein content (%)	29.88	2.24	0.92

Cutting of wheat crops with different stages (35, 55 and 75 DAS) had a significant (P< 0.05) impact on productivity and its parameters 1000-grain weight, nutrient content of N, P, K, Fe, Zn and protein content except plant height (Table 2).

Plant height was observed with the various cutting stages with balanced nutrition was non-significant whereas, productivity and its contributing parameters 1000-grain weight produced less or equal with no cutting plot. Moreover, late cutting increased low values as compared to no cutting plot (Table 3).

Table 3. Application of fertilization with different cutting stages on growth and yield of wheat variety

Treatment	Plant height (cm)	1000- grain weight (g)	Grain Yield (Kg ha^{-1})
No Cut +Rec: NPK	118.5a	47.6a	5051a
Cut 35 DAS+ Rec: NPK	89.5b	44.1b	4817a
Cut 55 DAS + Rec: NPK	83.7c	36.8c	4196b
Cut 75 DAS + Rec: NPK	77.6d	34.7c	3833c
Rec: Recommended NPK (150:90:60 kg ha^{-1}), Cut 35DAS cutting (35 days after sowing)			

Data are mean of (n=4), means tailed by various letter (A, B, C and D) are significantly different from each other at (P< 0.05) values.

Plant height (cm)

Plant height is the basic and key important parameter and finding revealed in Table 3 that plant height grew highest (118cm) at control plot where cutting was not done. The cutting stages showed decreasing trend over control. However, study data revealed that the different cutting stages were significant with decreasing cutting stages among them. This was decreased by 20% in treatment 2 (35 DAS) over the control plot exhibited the highest plant height (118.5cm), whereas, treatment 2 which established the cutting of crop after 35 DAS with full NPK, showed a slightly decreased plant height of 87m. Furthermore, examination of the data showed in (Table 3) revealed when cutting stage (35 DAS) with full NPK showed 17.5% decrease in height compared to the control treatment.

1000-grain weight (g)

The data in Table 3 showed significant influence of the various cutting stages of crop in 1000-grain mass. In every treatment, the 1000-grain mass were varied. The no cut treatment had the maximum 1000-grain weight (49.6g), and treatment 2 cutting stages 35 DAS with balanced nutrition had slightly less 1000-grain

weight specially, (44.18). However, the further, least grain weight (36.8) were shown in treatment 3 and followed by 4. Actually, all the treatment were different from each other but in case of 1000-grain weight which means these differences are meaning full. Thus, there was decrease 11% over control (no cut). Moreover, the lasting cutting levels from 55 to 75 DAS exhibited same results and statistically were non-significant.

Grain yield (kg ha^{-1})

The increasing effect of cutting stages from 35 to 75 DAS got to an edge over no cutting with Rec: NPK by producing significantly lower productivity. The lowest grain productivity was calculated in the treatment 4 where cutting was done after 75 DAS followed by T_3 and T_2 with full NPK where (4196) and (4817) kg per hectare. Whereas grain productivity (5051 kg ha^{-1}) was noted where no cutting was done but treatment 2 was in best for productivity. Results showed that the treatment 2 mean cutting at 35 DAS with full NPK equal or little bit difference or equal the yield of wheat crop by 4.6% over no cut treatment (Table 3).

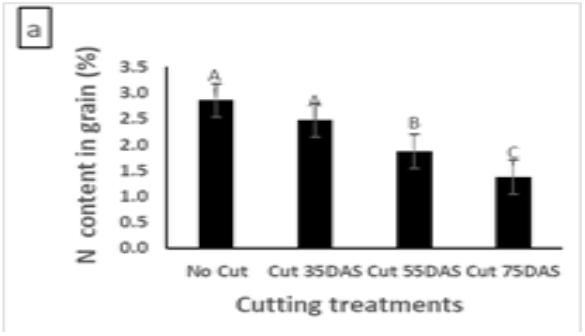
Nutrient content

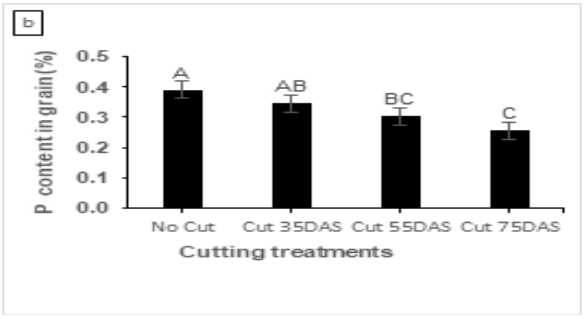
Total N content in grain

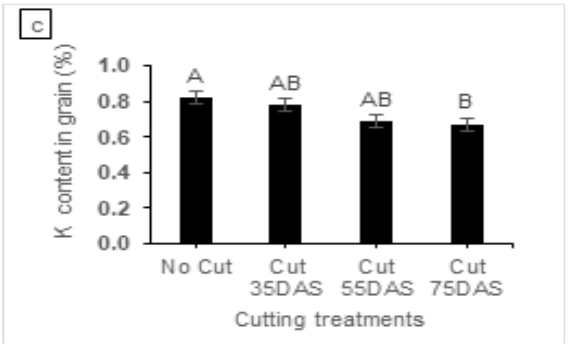
The data about total N content in grain is represented in Figure 1a. Total N content was considerably affected by cutting stages. The maximum total N content (2.86 %) in grain was significantly higher in no cut treatment as well as treatment 2 where cutting was done 35 DAS. There was no variance in total N content in grain of the two treatments. It means that the statistically data was non-significant. All treatments were different from each other cut and not cut when it comes to the total N content in grain (P<0.05) which means 35 DAS cutting of wheat crop, differences are meaning full. Whereas the lowest total N content in grain was observed with delaying the cutting stage 75 DAS followed by 55 DAS.

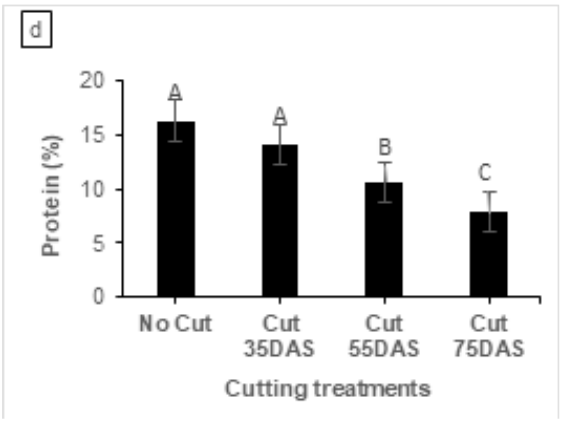
Total P content in grain

Total P content in grain was significantly affected by cutting stages. Total P content data Figure 1b decreased gradually from 0.39% under control (no cut) plot to 0.35, 0.30 and 0.26% at the treatment having cutting stages (35, 55 and 75 DAS). Thus, this was decreased by 33% from 0 to 75 DAS cutting. Decreasing trend of P content in grain showed delayed the cutting stage decrease nutrient in grain. Further, only cutting 35 DAS stage treatment 2 responsible to enhance P content in grain but the treatment variances were no large enough in treatment 1 and 2.









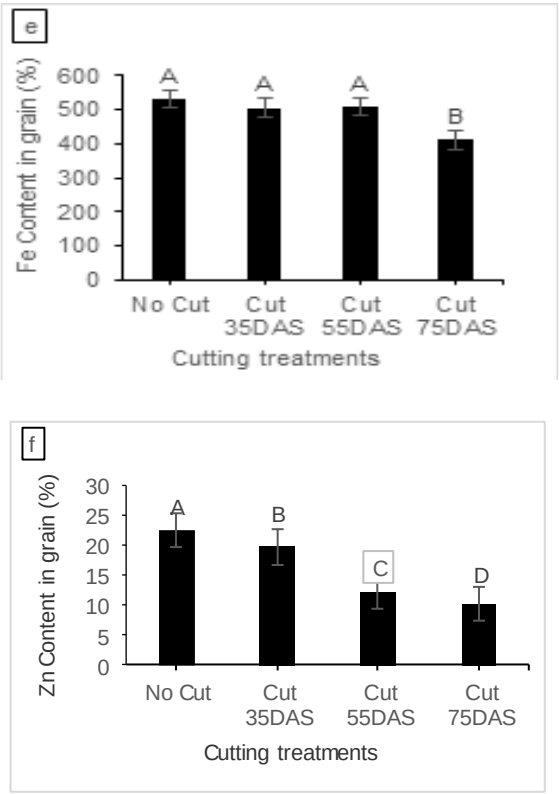


Figure 1. Fertilization and cutting stages on (a), N content (%), (b) P content (%), (c) K content (%), (d), Protein content (%), € Fe content (%), (f) Zn content of wheat grain

Total K content in grain

The data about total K content is represented in Figure 1c. Total K content was significantly affected by cutting stages. The lowest K content (0.67%) was observed in cut 75 DAS, whereas the highest total K content in grain was analysed in no cut tailed by cut 35 and 55 DAS. Early cut resulted in high content of K as compared to late cut.

Protein content %

Protein content % in grain increased from (7.84%) treatment 4 late cut (cut 75 DAS) plot followed by T_3 (10.66%) (cut 55 DAS) and T_2 (14.10%) at 35 DAS to 16.31% under no cut plot treatment respectively. Correspondingly, to 52, 34 and 13.7% reduce protein content in wheat crop. The highest protein content was calculated in no cut plot Figure 1d.

Total Fe content in grain

The results in Figure 1e, showed that the fertilization and cutting stages significantly affected the total Fe content % in grain in all treatments. The lowest total Fe content was verified in the treatment 4 (cut 75 DAS) (411mg kg^{-1}) followed by T_3 and T_2 (cut 55 and 35 DAS) with fertilization NPK application 507 and 505 mg kg^{-1} total K were calculated respectively. However, highest total Fe content (531mg kg^{-1}) was noted, where not cut was practical.

Total Zn content in grain

Data in Figure 1f examines that the fertilization and cutting stages significantly affected the total Zn content in grain in all treatment. Treatment (cut 35 DAS) T_2 gave similar results as compared to no cut treatment T_1. Dual purpose practices considerably reduced nutrient content in grain specially Zn. Higher accumulation of Zn content (%) were noted by grain in no cut plot than cut plot.

DISCUSSION

To obtain a satisfactory yield of wheat grain with high nutrient quality, with protein being the most key trait. Current research comprised the experiment to assess the impact of cutting stages with balanced fertilization on productivity and nutrient content percentage in grain of wheat cultivar (Akbar 2019) under the southern environment of Sindh. According to the soil analysis, soil was clay loam, non-saline, low organic matter, total N and P whereas, K was Adequate in level. Pakistani soils are calcareous due to chemical composition of their parent material (Imran *et al.,* 2020). and Morrison *et al.* (2017) also observed most soils are low organic matter due to the oxidation of organic fractions in the soil brought by high temperature.

Hence, soils have strong buffering capacity and micronutrients may be affected by the pH, texture, organic matter, type and quantity of oxyhydroxides present (Afonso, *et al.,* 2020). Lodging was not done due to clay loam soil. Due to the non- availability of nutrients, application of balanced nutrition NPK with cutting stages getting productivity and nutrient accumulate in grain. Our findings revealed that cutting stages of tall crops had adverse effect on all the beneficial plant attributes measured in this experiment. However, cutting stages early cut T_2 (35 DAS), mid cut T_3 (55 DAS) and late cut T_4 (75 DAS) with fertilization mitigated the effect on yield and nutrient composition of grain during mid to late cuttings in clay loam soil. Whereas, early cut T_2 (35 DAS) improved and equal its growth, yield and enhancing nutrient composition in wheat grain. Detailed reasoning for these outcomes is as follows. We observed a negative relationship between the cutting stages and wheat plant height. This aligns with findings

reported by multiple researchers (Shujra *et al.*, 2010; Islam *et al.*, 2015; Mean *et al.*, 2017) who found that continuous cutting of crop with different stages reduces plant height. The reason is that the cutting causing termination of growth and new growth of the shoot could not attain the same plant height. It means that the highest plants in control treatment are other than cut plot. Grain weight is an important contributor to the grain yield of wheat. Our results' findings presented similarly by Khalil *et al.* (2011); Munsif and Arif (2011) and Islam *et al.* (2015) who reported significant variation for grain productivity. Decapitation stress lowered 1000-grain weight and grain productivity due to late cutting about 100 DAS because late cutting covers all nutrient applying cycles before cutting. Naveed *et al.* (2014) concluded that the dual-use wheat system had higher providing fodder and less grain production as compared to no cut. Further, minimum productivity (3690.2 kg ha^{-1}) was calculated in cut treatment as compared to no cut treatment of grain yield (4810.5 kg ha^{-1}). Similar findings have been described by Tiwana *et al.* (2012); Raval *et al.* (2014); Meena *et al.* (2017) who reported higher grain productivity (4.1 t ha^{-1}) significantly higher at 40 DAS over 50 and 60 DAS green fodder cuttings. Iqbal *et al.* (2018) concluded that the no cut is recommended for grain yield while based on weed control, cut Zado % growth stage 18 is recommended. Javed *et al.* (2023) found highest productivity (6023 kg ha^{-1}) with fertilization of NPK (150:100:60 kg ha^{-1}) + B (70g ha^{-1}) was practical at booting, flowering and milky stages in Faisalabad soil. Availability of sufficient time for treatments that were not exposed to the cuttings, increasing the accumulation of dry matter in the grain, the cutting caused the depletion of nutrients in the plants that were exposed to the cuttings, as a result, there was reduce the accumulation of dry matter in it. The reason for low 1000 grain weight, grain productivity and nutrient content due to drain on photosynthates happened as a outcome of regeneration due to cutting, therefore, reducing translocations of assimilates towards spike formations. Low grain weight in cut treatments might be due to the removal of photosynthetic organs by clipping which negatively affected source risk relatively time and time under to crop. low nutrient content in cut treatment was probably due to drain on photosynthetic that occurred as a result of regeneration because of cutting thereby reducing translocation of assimilates toward plant.

Few studies were observed on cutting stages with fertilization related to the nutrient composition of total N, P, K, Fe, Zn and protein content. A highly significant effect was observed on grain N and protein content %. Sangwan *et al.* (2019) conducted field experiment under various nitrogen doses with cutting stages. They concluded that the highest plant height and productivity were noted with the treatment of cutting stage at 55 days after sowing with application of 75 kg N ha^{-1} (it was scheduled 33% before cut and 67% after cut). Further, other scientists showed early cutting (80 DAS) with 80 kg ha^{-1} N applied increased grain yield and biological yield by Ahmed *et al.* (2016). Similarly, Naveed *et al.* (2014) and Kadam *et al.* (2022) concluded that among cutting schedules, no cut showed higher values for all productivity and nutrient content. The maximum and significantly higher N (1.466%), P (0.433%) and K (0.773%) contents were registered in oats grain with no cut treatment. Similar results were in line by Meena *et al.* (2016) reported that the N, P, and K content in barley grain were significantly affected due to various cutting schedules. Naveed *et al.* (2013) gave similar results. In continuation of field work, Waheddullah *et al.* (2018) showed four sowing time and five cutting schedules on productivity of wheat. Highest values of protein content 13.97%, Fe 142 ppm, and Zn 33.7 ppm in wheat (Akber-2019) in grain was observed in first date of sowing (1st November) (Annual Report 2019-20). Few scientists showed P rates application concerned to protein. Goud *et al.* (2014) described protein content as a key factor in the plant growth and N concentration is important for its co-relation under various legume varieties. Similarly, Rajput and Memon (2023) observed on various P application (0, 25, 38, 50, 75, 100, 125, 150 P_2O_5 kg ha^{-1}). It was concluded that protein content 20% higher in 50 P_2O_5 kg ha^{-1} applied treatment. Our highest values of protein content 13.97% in no cut application are valuable and similar relate to other scientists. Uddin *et al.*, 2014; Dragicevie *et al.*, 2015; Meena and Verma, 2016; Memon *et al.*, 2016; Rajput, 2018 gave similar results.

It was concluded that the highly significant positive relationship was found on wheat growth, yield and nutrient content (N, P, K, Fe, Zn) and protein content. Rajput (2018) examined that the positive correlation among all yield, N, P, K except straw productivity due to application of

potassium on chickpea crop. Similarly, Rajput and Memon (2023) showed comparable relationship among yield and yield contributing parameters. Further, regression relation was linear, positive and significant for all nutrients i.e N, P, K, Cu, Fe, Mn and Zn in banana crop (Rajput *et al.,* 2017) who studies nutrient composition of banana fruit as affected by Farm manure, composted press mud and mineral fertilizers. Almost, same data were noticed by Patel *et al.* (2013); Iqbal *et al.* (2012) concluded that the lowest productivity and nutrient content in grain N, P, K, Fe, and Zn where late wheat cutting (100 DAS).

CONCLUSION AND RECOMMENDATIONS

It was concluded that the effect of cutting stages highly significant. Lodging data was observed that the there was little bending appeared in control plot (no cut treatment). Highest data were noted in growth, yield and nutrient content in treatment 2 where cutting was done after 35 DAS and similar results was appeared in control plot. Therefore, keeping in view the above conclusion and recommendations can be given on the basis of lodging (little bending) and increased nutrient content in early cut at 35 DAS is recommended for Akber 2019 for clay loam soil.

AUTHOR'S CONTRIBUTION

A. Rajput: Collect grain samples, sample preparation and analysis, wrote initial to Final draft. Technically check it, statistical analysis, proof reading, and editing

H. Babar: Conceptualization and financial assistance

A. A. Odhano: Data collection.

M. S. Memon: Data collection.

A. A. Memon: Data collection.

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