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Urease Inhibitor Application Stages and Nitrogen Levels Influenced on Morpo-Phenological Traits of Wheat Cultivars

Aman Khan Amir Zaman Khan Shahzad Ali Amanullah Jan Muhammad Tufail
Department of Agronomy, The University of Agriculture, Peshawar, Pakistan
Corresponding Author: Student of agronomy department
E-mail: shahzadali320@aup.edu.pk

Abstract
A field trial was carried out at New Developmental Farm of The University Agriculture, Peshawar, Pakistan during winter 2012-13, in order to study the urease inhibitor application stages and nitrogen levels influenced on morpo-phenological traits of wheat cultivars. Therefore the field experiment was conducted in randomized complete block design with split plot arrangement having four replications. Nitrogen levels (60, 120 and 150 kg ha^{-1}) and urease inhibitor stages (100% sowing stage, 50% sowing stage + 50% booting stage and 100% booting stage) were allotted to main plots, while wheat cultivars (Siran and Atta Habib) were allotted to sub plots. Plots treated with 120 kg N ha^{-1} took maximum days to booting (128), improved plant height (97.9 cm), leaf area tiller^{-1} (117.8 cm^2), spike length (11.3 cm) and biological yield (10382 kg ha^{-1}) but maximum (185) days to maturity was observed when plots treated with 150 kg N ha^{-1} as compared with control plots. Application of urease inhibitor 100% at sowing stage took maximum booting (133) days, maturity (186) days, improved plant height (102 cm), leaf area tiller^{-1} (128 cm^2), spike length (11.6 cm) and biological yield (11386 kg ha^{-1}) as compared with urease application 100% at booting stage. Wheat cultivar Siran had significantly took maximum booting (123) days, maturity (178) days, plant height (94.5 cm), leaf area tiller^{-1} (97.6 cm^2), spike length (10.3 cm) and biological yield (9331 kg ha^{-1}) as compared to Atta Habib. Hence cultivar Siran treated with 120 kg N ha^{-1} and coated urease inhibitor 100% at sowing stage produced the best results in terms of plant height, leaf area tiller^{-1}, physiological maturity and biological yield.
Keywords: Wheat (Triticum aestivum L.), urease inhibitor application stages, nitrogen levels, wheat cultivars, phenology, morphology

INTRODUCTION

Wheat (*Triticum aestivum* L.) a member of family Gramineae, is a world first grain crop. Wheat is generally cultivated for grain production. In countries like Argentina, Australia, Morocco, Syria and Uruguay wheat exceeds from all other crops both in area and production (Arzadun, *et al*., 2006). It is also grown as fodder crop for livestock due to it palatability, higher crude protein and digestibility compared to other fodder crop (Krenzer, 2000). In Pakistan the total area occupied by wheat was 8900.7 hectares, which produced 25214 tones with average yield of 2833 kg ha^{-1} where as in Khyber Pakhtunkhwa, it was grown of on an area of 725 hectares produced 1156 tones with an average yield of 1595 kg ha^{-1} (MINFA, 2011). A major pathway by which Nitrogen is lost from agricultural settings is through NH_3 Volatilization. Mosier (2001) estimated that 65% of the global NH_3 flux to the atmosphere is emitted from agricultural systems, including animal production and the use of synthetic Fertilizers. Bouwman *et al*. (2002) Urea is an organic fertilizer that needs to be hydrolyzed by the enzyme urease inhibitor before NH_3 can be volatilized. This hydrolysis of urea can be rapid under certain environmental conditions (Black *et al.*, 1987). The prevalent concern over N fertilizer losses has led to various researches that have revealed the role of Humic Acids (HA), Fulvic Acids (FA) and Triple Super-Phosphate (TSP) as amendments to delay hydrolysis of urea fertilizer, thereby controlling ammonia volatilization. Low pH and high total acidity (Cation Exchange Capacity, CEC) associated with HA and FA enable them to inhibit urease inhibitor activity, retain ammonium, delay hydrolysis of urea, thereby reducing ammonia volatilization (Ahmed, *et al*, 2012).

Timing of Nitrogen application had a significant role on the N indices and can help in Reducing N losses. Zaman, *et al*., (2008) reported that N losses could be minimized if N application is made before the onset of stem elongation. When N was applied at first node stage, the total N uptake was greater than at planting time (Limon- Ortega *et al*., 2000). Similarly, Tran & Tremblay (2000) reported that early application of N at planting and tillering had lower N fertilizer uptake than later application (shooting) in wheat. Split and latter application of N increased NUE through avoiding unnecessary vegetative growth and losses of N (Alcoz *et al*., 1993). Between the different management options (avoiding heavy N application rates, applying N fertilizer at appropriate time, splitting N applications, using slow release fertilizer, or coating N fertilizers with polymers or elemental S), adding urease inhibitor to urea may have the greatest potential to reduce N losses and enhance its N efficiency (Zaman, *et al*., 2008). Nitrogen application promotes tillering and leaf growth, whereas late application prolongs leaf area duration and expansion (Spierz, *et al*., 1984). Urease inhibitor catalyses urea hydrolysis thus making urea-N available to be assimilated into organic compounds (Hogan *et al*., 1983). Keeping in view the above constraints this experiment was conducted to determined best urease inhibitor stage, nitrogen level and wheat cultivar suitable under agro-climatic condition of Peshawar.

MATERIALS AND METHODS

To find out the effect of urease inhibitor stages and nitrogen levels on plant growth of wheat cultivars, an experiment was conducted at New Developmental Farm The University of Agriculture, Peshawar (34^o 00 N, 71^o 30 E, 510 MASL) Pakistan during winter 2012-13. The experiment was laid out in randomized complete block design with split plot arrangement having four replications. Nitrogen levels (60, 120 and 150 kg ha^{-1}) and urease inhibitor stages (100% sowing stage, 50% sowing stage + 50% booting stage and 100% booting stage) were allotted to main plots, while wheat cultivars (Siran and Atta Habib) were allotted to sub plots. A subplot size of 5 x 3 m was used. Each sub plot was consisted of 10 rows having 30 cm row-to-row distance. Phosphorus as P_2O_5 was applied at the rate of 90 kg ha^{-1}, as a basal dose. Seed were sown at rate of 100 kg ha^{-1}. Data on days to booting was recorded by counting days from sowing to the data when 70-80% plants reached to booting stage in each sub plot. Data on leaf area tiller^{-1} was recorded by measuring leaf area tiller^{-1} of five randomly selected plants with the help of meter rod from each sub plot. For spike length data the length of eight randomly selected spikes were measured from the basal joint of the spike till the top of the spike. Data on plant height was recorded by measuring randomly selected eight plants in each sub plot, from the base of plant to the tip of spike. Days to physiological maturity was recorded by counting the days from the date of sowing to the date when 80-90% plants become physiologically maturity in each sub plot. Harvested crop was sun dried and weighed by using electronic balance and then converted into kg ha^{-1} by the following formula.

$$\text{Biological yield (kg ha}^{-1}) = \frac{\text{Weight of plant materials in four rows (kg)}}{\text{No of rows x Row length x R-R}} \times 10{,}000 \text{ m}^2$$

Data were analyzed using the statistical package MSTAT-C (Steel and Torrie 1980) and the significant differences among the treatments were determined using least significant difference (LSD) test at 5% level of probability.

RESULTS AND DISCUSSION

Days to booting

Mean value of days to booting given in table 1 showed that increasing nitrogen levels significantly delayed days to booting. Plots treated with 120 kg N ha^{-1} delayed booting (128 days) as compared to control, which took early 116 days to booting. The possible reason should be that accessibility and uptake of nitrogen which leads to comparative prolonged days to booting with more vegetative growth. This finding agrees with the reports of Khan *et al*., (2008) who reported that nitrogen improve vegetative growth and delayed days to booting. The mean values of control vs rest contrast indicated that rest plots resulted delayed (127) days to booting as compared with control plots which produced early (116) days to booting. Plots treated with urease inhibitor 100% at sowing time delayed days (133) to booting while early (121) days to booting was recorded when urease inhibitor coated 100% at booting stage. These results agree with those of Pereira *et al*., (2009) who studied that urease inhibitor and urea minimized volatilization nitrogen which result in higher productivity and delay days to booting. Cultivar Siran produced delayed (123) days to booting as compared to cultivar Atta Habib (120) days to booting. These results agree with those of Arzadun, *et al*., (2006) who reported that the difference in days to booting among the cultivars might be due to genetically determined differences in uptake of nutrient especially nitrogen.

Leaf area tiller^{-1} (cm^2)

Mean values of the data indicated in table 1 that leaf area tiller^{-1} were significantly affected by urease inhibitor, wheat cultivars and nitrogen levels. Increasing in nitrogen level significantly increase in leaf area tiller^{-1} was recorded. Plots treated with 120 kg N ha^{-1} produced maximum leaf area tiller^{-1} (117.8 cm^2) while minimum leaf area tiller^{-1} (78 cm^2) was recorded in control plots. The probable reason could be that high dose of nitrogen application might have increased leaf area and sustaining leaf photosynthetic activity. These results are in line with Deldon (2001) who recorded that nitrogen fertilizer application had significant effect on leaf area tiller^{-1} with increase the nitrogen level leaf area tiller^{-1} increased up to (40 %) if we compared with control plots. The mean values of control vs rest contrast indicated that rest plots produced maximum (110 cm^2) leaf area tiller^{-1} as compared with control plots which produced minimum (78 cm^2) leaf area tiller^{-1}. Plots treated with urease inhibitor 100% at sowing stage produced maximum (128 cm^2) leaf area tiller^{-1}, while minimum (93.7 cm^2) leaf area tiller^{-1} was recorded when urease inhibitor coated 100% at booting stage. The probable reason for higher leaf area tiller^{-1} could be associated with more nutrient availability less NH_3 volatilization and increase microbial activity. Similar result is reported by Chen *et al*., (1998) who studied that application of urease inhibitor has increased nitrogen recovery and increased leaf area tiller^{-1} of wheat by reducing NH_3 volatilization and NO_2 emission from the plant soil system. Cultivar Siran produced maximum (97.6 cm^2) leaf area tiller^{-1} as compared to cultivar Atta Habib (90.9 cm^2) leaf area tiller^{-1}. The difference among the cultivars might be due to genetic makeup and nutrients absorption.

Spike length (cm)

Data regarding spike length given in table 1 revealed that spike length increase with increasing nitrogen levels and maximum spike length (11.3 cm) was recorded for 120 kg N ha^{-1} but statistically at par with 150 kg N ha^{-1} while minimum spike length (8.5 cm) was produced in control plots. Similar results were reported by Nad *et al*. (2001) who observed that nitrogen increase spike length with increase the nitrogen level up to 150 kg ha^{-1} as compared to control plots. The mean values of control vs rest contrast indicated that rest plots produced maximum (10.9 cm) spike length as compared with control plots which produced minimum (8.5 cm) spike length. Cultivar Siran produced maximum (10.3 cm) spike length as compared to cultivar Atta Habib (9.3 cm).The possible reason could be genetic constitution of wheat cultivars that affect spike length. Plots treated with urease inhibitor 100% at sowing time produced maximum (11.6 cm) spike length, while minimum (9.9 cm) spike length was recorded when plots treated with urease inhibitor 100% at booting stage. The ability of urease inhibitor to inhibit the nutrient and release slowly which enough for longer time and protect urea from leaching could be the possible reason for increased spike length. These results agree with the findings of Sheng and Lin (2007) who reported that nitrogen use efficiency had increased with use of urease inhibitor with urea in wheat which minimized hydrolysis and retarded nitrification process as a result spike length increased.

Plant height (cm)

Data regarding plant height are presented in table 1 showed that nitrogen levels had significantly effect on plant height. Plots treated with 120 kg N ha^{-1} attained maximum plant height (97.9 cm) while minimum plant height (83.7 cm) was recorded in control plots. The suitable reason could be that highest doze of nitrogen might be increased vegetative growth as a result plant height increased. These results are accordance with Awasti and Bham (1994) agree with my results, who concluded that high rates of nitrogen increased plant height. The mean values of control vs rest contrast indicated that rest plots produced taller (95.7 cm) plant height as compared with control plots which produced dwarf (83.7 cm) plant height. Plots treated with urease inhibitor 100% at sowing time produced taller plants height (102 cm), while dwarf (89.2cm) plant height was recorded when urease inhibitor coated 100% at booting stage. These results are in line with Zhang *et al*., (2010) who reported that coated urease inhibitor increased total nitrogen recovery in plants by 22.20% with increased nitrogen use efficiency by 17.60% and reducing NH_4 volatilization as a result plant height increased. Cultivar Siran produced taller (94.5 cm) plant height as compared to cultivar Atta Habib (89.8 cm) plant height. The difference among the cultivars might be due to genetic makeup and nutrients absorption. Interaction between N x U x V indicated in fig. 1 that both cultivars treated with urease inhibitor 100% at sowing stage produced taller plant height with increasing nitrogen up to120 kg ha^{-1} further increased in nitrogen slightly decrease in plant height was produced in both cultivars. But a linear increased for plant height was recorded when cultivar Siran treated with 120 kg N ha^{-1} and coated urease inhibitor 100% at sowing stage however sharply decreased in plant height produced when nitrogen coated with urease inhibitor 100% at booting stage.

Physiological maturity

Mean value of days to maturity given in table 1 showed that maturity was significantly delayed with increasing nitrogen levels. The effect of nitrogen levels on days to maturity was significant. A plot treated with 150 kg N ha^{-1} delayed days to maturity (185) was observed as compared with control plots which produced early (171) days to maturity. The possible reason should be that accessibility and uptake of nitrogen which leads to comparative prolonged days to maturity with more vegetative growth. This agreed with the finding delay in maturity with increase nitrogen level as compared to control plots has been reported by Woyma *et al*., (2012). The mean values of control vs rest contrast indicated that rest plots took maximum (181) days to maturity as compared with control plots which produced early days (171) to maturity. Plots treated with urease inhibitor 100% at sowing stage delayed (186) days to physiological maturity while minimum (177) days to physiological maturity was recorded when urease inhibitor coated 100% at booting stage. These results agree with those Jiao *et al*., (2004) who concluded that urease inhibitor combined with urea, increased soil ammonia nitrogen by 2 to 54%, increased wheat nitrogen uptake by 0.26 to 6.79% and increased total soil nitrogen by 35 to 45% as a result plant uptake more nitrogen and delay physiological maturity. Wheat cultivar Siran took maximum (178) days to maturity as compared to Atta Habib (171 days). The possible reason could be genetic constitution of wheat cultivars that affect days to maturity. Interaction between N x U x V indicated in fig. 2 that both cultivars treated with urease inhibitor 100% at sowing stage delayed physiological maturity with increasing nitrogen up to120 kg ha^{-1} further increased in nitrogen slightly decrease in physiological maturity was produced in both cultivars. But a linear increased for physiological maturity was recorded when cultivar Siran treated with 120 kg N ha^{-1} and coated urease inhibitor 100% at sowing stage however sharply decreased in physiological maturity produced when nitrogen coated with urease inhibitor 100% at booting stage.

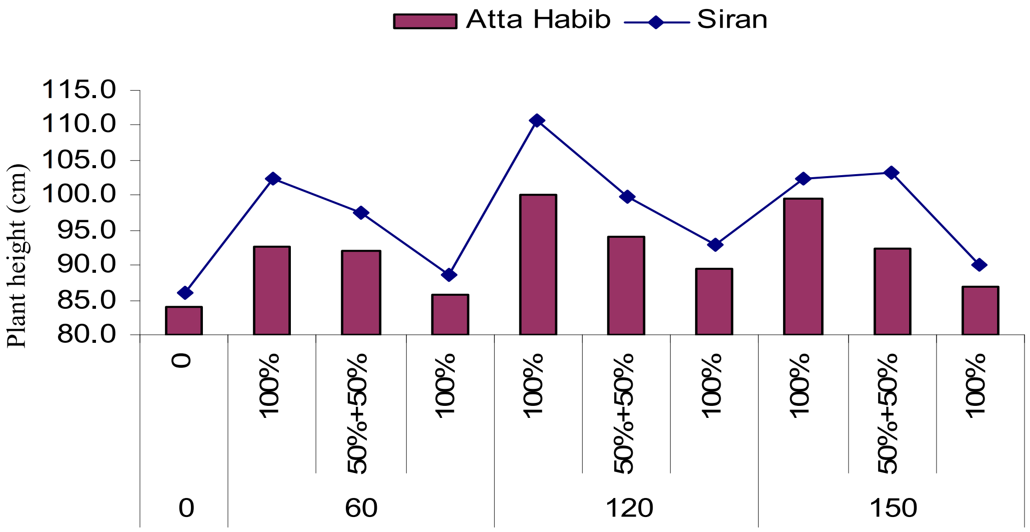
Biological yield (kg ha^{-1})

Mean value of nitrogen levels showed in table 1 that biological yield significantly increase with increasing nitrogen level. Therefore the highest level of nitrogen (120 kg ha^{-1}) produced maximum biological yield (10382 kg ha^{-1}) but statistically at par with 150 kg N ha^{-1} while lowest yield is recorded in control plot (7350 kg ha^{-1}). Nitrogen fertilizer delay physiological maturity due to this extended the vegetative period of the crop, plant attained maximum tiller plant^{-1} and plant height thus increase biological yield. These results are in line with the findings of Zaman *et al*., (2009) who reported that significantly increase in biological yield produced with increased nitrogen level. The mean values of control vs rest contrast indicated that rest plots produced maximum (9975 kg ha^{-1}) biological yield as compared with control plots which produced minimum (7350 kg ha^{-1}) biological yield. Cultivar Siran recorded maximum (9331 kg ha^{-1}) biological yield as compared to cultivar Atta Habib (8994 kg ha^{-1}). It may be due to their genetic as well as phenotypic difference form cultivar Atta Habib. Plots treated with urease inhibitor 100% at sowing time produced maximum (11386 kg ha^{-1}) biological yield, while minimum (8684 kg ha^{-1}) was recorded when plots treated with urease inhibitor 100% at booting stage. The ability of urease inhibitor to inhibit the nutrient and release slowly which enough for longer time and protect urea from leaching could be the possible reason for increased biological yield. These results agree with the findings of Sheng and Lin (2007) who reported that nitrogen use efficiency has been increased with use of urease inhibitor with urea in wheat which minimized hydrolysis and retarded nitrification process. Interaction between N x U x V indicated in fig. 3 that both cultivars treated with urease inhibitor 100% at sowing stage produced maximum biological yield with increasing nitrogen up to120 kg ha^{-1} further increased in nitrogen slightly decrease in biological yield was produced in both cultivars. But a linear increased for biological yield was recorded when cultivar Siran treated with 120 kg N ha^{-1} and coated urease inhibitor 100% at sowing stage however sharply decreased in biological yield produced when nitrogen coated with urease inhibitor 100% at booting stage.

Table II. Days to booting, leaf area tiller^{-1}(cm^{-2}), spike length (cm), plant height (cm), physiological maturity and biological yield (kg ha^{-1}) of wheat cultivars as affected by urease inhibitor stages and nitrogen levels

Treatment	Days to booting	Leaf area tiller^{-1} (cm^2)	Spike length (cm)	Plant height (cm)	Days to maturity	Biological yield (kg ha^{-1})
Urease inhibitor Stages						
Sowing	133 a	128.0 a	11.6a	102 a	186 a	11386a
(Sowing + Booting)	128 b	106.7 b	11.0b	96.5 b	182 b	9855b
Booting	121 c	93.7 c	9.9c	89.2 c	177 c	8684c
LSD (0.05)	2.22	4.78	0.48	1.71	1.66	469.7
Nitrogen (kg ha^{-1})						
60	122 b	98.7 c	9.2b	90.2 c	178 c	9511b
120	128 a	117.8 a	11.3a	97.9 a	181 b	10382a
150	129 a	111.9 b	11.1a	95.9 b	185 a	10032a
LSD (0.05)	2.22	4.78	0.48	1.71	1.66	469.7
Control vs Rest						
Control	116b	78b	8.5b	83.7b	171b	7350b
Rest	127a	110a	10.9a	95.7a	181a	9975a
Cultivars						
Siran	123a	97.6a	10.3a	94.5a	178a	9331a
Atta Habib	120b	90.9b	9.3b	89.8b	171b	8994b
Interaction						
N x U	ns	ns	ns	ns	ns	ns
U x V	ns	ns	ns	ns	ns	ns
N x V	ns	ns	ns	ns	ns	ns
N x U x V	ns	ns	ns	*	*	*

Means in the same category followed by different letters are significantly different at P ≤0.05 levels. ns = non-significant * = significant



Cultivars, urease inhibitor stage and Nitrogen (kg ha^{-1})

Fig. 1. Plant height of wheat is affected by urease inhibitor stage, cultivars and nitrogen levels.

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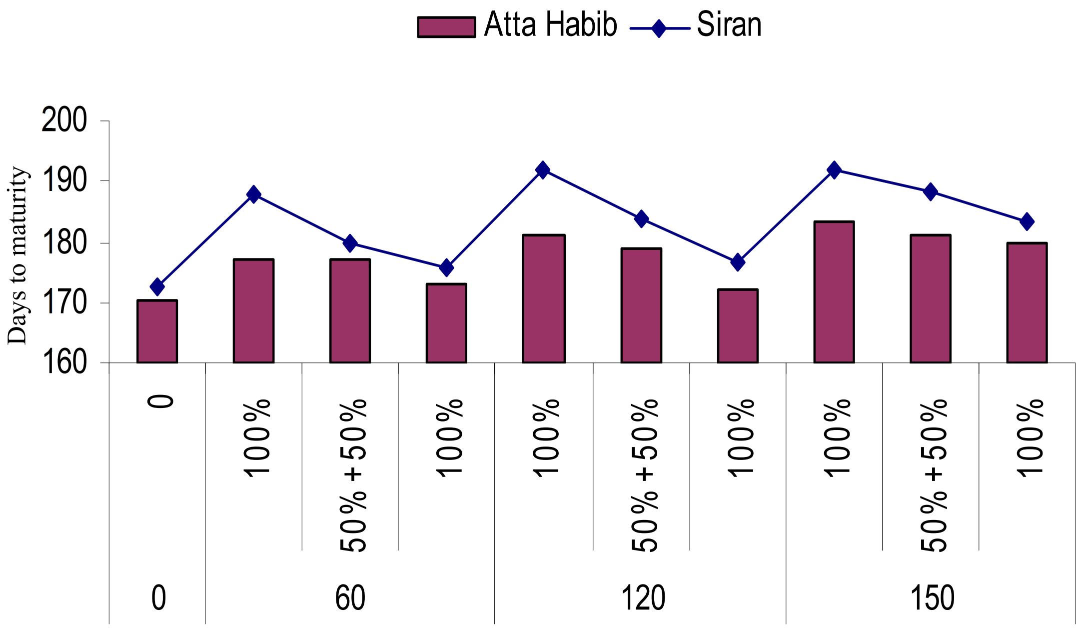

Cultivars, urease inhibitor stage and Nitrogen (kg ha^{-1})

Fig. 2. Days to maturity of wheat is affected by urease inhibitor stage, cultivars and nitrogen levels

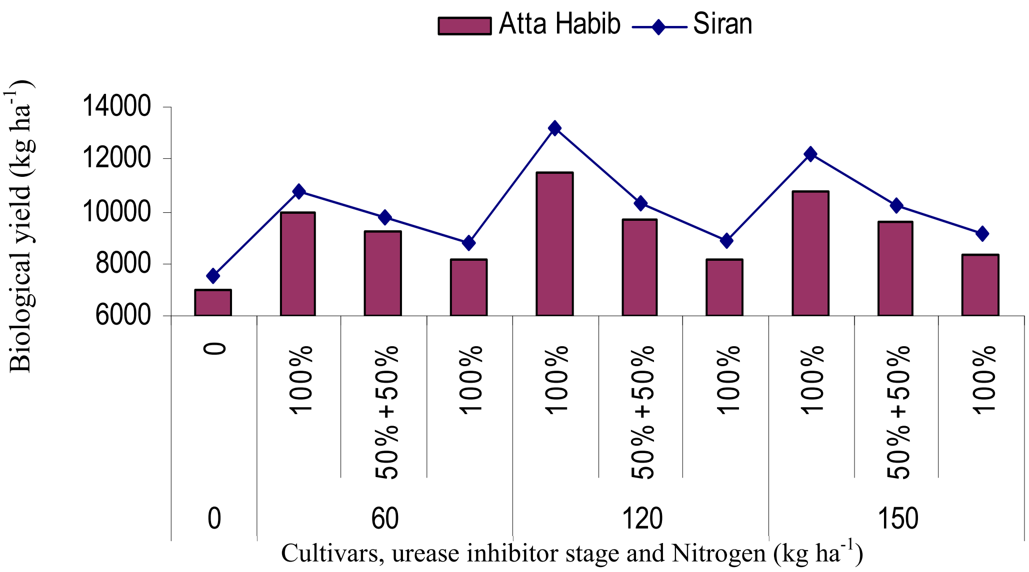

Fig. 3. Biological yield of wheat is affected by urease inhibitor stage, cultivars and nitrogen levels.

CONCLUSION AND RECOMMENDATIONS

The results obtained from the present study indicated that cultivar Siran treated with 120 kg N ha^{-1} and coated urease inhibitor 100% at sowing stage delayed days to booting, physiological maturity, improved plant height, leaf area tiller^{-1} and biological yield significantly and therefore, it is recommended that cultivar Siran treated with 120 kg N ha^{-1} and coated urease inhibitor 100% at sowing stage for improved biomass productivity in agro-climatic condition of Peshawar valley.

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