ROOT SYSTEM ARCHITECTURE VARIABILITY AND NITRATE REDUCTASE ACTIVITY IN WHEAT GENOTYPES FOR NITROGEN USE EFFICIENCY

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Abstract

Selection of nitrogen (N) efficient genotypes based on N assimilating enzymes and root architectural traits are among the strategies to achieve improved nitrogen use efficiency (NUE). Twenty wheat genotypes were evaluated in this study out of which three genotypes Pirsabak-13, Shakar-13 and AAS-2011 performed well under different treatments. The highest NUE of 45.6% was estimated in Pirsabak-13 under 100% level of calcium nitrate followed by 22.7% in Shakar-13 under 50% level of calcium nitrate whereas under both levels of urea only AAS-2011 performed well with estimated NUE of 25.6% and 12.9% respectively. Significant variation has been observed in terms of nitrate reductase activity in these three genotypes. Under N-deficient conditions shakar-13 and AAS-2011 showed 0.34 and 0.37µmol NO_2^- h^{-1} g^{-1} FW NR activity respectively whereas in N-sufficient conditions Pirsabak-13 and AAS-2011 showed 0.43 and 0.42 µmol NO_2^- $^{h-1}$ g^{-1} FW NR activity respectively. In case of root-architectural traits, significantly higher total root length of 122.7 cm and lateral root density of 1.96 cm/cm^3 was measured in AAS-2011 when recommended dose of urea was applied as compared to nitrate source. But primary root length was more in Pirsabak-13 i.e. 33.17 cm when full dose of nitrate source was applied. This showed the selective behaviour of genotypes with reference to root growth and nitrate reductase activity in different N sources and better NUE.

Keywords: Nitrogen, NUE, Nitrate reductase, Root architecture, Wheat

1. Introduction

Among the nationals of Pakistan wheat is considered as the most important staple food and is cultivated on 9 million hectares acreage that accounts almost 40% of country's total cultivated area, with average production of 20-24 million tons and dominated over other major crops. Share of wheat in GDP is 3% which is 14.4% to the value-added agriculture Abid et al., (2018)

Nitrogen (N) is the most limiting macronutrient for wheat production, crucial for protein synthesis, enzymes activation, plant signalling pathways and photosynthetic processes that affects plant growth and grain yield. Nitrogen use efficiency (NUE) is estimated up to 60% in wheat crop, which is not sufficient to compete with population induced grain yield demand. Excessive un-judicious application of N fertilizers to combat yield demand, has resulted in undesirable consequences of soil acidification, degradation of water by N leaching in ground water and gaseous loses to atmosphere causing severe effects to air quality. In recent times, the most important approach to enhance NUE is to optimize the nitrogen assimilating enzymes and root architectural traits to screen nitrogen use efficient genotypes for sustainable agriculture to save the future generations.

2. Material and Methods

A hydroponic experiment was conducted in 2020 at University of agriculture, Faisalabad. Twenty wheat varieties were evaluated under following treatment plan.

Image J based smart root software was used for the determination of root architectural parameters mentioned in the table. Total N content in shoot and root for NUE estimation was done by kjeldahl method. Shoot Nitrate Reductase (NR) activity was measured spectrophotometric ally through method proposed by Baki et al., (2000).

3. Results

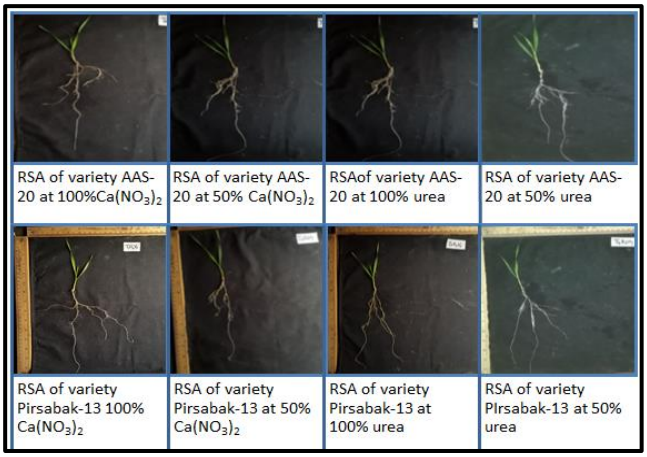
Significant variation was observed in morphological and physiological parameters as some genotypes showed improved morphological parameters including primary root length, total root length, lateral root length, plant height, shoot length, fresh root weight, fresh shoot weight and root dry weight. When full and half dose of Ca $(NO_3)_2$ was applied, mostly parameters of genotype Pirsabak-13 showed the maximum significant results. In case when full and half dose of urea were applied, maximum significant results were noticed in genotype AAS-2011. There is a positive correlation between genotypes chlorophyll contents, total plant N and NR activity. The genotype Pirsabak-13 showed the maximum NUE in nitrate source and AAS-2011 showed maximum NUE in ammonical source of N.

In conclusion Pirsabak-13 performed better in recommended dose of calcium nitrate treatment and Shakar-13 in half of recommended dose application of calcium nitrate and genotype AAS-2011 performed better when full and half dose of urea was applied. Improved NUE can be attributed to better NR activity and intensive root system architecture.

Parameters	N-efficient genotypes			
	Full dose of $Ca(NO_3)_2$	Half dose of $Ca(NO_3)_2$	Full dose of urea	Half dose of urea
	Pirsabak-13	Shakar-13	AAS-2011	AAS-2011
PRL (cm)	33.17±0.5	20.2±0.3	22.4±0.2	18.8±0.22
SLRL (cm)	89.53±0.4	77.06±0.3	75.9±0.5	67.9±0.7
TRL (cm)	122.7±0.5	97.26±0.5	98.3±0.5	86.7±0.5
RFW (mg)	1030±43.9	953.3±29.	980±34.6	995.7±20.2
RN (%)	0.9±0.08	0.6±0.03	0.9±0.05	0.7±0.03
SN (%)	3.409±0.2	2.11±0.04	2.9±0.04	2.3±0.04
NUE (%)	45.6±0.9	22.6±0.5	25.6±0.5	12.9±0.5
NR activity*	0.42±0.01	0.34±0.01	0.42±0.01	0.4±0.01

*(µmol NO_2^- h^{-1} g^{-1} FW)

PRL= Primary root length, SLRL= Sum of lateral roots length, TRL= Total root length, RFW= Root fresh weight, RN= Root nitrogen, SN= Shoot nitrogen, NUE= Nitrogen use efficiency, NR= Nitrate reductase activity. Data are means ± SE.



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