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Variation of Nitrogen Uptake Efficiency in Local Landraces of Wheat in Mahabad–Iran

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ABSTRACT

The efficiency with which nitrogen (N) is used by wheat and other cereals is gaining importance, because of increasing costs of N fertilizer and environmental contamination. Breeding of N efficient wheat depends, beside other factors, on the existence of genetic variation for N uptake efficiency. 20 local landraces of wheat were selected randomly from different rainfed regions of Mahabad and evaluated for nitrogen uptake efficiency as a randomized complete block design with four replications. Results showed a significant variation among local genotypes for nitrogen uptake. Genotypes numbered 2 and 14 had the highest N uptake efficiency. There was no significant interaction between nitrogen rate and genotypes; nonetheless highly efficient landraces could be involved in hybridization programs, advanced yield testing trials and may be released as superior cultivars after demonstration.

Key Words: Genetic variability; N efficiency; *Triticum aestivum*

INTRODUCTION

The principal objective of breeding wheat is increasing grain yield per unit land surface. The green revolution in the past century depended mainly on the fertilizer application. Increased use of fertilizer nitrogen (N) in agricultural production has raised concerns, because the N surplus is at risk of leaving the plant-soil system causing environmental contamination and also increased costs associated with the manufacture and distribution of N fertilizer. This has renewed research interest in increasing the efficient use of N fertilizer in different crops. Worldwide interest associated with increasing cereal grain protein has focused added attention on improving the utilization of N in cereals (Desai & Bhatia, 1978). Wiesler *et al.* (2001) have reported the combination of both reduced N supply and cultivation/breeding of N efficient cultivars as the means to reduce the N surpluses in oilseed rape. Successful breeding of N efficient crop depends beside other factors on the existence of genetic variation. Genotypic variation in nutrient efficiency is complicated by the absence of a generally accepted definition of N efficiency. A genotype can be termed N efficient either, when realizing a high yield under conditions of low N supply (Graham, 1984) or when converting N fertilizer efficiently in to yield under conditions of high N supply (Sattelmacher *et al*., 1994). Hence, N efficiency can be split in to two components (Moll *et al*., 1982) i.e. N uptake (the efficiency with which the soil N can be taken up by the plant) and N utilization efficiency (the seed dry weight per unit of absorbed N fertilizer). Genotypic variation in N efficiency could generally be attributed to high N uptake and/or high N utilization (Sattelmacher *et al*., 1994).

Effective selection for improved N efficiency necessitates testing at different N levels. Testing only under optimal conditions of crop production may mask the differences among the genotypes for N use efficiency (Gueye, 2002). Genetic variation in the N uptake and N utilization has been demonstrated in many field crops. Spanakakis (2000) reported the feasibility of selecting high yielding wheat cultivars with better quality. Presterl *et al.* (2000) selected N efficient maize genotypes under low and high N input. Maidl *et al*. (2000) studying N efficiency in 40 cultivars of barley under 3 N levels found significant genotypic differences for N uptake and utilization under deprived N supply. Yau and Thurling (1987) demonstrated the existence of genotypic variation for N utilization under sub-optimal N supply and for N uptake in the intermediate N supply in a segregating population of oilseed rape. Uptake and partitioning between straw and grain are the two major components of N economy in plants (Desai & Bhatia, 1978). The relative contribution of these processes to genotypic differences in nitrogen use efficiency (NUE) is un-known and varies among genetic populations and among environments. Wuest and Cassman (1992) found recovery of N applied at planting ranged from 30 to 55%, while recovery of N applied at anthesis ranged from 55 to 80% in irrigated wheat. Amount of N applied at anthesis had the greatest influence on post-anthesis N uptake, which ranged from 17 to 77 kg N ha^{-1}, showing that late N application can be efficiently taken up by plants. NUE by any plant is typically perceived based on the fact that maximum N accumulation of grain crops to be reached sometime between pollination and maturity (Francis *et al*., 1993). Dhugga and Waines (1989) noted genotypic differences in wheat for shoot N accumulation before and after anthesis at the highest soil N level. Some genotypes either stopped accumulating or showed a net loss of shoot N between anthesis and maturity, which was associated with superior pre-anthesis N accumulation capacity and reduced grain N yield.

Since NUE is represented by both N uptake and N utilization, any studying in this field should be related to either of the two components. The present work is a further contribution in an effort to find the genetic variation of local wheat for N uptake at different N levels.

MATERIALS AND METHODS

Twenty local landraces of wheat were selected randomly from different rain-fed regions of Mahabad in North-West of Iran and were planted after vernalization (50 days at 4^{oC}) in pods containing about 3 kg double dionized water washed sand. All required nutrients were applied according to Feiziasl *et al.* (2003). Nitrate rates of 6, 8, 10 and 12 (mg/kg) from origin of urea and ammonium nitrate were used as the N treatments. A complete factorial arrangement of treatments was used (N rate × genotype) as a randomized complete block design with four replications. Total biomass of each plot (including roots after washing) was harvested at anthesis. Total N was determined using a Carlo-Erba NA 1500 dry combustion analyzer. Nitrogen use efficiency was analyzed according to an expanded model of Moll *et al.* (1982), while that of N uptake efficiency was obtained as ratio of total plant N to N supply per plot. Genotype and replication effects were assumed to be random parameters, while N levels were assumed to be fixed variables in estimating expected mean squares.

RESULTS AND DISCUSSION

Although for total biomass weight there was no significant difference, the landraces showed that significant differences for nitrogen contents (Table I). Data revealed significant difference between at least two landraces in terms of nitrogen uptake efficiency (Table II). Significant genetic variation in nitrogen uptake efficiency has been reported on oilseed rape (Yau & Thurling, 1987; Kessel & Becker, 1999). Comparison of means showed that landraces numbered 2 and 14 had the highest and landrace 11 had the least nitrogen uptake efficiency, respectively (Fig. 1). Spanakakis (2000) studied 30 wheat lines and selected three N efficient genotypes. Maidl *et al.* (2000) selected some nitrogen efficient genotypes by studying on 40 barley cultivars.

There was no significant interaction between genotype and nitrogen content of landraces (Table II). Hence it was not possible to select some landraces suitable for high nitrogen conditions and vice versa. Non-significant interactions between genotype and N level, suggesting that the high yielding genotypes in high N supply, were not necessarily high yielding in the low N supply. Moll *et al.* (1982) observed an interaction between corn hybrids and N levels for all traits except grain yield. At low N supply, differences among hybrids for NUE were largely due to variation in utilization of accumulated N, but with high N they were largely due to variation in uptake efficiency. They concluded that variation of NUE appeared to result from differences among genotypes and levels of N supplied. However, absence of significant interaction has been reported earlier (Spanakakis, 2000). In the general, presence or absence of interactions strongly depends upon the behavior of the genotypes.

It is concluded that evaluation of larger germplasm in various nitrogen levels may be accompanied with significant interaction between genotypes and nitrogen content. In the other hand, highly N-efficient landraces may

Table I. Analysis of variance on biomass weight of wheat landraces

Source of variation	df	MS
Replication	3	0.1^{ns}
Nitrogen	3	0.3^{ns}
Genotype	19	0.8^{ns}
Genotype × Nitrogen	57	0.2^{ns}
Error	237	0.2

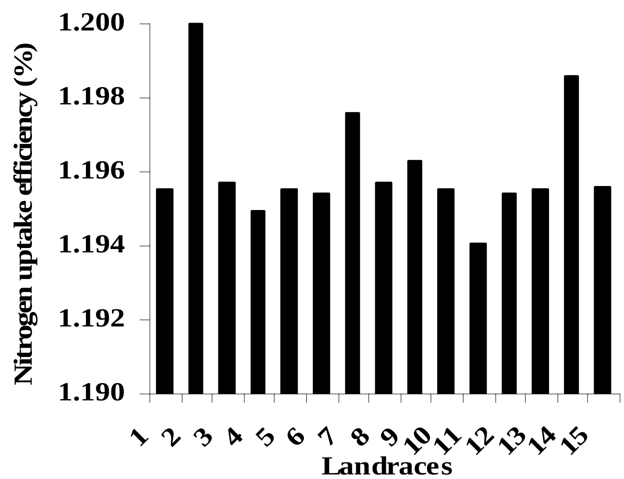
^{ns} non significant at 5%

Table II. Variation and its components in some wheat landraces in terms of nitrogen content (NC) in biomass and nitrogen-uptake efficiency (NUE) (as ratio of present nitrogen to applied total)

Source of variation	df	MS		EMS
		NC	NUE	
Replication	3	0.2^{**}	0.0002^{**}	
Nitrogen	3	5.47^{**}	0.00002^{*}	
Genotype	19	0.11^{*}	0.00008^{*}	$\sigma^2e + 16\sigma^2g$
Genotype × Nitrogen	57	0.03^{ns}	0.00001^{ns}	$\sigma^2e + 4\sigma^2gn$
Error	237	0.04	0.00001	σ^2e

^{ns} non significant at 5%. *Significant at 5%. ** Significant at 1%

Fig. 1. Nitrogen uptake efficiency in 15 landraces of wheat



be involved in advanced yield testing trials and may be released as superior cultivars. Mean-while, they can be used as a suitable parent in hybridization programs.

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