Global Journal Of Biodiversity Science And Management, 3(2): 125-129, 2013
ISSN 2074-0875

Effect of nitrogen sources on durum wheat (*Triticum durum* desf.) yield and yield components under Mediterranean rainfed environment

[1]Sameh Boukef, [2]Chahine Karmous, [1]Sawsen Ayadi, [1]Youssef Trifa, [1]Salah Rezgui

[1]*Department of Agronomy and Plant Biotechnology, National Institute of Agriculture of Tunis, Avenue Charles Nicolle 1002 Tunis, Tunisia*
[2]*Department of Plant Sciences, Agricultural High School of Mateur. Route de Tabarka, 7030, Mateur. Tunisia.*

ABSTRACT

Nitrogen (N) fertilization constitutes one of the most important wheat cropping practice. In addition to ammonium-nitrate which was the most used In Tunisian agriculture, many N chemical sources were introduced recently. A field study was conducted on three durum wheat genotypes. Ammonium sulfate nitrate (ASN) and urea fertilizers N source were used to generate seven N levels. The experiment was designed as a split-split-plot arrangement with three replications. In addition to plant high (H), yield and yield component parameters were measured as: number of spike per m^2 (NS), number of grains per spike (NG), thousand kernel weight (TKW), average yield (Y). The results showed a positive correlation between N levels and all measured parameters. Only thousand kernel weight (TKW) was significantly affected by the interaction of genotypes, N sources and levels. In addition, ASN was more efficient than urea as N source. ASN Nitrogen source was more efficient with an average yield increase of 6.05% for 'Karim', 3.70% for 'Om Rabia' and 8.98% for 'Nasr' compared to urea. The highest yield (40.86 qx/ha) was obtained by 'Om Rabia' under the highest ASN treatment (93.8 $KgNha^{-1}$). This efficient genotype under ASN showed an increase of H (22.67%), TKW (2.57%), NS (1.28) and NG (1.61) compared to urea. Our results showed that ASN was a more efficient N source than urea due mainly to its mineral and available form for wheat roots.

Key words: Ammonium sulfate nitrate, urea, genotypic variability, efficient nitrogen source.

Introduction

Nitrogen fertilizers are among fundamental crop growth demand (Lam *et al*. 1996; Giller 2004), contributing to 50% of the human food consumption (Ladha *et al.* 2005). The use of N fertilizers increased 100 fold over the last 100 years to improve grain yield and protein content (López-Bellido *et al*. 2008). In fact, 60% of worldwide (Ladha *et al.* 2005) and 81% of Tunisian (CTC 2008) global N fertilizer are used for producing grain cereals. N fertilization constitutes one of the most expensive agricultural nutrient inputs (Good *et al*. 2004; Foulkes *et al*., 2009). Wheat yields and especially those of new developed genotypes are among the most depending nitrogen fertilization plant species (Hirel *et al.* 2001). N fertilization increased wheat biomass (Golik *et al.,* 2005), yield (Oad *et al.* 2004; Fallahi *et al.* 2008) and protein content (Carr *et al.* 1992; Saint Pierre *et al.* 2008). In fact, nitrogen is a constitutive component of chlorophyll and proteins affecting thus photosynthesis process (Triboï *et al.* 2002; Tranavičienė *et al*., 2007). The wheat needs of nitrogen is a complex trait depending on genotypes, years, sites and stage of development (Gate 1995; Gastal *et al.* 2002). Besides, wheat response to N fertilizer is influenced by soil type, tillage methods, crop rotation and amount of mineralized nitrogen (López-Bellido *et al*. 2001). Genetic diversity was noted among wheat nitrogen use efficiency at low and high N supply (Foulkes *et al*. 2009; Khalilzadeh *et al.* 2011) leading to numerous selection programs (Ortiz Monasterio *et al*., 1997; Van Ginkel *et al.* 2001).

In Tunisia, durum wheat occupies 50-75% of the area reserved for cereals and accounts for 60% of national cereal production. Water and N fertilizers are the most limiting factor of the Tunisian wheat production (Latiri-Souki *et al.* 1992). N requirements for durum wheat are important and were estimated to 3.2 kg / quintal of produced grains (Ben Ali 2004) contrasting with only 2.4 kg/quintal for barley (Gate 1995). The used N fertilizers for wheat are constituted at 90% by ammonium-nitrate (NH_4NO_3) (CTC, 2008). Many other N sources are available in market as inorganic forms like ammonium sulfate ($(NH_4)_2SO_4$), calcium nitrate ($Ca(NO_3)_2$), ammonium sulfate nitrate ($NH_4NO_3(NH_4)_2SO_4$), potassium nitrate (KNO_3) and/or organic form mainly as urea ($CO(NH_2)_2$) (Sartain and Kruse 2001).

Significant effects of the fertilization treatments on all growth stages were obtained for wheat genotypes using urea N source (Golik *et al.* 2005) and ammonium sulfate (Malhi *et al.* 2009). In fact, plants are capable of assimilating nitrate (NO_3^-) and ammonium (NH_4^+) into amino acid (Xu *et al.* 2011). In addition, plants are able to use urea as N source from the soil and/or leaves from the foliar applications (Criddle *et al.* 1987; Merigout *et al,* 2008). In soils, urea is rapidly degraded to NH_4^+ by urease (Cartes et al. 2009) and then oxidized to NO_3^- by

Corresponding Author: Sameh Boukef, Department of Agronomy and Plant Biotechnology, National Institute of Agriculture of Tunis, Avenue Charles Nicolle 1002 Tunis, Tunisia
E-mail: samehboukef@yahoo.fr; Telephone: (+216) 71 287 110 / 71 289 431 / 71 892 785

the nitrification process. Besides, plants could capture urea throw passive and/or active pathways (Kojima *et al.* 2007). In addition, concomitant sulfate (S) and N application enhanced durum wheat grain quality parameters (Lerner *et al.* 2006). Indeed, S deficiency is known to reduce baking quality of wheat flour (Kettlewell *et al.* 1998).

N ion chemical form present in nutrient solution is among chlorophyll content changes in wheat (Mihailovic *et al.* 1997) and thus in field wheat and barley yield (Jones *et al.* 2007). Uptake interaction studies on wheat showed that urea uptake was too slow and its presence had major inhibitory effects on the uptake of each of NO_3^-, NH_4^+, and $N0_2^-$ (Criddle *et al.* 1987).

We present in this paper the variation of durum wheat grain yield and yield components under two main nitrogen sources (urea and ASN) at different N levels.

Material and Methods

Field experiments:

Three local durum wheat genotypes (Karim, Om Rabia and Nasr) (Deghaïs *et al*. 1999; Gharbi *et al*. 2000) were grown during the growing season 2010-2011 in northern Tunisia (Boulifa station, Kef) (36° 07' N; 8° 43' E; elevation 520m) under rainfed conditions, with a mean annual precipitation and average relative humidity of 557.3mm and 54.34%, respectively (Table 1). The crop received 411mm during the growing season.

Table 1: Precipitation, relative humidity and air temperature during growth season of 2008-2009.

	Precipitation (mm)	Relative humidity (%)	Temperature (°C)
September	42.41	47.4	24.8
October	40.38	58.3	19.4
November	14.72	60.6	13
December	27.96	69.2	8.5
January	67.57	74.4	9.2
February	42.93	66.6	8.8
Mars	44.71	62.9	12.1
April	157.47	66.8	14.4
May	54.62	48.9	22.1
June	1.02	29.9	28.1

The durum wheat genotypes were sown on a typical alluvial soil of Mediterranean region (Table 2).

Table 2: Soil properties at the beginning of the experiment.

	Soil characteristics
Sand (%)	56
Silt (%)	18
Clay (%)	26
pH	7.7
MO (%)	2.21
$CaCO_3$	16
P Olsen (mg/kg)	12
K (cmol/kg)	16
CEC (cmol/kg)	0.74
K/ CEC (%)	4.1

Two nitrogen sources were tested: urea (46% N) and ASN (26% N). Seven nitrogen levels were applied: 13.4 $Kgha^{-1}$, 26.8 $Kgha^{-1}$, 40.2 $Kgha^{-1}$, 53.6 $Kgha^{-1}$, 67 $Kgha^{-1}$, 80.4 $Kgha^{-1}$ and 93.8 $Kgha^{-1}$. Nitrogen fertilizers were applied in three fractions at key growth stages: early tillering (30%), elongation (40%) and 2^{nd} node (30%).

The experiment was designed as randomized complete block with a split-split plot arrangement with three blocks. The area of each sub-subplot was $10m^2$ (10m×10m). Main plots were considered nitrogen sources as main factor, durum wheat genotypes as second factor and nitrogen level as third factor.

To assess the effect of nitrogen sources and level on rainfed durum wheat genotypes, plant high (H), number of spike per m^2 (NS), number of grains per spike (NG), thousand kernel weight (TKW) and average yield (Y) were measured in the experimental plots.

Statistical analysis:

Data were analyzed with significant genotypes, N source, N level and their resultant interactions were tested by ANOVA using SAS proc GLM (SAS Institute Inc., 1999). Treatment means were compared by Duncan's multiple range test (α=0.05).

Results:

The simple effect of N source and N level were noted for all measured yield components. The same pattern was observed for the tested genotypes except for the number of grains per spike (NG) (Table 3). Only thousand kernel weight (TKW) showed a significant effect of the interaction N source x Genotype x N level.

Table 3: Analysis of variance (mean square and *F test*) for yield components: height (H), number of spike per m^2 (NS), number of grains per spike (NG), thousand kernel weight (TKW) and average yield (Y).

Source of variation	df	H	NS	NG	TKW	Y
Bloc	2	9.53*	16.67ns	6.43**	3.98**	13.72**
N source	1	5100.34**	339.17**	5.72**	65.44**	35.17**
N level	7	4286.89**	35782.12**	985.42**	1537.91**	2330.13**
Genotypes	2	264.92**	82.69ns	5.82**	59.25**	51.81**
N level x N source	7	107.26 **	3.20ns	0.35ns	9.17**	2.79**
N source x Bloc	2	0.53ns	7.09ns	0.005ns	0.08ns	0.02ns
N level x Genotypes	14	4.73*	385.64**	2.96**	4.58**	8.28**
N source x Genotypes	2	17.96*	85.44ns	0.10ns	8.50**	1.48ns
N source x Genotypes × Bloc	8	4.91 ns	64.84ns	0.08ns	0.63ns	0.59ns
N source x Genotypes x N level	14	1.41ns	30.61ns	0.16ns	1.58**	0.64ns
Error	84	2.53	33.56	0.25	0.37	0.51
C.V (%)		2.58	2.51	2.29	1.94	4.29
R^2		0.99	0.98	0.99	0.99	0.99

ns: not significant (P>0.05); *: F test significant (P < 0.05); **: F test significant (P < 0.01).

Plant height increased significantly by both N fertilizers. An average increase of 121% was registered with the highest N level (93.8 $KgNha^{-1}$). N level and genotypes and also by their resultant interactions as: N level × N source; N source × genotypes and N level × genotypes (Table 3). The same trend of the increasing plant high for the tested genotypes were noted under the two N sources (Fig. 1).The genotypic difference was more remarkable in ASN than urea nitrogen source mainly since 40.2 $KgNha^{-1}$. Nasr was in average the tallest tested genotype (64.16 cm) followed respectively by Om Rabia (60.97 cm) and Karim (59.58 cm) under urea and ASN nitrogen sources. In addition, ASN was more efficient N source for durum wheat growth (67.52 cm) compared to urea (55.62 cm).

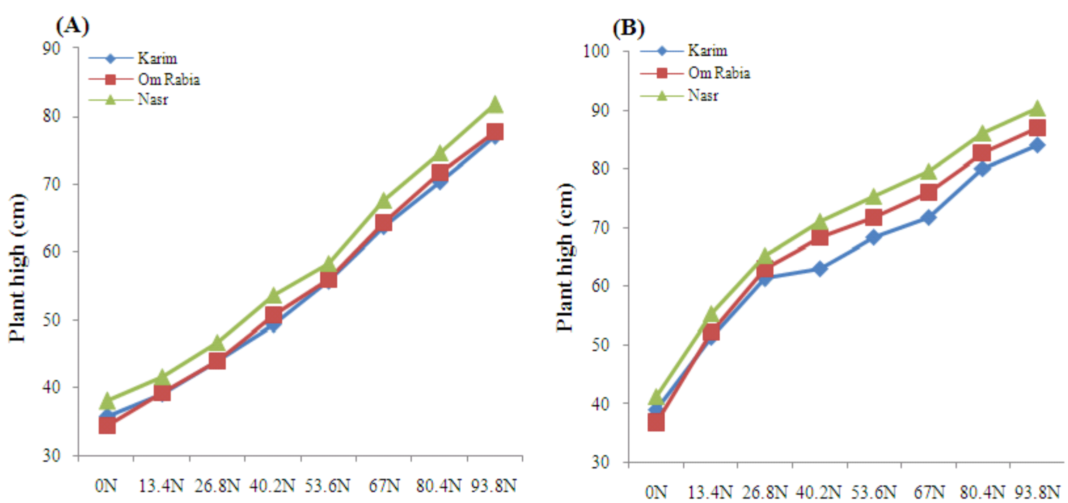

Fig. 1: Variation of plant high of three durum wheat genotypes under two N sources and eight N levels. (A) Urea, (B) ASN.

In addition to the simple effects of N source and N level; only the interaction N level × genotypes affects significantly the number of spike per m^2 (Table 3). No genotypic difference was noted for NS under the different N level for both N sources (Fig. 2). The number of spike per m^2 (NS) increased proportionally to the level of nitrogen fertilizer with an average increase for the urea and ASN nitrogen sources respectively of 88.5% and 84.6% at 93.8 $KgNha^{-1}$ compared to the control (Fig. 2). However, for all level of nitrogen and tested genotypes the ASN nitrogen source was more efficient with an average of 232 spikes per m^2 compared to urea (229 spikes/ m^2).

The analysis of variance showed in addition to the simple effects of N sources, N levels and genotypes that the interaction N level × genotypes had a significant effect on the number of grains per spike (Table 3). As nitrogen level increased, the number of grains per spike (NG) increased afterward with the same trend for both N sources to reach a maximum with 34.28 at 93.8 KgNha^{-1} (Fig. 3). For both N sources, Om Rabia was more efficient for NG with 22.5 grains/ spike followed by Karim (22.81 grains/spike) and Nasr (22.1 grains/spike). The most marked genotypic difference was noted since 53.6 KgNha^{-1} for both N sources. However, ASN nitrogen source showed a better NG with an increase of 1.82% compared to urea.

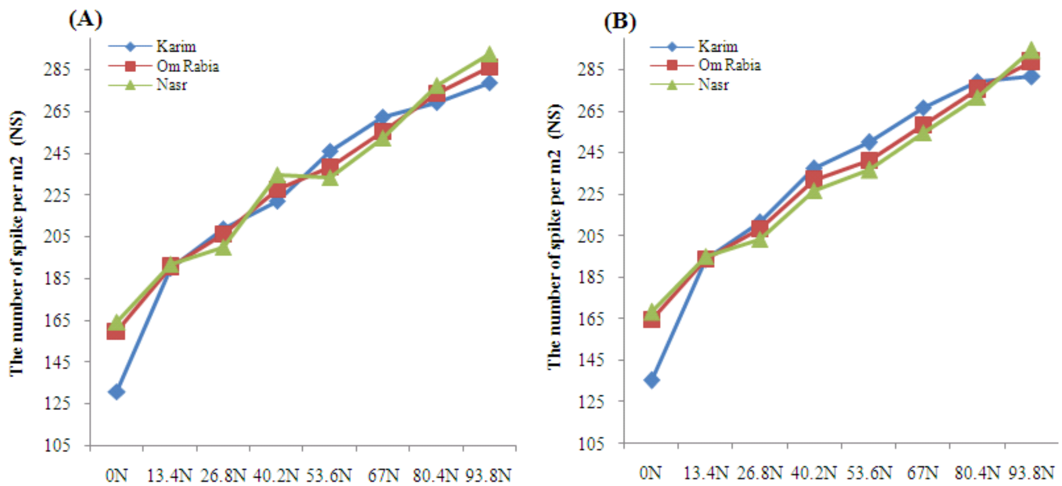

Fig. 2: Variation of the number of spike per m2 (NS) of three durum wheat genotypes at eight N levels and two N sources. (A) Urea, (B) ASN.

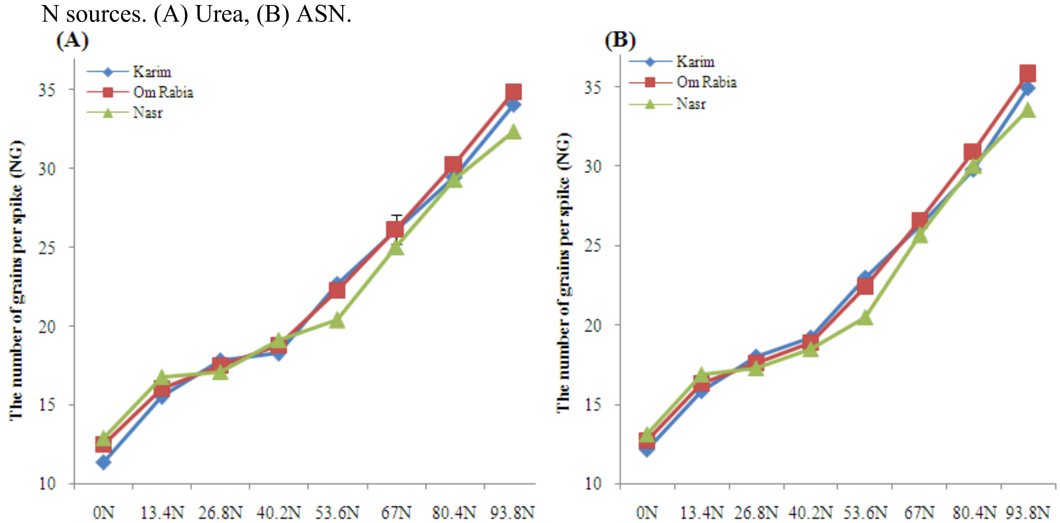

Fig. 3: Variation of the number of grains per spike (NG) of three durum wheat genotypes at eight N levels and two N sources. (A) Urea, (B) ASN.

Thousand kernel weight (TKW) showed a significant effect of the interaction N source × genotypes × N level (Table 3). The TKW increased with the N level to reach a maximum under 93.8 KgNha^{-1} with 45.64 g and 43.62 g respectively for ASN and urea. The average highest N level (93.8 KgNha^{-1}) increased TKW of 118.77% compared to the control. In addition, the ASN was in average more efficient N source than urea with a TKW increase of 2 g (Fig. 4). The genotypic difference was not observed under the low N level (0 to 53.6 KgNha^{-1}). The maximum TKW was obtained under both N source for the genotype Om Rabia (46.7 g) followed by Karim (44.66 g) and Nasr (42.54 g).

Yield of tested durum wheat genotypes was under the effect of the interactions: N level × N source and N level × genotypes (Table 3). The maximum yield was obtained for Om Rabia under 93.8 KgNha^{-1} with 3.93 t ha^{-1} and 4.08 t ha^{-1} respectively for ASN and urea N sources (Fig. 5). In fact, the ASN nitrogen source was more efficient with an increase of 6.09 % then urea. The genotypic variation was observed from 53.6 KgNha^{-1} to 93.8 KgNha^{-1}. Om Rabia showed the maximum average yield over all N sources and N levels (1.78 t ha^{-1}) followed by Karim (1.65 t ha^{-1}) then Nasr (1.58 t ha^{-1}).

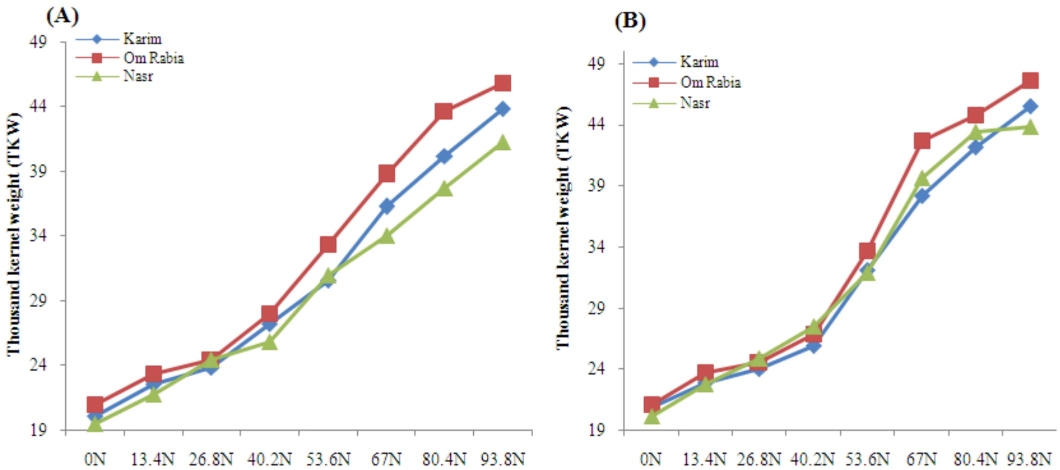

Fig. 4: Variation of thousand kernel weight (TKW) of three durum wheat genotypes at eight N levels and two N sources. (A) Urea, (B) ASN.

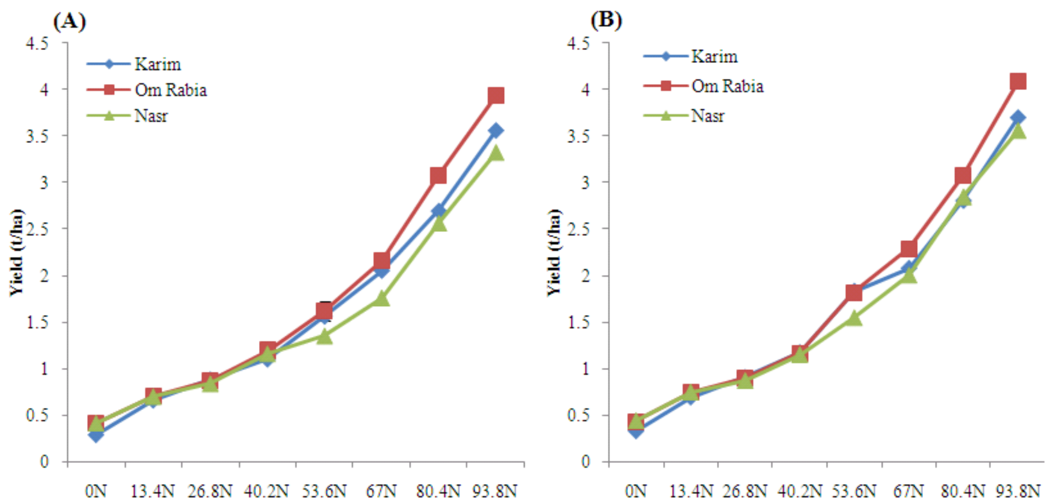

Fig. 5: Variation of the yield (Y) of three durum wheat genotypes at eight N levels and two N sources. (A) Urea, (B) ASN.

Discussion:

Nitrogen application had positive influence on all the yield components. The increase of yield and yield component showed an exponential trend for the tested durum wheat genotypes. It's well known that increase of nitrogen rate induces a raise of wheat growth and plant high (Weisz *et al.* 2007; Hussain *et al.* 2006).

However, the maximum applied N level of 93.8 $Kgha^{-1}$ was insufficient to optimize yield of durum wheat. Controversy about the optimum N rate to maximize wheat yield was noted in previous studies. In fact, Oad *et al.* (2004) showed that application of 120 $KgNha^{-1}$ in bands was better way to apply N fertilizers resulting in greater wheat yield and yield components. However, Fallahi *et al*. (2008) noticed that increasing nitrogen from 60 to 90 $KgNha^{-1}$ did not increase agronomic and yield components. In fact, hard red spring wheat showed no yield increase above 100 kg ha^{-1} (López-Bellido *et al.* 2001). In addition, the scarcity of rain (411 mm) in the rainfed durum wheat adopted system in this assay could be a limiting factor to plant growth. In fact, no N fertilization effects on wheat yield were observed with a rainfall below 450 mm (López-Bellido *et al.* 1996).

The optimum nitrogen rate to achieve plant yield potential seems to be related to N fertilizers source and to soil components as: N soil content, water soil content and soil texture (Selim, 2004). In fact, Nanwai et al. (1998) reported that, highest wheat grain yield (7.04 and 6.05 T / ha) was recorded with 125% of the recommended dose of inorganic fertilizers (150, 75 and 50 kg N, P_20_5 and k_20/ha) integrated with 25 kg $ZnSO_4$ and organic fertilizer (farmyard manure) at 10 T/ha.

Our results confirmed that N sources have a significant effect on grain yield and yield components under all N levels. Moreover, ASN was the most efficient N source compared to urea. Studies on soft wheat showed that growth was highest under ammonium-nitrate and ammonium sulfate nutrition and lowest with the urea solution after 3 weeks of hydroponic culture (Merigout *et al.* 2008). Besides, uptake interaction studies showed that urea uptake was too slow and its presence had major inhibitory effects on the uptake of NO_3^-, NH_4^+, and NO_2^- (Criddle *et al.* 1987). This difference may be attributed to the organic form of urea which limits its availability to wheat roots. An increase of the urea fertilizer rate over those of mineral fertilizers would be necessary to reach wheat yield optimum. In fact, nitrogen applied as urea source at 150-200 $kgha^{-1}$ increased soft wheat yields to an optimum (Hussain *et al.* 2006).

A genotypic variability was noted for all tested parameters except for the number of spike per m2 (NS). These results confirm the findings of Hussain *et al.* (2006), who observed no significant differences between four wheat genotypes in total spikes per meter square unlike the other yield components. Throw the tested yield parameters and over all N sources and N rates, the 'Om rabia' was the most productive and efficient durum wheat genotype followed by 'Karim' and then 'Nasr'.

Abbreviations:

N: nitrogen; NG: number of grains per spike; NS: number of spike per m^2; TKW: thousand kernel weight, Y: yield; ASN: ammonium sulfate nitrate.

References

Cartes, P., A.A. Jara, R. Demanet and M.L. Mora, 2009. Urease activity and nitrogen mineralization kinetics as affected by temperature and urea input rate in southern chilean andisols. J. Soil Sc. Plant Nutr., 9(1): 69-82.

Ben Ali, O., 2004. Possibilité d'utilisation du chlorophyllomètre comme outil d'aide à la décision à la fertilisation azotée des stades précoces des blés : cas des variétes cultivées en Tunisie. M.S. thesis. Institut national agronomique de Tunisie, Tunisie.

Carr, P.M., J.S. Jacobsen, G.R. Carlson and G.A. Nielsen, 1992. Influence of soil and N fertilizer on performance of barley and spring wheat cultivars. Canadian J. Plant Sci., 72: 651-661.

Centre Technique des Céréales (CTC), 2008. Maitrise de la fertilisation azotée des céréales en Tunisie : alternatives à l'ammonium nitrate.

Criddle, R.S., M.R. Ward and R.C. Huffaker, 1987. Nitrogen Uptake by Wheat Seedlings, Interactive Effects of Four Nitrogen Sources: NO_3^-, NO_2^-, NH_4^+, and Urea. Plant Physiol., 86: 166-175.

Deghais, M., M. Kouki, M.S. Gharbi and M. El Felah, 1999. Les variétés de céréales cultivées en Tunisie. CERES. 430p.

Fallahi, H., A. Nasseri and A. Siadat, 2008. Wheat Yield Components are Positively Influenced by Nitrogen Application under Moisture Deficit Environments. International Journal of Agriculture & Biology, 10: 673-676.

Foulkes, M.J., M.J. Hawkesford, P.B. Barraclough, M.J. Holdsworth, S. Kerr, S. Kightley and P.R. Shewry, 2009. Identifying traits to improve the nitrogen economy of wheat: Recent advances and future prospects. Field Crops Research, 114: 329–342.

Gastal, F. and G. Lemaire, 2002. N uptake and distribution in crops: an agronomical and ecophysiological perspective. Journal of Experimental Botany, 53(370): 788-799.

Gharbi, M.S., M. Deghais and F. Ben Amar, 2000. Breeding for resistance to Septoria tritici in durum wheat. Options Méditerranéennes: Série A. Séminaires Méditerranéens, 40: 397-401.

Giller, K.E., 2004. Emerging technologies to increase the efficiency of use of fertilizer nitrogen. In: A.R. Mosier, J. K. Syers and J.R. Freney (eds), Agriculture and the nitrogen Cycle. Scope 65. Island Press Washington DC, 35-51.

Golik, S.I., H.O. Chidichimo and S.J. Sarandón, 2005. Biomass Production, Nitrogen Accumulation and Yield in Wheat Under Two Tillage Systems And Nitrogen Supply In The Argentine Rolling Pampa. World Journal of Agricultural Sciences, 1(1): 36-41.

Good, A.G., A.K. Shrawat and D.G. Muench, 2004. Can less yield more? Is reducing nutrient input into the environment compatible with maintaining crop production? Trends in Plant Science, 9 (12): 597-605.

Hirel, B., P. Bertin, I. Quilleré, W. Bourdoncle, C. Attagnant, C. Dellay, A. Gouy, S. Cadiou, C. Retailliau, M. Falque and A. Gallais, 2001. Towards a better understanding of the genetic and physiological basis for nitrogen use efficiency in maize. Plant Physiol, 125: 1258-1270.

Hussain, I., M.A. Khan and E.A. Khan, 2006. Bread wheat varieties as influenced by different nitrogen levels. J Zhejiang Univ Science B 7 (1): 70-78.

Jones, C.A., R.T. Koenig, J.W. Ellsworth, B.D. Brown and G.D. Jackson, 2007. Management of urea fertilizer to minimize volatilization. he U.S. Department of Agriculture (USDA), Montana State University and the Montana State University Extension, pp:12.

Kettlewell, P.S., M.W. Griffiths, T.J. Hocking and D.J. Wallington, 1998. Dependence of wheat dough extensibility on flour sulphur and nitrogen concentrations and the influence of foliar-applied sulphur and nitrogen fertilisers. Journal of Cereal Science, 28: 15–23.

Khalilzadeh, G.H., J. Mozaffari and E. Azizov, 2011. Genetic differences for nitrogen uptake and nitrogen use efficiency in bread wheat landraces (*Triticum aestivum* L.). International Journal of AgriScience, 1(4): 232-243.

Kojima, S., A. Bohner, B. Gassert, L. Yuan and N. vonWir´en, 2007. AtDUR3 represents the major transporter for high-affinity urea transport across the plasma membrane of nitrogen-deficient Arabidopsis roots. Plant J., 52: 30–40.

Ladha, J.K., H. Pathak, T.J. Krupnik, J. Six and C. van Kessel, 2005. Efficiency of Fertilizer Nitrogen in Cereal Production: Retrospects and Prospects. Advances in Agronomy, 87: 85-156.

Lam, H.M., K.T. Coschigano, I.C. Oliveira, R. Melo-Oliveira and G.M. Coruzzi, 1996. The molecular-genetics of nitrogen assimilation into amino acids in higher plants. Annu. Rev. Plant Physiol. Plant Mol. Biol., 47: 569-93.

Lerner, S.E., M.L. Seghezzo, E.R. Molfese, N.R. Ponzio, M. Cogliatti and W.J. Rogers, 2006. N- and S-fertiliser effects on grain composition, industrial quality and end-use in durum wheat. Journal of Cereal Science, 44: 2–11.

López-Bellido, L., M. Fuentes and J.E. Castillo, 1996. Long-term tillage, crop rotation, and nitrogen fertilizer effects on wheat yield under rainfed mediterranean conditions. Agron J., 88: 783-791.

López-Bellido, R.J., J.E. Castillo and L. López-Bellido, 2008. Comparative response of bread and durum wheat genotypes to nitrogen fertilizer in a rainfed Mediterranean environment: soil nitrate and N uptake and efficiency. Nutr Cycl Agroecosyst, 80: 121-130.

López-Bellido, R.J. and L. López-Bellido, 2001. Efficiency of nitrogen in wheat under Mediterranean conditions: effect of tillage, crop rotation and N fertilization. Field crop research, 71: 31-46.

Malhi, S.S., J.J. Schoenau and C.L. Vera, 2009. Influence of six successive annual applications of sulphur fertilizers on wheat in a wheat–canola rotation on a sulphur deficient soil. Canadian Journal of Plant Science, 89 (4): 629-644.

Merigout, P., V. Gaudon, I. Quillere, X. Briand and F. Daniel-Vedele, 2008. Urea Use Efficiency of Hydroponically Grown Maize and Wheat. Journal of plant nutrition, 31(1-3): 427-443.

Nanwai, R.K., B.D. Sharm and K.D. Taneja, 1998. Role of organic and inorganic fertilizers for maximizing wheat (Triticum aestivum) yield in sandy loam soils. Crop research Hisar, 16(2): 159-161.

Oad, F.C., U.A. Buriro and M.H. Siddiqui, 2004. Yield and Yield Components of Wheat Under Inorganic Nitrogen Levels and Their Application Method. International Journal of Agriculture & Biology, 6 (6): 1159–1161.

Ortiz-Monasterio, J.I., K.D. Sayre, S. Rajaram and M. McMahom, 1997. Genetic progress in wheat yield and nitrogen use efficiency under four nitrogen rates. Crop Sci, 37: 898–904.

Saint Pierre, C., C.J. Peterson, A.S. Ross, J.B. Ohm, M.C. Verhoeven, M. Larson and B. Hoefer, 2008. White wheat grain quality changes with genotype, nitrogen fertilization, and water stress. Agron. J., 100: 414–420.

Sartain, J.B. and J.K A Kruse JK, 2001. Selected fertilizers used in turfgrass fertilization. This document is CIR1262, a circular of the Soil and Water Science Department, Florida Coperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, pp:12.

Selim, A.M., 2004. Response of wheat to different N- applications and irrigation systems under arid conditions. 1st International Conf. on Water Resources & Arid Environment. 5-8 December 2004 King Saud University, Riyadh, Saudi Arabia. http://www.psipw.org/English_PDF/2_Dry/E2-16.pdf

Tranavičienė, T., J.B. Šikšnianienė, A. Urbonavičiūtė, I. Vagusevičienė, G. Samuolienė, P. Duchovskis and A. Sliesaravičius, 2007. Effects of nitrogen fertilizers on wheat photosynthetic pigment and carbohydrate contents. Biologija, 53(4): 80–84.

Triboi, E. and A.M. Triboi-Blondel, 2002. Productivity and grain or seed composition: a new approach to an old problem. Invited Paper. Eur J Agron, 16: 163-186.

Van Ginkel, M., I. Ortiz-Monasterio, R. Trethowan and E. Hernandez, 2001. Methodology for selecting segregating populations for improved nitrogen use efficiency in bread wheat. Euphytica, 119: 223–230.

Weisz, R., R.P. Sripada, R.W. Heiniger, J.G. White and D.C Farrer, 2007. In-Season Tissue Testing to Optimize Soft Red Winter Wheat Nitrogen Fertilizer Rates: Influence of Wheat Biomass. Agron. Jour, 99: 511-520.

Xu, G., X. Fan and A.J. Miller, 2011. Plant nitrogen assimilation and use efficiency. Annu. Rev. Plant Biol., 63: 5.1–5.30.