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# Nitrogen and Water use efficiencies by Wheat using the Neutron hydro probe and the Isotope $^{15}N$

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## Abstract

A field experiment was conducted in South Morocco to investigate means to increase water and N fertilizer use efficiency by wheat. Wheat production depends on N fertilizer addition and better management of irrigation water. The soil of the experimental farm was loamy with an average rainfall of 90 mm/year in a desert climate. Wheat was grown on a soil which was previously amended by Phosphate (124Kg P2O5/ha) and Potassium (42Kg K2O/ha). Three irrigation treatments were investigated in a split plot design with three replications: Treatment I1 (60% field capacity = HCC); I2 (40% HCC); I3 (20% HCC). The three irrigation treatments were maintained and controlled by periodic measurements of soil humidity by a neutron probe. Within each irrigation treatment, five nitrogen treatments were used: nitrogen was added to soil as wheat residues enriched with $^{15}N$ and as ammonium sulphate enriched with 9.96 % atom $^{15}N$ excess, in different applications and at different stages of plant development. The use of wheat residues at the rate of 4.8 T/ha together with the addition of 84kg N/ha ammonium sulfate gave similar wheat yields as when fertilizer N was added at the rate of 168Kg N /ha and 126Kg N/ha. The straw incorporation was more beneficial under more frequent irrigations. For all irrigation treatments, the %N recovery by plants was higher when the soil received labeled mineral nitrogen at seedling development (63 % and 49% respectively for irrigation treatments I1 and I2) than when labeled mineral nitrogen was added to soil after seeding (28 % for irrigation I1 and I3). Wheat yields were increased in relation to currently recommended practices, by application of residues together with increased levels of inorganic nitrogen and in the same time irrigation water was reduced. One irrigation every two weeks (I2 or 40%HCC) during the growing season allows higher wheat yields.

Des essais On été réalisés dans le sud du Maroc pour améliorer l'efficience d'utilisation de l'engrais azoté et des eaux d'irrigation. Le sol était limoneux avec une précipitation annuelle de 90 mm. Le blé a été semé sur une parcelle avec un sol amendé par 124Kg P2O5/ha et 42Kg K2O/ha avec trois traitements d'irrigation en Split plot avec trois répétitions: traitement I1 avec 60% HCC; I2 avec 40% HCC; I3 avec 20% HCC. Les trois traitements ont été contrôlés et maintenus par des mesures de l'humidité du sol par une sonde à neutron. Dans chaque traitement d'irrigation, 5 traitements azotés ont été utilisés : N a été apporté au sol sous forme de résidus de blé enrichi en 15N et de sulfate d'ammonium enrichi avec 9.96 atome $^{15}N$ en excès. L'utilisation de 4.8 T/ha de résidus de blé avec l'addition de 84kg N/ha de sulfate d'ammonium a donné des rendements similaires qu'avec 168Kg N /ha et 126Kg N/ha de sulfate d'ammonium. L'incorporation de la paille au sol était plus bénéfique avec des irrigations plus fréquentes.

Keys words: Wheat, water use efficiency, nitrogen use efficiency, $^{15}N$, neutron hydro probe.

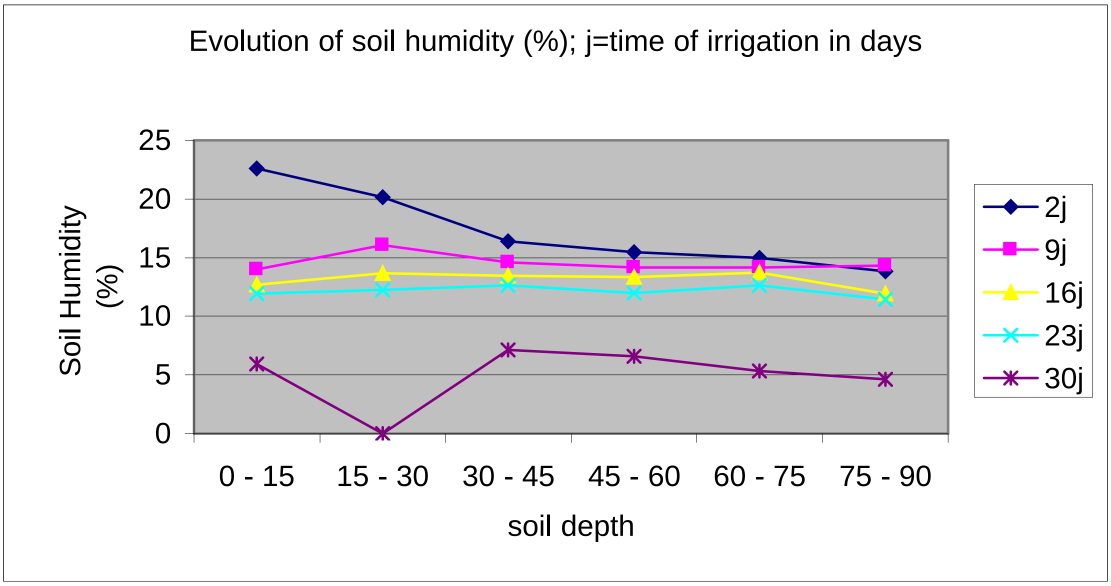
# INTRODUCTION

In south Morocco, the agriculture is mainly based on irrigation (oasis along border of rivers) and heavy use mineral nitrogen. Irrigation water is scarce and should be used very efficiently. Organics inputs are always recommended as logical alternatives to expensive mineral fertilizers in Africa 'low input agriculture' to achieve sustainability in dry land agriculture. Extensive research has been conducted to study the nutrient supply capacity of various organic residues (Soon et al., 2004). Total N recovery in first crop derived from organic residues is very variable but less than 20%. The combination of the organic input and supplementary application of fertilizer N has been proposed as a more attractive management option to solve problems of N deficiency in degraded soil (Ichir et al., 2003). Climatic conditions play an important role in decomposition rates and release of available N to crops (Lupwayi et al., 2004). Different cycles of dry and moist conditions stimulate soil microbial activity and N mineralisation (Curtin et al, 1998). Straw incorporation to soil was more beneficial under increased moisture stress. The aim of this study was to evaluate the effect of wheat residues with fertilizer N on the N uptake and yield of wheat under different irrigation treatments.

## MATERIALS AND METHODS

A field experiment was conducted on the Regional Office of Agricultural Development of Tafilalet farm, in South of Morocco. The annual rainfall averages 90mm. The soil was sandy loam with a pH of 7.84, 0.97 %OM, 0.069 %N, 5ppm exch. K, and 8.8 available P.

Experimental plots of 3 x3 m were delimited. Before seeding triple super phosphate and potassium were applied at the rates of 124.4kg $P_2O_5$/ha and 84kg $K_2SO_4$/ha respectively. The plots were cover cropped two times. All plots were seeded with durum wheat variety karim in December. Seeding depth was 3cm. The plants were thinned to have 20cm between them (160 kg/ha). Three irrigation treatments were investigated in a split plot design with three replications: I1 (60% field capacity = HCC); I2 (40% HCC); I3 (20% HCC). The three irrigation treatments were maintained and controlled by periodic measurements of soil humidity by a neutron probe which was equilibrated under dry and humid soil conditions.




From the count ratio necessary for each irrigation treatment, we determine the Volumetric Humidity necessary for I1, I2, and I3:

| Depths (cm) | 0 - 15 | 15 - 30 | 30 - 45 | 45 - 60 | 60 - 75 | 75 - 90 |
|---|---|---|---|---|---|---|
| I1 (60% HCC) | 19.15 | 18.28 | 14.85 | 14.18 | 13.83 | 12.83 |
| I2 (40% HCC) | 12.76 | 12.18 | 9.90 | 9.46 | 9.22 | 8.56 |
| I3 (20% HCC) | 6.20 | 6.09 | 4.95 | 4.73 | 4.61 | 4.28 |

Within each irrigation treatment, five nitrogen treatments were used: N1 where 835g/m2 wheat residues enriched with 1.711 % atom $^{15}$N excess were added at seeding and 4.10g N/m2 as ammonium sulphate a month after seeding (105 mg $^{15}$N /m2); N2 where 4.10g N/m2 was added at seeding as ammonium sulphate enriched with 9.96 % atom $^{15}$N excess and another 4.10g N/m2 as ammonium sulphate enriched with 9.96 % atom 15N excess a month after seeding (836 mg $^{15}$N /m2), N3 where nitrogen was added as 42kg N/ha of ammonium sulfate before seeding, 42kg N/ha of ammonium sulfate enriched with 9.764 at % $^{15}$N excess at seedling development and 42kg N/ha ammonium sulfate at flowing, N4: where N was added as 42kg N/ha ammonium sulfate enriched with 9.764 at % $^{15}$N excess at seeding, 42kg N/ha at seedling development and 42kg N/ha at flowing; N5 where N was added as 42kg N/ha ammonium sulfate and 4800 kg/ha of wheat residue enriched with 1.504 at % $^{15}$N excess before seeding and 42kg N/ha ammonium sulfate at flowing.

The experimental plots were irrigated at field capacity, and then soil humidity was determined after 48 hours, after one week, two weeks, three weeks and when the soil was dry.

The plots were harvested on June. Seeds were separated from residues. The samples were oven dried at 75°C for 48 hours, weighed and analyzed for total nitrogen and %15N atom excess.

## RESULTS AND DISCUSSIONS

For irrigation treatments I1 and I2 the results show no significant difference of TN and DW of wheat when the soil was amended with wheat residues and 84Kg N/ha and when the soil was amended with 168kg N/ha and 126kg N/ha. For treatment I3, the difference was significant between the grain yields for the treatment with residues and without residues. The

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production of dry matter yield decreased with increased water stress. Interaction between irrigation treatments and N treatments was not significant for straw and grain yields. For I1 and I2, TN in grain and straw in treatments which received mineral N at seedling development was significantly higher than that of treatments which received mineral N after seeding. This can be explains by nitrogen loss by drainage. Thus, in irrigated plots, the efficiency of the use of nitrogen by plants depends on time of N application.

When water is not limiting, the nitrogen has a distribution of about 2/3 in the grain and about 1/3 in the straw; only about 4 % in roots. On the other hand, in water stressed conditions, the nitrogen has a distribution of about 50% in the grain and in the straw for all treatment. The proportion of N in roots is increased to 13 % for treatment with residues. The total amount of 15N taken by the plant significantly differed between the treatment with residues and without residues for all irrigation treatments.

The N derived from fertilizer (Ndff) and from soil (Ndfs) was determined. In I1, N derived from fertilizer was 41% when N was applied at seedling development, was 33% when N was applied at seeding and 24% when N was applied with labeled residues. The fertilizer N was mainly recovered by the seeds followed by straw, while the amount in roots was very low. In I1, the %N recovery by plants was 63.35% when fertilizer N was applied at seedling development , 28.13% when fertilizer N was applied at seeding and 8.47% labeled residues and mineral N were added to soil. In I3, the %N recovery was 49.07%, 27.87 % and 5.33% for N3, N4 and N5 respectively. The results indicated that wheat yields in desert environments can be improved significantly by modifying agronomic practices (Following Table).

Nitrogen recovery by wheat, under different N and irrigation treatments.

| Treatments | %recovery seeds | % Ndff seeds | %Ndfs seeds | %recovery straw | %Ndff straw | %Ndfs straw | %Recovery root | %Ndff root | % Ndfs root |
|---|---|---|---|---|---|---|---|---|---|
| I1N1 | | 2.45 | 97.5 | | 1.87 | 98.1 | | 2.45 | 97.5 |
| I1N2 | | 20.23 | 79.97 | | 21.8 | 78.2 | | 18.7 | 81.3 |
| I1N3 | 41.25 | 12.57 | 87.43 | 21.77 | 14.94 | 85.06 | 0.33 | 13.91 | 86.09 |
| I1N4 | 17.26 | 9.86 | 90.14 | 9.42 | 10.22 | 89.78 | 1.45 | 12.89 | 87.11 |
| I1N5 | 4.83 | 6.34 | 93.66 | 3.44 | 7.65 | 92.35 | 0.09 | 9.51 | 90.49 |
| LSD0.05 | 14.94 | 3.00 | 5.80 | 7.80 | 5.70 | 5.69 | 0.62 | 4.55 | 4.55 |
| I2N1 | | 2.86 | 97.1 | | 2.98 | 97.02 | | 4.10 | 95.9 |
| I2N2 | | 15.10 | 84.9 | | 12.32 | 87.6 | | 16.64 | 83.3 |
| I2N3 | 22.65 | 14.91 | 85.09 | 16.90 | 15.77 | 84.23 | 0.38 | 15.08 | 84.92 |
| I2N4 | 11.84 | 10.56 | 89.44 | 9.51 | 10.86 | 89.14 | 0.42 | 13.81 | 86.19 |
| I2N5 | 4.45 | 6.40 | 93.60 | 2.58 | 9.80 | 90.20 | 0.99 | 10.99 | 89.01 |
| LSD 0.05 | 13.00 | ns | ns | 6.17 | 2.40 | 2.20 | 0.24 | ns | ns |
| I3N1 | | 1.46 | 98.5 | | 1.23 | 98.7 | | 2.11 | 97.9 |
| I3N2 | | 12.0 | 88 | | 14.75 | 85.2 | | 13.93 | 84 |
| I3N3 | 26.76 | 18.52 | 81.48 | 21.77 | 20.04 | 79.96 | 0.54 | 16.52 | 83.48 |
| I3N4 | 11.31 | 9.84 | 90.16 | 16.17 | 15.84 | 84.16 | 0.39 | 17.87 | 82.13 |
| I3N5 | 2.55 | 6.98 | 93.02 | 2.31 | 7.8 | 92.20 | 0.47 | 11.55 | 88.45 |
| LSD 0.05 | 9.40 | 5.60 | 12.70 | 7.00 | 1.30 | 2.70 | 1.43 | 5.52 | 5.44 |

Yields were increased in relation to currently recommended practices, by application of residues together with increased levels of inorganic nitrogen and in the same time irrigation water was reduced. One irrigation every two weeks (I2 or 40%HCC) during the growing season allows higher wheat yields. Higher yields were reached by keeping soil humidity at 60%HCC. Under 20%HCC, yield and total N were higher when wheat residues were added with mineral N. Under 40%HCC, addition of mineral N alone or mineral N residues gave

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similar results. Under 60%HCC, addition of mineral N alone allowed more yield than when residues and mineral N were added.

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