The effect of potassium fertilization on mineral absorption and yield of durum wheat on sub-humid and semi-arid bioclimatic stages of Tunisia

[1]Dorsaf HLEL, [2]Wael TOUKEBRI, [3]Wissaf KHEMIRI, [1]Oussama KHERIJI

1 Institut National des Grandes Cultures
2 Faculté des sciences de Tunis
3 Institut Supérieur de Biotechnologie de Béja

BACKGROUND AND AIM

Cereal farming, and particularly durum wheat, is a very important crop in the structure of Tunisian agricultural production. However, the yield of this crop is often limited and below the genetic potential of the varieties used and the target yield. An improvement in the yield of cereals is achievable through the good mastery of the "technological package" of which mineral fertilization plays an important role. The management of the nutrient fertilizers for optimising plant nutrition is based on one old concept on Liebig's "Law of the minimum", that is that any deficiency of one nutrient will severely limit the efficiency of others. N fertilization is largely controlled and much research has shown that durum wheat requirements are dependent on soil moisture and crop development stage and that by fixing the objective yield (Mhiri 1995; Souki el al, 1992). On the other hand, potash fertilization of durum wheat remains, up to now, a controversial issue, where opinions are divided and sometimes even divergent as to its justification, specifically in the semi-arid zones of Tunisia.

This work is part of a development research program on the reasoning of potassium fertilization of durum wheat grown in two different bioclimatic stages of Tunisia and proposes by means of field experiments, compare the effects of different modes of potassium intake on the nutritional behavior and yield of this crop.

MATERIAL AND METHODS

The experimental trials were carried out at the INGC experimental platforms, Hkim platform of Oued Mliz delegation -governorate of Jendouba and the El Gnadil platform of Beja North delagation the Governorate of Beja (Figure.1).

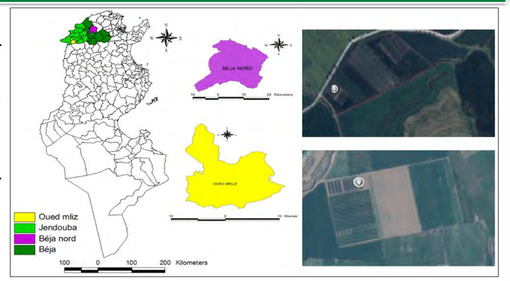

Figure 1 : Location of INGC experimental platforms

The weather conditions that prevailed, in 2015/2016 cropping season, at both platforms of trials during the crop growth cycle are summarized in figure 2.

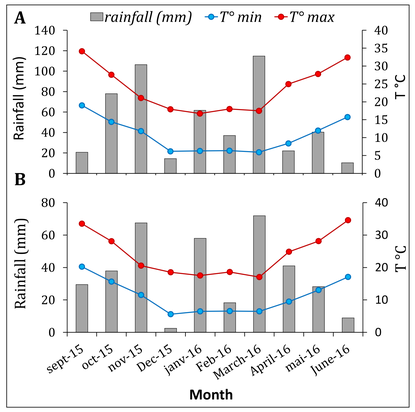

Figure 2 : Precipitations and temperatures recorded at El Gnadil (A) and Hkim (B) platforms during crop season 2015/2016

Sites are characterized by soils of alluvial origin. The characteristics of their surface layers are shown in table 1.

Table 1 : Characteristics of the surface layers of the two platforms soil

	El Gnadil platform	Hkim platform
Texture	Clay loam	Clay
pH	8,16	8,1
OM (%)	1,52	1,15
P_2O_5 (ppm)	14,21	47
K_2O (ppm)	395	282

The subject culture of our trial is Maali durum wheat (*Triticum durum* Desf.) variety.

The experimental protocol, conducted in the two sites includes 4 different potassium fertilization treatments, with 3 repetitions for each treatment (Figure. 3).

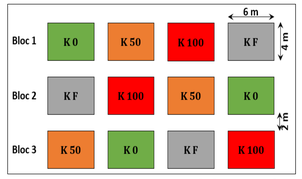

Figure. 3 : Experimental design of trials of different potassium treatments

The different treatments of potassium fertilization consisted of three dose of K: K0 control (0 kg / ha), K 50 (50 kg / ha) and K 100 (100 kg / ha) applied at sowing in the form of granulated sulphate of potash, and K-foliar (K F) treatment in the form of foliar fertilizer NPK (3-2-5) applied in sprays (5 l / ha) at the beginning of the heading. Shoot were collected at different growth stages for N, P and K analyzes.

The harvest was carried out using an experimental harvester and the various parameters of the yield components as grains yield (q/ha) and PMG(g), were carried out according to the standards.

The results were analyzed statistically using the SPSS version 20 software. For each analysis the mean and the coefficient of variation (CV) were determined. An analysis of variance (ANOVA) was conducted. The TUKEY test was used for all parameters. Differences with P <0.05 were considered significant.

RESULTS AND DISCUSSION

Effects of potassium fertilization on grains yield and yield components

The average wheat grain yield obtained from the fertilized treatments was 15 qx ha–1, 20% higher than from the control in Hkim platform and 36,45 qx ha–1, 10% higher than from the control in El Gnadil platfom (Figure. 4).

The intake of basal potassium fertilizer (granulated sulphate of potash) at sowing produced a significant increase in grain yield in both platforms. On the other hand, KF intake produced an increase in grain yield of 30% compared to the K0 control at Hkim platform site and 11% at El Gnadil platform site.

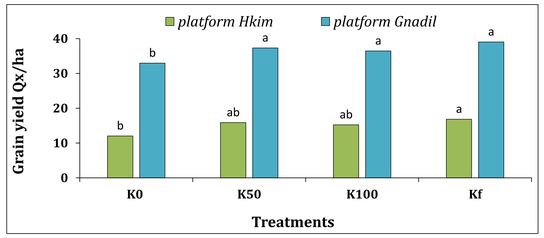

Figure. 4 : Effects of different doses of potassium fertilization on grains yield of durum wheat at both experimental platforms (Hkim and El Gnadil)

The statistical analysis (Table.2), has shown that the treatments whom received potassium were significantly less affected by this heat stress. This positive effect is particularly recorded at the Hkim platform with the K contribution to the soil of 100 kg / ha, with a gain of 15%, compared to the control.

It appears therefore from these results that the water deficit for the crop would be the limiting factor of the efficiency of the potassic fertilization of the wheat under the two modes of contribution considered. Potassium is rarely referred to in the world's literature as an element limiting plant production, although it is most often pointed out as the main nutrient shaping the quality of products (Usherwood, 1985; Whitehead, 2000).

Table. 2 : Effects of different doses of potassium fertilizer on yield components of durum wheat at both experimental platforms (Hkim and El Gnadil)

Treatments	Number of spikes / m^2	Number of grains / spike	PMG (g)	Specific weight (g)
Platform Hkim- Jendouba				
K0	309,77 ^{a}	23,3 ^{c}	33,44 ^{c}	75,93 ^{a}
K50	325,33 ^{a}	28,4 ^{bc}	38,47 ^{b}	74,93 ^{a}
K100	330,44 ^{a}	30,8 ^{ab}	41,33 ^{ab}	74,77 ^{a}
Kf	314,66 ^{a}	34,6 ^{a}	43,7 ^{a}	78,27 ^{a}
Platform Gnadil				
K0	459,88 ^{b}	33,73 ^{b}	57,07 ^{a}	83 ^{a}
K50	698,44 ^{a}	35,93 ^{b}	59,81 ^{a}	82,4 ^{a}
K100	630,22 ^{a}	39,06 ^{ab}	61,24 ^{a}	82,6 ^{a}
Kf	580,94 ^{ab}	44,06 ^{a}	59,38 ^{a}	82,4 ^{a}

Effects of Potassium Fertilization on mineral nutrition of plants

For the Hkim platform (A), the (K100) treatment recorded the highest concentration of potassium (K) at the leaf level (1.31 meq /l) and at the stem level (1.27 meq /l) compared with the other treatments (K0), (K50) and (KF) which recorded respectively 0.34 meq/l, 0.71 meq/l and 0.74meq/l at leaves and 0.51 meq/l, 0.92 meq/l and 0.71 meq/l at stems. These results were confirmed with analysis of variance, which showed that K100 treatment recorded the slightly significant difference with K0, K50 and KF treatments (figure.5).

As Gnadil platform, the results recorded shown that (K100) treatment has the highest potassium concentration at the leaves level (1.04 meq/l) compared with K0, K50 and KF treatments whom recorded respectively (0.45 meq/l),(0.71 meq/l) and (0.78 meq/l). Also, these results were confirmed with statistical analysis that registered the weakly significant difference between K100 and others treatments. For the K concentration at the stem, the highest level was recorded for the KF treatment (1.36 meq/l), then with a lower level with K100 treatment (1.19 meq/l) and finally the lowest levels are registered respectively with K0 (0.56 meq/l) and K50 (0.82 meq/l).

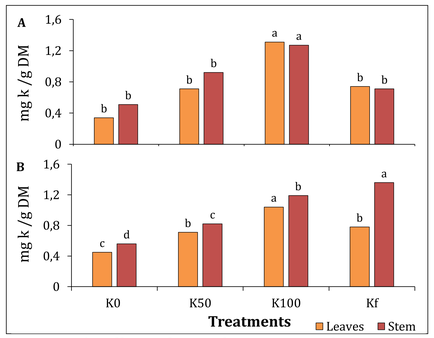

Figure. 5 : Effects of several treatments of potassium fertilization on potassium content of durum wheat leaves and stem at Hkim (A) and Gnadil (B) platforms.

For platform Hkim (A) (semi arid climate), the results of ash grains content (%) (figure.6) obtained shown that whatever the form and amount of potassium fertilizers brought, there is a significant difference between the control treatment (K0) and 3 treatments potassium (K50), (K100) and (KF). On the other hand, for Gnadil platform, we recorded a significant difference for granulated potassium fertilizer applied at sowing with rate of 100 kg/ha(K100) and foliar fertilizer (KF) sprayed at early heading compared to the control (K0) and (K50) treatments. For both sites, results shown the positive effect of potassium fertilization on the grain ash content (%).

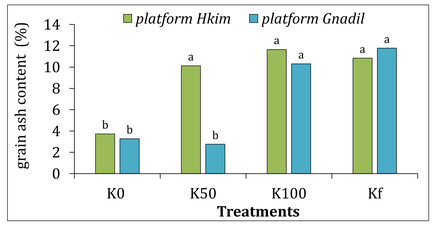

Figure 6 : Effects of different doses of potassium fertilization on grain ash content of durum wheat at Hkim platform and Gnadil platform.

CONCLUSION

This study highlight the effects of potassium fertilizers on the yield and quality of the grains of durum wheat under two different bioclimatic stages. The addition of potassium fertilizers proved useful in intensive cultivation of wheat and the foliar contribution of K to the stages of upstream growth and heading was more advantageous than the contribution of K to the soil with, in addition, of the smaller quantities to be brought. This effect is only verified under culture conditions where water is not a limiting factor.

In semi arid conditions (Hkim platform),there is no doubt that large grain harvests are associated with healthy plants made up of succulent cells. To obtain high grain yields the plants should not be subjected to undue stresses. Is important that plants be able to maintain turgor and be capable of synthetising and transporting photosynthates efficiently. The futility of attempting to grow high yielding crops and maximise the uptake of N without adequate P and K is now very widely appreciated. In brief, it can be argued that in K-sufficient soils, K stimulates N uptake.

Results obtained during this crop season 2015-2016, characterized by specific climatic conditions, linking the positive effect of potassium fertilization on grains yield and under specific climatic conditions, requires reinforcement and confirmation for a second year to develop, in the light of these results, reasoned recommendations of potassium fertilizer appropriate to the main agro-pedoclimatic situations of an intensive durum crop under different bioclimatic conditions, taking into account the target yield and fertility of the soil assessed by soil analysis before installing culture accompanied by a study of economic profitability for the farmer benefit who continues to refuse to speak of potassium fertilization on cereals given the relatively expensive purchase price of potash fertilizer and which increases the cost of production.

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FOR MORE INFORMATION

Dorsaf Hlel *Ingénieur Agronome- Chef Service Formation- INGC*
Mobile: +216 50 260 651
Phone: + 216 78 602 963
+216 78 602 964
Fax : + 216 78 602 966
Mail : dorsafhlel@gmail.com
dorsaf.hlel@ingc.tn

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