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# The Behavior of 11 Varieties of Durum Wheat (Triticum durum Desf.) against Phosphate Fertilizer TSP 46%. Effects on Yield Components

L. Mazouz [1,2] ; A. Kentour[3]

*[1]Agroveterinary Institute, Batna 1 University, Algeria, phone : +2133.331.90.26*
*[2]Department of Agronomy, Faculty of Natural and Life Sciences, Abbès Laghrour khenchela University, Algeria*
*[3]Culture Field Institute, Khroub, Constantine, Algeria,*

***Corresponding author:** Mazouz.lakhdar@univ-khenchela.dz*

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**Abstract.** The study was conducted at the ITCMI Agricultural Research Station of Oum El Bouaghi during two successive agricultural seasons. The trial set up consists of 11 durum wheat genotypes. The objective was to study the response of these varieties to different inputs of phosphate fertilizer and see their effects on yield components.
These components are NEM (Number of ears per square meter), NGE (number of grains per ear), TGW (Thousand grains weight) and Yield. The results indicate that the phosphorus input, in the form of triple superphosphate, allows, at the average dose used in this field trial, 20 kg $P_2O_5$.ha-1, to achieve an increase in grain yield between 40 and 60% compared to the phosphorus-free control for all the varieties tested except for the Cirta and Essalam varieties which followed a certain cross order in terms of phosphate fertilizer to increase their grain production. All the other varieties gave their best with only the 20 kg dose. $ha^{-1}$ of $P_2O_5$ i.e. 40 kg of TSP 46%. Gta dur and Vitron in this perspective remain among the best varieties. Semito is the variety that seems to be the best adapted to the absence of phosphate fertilization and a low dose. A high TGW is in favor of a better use of the available phosphorus.
A more generous rainfall is a favorable factor for a better assimilation of the phosphate fertilizer. These results show that it is possible to reduce the doses of phosphate fertilizer currently used, which represents savings for the farmer in terms of expenses, for non-renewable phosphate deposits a better efficiency of use and for the environment a better preservation.

***Keywords.*** Durum wheat, phosphorus, yield component, TSP 46 %, fertilizer

## INTRODUCTION

Phosphorus input can contribute to improved wheat yields (Morel et al, 1992; Aissa and Mhiri, 2002). Any deficiency in this element leads to lower yields (Le Buanec, 1973; Vance et al., 2003). Intensification and increase in the productivity of cereal crops in favorable areas require, among other things, a rational and reasoned use of chemical fertilizers. (Mhiri, 1995). If, over the last few years, the "technological package" of nitrogen fertilizer use for cereals has been largely mastered, with numerous studies carried out in this field (Gharbi et al., 1991; Sboui et al., 1997), on the contrary, phospho-potassium fertilization of cereals remains insufficiently explored and few studies have been carried out under conditions of intensification. The results of the work carried out at the National Agronomic Institute of Tunisia (Rguez, 1998) and by the Higher School of Agriculture of Kef (Meynard , 1985; Meynard, 1994; Couvreur, 1981; Batten, 1992; Gate et al., 1996; Mhiri, 2000) to name but a few, have proved the effectiveness of phospho-potassium intake on the increase of grain and biomass yields and grain quality of durum wheat conducted in intensive farming as well as a better resistance of this crop to heat stress. Determining the optimal dose for a better use as well as the components most sensitive to this fertilizer and hence the most profitable varieties at lower (efficient) doses is the objective of this work.

## MATERIAL AND METHODS

### Conduct of the experiment and plant material

The study was conducted on the sites of the EPO's ITCMI Agricultural Research Station during the 2011/2012 and 2012/2013 academic years. The station is located in the highland’s region. The area belongs to the semi-arid domain characterized by a typically Mediterranean continental climate. The trial set up consists of 11 durum wheat genotypes (Table 1).

These cultivars whose seed was provided by the ITGC khroub are of diverse origins and characterized by a contrasted agricultural production and include Algerian commercial varieties and advanced breeding lines of the national durum wheat breeding programs and those of Cimmyt-ICARDA.

Sowing was done on December 30th. Nitrogen fertilizer was provided during the tillering stages in the form of Urea 46% at 100 kg / ha.

Wedding was done manually. The harvest was made on June 30th.

Table 1. Lists of durum wheat varieties studied, origin and pedigree (obtained from ITGC Constantine).

| **Varieties** | **Origin** | **Pedigree** | **Type** | **Registration year** |
|---|---|---|---|---|
| Waha | Sélection CIMMYT-ICARDA-El Khroub, Origin Syrie | PLC/Ruff/Gta S »/3/Rolette Cm.17904 (genealogical selection) | pure line | 1997 |

| | | | | |
|---|---|---|---|---|
| GTA dur | Algeria (Guelma) Origin Mexique | Gaviota x durum Crane/4/PolonicumPI1 85309//T.glutin en/2* Tc60/3/Gll | pure line | 2001 (year of obtaining 1930) |
| Semito | Italia | Capeiti x Valvona | Pure line | 2001 |
| Boussellam | ICARDA-CIMMYT | Heider/Martes//Huevos de Oro | Pure line | 2000 |
| Vitron | Espagne | genealogical selection Turkey77/3/Jori/ Anhinga//Flamingo | Pure line | 1997 |
| Cirta | Algérie (constantine) | KB2140KBOKB2KB OKBOKB1KBOKB (T2) | Pure line | 1999 |
| Wahbi | Algérie | T4 | Pure line | |
| Essalam | ITGC Algérie | Ofanto/*2/Waha | Pure line | |
| Mohamed Ben Bachir | Algeria (Central Crop Plant Improvement Station | selection of local population | Local population | 2001 (year of obtaining 1931) |
| Sétifis | | Ofanto/Waha//MBB | Pure line | |
| Badre | | Boussalem/Ofanto | Pure line | |

**Experimental device**

These varieties were grown under 3 doses of $P_2O_5$ made according to the sowing treatment in the form of 46% TSP for two consecutive years. The doses were chosen according to the following reasoning:

Dose 0 (P-). Without any external supply of phosphorus

Dose 1 (P): estimated as follows: crop requirement (1.8 kg of phosphorus to produce 1 quintal of X grains yield expected in the region (22 qx.ha-1) and we obtain 22 * 1.8 = 39.6 that is 40 kg. Ha-1

Dose 2 (p +): the dose of the need + a complement and in this case we opted for double that is to say a dose of 80 kg / ha. (Rate required for a yield goal of 44 qx / ha).

This reasoning is the modest reflection of the authors of this study and is based on the P content of the soil and the potential of the region: currently obtained and expected yields.

The experimental setup is a split plot with 3 repetitions and two factors where the phosphatic treatment is assigned to the large plot while the variety to the small plot.

Each experimental plot consists of 4 rows of 2 m length spaced 0.5 m, each block will be 144 $m^2$. The distance separating phosphate treatments is 1 m.la Total area of the test is 600 $m^2$

Sowing dose 250 g / $m^2$

The number of seeds sown per elementary parcel is 500 seeds.

**Conditions of conducting the test**

Tillage consisted of deep plowing to a depth of 30 cm followed by a cover crop and harrow. Sowing was done on 17-11-2011 (23-11-2012 for the second year) by hand, at the rate of 0.24 t. $ha^{-1}$ and at an average depth of 4 cm. Nitrogen fertilizer (Urea 46%) is provided in a single intake at the 3-leaf stage at the rate of 1 quintal per hectare. The harvest took place on June 30, 2012. (June 27, 2013 for the second year).

**Follow-up and notations**

Variety characterization was based on the yield components of the plant as well as soil phosphorus analysis. The level of available phosphorus in the soil was measured prior to the installation of the test

**Number and weight of ears**

The number and weight of ears produced per unit area is deducted from counting and weighing the number of ears present in the mature vegetation booties. They are expressed in the number of ears / $m^2$ and in g / $m^2$.

**Grain yield and yield components**

The grain yield is determined by the weight of the seeds resulting from the threshing of the ears counted by vegetation boot. It is expressed in g / $m^2$. 250 seeds are counted from the product of threshing ears and weighed to determine the yield component which is the weight of 1000 grains. The number of grains / ears (NGE) and the number of seeds produced per m2 (NSM2) are estimated by direct calculation from the grain yield estimates (Y, g / $m^2$), the weight of 1000 grains (TGW, g / 1000 grain) and number of ears / $m^2$ (NE, number / $m^2$):

NGE = (1000 Y) / (TGW x NE) (2)

NSM2 = NGE X NE (3)

To determine the amounts of phosphorus taken at the three benchmark stages, tillering, flushing and flowering, wheat samples were collected at ground level and analyzed. At maturity, the determination of phosphorus is determined in grain and straw.

**Statistical analysis**

- Statistical analysis consists of a variance analysis at the 5% threshold, to identify the main dimensions of variability of the dose factor. The program used is Statitcf. then variance analysis for the varieties followed by a series of homogeneous groups with the doses using xl stat.

**RESULTS AND DISCUSSION**

The P content of 51 ppm according to the Truog method (Truog,1930) indicates that this rate reflects an average richness, because according to this method the interpretations of the contents are as follows:

P<20: very poor content

P 20 to 40: poor content

P 40 to 60: average content

P 60 to 80: rich content

P more than 80: very rich.

Table 2. Physico-chemical of soil.

| Parameters | | Soil sample |
|---|---|---|
| pH at 25° C | | 8.26 |
| EC à 25° C (µs/cm) | | 267.43 |
| N % | | 0.22 |
| C % | | 2.2 |
| C/N | | 10 |
| OM % | | 3.78 |
| Assimilable phosphorus ppm | | 51 (117.55 ppm of $P_2O_5$) |
| Active limestone % | | 5 |
| | Clay | 42.96 |
| | Fine silt | 16.10 |
| | coarse silt | 9.75 |
| | Fine sand | 28.21 |
| | Coarse sand | 2.98 |

Sources of variation in the split plot device:
p modalities of the first factor (the phosphate fertilizer dose) associated with the large plots (3)
q modalities of the second factor (varieties), associated with small parcels. (11).
r blocks (3).
We will first look at the effect of phosphorus doses on yield components and see which doses have the most effect and on which components while taking the varieties in their entirety and "ignore" for the moment their individual reactions. It should be noted that variance analysis for varieties and yield components were all significant.

Table 3. Sources of variation in the split plot device.

| Source of variation | Degrees of freedom | Degrees of freedom |
|---|---|---|
| Factor 1 (Phosphate fertilizer dose) | p-1 | 2 |
| Blocks | r-1 | 2 |
| Residual variation 1 | (p-1)(r-1) | 4 |
| Factor 2 (varieties) | q-1 | 10 |

| | | |
|---|---|---|
| Factor 1 * factor 2 (dose interaction * variety) | (p-1)(q-1) | 20 |
| Residual variation 2 | P(q-1)(r-1) | 60 |
| Totals | Pqr-1 | 98 |

**Number of ears per m²**

According to GERVY (1970), phosphorus favors the fertilization of plants by allowing a better heading. The results show that phosphorus significantly influenced the number of ears per m². The comparison of averages showed for the first year three homogeneous groups (A), (B), and (C), respectively represented by the treatments 40, 20 and 0 kg $P_2O_5.ha^{-1}$.

But only two homogeneous groups for the second year where the witness and the dose level of 20 $kg.ha^{-1}$ are in the same group while the dose level of 40 $kg.ha^{-1}$ of $P_2O_5$ was distinguished by a group apart as if to say that in a year when the rainfall is less generous, the plant needs more phosphorus to develop a larger number of ears per square meter. The same findings were noted by other authors as Ben naceur (1991) working on cowpea. (Naceur, 1991)

Table 4. ffect of phosphate fertilization on the number of ears per square meter.

| | **First year** | **Second year** |
|---|---|---|
| Ttreatments | Number of ears / $m^2$ | Number of ears / $m^2$ |
| Overall average | 154.4 | 107.18 |
| ET | 3.66 | 3.64 |
| CV% | 2.40 | 3.4 |
| PPAS | 1.80 | 1.81 |
| Groups | D2= A<br>D1=B<br>D0=C | D2= A<br>D1=B<br>D0=B |

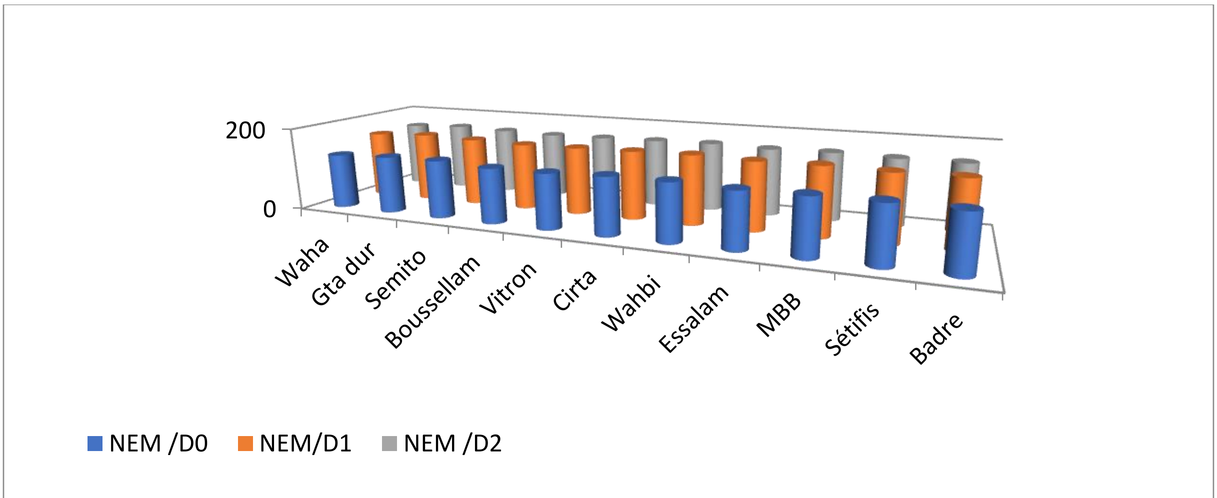


Fig. 1. Number of ears per $m^2$ during the first year.

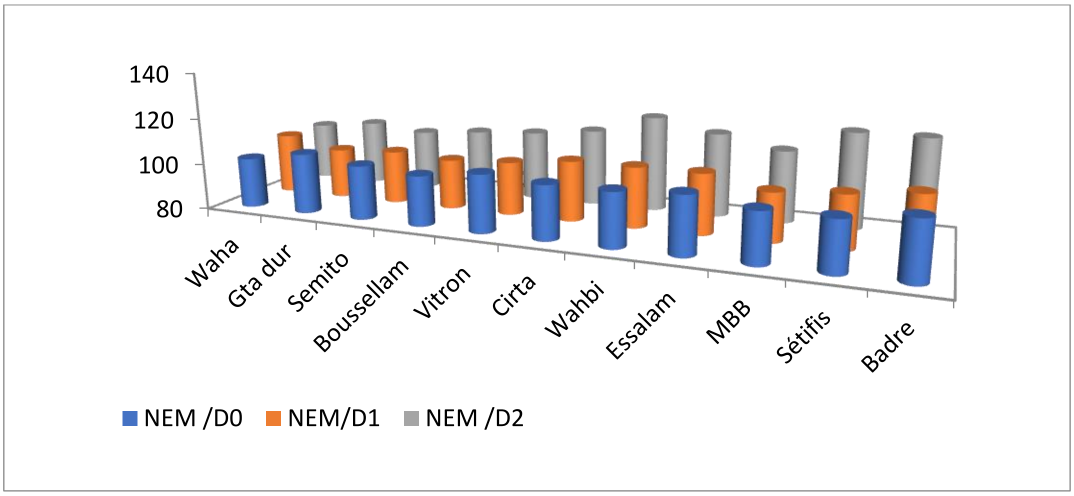


Fig. 2. Number of ears per $m^2$ during the second year.

The addition of phosphorus has led to an increase in the number of ears / m². The higher the phosphorus dose, the higher the number of ears.

The highest value of the number of ears / m², 171 ears per m², was obtained at the level of 40 kg $P_2O_5.ha^{-1}$ (dose 3) for the Boussellam and Vitron varieties. It exceeds the best of the treatment (Semito) without phosphorus intake (138 ears / m²) of 19% (Table 3).

The best stands per square meter for the different levels 0.20 and 40 kg $P_2O_5$ / ha are respectively 136.66, 166.6 and 171.6 respectively obtained by Gta dur for the first and second level and Boussellam and Vitron for the third level and this for the first year.

For the second year, the highest value of the number of ears / m², ie 121 ears per m², was also obtained at the level of 40 kg $P_2O_5.ha^{-1}$ (dose 3) for wahbi, sétifis and badre varieties but with lower values because this year is less rainy than the previous one.

**Number of grains per ear**

The number of grains per ear is a varietal characteristic, very influenced by the number of ears / m² (Couvreur, 1981). Variance analysis reveals a difference between the treatments studied for this parameter. Nevertheless, the dose level of intermediate phosphorus appears to be best suited for this parameter, at least for most tested varieties (8 out of 11 varieties in the first year, and 10 out of 11 varieties in the second year).

The intermediate phosphorus dose level 20 kg of $P_2O_5.ha^{-1}$ formed a separate group (a) with 35 grains / epi for Sétifis and 34.33 for Waha and MBB. On the other hand, the dose level of 40 $kg.ha^{-1}$ and the treatments without supply form respectively groups b and C with 33 grains / epi at Wahbi and 32.66 at Boussellam and MBB for the treatment without intake and 34.33 at Cirta, 33.33. in Vitron and 32.66 in Wahbi for the dose of 40 $kg.ha^{-1}$.

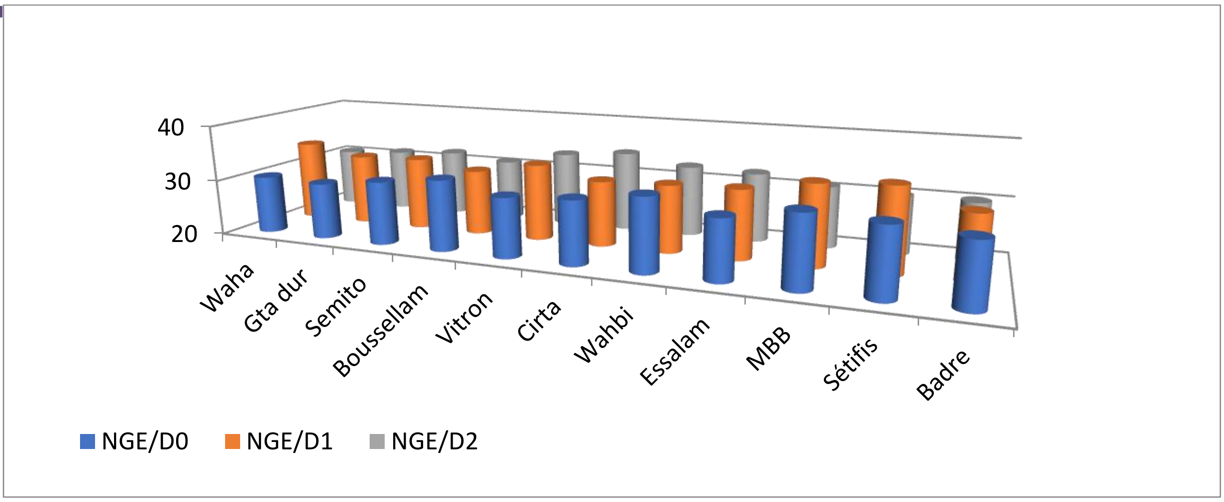


Fig. 3. Number of grains per ear during the first year.

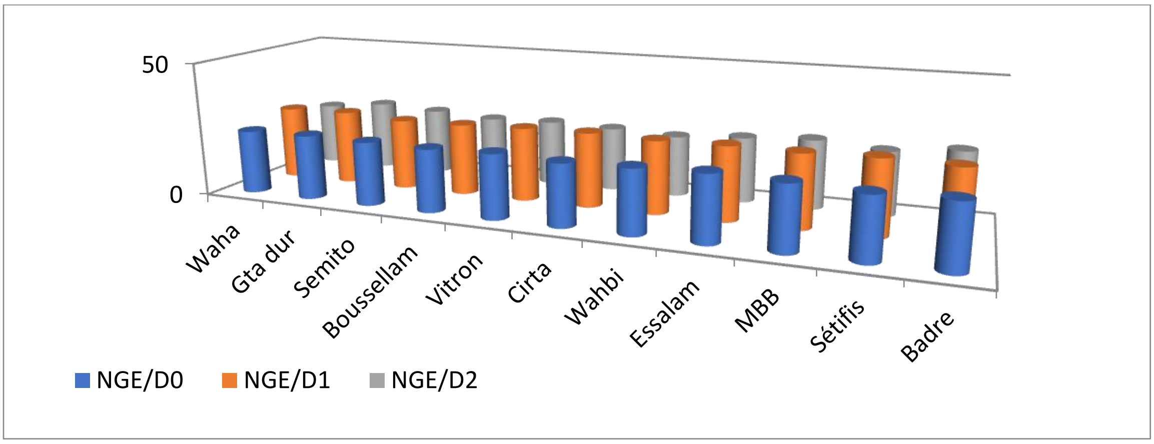


Fig. 4. Number of grains per ear during the second year.

**One thousand grains weight**

Variance analysis results revealed an effect of phosphorus on TGW (PMG in the graph) (Table 5). The correlation between the doses of phosphorus and the weight of 1000 grains is significant (r = 0.29 *).

The comparison of averages for the first year yielded three homogeneous groups (a, b and c). The intermediate 20 kg dose level of $P_2O_5.ha^{-1}$ formed the group (a) with 35.24g per 1000 grains noted in the Semito variety.

The second group (b) is represented by the maximum dose of 40 kg / ha of $P_2O_5$ (32.36 g for the Cirta variety), ie a difference of 3 g of the weight of 1000 grains.

The phosphorus-free control formed a last group (c) with 32.27 g for 1000 grains obtained by the variety Essalam.

The weight of 1000 grains is a parameter influenced not only by the conditions of mineral nutrition and more particularly phospho-potassium (Batten, 1992), but also by the climatic conditions (Gate et al, 1996), which proves the comparison of the averages.

The second year when the sky was less generous; the two doses of phosphorus are in the same class (A) while the treatment without phosphorus is in class (B). This means that when rain is sufficient, durum wheat can be satisfied with the intermediate dose to achieve its best performance.

The two dose levels 20 and 40 kg of $P_2O_5.ha^{-1}$ formed the group (a) with respectively 29.16g and 30.85g per 1000 grains. The second group (b) is represented by the treatment without phosphorus (27.77 g), a difference of 3 g of the weight of 1000 grains.

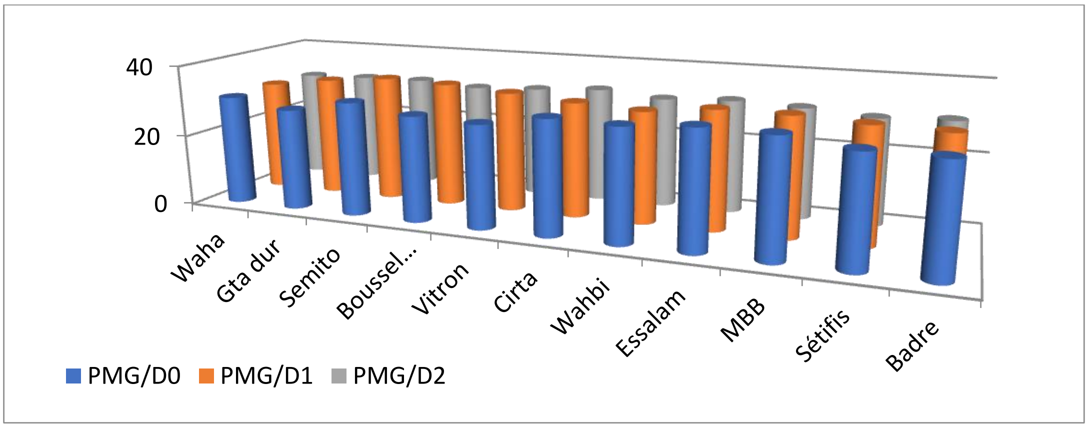


Fig. 5. Weight of thousand grains (PMG) during the first year .

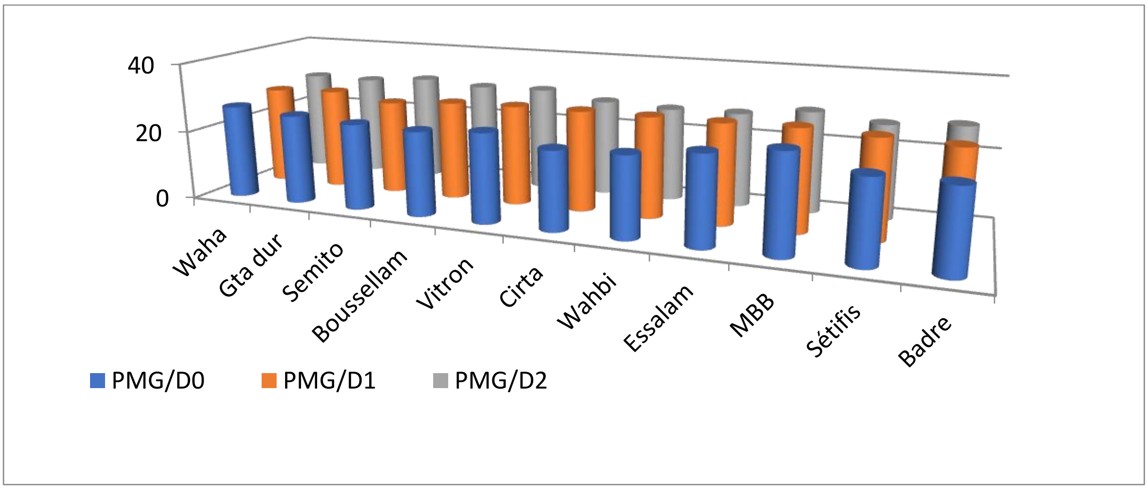


Fig. 6. Weight of a thousand grains (PMG) in the second year.

Table 5. effect of phosphate fertilization on the weight of a thousand grains.

| | First year | Second year |
|---|---|---|
| Treatments | PMG | PMG |
| Overall average | 31.53 | 27.27 |
| ET | 1.44 | 1.69 |
| CV% | 4.6 | 6.2 |
| PPAS | 0.71 | 0.83 |
| Groups | D2= B<br>D1=A<br>D0=C | D2= A<br>D1=A<br>D0=B |

## Grain yield

The analysis of variance for the yield classifies in the same category the doses 40 and 80 kg / ha of TSP46% and this for the two years of study, that can be interesting since one can save the fertilizer while achieving good returns.

Table 6. Effect of phosphate fertilization on grain yield.

| | First year | Second year |
|---|---|---|
| Treatments | yield | yield |
| Overall average | 7.34 | 7.34 |
| ET | 0.69 | 0.69 |
| CV% | 9.4 | 9.4 |
| PPAS | 0.34 | 0.34 |
| Groups | D2= A<br>D1=A<br>D0=B | D2= A<br>D1=A<br>D0=B |

According to authors such as Boukhalfa-Deraoui et al, (2011), the grain yield increases with the increasing doses of phosphorus, this is also true in our experiment but not for all varieties, some indeed stand out and manage to achieve better performance with only the intermediate dose.(yield is mentionned RDT in the graph).

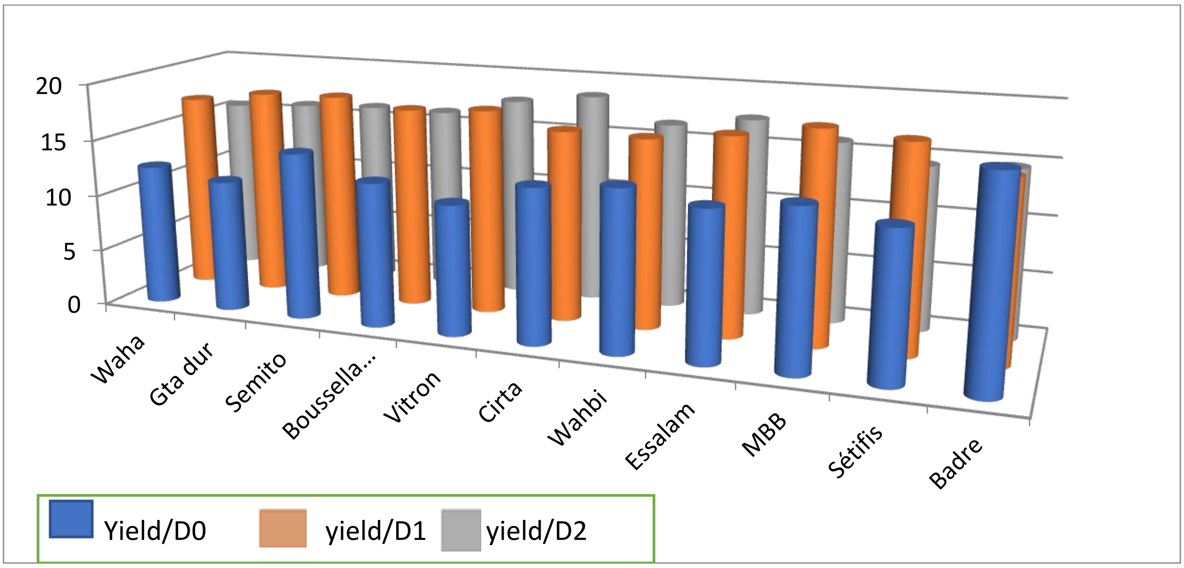


Fig.7. Yield (RDT) during the first year.

Others, on the other hand, do not achieve the maximum with the maximum dose provided in this study, in this case the dose of 40 kg.ha$^{-1}$ $P_2O_5$ per hectare.

For the first year, the highest yield is obtained at the level of 40 $kgP_2O_5.ha^{-1}$ with 18.55 qx / ha for the Cirta variety. Both inputs and despite the difference in quantity that existed between them formed a single homogeneous group (A) because the yields are very close (18.49 for MBB and 18.25 for GTA dur with the median dose) while the witness without phosphorus formed a separate group (B) with a better yield of 17.74 qx / ha for the Badre variety. The application of phosphorus generated a gain of more than 40% of the fertilized "waha" treatment compared to the waha treatment without phosphorus. This gain is 57% for Gta dur and 58% for Vitron. As for the Semito variety, it is able to cope with low doses of fertilizer (0 to 20) to achieve good performances.

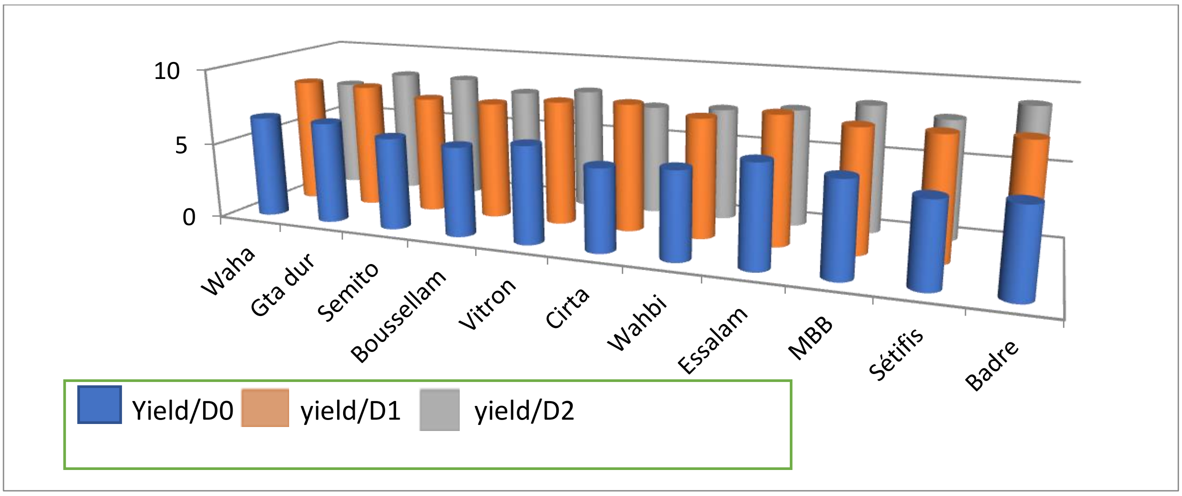


Fig.8. Yield in the second year 2012/2013.

For the second year, the decrease in rainfall compared to the previous year seems to affect this parameter only in quantities; yields have dropped significantly, but the reasoning of the fertilization has remained the same: the highest yield is obtained by Badre fertilized by the dose 40 $kg.ha^{-1}$ of $P_2O_5$. (8.98 qx / ha), yields of 8.36 and 8.33 were obtained respectively by varieties like Essalam and Cirta but with the dose of 20 $kg.ha^{-1}$ of $P_2O_5$.

The comparison of the averages allowed to group the two doses 20 and 40 kg $P_2O_5$ $.ha^{-1}$ in the same group (a) with respectively 8.36; 8.98 $qx.ha^{-1}$ an increase of 36.8%, 41.2% over the treatment without phosphorus. The phosphorus free treatment formed a separate group (b) with the lowest grain yield on the order of 6.67 $qx.ha^{-1}$.

**Study of some correlations**

Statistical analysis shows that the number of grains per ear, the number of ears per m² and the weight of 1000 grains have been decisive for the achievement of good yields. Indeed, there are good correlations between these three components and grain yield. However their degree of connection with the yield is not of the same importance: the difference stems from the nature of the parameter but also from the dose of phosphorus applied. Indeed, the weight of a thousand grains seems to have the strongest binding with the yield (r = 0.86) but with the dose 2 of phosphorus during the first year of study and 0.65 with the dose 1 whereas this link does not is only 0.32 for varieties without phosphate feed. Phosphatic fertilization in dry conditions seems to have a depressive effect on this link: in the second year, r which was 0.78 for the control without intake increases to 0.47 and 0.30 for D1 and D2 respectively. Same observation for the number of grains per spike (0.93, 058 and 0.28 respectively for D2, D1 and D0) during the first year of study. While for the dry year this parameter seems stable and high especially for the maximum dose helped in this may be by the phenomenon of compensation. (0.84, 0.75 and 088 for D0, D1 and D2 respectively). For the number of ears per square meter, it is clear that its very weak bond at the beginning evolves rapidly towards a strong link with the yield as soon as it passes to phosphorus inputs (0.02, 0.17 and 0.62 for respectively D0, D1 and D2) .The results we obtained with respect to the positive effect of phosphate intake on the yield components by still classifying the control in a group apart from those obtained by Boukhalfa-Deraoui et al, (2011) on wheat tender and Garba (2007) on cowpea in Niger where the climate is arid. the positive effect on pmg and NEM demonstrated in this study is consistent with the work of Belaid (1998) working on durum wheat, which found that the clearest effect of phosphorus is on sterility of spikelets . It went from 3.34 to 2.41 following a supplement of 92 superphosphate units. As for the weight of 1000 grains, it goes from 39 to 44 grams in the same experimental range. This beneficial effect of phosphorus on the sterility of the ear. and the weight of 1000 grains, however, sees its reduced effect with the increasing contributions of nitrogen

## CONCLUSION

The phosphorus supply, in the form of triple superphosphate, makes it possible, at the average dose used in this field trial, to be 20 kg P2O5.ha-1, an increase in grain yield obtained between 40 and 60% relative to that of the phosphorus-free control for all the varieties tested. This increase in yield is due to an increase of 20 to 22% in the number of ears per m², 41.5% in the number of grains per ear, and 9% in the average weight of the grain.

The maximum dose, in this case 40 kg / ha $P_2O_5$ has also achieved a yield improvement compared to the control but is lower than that achieved by the average dose except for Cirta and Essalam year relatively well-supplied rain. This leads us to say that, in our opinion, it is useless to use a larger quantity of phosphate fertilizer if a smaller quantity can give us satisfaction; This is a very modest study: with the exception of the cirta and Essalam varieties, which have followed a certain order in phosphate fertilizer to increase their grain production, all the other varieties have given the best results. of them with only the dose of 20 kg. $ha^{-1}$ P2O5 that is to say 40 kg of TSP 46% .GTA Dur and vitron in this perspective remain among the best varieties. Semito is the variety that seems best to cope with the lack of phosphate fertilization and low dose intake. A high PMG favors a better use of available phosphorus. this is of course valid for soils with average phosphorus richness.A more generous rainfall climate is a factor favoring a better assimilation of phosphate fertilizer.

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