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Contribution to the Optimization of Phospho-Nitrogen Fertilization on a Durum Wheat Crop in Saline and Calcareous Soil

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Abstract. The soils of Algeria are generally poor in nitrogen and always pose the problem of the availability of available phosphorus especially in arid regions, where there is also the problem of salinity which is often accompanied by the presence of limestone. The present work aims to examine the optimization of phospho-nitrogen fertilization on a durum wheat crop in saline and carbonate conditions through the use of different types, forms and doses of nitrogen and phosphate fertilizers. The fertilizers used are: Urea(46%), triple super phosphate TSP(46%), simple super phosphate SSP(20%), Potassium Nitrate KNO_3(13%), Monammonium phosphate MAP(12%, 61%), NPK(15%,15%,15%), NPK(20%,20%,20%), NPK(13%,40%,13%), NPK(30%,10%,10%), NPK(4%,20%,25%), combined with three doses (D1=150U N and P ha^{-1}, D2=200U N and P ha^{-1} and D3=250U N and P ha^{-1}). The results obtained show that phospho-nitrogen fertilization has a very important effect on the parameters studied. Indeed, we notice that the best results are obtained by compound fertilizers, height of the plants: (HP) =MAP and NPK(15%,15%,15%) (250U ha^{-1}) and (KNO_3-SSP) (150U ha^{-1}), yield and its components: Number of grains ear^{-1} (NG E^{-1}) =NPK(13%,40%,13%) (250U ha^{-1}), 1000 grains weight (TGW) =NPK(4%,20%,25%) (250U ha^{-1}), grain Yield (GY) =NPK(13%,40%,13%) (250U ha^{-1}) and NPK(15%,15%,15%) (150U/ha), straw yield (SY) =NPK(15%,15%,15%) (250U ha^{-1}) and (KNO_3-SSP) (150U ha^{-1}). However the highest nitrogen and phosphorus content of the grains is obtained by simples fertilizers, N= (Urea-SSP) with the dose (200 and 250 U ha^{-1}), and P = (Urea-TSP) with the dose (150U ha^{-1}). It is noted that the NPK(15%,15%,15%) fertilizer was able to give better grain and straw yields with the lowest dose as well as obtaining the best plant height and better straw yield with the lowest dose of (KNO_3-SSP) fertilizer.

Keywords. Calcareous, Fertilization, Fertilizers, Nitrogen, Phosphorus, Saline.

I. INTRODUCTION

In developing countries, harsh climatic conditions, demographic pressure, land tenure constraints and the decline of traditional soil management practices have often reduced soil fertility [1]. Soil fertility is defined as the state of the soil in terms of its ability to provide essential elements for plant growth [2]. Soil nutrient content (mainly nitrogen, phosphorus and potassium) has been interpreted as an indicator of fertility [3]. Plants often suffer from an insufficient soil nutrients supply [4]. These deficiencies are satisfied by the use of fertilizers [5, 4]. Fertilizers are known as any materials added to soil or plant leaves to provide nutrients [4]. According to Jiao et al [6]; Brar et al [7]; Yang et al [8]; Shabani et [9], the application of chemical fertilizers was the best way to increase and maintain crop yields.

Agronomic efficiency (fertilizer productivity or economic efficiency) can be defined as the increase in crop yield depending on the amount of fertilizer applied (kg in crop yield increase per kg of fertilizer applied) [10]. Balanced fertilization is the key to sustainable agricultural production; it has both economic and environmental

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impacts. However, imbalanced fertilizers use leads to lower economic yields and increased threat to the environment [11].

In Algeria, the arid zone represents nearly 95% of the national territory, 80% of which is in the hyper arid domain [12]. According to Taffouo et al [13], the degradation processes of arid and semi-arid regions are the depletion of soils in mineral elements and their salinization. The problem of soil salinity leads to the insolubilization of many elements essential to the plant, and soil fertility is greatly reduced [14]. Therefore, reasoned fertilization remains at present the most effective way for obtaining optimal productivity [15, 16 and 17]. The problem of soil and water salinity is a major factor limiting cereal yields [18, 19 and 20]. On the other hand, cereals express high requirements for nutrients, especially at the growth and grain formation stages [21]. In addition, the majority of agricultural soils in Algeria is limestone [22] and have an adverse influence on the physic-chemical properties, in particular the availability and absorption of mineral elements necessary for plant life [23]. When Phosphorous fertilizer is added to calcareous soils, a series of fixation reactions occur and gradually decrease its solubility and eventually its availability to plants [24]. Limestone affects the pH of the soil which in turn influences phosphorus assimilation [25] by forming insoluble Ca-P which is considered the main factor of phosphorus unavailability [26]. A good technical itinerary of fertilization based on the use of acidifying fertilizers, chemical forms offering good bioavailability, the fractionation of the intakes and the balance of the formulas, will make it possible to optimize the fertilization to achieve high yields [21].

In this context, the present work, which aims to examine the optimization of phospho-nitrogen fertilization on a durum wheat crop in saline and carbonate conditions by the use of different types, forms and doses of nitrogen and phosphate fertilizers.

II. MATERIALS AND METHODS

- **Experimental Details**

The experiment was conducted during the agricultural season (2018/2019) at the Department of Agricultural Sciences of Biskra University.

The study involved a durum wheat variety known as Mohammed ben Bachir (MBB) which is a genealogical selection of a local population. This variety is highly appreciated on the highlands of Eastern Algeria. The tested seeds have a germinative faculty of 98%.

The experimental run was carried out in plastic vegetation pots, with a capacity of 12 kg, and a diameter of 30 cm, whose bottom is lined with gravel to ensure good drainage. The pots are filled with silty-clay texture, taken from the experimental field of the Department of Agricultural Sciences of Biskra University. Physical-chemical analyses of the soil were carried out before the beginning of the experiment. The physico-chemical characteristics of the soil are summarized in the following table:

TABLE 1. Results of physico-chemical soil analyzes**.**

Measurement	Values
Electrical conductivity (ms m^{-1}) (1:5)	2.83
pH	7.89
Total $CaCO_3$(%)	36.82
Active $CaCO_3$ (%)	16.54
Organic matter (%)	1.45
Total Nitrogen (%)	0.083
Available phosphorus (ppm) (Joret –Hébert Methode)	192.2
Granulometry (%)	
- Coarse sand	13
- Fine sand	6
- Coarse silt	26
- fine silt	27
- Clay	28

- **Treatments and Experimental Layout**

The study is based on the use of two types of phospho-nitrogen fertilizers: simple and compound in different forms: Urea (46%) (NH_2–CO–NH_2), triple super phosphate TSP (46%) ($Ca(H_2PO_4)_2.H_2O$), simple super phosphate SSP (20%) ($Ca(H_2PO_4)_2+CaSO_4$), Potassium Nitrate (KNO_3) (13%), Monoammonium phosphate MAP ((NH_4) H_2PO_4) (12%, 61%), NPK (15%, 15%, 15%), NPK (20%, 20%, 20%), NPK (13%, 40%, 13%), NPK (30%, 10%, 10%) and NPK (4%, 20%, 25%). We used potassium sulphate (K_2SO_4) as a potassium fertilizer with a dose of 85U K ha^{-1} for all treatments.

The experimental device adopted in this study is the split plot which includes 30 treatments with three repetitions and a control C (0) with three repetitions. The treatments used (F) are ten phospho-nitrogen fertilizers: F1 (Urea_TSP), F2 (Urea_SSP), F3 (KNO_3_TSP), F4 (KNO_3_SSP), F5 MAP (12%, 61%), F6 NPK(15%, 15%, 15%), F7 NPK(13%, 40%,13%), F8 NPK(20%, 20%, 20%), F9 NPK(30%, 10%, 10%) and F10 NPK(4%, 20%,25%). Each fertilizer is combined with three doses (D1=150U N and P ha^{-1}, D2=200U N and P ha^{-1} and D3=250U N and P ha^{-1}). The pots are arranged randomly, making a total of 93 pots. The treatments are given in Table 2:

TABLE 2. Experimental treatments.

F1D1	F2D1	F3D1	F4D1	F5D1	F6D1	F7D1	F8D1	F9D1	F10D1
F1D2	F2D2	F3D2	F4D2	F5D2	F6D2	F7D2	F8D2	F9D2	F10D2
F1D3	F2D3	F3D3	F4D3	F5D3	F6D3	F7D3	F8D3	F9D3	F10D3

- **Statistical Analysis**

The data collected have been statistically analyzed. Analysis of variance (ANOVA) was performed using XLSTAT software. The comparison of the means is made by the Newman-Keuls test at the 5% probability threshold which was used to assess the differences between the treatments means.

III. RESULTS

The results of plant growth, yield and its components, and the content of durum wheat in (N) and (P), obtained were analyzed by ANOVA to determine the effect of fertilizer type and fertilizer dose under saline and carbonate conditions.

TABLE 3. Variance analysis results for the effect of the type and dose of fertilizer on plant growth, yield and its components.

Treatments	N(%)	P(%)	HP (Cm)	NG E^{-1}	TGW (g)	SY (q ha^{-1})	GY (q ha^{-1})
F1(150)	1,93^{bc}	0,26^{a}	69,46^{abcdefg}	24,17^{defghij}	46,6^{bcdefgh}	67,43^{bcdefg}	24,33^{cdefgh}
F1 (200)	1,76^{cdefg}	0,23^{defghijkl}	73,63^{ab}	29,75^{ab}	49,73^{ab}	74,1^{abcde}	27,51^{abcd}
F1(250)	1,56^{hijk}	0,21^{m}	70,87^{abcde}	26,67^{abcdef}	45,87^{bcdefghi}	72,45^{abcdef}	25,87^{abcdef}
F2(150)	1,87^{bcd}	0,21^{ijklm}	63,33^{ghij}	22,58^{ghijk}	43,53^{ghijk}	58,78^{g}	21,83^{efghij}
F2(200)	2,14^{a}	0,23^{defghijkl}	66,57^{defghi}	25^{cdefghij}	45,53^{bcdefghij}	65,75^{bcdefg}	26,4^{abcde}
F2(250)	2,17^{a}	0,23^{defghijkl}	71,95^{abcde}	28,13^{abcd}	48,9^{abcd}	76,04^{abc}	29,26^{ab}
F3(150)	1,62^{ghij}	0,21^{klm}	68,03^{bcdefgh}	22,83^{fghij}	44,53^{defghij}	67,12^{bcdefg}	19,86^{hijk}
F3(200)	1,67^{fghi}	0,23^{defghijk}	69,69^{abcdef}	26,67^{abcdef}	48,67^{abcde}	74,15^{abcde}	26,96^{abcde}
F3(250)	1,89^{bcd}	0,25^{bc}	61,91^{hijk}	25,33^{bcdefghi}	45,27^{bcdefghi}	63,04^{defg}	18,17^{ijkl}
F4(150)	1,44^{k}	0,22^{defghijklm}	75,12^{a}	21,5^{ijkl}	41^{jk}	80,93^{a}	15,91^{kl}
F4(200)	1,61^{ghij}	0,25^{b}	69,6^{abcdef}	25,33^{bcdefghi}	44,2^{efghij}	72,67^{abcde}	21,64^{efghij}
F4(250)	1,81^{cdef}	0,24^{bcdef}	68,15^{bcdef}	27,63^{abcde}	47,8^{abcdefg}	62,29^{efg}	26,35^{abcde}
F5(150)	1,88^{bcd}	0,22^{fghijklm}	66,28^{efghi}	23,58^{efghij}	45,07^{cdefghij}	59,39^{g}	22,99^{defghij}
F5(200)	1,7^{efgh}	0,23^{bcdefgh}	71,29^{abcde}	26,5^{abcdefg}	47,07^{bcdefgh}	65,09^{cdefg}	22,99^{defghij}
F5(250)	1,53^{hijk}	0,24^{bcde}	75,56^{a}	28,5^{abc}	48,87^{abcd}	76,64^{abc}	28,64^{abc}
F6(150)	1,98^{b}	0,21^{jklm}	61,75^{ijk}	28^{abcd}	45,7^{bcdefghi}	62,48^{efg}	30.18^{a}
F6(200)	1,74^{defg}	0,23^{cdefghij}	67,74^{bcdefghi}	24,92^{cdefghij}	43,8^{fghijk}	67,56^{bcdefg}	21,55^{efghij}
F6(250)	1,74^{defg}	0,24^{bcdefgh}	75,59^{a}	25,17^{cdefghi}	42,6^{hijk}	80,08^{a}	20,29^{ghijk}
F7(150)	1,76^{cdefg}	0,22^{fghijklm}	64,51^{fghij}	22,58^{ghijk}	44,47^{defghij}	60,36^{fg}	20,51^{fghijk}
F7(200)	1,7^{efgh}	0,24^{bcdefg}	66,93^{cdefghi}	26,17^{abcdefgh}	45,3^{bcdefghij}	65,47^{cdefg}	23,88^{cdefgh}
F7(250)	1,59^{ghijk}	0,24^{bcdefg}	72,71^{abcd}	30,08^{a}	48^{abcdefg}	75,52^{abc}	28,5^{abcd}
F8(150)	1,47^{jk}	0,22^{hijklm}	71,01^{abcde}	25,33^{bcdefghi}	43,6^{ghijk}	73,73^{abcde}	21,73^{efghij}
F8(200)	1,66^{fghi}	0,23^{cdefghij}	72,93^{abc}	26,75^{abcdef}	44,47^{defghij}	77,73^{ab}	25,33^{bcdefg}
F8(250)	1,77^{cdefg}	0,21^{klm}	66,23^{efghi}	28,83^{abc}	47,33^{bcdefg}	66,11^{bcdefg}	27,8^{abcd}
F9(150)	1,88^{bcd}	0,21^{lm}	56,59^{k}	18,67^{kl}	41,33^{ijk}	56,31^{gh}	17,63^{jkl}
F9(200)	1,67^{fghi}	0,22^{efghijklm}	61,75^{jk}	21^{jkl}	44,47^{defghij}	59,46^{g}	18,33^{ijkl}
F9(250)	1,54^{hijk}	0,22^{ghijklm}	67,45^{bcdefghi}	23^{fghij}	49,4^{abc}	67,81^{bcdefg}	23,13^{defghi}
F10(150)	1,51^{ijk}	0,24^{bcd}	63,95^{fghij}	22,42^{hijk}	41,73^{ijk}	64,59^{cdefg}	17,76^{ijkl}
F10(200)	1,66^{fghi}	0,24^{bcdefgh}	71,41^{abcde}	25,92^{bcdefgh}	48,4^{abcdef}	74,78^{abcd}	23,04^{defghij}
F10(250)	1,85^{bcde}	0,23^{cdefghi}	71,33^{abcde}	27,33^{abcde}	52,2^{a}	73,35^{abcde}	29,98^{a}
C(0)	1,27^{l}	0,19^{n}	56,4^{k}	18,33^{l}	39,27^{k}	45,76^{h}	14,31^{l}

Different letters in the same column indicate the separation index of homogeneous groups by the NEWMAN - KEULS test at α=5% threshold.

HP= height of the plants, NG E^{-1}= Number of grains ear^{-1}, TGW= 1000 grains weight, GY= grain Yield, SY= straw yield, N (%) = the nitrogen content of wheat, P (%) = the phosphorus content of wheat.

1. Effect of the type and dose of fertilizer on plant growth

At the harvest stage we measured the height of the plants in order to know the effect of type and dose of fertilizer on plant growth.

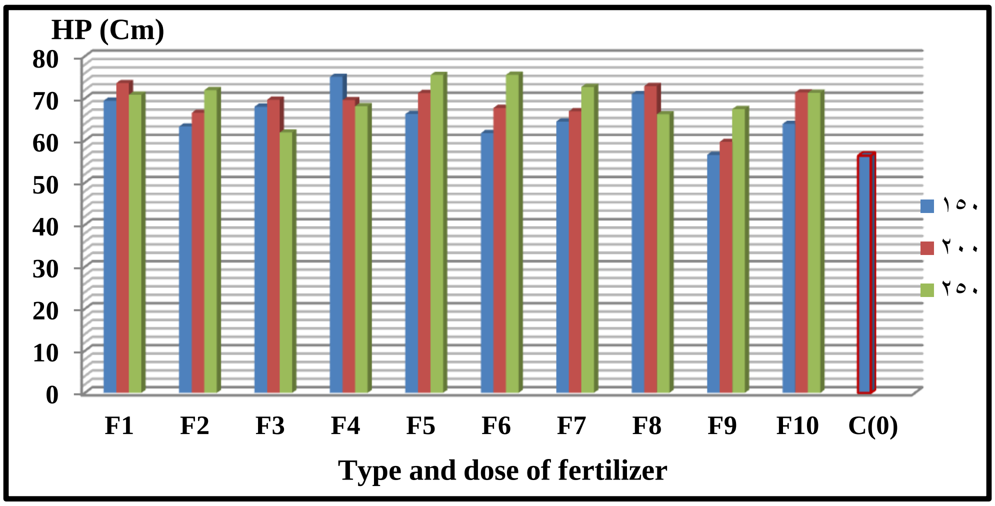

FIGURE 1. Variation of plants height according to the type and dose of fertilizer.

Statistical analysis reveals a very highly significant effect of phospho-nitrogen fertilization on wheat plant height (Table 3), where treatments F4 [(KNO_3-SSP) (150U ha^{-1})], F5 [MAP (250U ha^{-1})] and F6 [NPK (15%,15%,15%) (250U ha^{-1})], show the highest heights with averages 75.12 cm, 75.56 cm and 75.59 cm respectively. However, the lowest plant height averages were for the F9 treatment [NPK (30%,10%,10%) (150U ha^{-1})], and the control with averages 56.59 cm and 56.40 cm respectively. Thus, we can say that the growth of wheat plants is affected by the type of fertilizer used. This is what is observed for the F4 treatment with the dose (150U ha^{-1}) that gives the best result despite the low dose compared to the other treatments. On the other hand and according to figure (1), we generally observe that the height of the plants is influenced by the increase of the fertilizer dose. Indeed, we see that the height of the plants increases with the increase of the fertilizer dose for treatments F2, F5, F6, F7, F9 and F10. But for treatments F3, F1 and F8, the height of the plants increases only up to the dose (200 U ha^{-1}). On the other hand, for F4 treatment the height of the plants decreases with the increase of the fertilizer dose. Thus, the effect of increasing the fertilizer dose on the wheat plant growth varies according to the type of fertilizer.

2. Effect of the type and dose of fertilizer on yield and its components:

The evolution of yield and its components in this study indicate the significant response of durum wheat cultivation to phospho-nitrogen fertilization according to the type and dose of fertilizer, as well as the efficiency of the latter in salty and calcareous soils (Table 3).

2.1. Number of grains per ear (NG E^{-1}):

The results obtained, with regard to the effect of fertilizer type and dose on the number of grains per ear (NG E^{-1}), indicated that there are very highly significant differences (figure 2).

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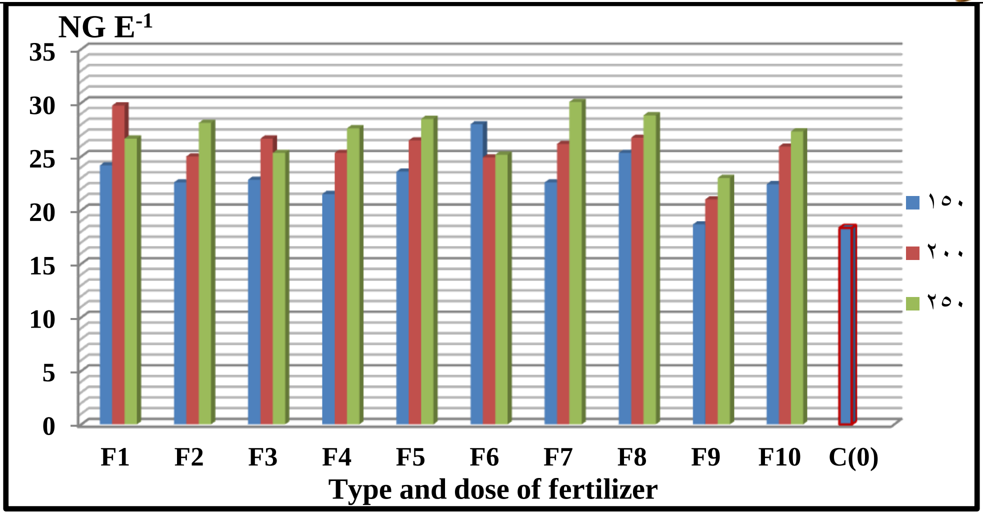

FIGURE 2. Variation of NG E^{-1} according to the type and dose of fertilizer.

According to the analysis of variance (Table 3), the means of number of grains per ear show that the highest value of NG E^{-1} relates to the F7 treatment [NPK (13%, 40%, 13%) (250 U ha^{-1})], with an average of 30.1 grain ear^{-1}. On the other hand the lowest value is recorded by the control (18.3 grain ear^{-1}). This difference clearly reflects the effect of phospho-nitrogen fertilization in salty and calcareous soils. On the other hand, the increase in fertilizer dose (figure 2) has a significant effect on the number of grains per ear, where it can be seen that the NG E^{-1} rises with the fertilizer dose for the majority of the treatments (F2, F4, F5, F7, F8, F9 and F10). While for the F1 and F3 treatments, the number of grains per ear increases up to the 200 U ha^{-1} dose only. But for the F6 treatment, the NG E^{-1} decreases with increasing fertilizer rate.

2.2. 1000 grains weight (g) (TGW)

On the one hand, the results obtained as displayed in Figure 3 show that the type and dose of fertilizer has a significant effect on the weight of 1000 grains (TGW**).** The effect is clear on the control treatment without fertilizer, marked by the lowest weight of 1000 grains (39.27g). This shows the positive effect of phospho-nitrogen fertilization in salty and calcareous soils.

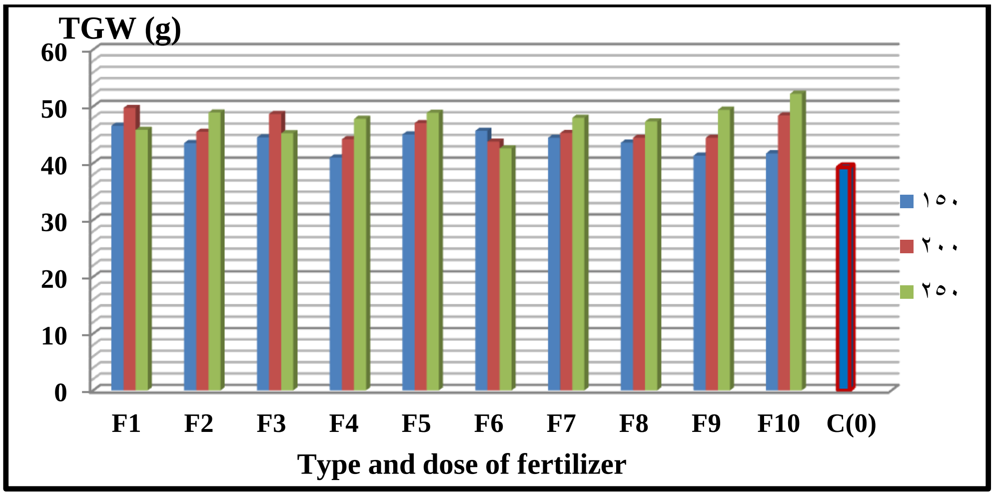

FIGURE 3. Variation of 1000 grains weight according to the type and dose of fertilizer.

On the other hand, and according to the statistical analysis (Table 3), the highest TGW is observed for the F10 treatment [NPK (4%, 20%, 25%) (250U ha^{-1})], with an average of 52.2g. It can also be seen from these results that the weight of 1000 grains increases with the increase in the fertilizer dose for the treatments F2, F4, F5, F7, F8, F9 and F10. But treatments F1 and F3 are negatively affected by the high dose of fertilizer (250U ha^{-1}). For treatment F6, the opposite result is observed. Indeed, the TGW decreases with the increase in fertilizer dose.

2.3. Grain yield (GY) (quintal h^{-1})

The comparison of the means for the effect of fertilizer type and dose on wheat crop grain yield (Table 3) shows that treatments F6 [NPK (15%,15%,15%) (150U ha^{-1})], and F10 [NPK (4%, 20%, 25%) (250U ha^{-1})], constitute the first homogeneous group, with averages 30.18q ha^{-1} and 29.98 q ha^{-1} respectively. However, the lowest yield is given by the control with a yield of (14.31q ha^{-1}). This shows the effective contribution of phospho-nitrogen fertilization on the grain yield of the durum wheat crop. Furthermore, the effect of the fertilizer dose depends on the type of fertilizer where the best yield is observed to be given by the 150U ha^{-1} dose (F6) and the 250U ha^{-1} dose (F10). It is also observed that the yield increases with the increase of fertilizer dose for the treatments (F2, F4, F5, F7, F8, F9 and F10), but this yield is reduced with the increase of the fertilizer dose for the F6 treatment. The F1 and F3 treatments are negatively affected by high fertilizer dose (250 U ha^{-1}).

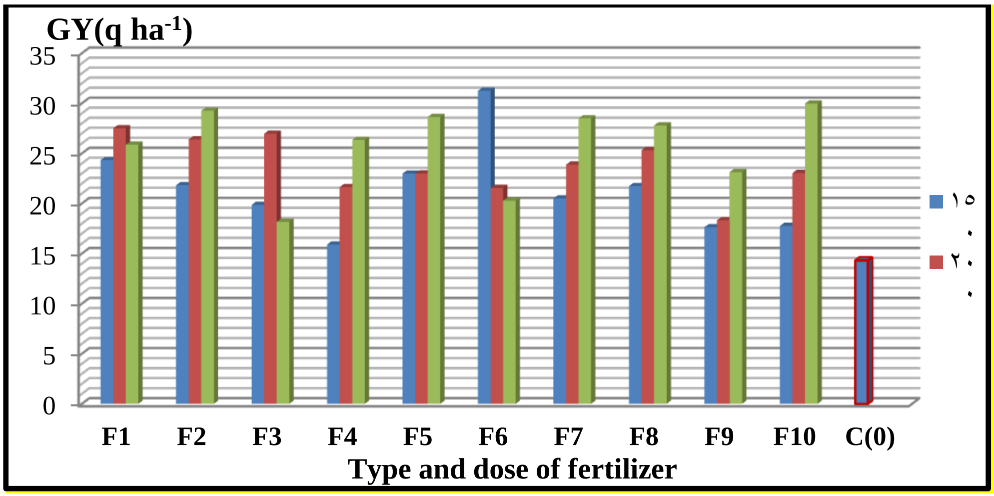

FIGURE 4. Variation of Grain Yield according to the type and dose of fertilizer.

2.4. Straw yield (SY) (quintal ha^{-1})

As noted earlier, the importance of phospho-nitrogen fertilization on the growth and yield and its components, of the durum wheat crop in both saline and carbonate conditions, also has an important effect on the straw yield (figure 5).

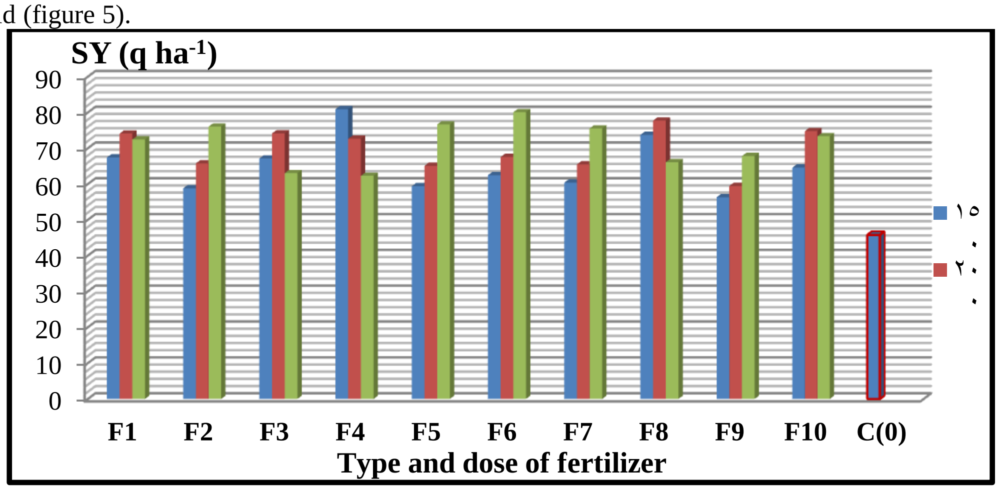

FIGURE 5. Variation of Straw Yield according to the type and dose of fertilizer.

According to the analysis of variance (Table 3), it can be seen that the type and dose of fertilizer have a very highly significant average effect on straw yield. The highest yields are obtained by the treatments F4 [(KNO_3-SSP) (150U ha^{-1})] and F6 [NPK (15%,15%,15%) (150U ha^{-1})], with averages 80.93q $ha^{-1}$and 80.08q ha^{-1}respectively, However the lowest yield was obtained by the control (45.76q ha^{-1}). It can also be seen that increasing the fertilizer dose leads to increased straw yields for the treatments F2, F5, F6, F7 and F9 (Figure 5). In contrast, the application of the F4 treatment decreases the yield despite the increase in the fertilizer dose. For treatments F1, F3, F8 and F10, the straw yield is negatively affected by the high dose of fertilizer (250U ha^{-1}).

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3. Effect of the fertilizer type and dose on Nitrogen (N %) and Phosphorus (P %) content of the grains

3.1. Nitrogen (N %) content of the grains

Phospho-nitrogen fertilization has a positive effect on the nitrogen content of wheat grains. This is clearly shown through the results of figure 6 where the lowest value of the nitrogen content of the grain is recorded by the control treatment without fertilizer (1.2% DM).

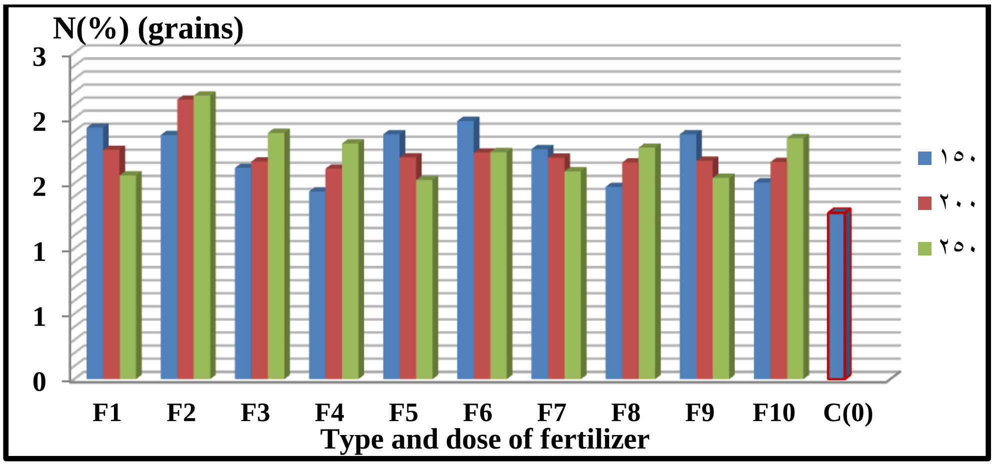

FIGURE 6. Nitrogen (N %) content by grains according to fertilizer type and dose.

Statistical analysis shows a very highly significant average effect of fertilizer type and dose on grain nitrogen content (Table 3). The highest content is obtained by treatments F2 [(Urea-SSP) (200U ha^{-1}) and (250U ha^{-1})] with averages 2.1% DM and 2.07% DM respectively. On the other hand, the effect of the fertilizer dose depends on the type of fertilizer (Figure 6). In fact, the N content of the grains rises with the increase of the fertilizer dose for the treatments F2, F3, F4, F8 and F10. In contrast, for treatments F1, F5, F6, F7 and F9 the N content of grain decreases as the fertilizer dose is increased.

3.2. Phosphorus (P %) content of the grains

The values of the phosphorus content of wheat grains for treatments F1 to F10 are higher than the control value without fertilizer. This indicates the importance of phospho-nitrogen fertilization in salty and calcareous soil (Figure 7).

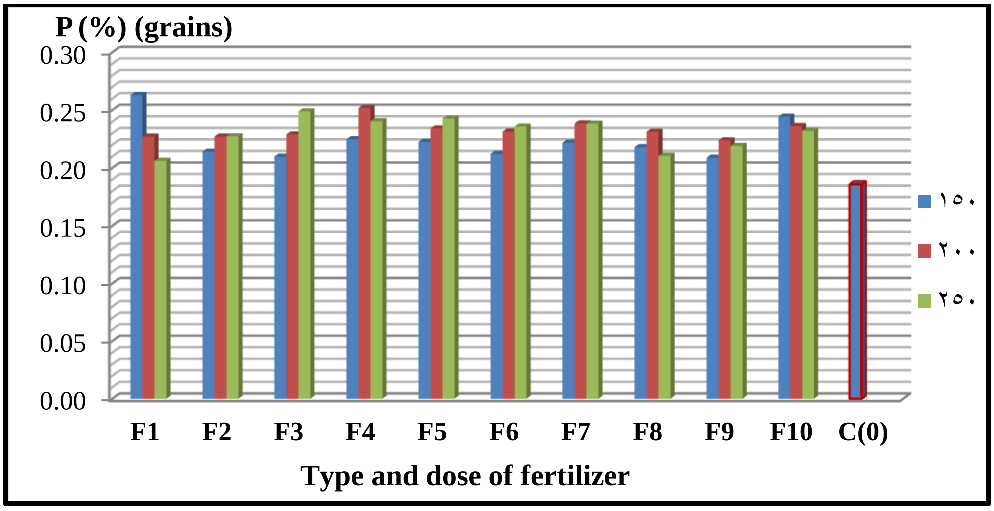

FIGURE 7. Phosphorus (P %) content by grains according to fertilizer type and dose.

This is also confirmed by the analysis of variance (Table 3), which shows a very highly significant average effect of fertilizer type and dose on the phosphorus content of grain. The highest content is observed for the F1 treatment [(Urea-TSP) (150U ha^{-1})] with an average of 0.26% DM. The lowest average is observed on the control with an average of (0.19% DM). On the other hand, figure 7 shows that the effect of the fertilizer dose depends on the type of fertilizer used. In fact, we notice that the phosphorus content of the grains increases with the increase in the fertilizer dose for treatments F2, F3, F5, F6 and F7. But this content decreases with the increase in the fertilizer dose for the F1 and F10 treatments. For treatments F4, F8 and F9, this content decreases in the case of the highest dose (250U ha^{-1}).

IV. DISCUSSION

The results that we obtained through the statistical analysis showed that the phospho-nitrogen fertilization had a very highly significant effect on the entire parameters studied tab 3). But this effect varies according to the type and dose of fertilizer. The effect of some fertilizers on the one hand is positive on the parameters studies, as the results increase with the increase of fertilizer dose. On the other hand, this effect is negative, as we notice that the results reduced with the increase of the fertilizer dose. We also find that the parameters studied are negatively affected by the high dose of fertilizer (250U ha^{-1}).

- **Plant growth**

Phosphorus and nitrogen are essential minerals for plant growth [27, 28]. According to Aghdam and Samadiyan [29], plants height in cereal increases significantly with the increase in nitrogen application. Arshad et al. [30] and Masmoudi [17] show that applied phosphorus significantly increased the height of plants. Results obtained by Ishete and Tana [31] indicate that N and P fertilizer application increases wheat plant height. According to Prajapati et al [32] the increased availability of phosphorus favored nitrogen fixation and the rate of photosynthesis, resulting in better growth parameters. It seems that the positive effect of fertilizers (KNO_3-SSP), MAP and NPK (15%,15%,15%) is due to the specific properties of each fertilizer. KNO_3 is characterized by its nitrogen content, immediately available to plants as nitrate, while SSP is rich in sulphur and has a pH below 2 [33]. MAP is soluble and acidic, while NPK (15%,15%,15%) has a high acidifying power. Acidifying fertilizers are therefore very useful in calcareous soils as shown in the case of this study.

- **Number of grains per ear (NG E^{-1})**

The number of grains per ear varies significantly depending on the type of fertilizer used [16]. Results from Halilat and Dogar [34]; Moore [35]; Lakab [36]; Mandic et al [37]; Haffaf et al [38] conclude that the number of grains per ear increases significantly with the increasing nitrogen rate. It also increases with increasing phosphorus dose [39]. Furthermore, the results obtained by Khan et al [40] and Kaleem et al [41] show that the highest dose of NP intake produced a maximum number of grains per ear. In addition, NPK (13%, 40%, 13%) is a soluble crystalline fertilizer with high phosphorus (P) content, enriched with trace elements, specially designed to improve root development, stimulate flowering and fruit setting [42].

- **1000 grains weight (TGW)**

The weight of 1000 grains is one of the components of grain yield, reflecting the good grain quality and mineral feed of the wheat crop. In fact, it reflects the impact of biotic and abiotic stresses on the crop and the harvested product [43].

Several studies (Halilat and Dogar [34]; Halilat [15]; Lakab [36]; Mandic et al [37]; Haffaf et al [38]) have shown that the weight of 1000 grains is negatively affected by nitrogen input. On the other hand, work carried out by (Boukhalfa et al [44]; Mihoub et al [16]; Mihoub and Boukhalfa-Deraoui [26]; Masmoudi [17]) shows that the weight of 1000 grains positively affected by phosphorus input. So, and through the results obtained, we confirm the importance of the combination between phosphate and nitrogen fertilization on the weight of 1000 grains. This is confirmed by the results obtained by Kaleem et al [41], showing that the balanced rate of NP increases the weight of 1000 grains. It also seems that the positive effect of NPK (4%, 20%, 25%) is due to its richness at the same time, in phosphorus, potassium and sulphur [45].

- **Grain yield (GY)**

Fertilizer is the most important input that contributes significantly to the final wheat yield [26, 41]. According to Masmoudi [17], fertilizer contributed to increased yields in saline conditions. In addition, Chen et al [46] show that the increase in phosphorus application rate has increased grain yield. Ishete and Tana [31] conclude that the increase in the combined fertilizer rate has increased grain yield. According to Aissa and Mhiri [47], there are interactions between nitrogenous and phosphate fertilizers that increase yield. Thus, maximum economic yield is obtained by increasing fertilizer rates [48]. Finally, we can note the remarkable effect of the NPK fertilizer (15%, 15%, 15%) which provided the best grain yield with the low dose. This is due, as already mentioned to its acidifying power and nutritional balance.

- **Straw yield (SY)**

Straw yield increases due to higher nitrogen levels [38, 49 and 50]. Roger et al. [28] and Masmoudi [17] found that the addition of phosphate fertilizer significantly increases straw biomass. Likewise, the results of Tadele Alem and Legese [51] indicate that combined fertilizer has a significant effect on wheat straw yield; this is also evident through the results we obtained. In conclusion, fertilizers (KNO_3-SSP) and NPK (15%, 15%, 15%) gave the best plant height and therefore the best straw yield due to the positive characteristics cited above.

- **Nitrogen (N %) content of the grains**

Nitrogen availability to plants is determined by the form of nitrogen found in a fertilizer [52]. The type and rate of fertilizer applied also has a great influence on the intensity of N uptake [53]. It seems that urea, due to its high nitrogen content and its more or less slow transformation into ammonium and nitrate, ensures prolonged plant feeding, which increases the nitrogen content of the grains.

- **Phosphorus (P %) content of the grains**

As mentioned above and according to Stanojković et al [53] the type and rate of fertilizer applied have a large impact on the intensity of N and P absorption. There are interactions between nitrogen and phosphate fertilizers which increase yield and improve the solubility and absorption of phosphorus [41, 48]. Thus, the results obtained by Chen et al [46] show that increasing the rate of phosphorus application increases its absorption by the plant. The positive effect of the F1 treatment (Urea-TSP) on the phosphorus content of grain can result from its high phosphorus content and solubility.

V. CONCLUSION

In this work, we studied the use of two types of phospho-nitrogen fertilizer, simple and compound in different forms applied in three doses, in salty and calcareous soil. The results obtained confirm the importance of phospho-nitrogen fertilization for this type of soil. These results also indicate that the effect of phospho-nitrogen fertilization on the parameters studied varies according to the type and dose of fertilizer. Indeed, we notice that the best results are obtained by compound fertilizers i) height of the plants: HP = MAP and NPK (15%, 15%, 15%) (250U ha^{-1}) and (KNO_3-SSP) (150U ha^{-1}) ii) yield and its components: Number of grains per ear (NG E^{-1}) = NPK (13%, 40%, 13%) (250U ha^{-1}), 1000 grains weight (TGW) = NPK (4%, 20%, 25%) (250U ha^{-1}), grain Yield (GY) = NPK (13%, 40%, 13%) (250U ha^{-1}) and NPK (15%, 15%, 15%) (150U ha^{-1}), straw yield (SY) = NPK (15%, 15%, 15%) (250U ha^{-1}) and (KNO_3-SSP) (150U ha^{-1}). Compound fertilizers have the centesimal formula/composition ensuring the presence of the major nutrients in each granule. These fertilizers also allow uniform distribution of nutrients in each application because of to the stable quality and the sufficiently uniform size of their granules [27]. The principle of compound fertilizers, which combine in their composition a nitrification retardant, is more interesting. This limits the risk of nitrate leaching [54]. NPK (15%, 15%, 15%) is a fertilizer rich in sulfur, and this high content ensures a prolonged effect of phosphorus and improves nitrogen absorption from the soil and fertilizers [55]. However, the highest nitrogen and phosphorus content of the grains is obtained with simple fertilizers, N= (Urea-SSP) with the dose (200 and 250 U ha^{-1}), and P= (Urea-TSP) with the dose (150U ha^{-1}).

The most relevant results in this study are the achievement of better grain and straw yields with the lowest dose of NPK fertilizer (15%, 15%, 15%), as well as a better plant height and straw yield with the lowest dose of (KNO_3-SSP) fertilizer. Finally, we suggest the use of compound NPK fertilizer (15%, 15%, 15%) especially for wheat grain production and (KNO_3-SSP) fertilizer especially for growth and biomass production.

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