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Management of Nitrogen Fertilizer in Monoculture Wheat System under Mediterranean Climate Conditions

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ABSTRACT

The production of durum wheat in Algeria is hardly sufficient for the growing demand for this product. Dependent on climatic hazards, the national average yields which hardly exceed 10 q ha-1, are mainly due to a lack of mastery of production techniques such as fertilization, plant protection, supplemental irrigation, etc. The aim of the undertaken experimentation was to constitute a nitrogen fertilization strategy for durum wheat that fit the region of the plains of Constantine in Algeria. Based on the form of fertilizer, the method, and the time of application, the experimentation profited from good soil and good climatic conditions. For that, we established an experimental device including various methods of contribution: ground and foliar nitrogen fertilizers, split or fully applied at-planting. The analysis of growth parameters and yield components showed that any nitrogen input results in improvements whatever its form or modality. Moreover, the method with a single application of nitrogen fertilizer at-planting on the ground was most efficient for the whole of the studied parameters, except the length of the ear where we observed the best result with foliar supply.

Keywords: Nitrogen fertilizer; single application; splitting application; durum wheat; Mediterranean climate

INTRODUCTION

Cereal products in general and wheat in particular have always been the basic ration for the Algerians. The consumption is estimated at 200 kg per year^{-1} inhabitant^{-1} (MADR, 2011). The production of wheat in Algeria is hardly sufficient for the growing demand for this product.

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Dependent on climatic hazards, the national average yields, which hardly exceed 10 q ha^{-1}, are mainly due to a lack of mastery of production techniques such as fertilization, plant protection, and supplemental irrigation (Malki and Redjel, 2000). In addition, Algerian agricultural essentially depends on precipitation since the rainfed land covers 98.6 % of the total agricultural area (Chourghal *et al*., 2016; Cline, 2007) with 50 % of this area occupied by cereals and mostly durum wheat (Bensemane *et al*., 2011). Moreover, rainfall distribution is often unpredictable during the growing season, crop yields are most of the time low and variable from one year to another (Van Oosterom *et al*., 1993).

To face such climate changes and to reveal the challenge of increasing yields, for better coverage of wheat needs, it is more than necessary to adjust production techniques (use of quality seeds, fertilizers, pesticides, etc.). Among the production techniques, nitrogen fertilization is the backbone of cereal production as nitrogen is considered the second limiting factor after water. Thus, the upgrading of cereal production systems necessarily requires the establishment of nitrogen fertilization reasoning strategies in a regional context, according to potential and needs (Cui *et al*., 2010).

Nitrogen fertilizer efficiency depends essentially on the type and rate of fertilizer in addition to the time of application (Blankenau *et al*., 2002; Efretuei *et al*., 2016; Liu and Shi, 2013). Wheat response to N fertilizer is also influenced by soil type, crop sequence and the supply of residual and mineralized N. Decisions regarding fertilizer rate and application date pose a major challenge to the farmer. Splitting of N fertilizer application has been suggested as a strategy to improve wheat N use efficiency. However, (Alcoz *et al*., 1993) indicate that studies of the wheat response to split N application in the Mediterranean region and the USA have yielded inconsistent results.

In the plains of Constantine, the issues of optimizing yields mainly revolve around the reasoning of nitrogen fertilization. The nitrogen inputs practiced in this region are often inputs in the soil, mainly urea. Due to the fact that nitrogen is a labile element, easily washable on the one hand, the needs of the crop appear gradually during the development cycle, on the other hand, it appears necessary to study how the rate should be provided while taking into account the rainfall regime, and since the latter is irregular from one year to the next it would therefore be interesting to have the effect of foliar fertilization in a developed stage of the plant. This is the perspective of our study, which aims to determine the optimum yields through a nitrogen fertilization strategy that suits the region while taking into account the different means available to the farmer. For this, we tried to compare several methods of application of nitrogen fertilizer. The methods chosen make it possible to determine the response of the durum wheat variety "Simeto", a widely used variety in the region, to unfractionated nitrogen fertilization on the one hand, and the effect of fractional applications in various doses on the other hand.

Materials and Methods

Site description and agronomic management

The study was carried out on a Vertisol field, typical of the Mediterranean region, located in Ain Smara, Constantine, Algeria (36°14’11’’N, 6°26’13’’E; 636 elev.) during two growing seasons 2010/2011 and 2011/2012. The region falls within a transitional perimeter between sub-humid to semi-arid regions. The previous crop was durum wheat (*Triticum durum*, Desf.) cultivar Semito, which is the same cultivar studied in this work. Before each growing season, the residues of the previous crop were buried in the ground using a cover crop at the last week of July, then the seedbed was prepared on December 15th with minimum tillage at a depth of 20 cm. The sowing was carried out in both years on December 18th at a depth of 5 cm with a density of 250-300 plants m^{-2}. Phospho-potassium fertilization was carried out in a single application of 1 q NPK (15-15-15) on 12/11/2011. For Nitrogen fertilization which is the subject of our study, we tested several nitrogen fertilizer modalities (Table 1) using two types of fertilizer: 1) granular urea 46%, simple fertilizer with the chemical formula $CO(NH_2)_2$, dosing 46% of total nitrogen, brought to the soil during sowing or on the surface during vegetation using a centrifugal spreader, and 2) Safe-N, foliar fertilizer dosing 353 g L^{-1} of nitrogen, 70% of which is progressive release. Chemical weed control was carried out at the full tillering stage using the double-action herbicide Palace, the active ingredient of which is Pyroxsulam (125 mL L^{-1}) at a dose of 0.5 L ha^{-1}. The field was divided into 8 regular subareas of 18 m in length, 12 m large, and 2 m space between the plots.

Table 1: Nitrogen fertilization modalities of the application using on-ground fertilizer (Urea 46) and foliar fertilizer (Safe N).

Fertilization modalities	At-planting	Tillering	Early heading
N0	0	0	0
N1	200 kg ha^{-1} (on-ground)	0	0
N2	100 kg ha^{-1} (on-ground)	50 kg ha^{-1} (on-ground)	50 kg ha^{-1} (on-ground)
N3	100 kg ha^{-1} (on-ground)	50 kg ha^{-1} (on-ground)	5 L ha^{-1} (foliar)

Values represent the quantities of N applied (units) without taking into consideration the 15 kg ha^{-1} applied with the NPK fertilizer.

Field measurement

For the sampling, 10 plots of 0.25 m² were delimited in each subarea. Number of plants that emerged (NPE), stem high, ear length and number m^{-2}, the number of grain $ear^{-}1$, weight of 1000 grains, aerial biomass, and straw yield were determined by measuring 10 samples in each plot (for each growing season). All the measurements were done at the maturity stage, except for NPE which was done at an earlier stage.

At maturity, the grain yield (GY) was determined, after harvest, with a combine harvester of all the subarea. Harvest index (HI) was measured following the formula:

HI = GY/aerial biomass

Statistical analysis

Data were statistically assessed by analyses of variance (ANOVA) with Tukey's least significant difference (LSD) posthoc tests. Significances are indicated by different letters. ANOVA was conducted using the GLM procedure in SPSS version 20.

RESULTS

Soil and Weather conditions

To characterize soil physico-chemical proprieties, samples from 5 sites were taken using an auger (0-30 cm depth). The clay was the predominant texture (50,3 %) associated with a high level of calcareous reaching 34.1 % (15 % of which are active). The soil is alkaline (pH 8.4), and poor in organic matter, total nitr,ogen and available phosphorus (2.06%, 0.126% and 8.66 ppm respectively). The cation exchange capacity is medium (25.3 meq 100 g^{-1}) and the biological activity in this soil is low (Table 2).

Table 2: Soil properties at the beginning of 2 years experiment at Belbedjaoui farm, Ain Smara, Constantine, Algeria.

Proprieties	0-30cm depth
Clay	50.3%
Fine Sand	21.4%
Coarse Sand	4.4%
Fine Silt	18.2%
Coarse Silt	3.6%
Total N	0.126%
P_2O_2	8.66 ppm
K_2O	268 ppm
Total Calcareous	34.1%

Active Calcareous	15.5%
Carbon	1.2%
Biological Activity (C/N Ratio)	9.52
Organic Metter	2.06%
Cation Exchange Capacity	25.3 meq $100g^{-1}$
Electrical Conductivity	0.1383 mmhos cm^{-1}
pH	8.4

The rainfall in the region of study is more or less abundant (depending on the year) which generally oscillates between 400- and 600-mm $year^{-1}$. For the 2011-2012 crop year, we recorded a total of 468 mm. however in the year before, we recorded almost 503 mm. Follow rainfall (September–November) was 82.4 and 121.16 mm and the total growing season rainfall (December–May) was 399.8 and 346.8 mm respectively for the first and second growing season (Table 3). The partition of the growing season rain into monthly values showed that April was the high rainfall month with 113.3 mm in 2010/2011. In the next growing season, February records the most amount of rainfall with 106.21 mm (Table 3).

Table 3: Monthly rainfall, maximum temperature (T_M), minimum temperature (T_m) and mean temperature (T_{mea}) at Ain Smara during the two growing seasons 2010/2011 and 2011/2012.

		Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Mai	Jun
2010/ 2011	***Rainfall (mm)***	38.8	21	37.6	27	76.4	48.6	81.1	113.3	53.4	5.7
	T_M (°C)	29.1	23.7	16.3	12.1	12.1	11.9	16	16.5	25.3	31.7
	T_m (°C)	16	11.2	5.1	2.5	2.9	2.3	3.6	5.7	10	13.3
	T_{mean} (°C)	22.5	17.4	10.7	7.3	7.5	7.1	9.8	11.1	17.6	13.3
2011/ 2012	***Rainfall (mm)***	3.05	85.34	32.77	53.61	34.81	10.21	55.13	69.35	21.59	6.1
	T_M (°C)	28	23.1	16.5	12.5	12.2	8.9	17.3	19.6	30	39.1
	T_m (°C)	13	10.1	7	3	1.3	-0.6	4.4	6.4	10.6	20.1
	T_{mean} (°C)	22.3	15.9	12.2	7.8	6.2	3.8	10.3	12.8	17.8	25.5

The high plains of Constantine are characterized by a cold climate in winter, hot and dry in summer. Average temperatures vary from 3.8 °C for the month of February to 25.5 °C for the month of June, which correspond respectively to the coldest and hottest month of the crop year (Table 3).

Yield and yield components

The variability of grain yield for the growing seasons is shown in Figure 1. All fertilized treatments had significantly higher yields than the control. Moreover, N application timing had a significant effect on grain yield. N2 and N3 applications enhanced the grain yield by 60 and 57 % respectively compared to N0. However, N1 recorded the highest grain yield reaching 31.43 q ha^{-1} (87% higher than N0). Overall, these results show that the yields obtained with a single supply of nitrogen in solid form at sowing are higher than those obtained with divided inputs or in liquid form. The analysis of the results shows that there is no significant effect of the application mode on NPE (Figure 1). The highest number of emerged plants was obtained when the nitrogen was applied in a single supply at sowing (193 plant m^{-2}). The timing and splitting of the 200 kg N ha^{-1} rate had a significant effect on ear density over the crop season (Figure 1). The best ear density was obtained when the total nitrogen fertilizer was applied at sowing (233 ear m^{-2}). Splitting of the total N rate between the sowing, tillering and earing-up stage prompted a lower number of ears. We recorded a density of 226.3 and 220.9 ear m^{-2} for N2 and N3 respectively (Figure 1). No significant effect was recorded between the different modes of applying nitrogen fertilizer regarding the number of grain ear^{-1} and seed weight. However, the enhancement concerning grain number was seen when compared to N0 (Figure1).

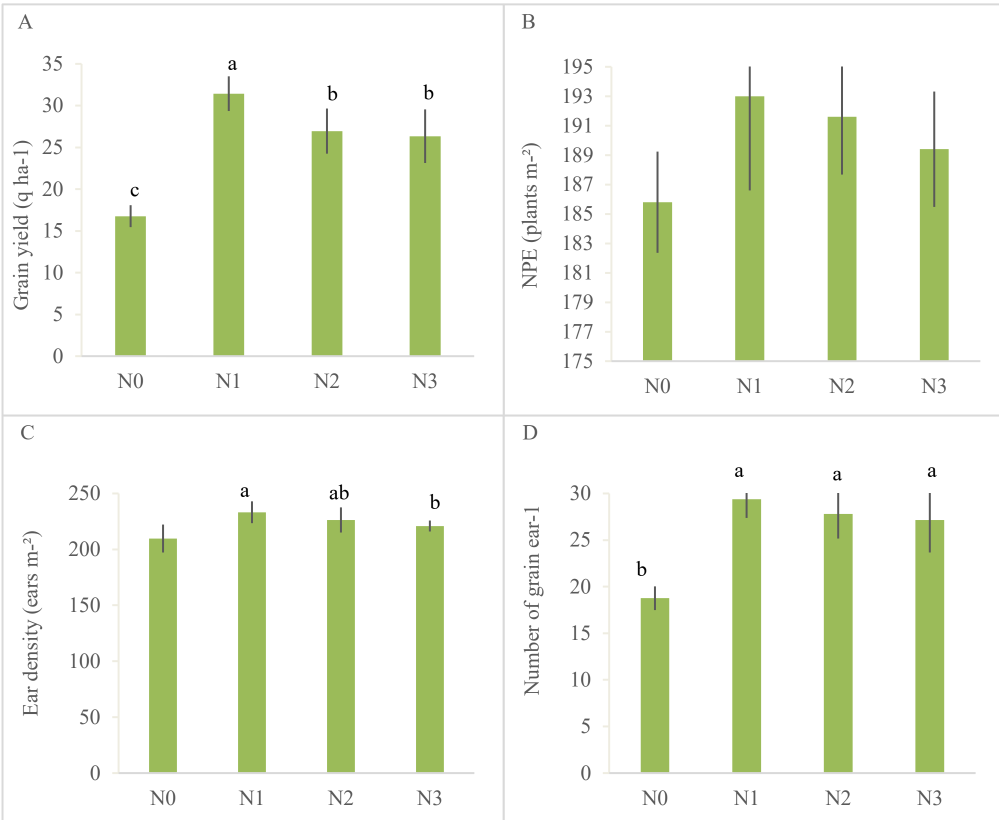

Figure 1: Effect of N fertilizer modalities on grain yield and yield components. A) grain yield, B) NPE per m², C) ear density, D) a number of grains per ear, e) weight of 1000 grain. Each value is the mean of 20 replicates. Error bars represent ± standard deviation. Different letters indicate significant differences between treatments tested by ANOVA and Fisher's LSD

Straw yield and stem high were highly affected by the splitting of N fertilizer (Figure 2). The decrease in the yield due to the splitting of the 200 q of nitrogen fertilizer was 32 % (between N1 and N2). Positively correlated with straw yield, the stem high was negatively affected by the splitting of N (Figure 2). Aerial biomass was more sensitive to fertilization mode. Applying 200 q of nitrogen at sowing gives obviously the best biomass (Figure 2). Also, Ear length was significantly affected by the application of N fertilizer. In contrast, the harvest index was less sensitive to the amount and the splitting of N (Figure 2).

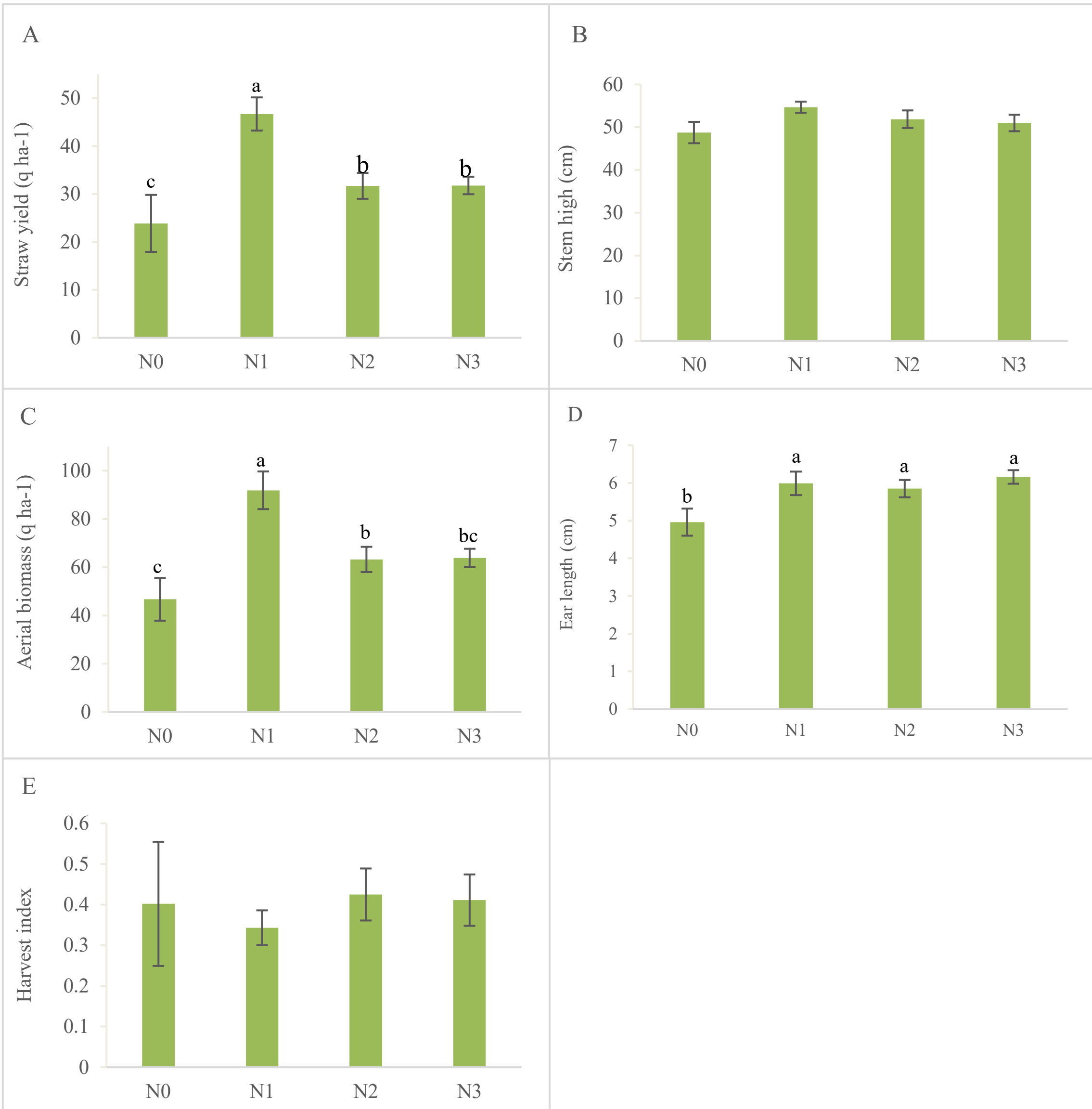

Figure 2: Effect of N fertilizer modalities on: A) straw yield, B) stem high, C) aerial biomass, D) ear length, E) harvest index. Each value is the mean of 20 replicates. Error bars represent ± standard deviation. Different letters indicate significant differences between treatments tested by ANOVA and Fisher's LSD

Discussion

Located in the Mediterranean region, Algeria is one of the countries most exposed to climate change. Numerous studies indicate that the north African region, characterized by rainy winters and dry summers, is facing big changes in the frequency of extreme weather events especially temperature and rainfall (Field and Barros, 2014; Ventrella *et al*., 2012). Increases in temperatures and disturbances in rainfall are the primordial challenge of the region. Several works have studied the effects of climate change on crop growth and yield (Chourghal *et al*., 2016; Tao and Zhang, 2011). Although cereal cultivation in Algeria is rainfed, the fact remains that the application of suitable technical procedures greatly contributes to improving yields. Since nitrogen is a limiting factors in Algerian soils, management of N fertilization is the key to facing such challenge.

Good nitrogen fertilization is linked to the good management of time and rates of fertilizer since these factors directly affect yield components. Failure to accurately estimate the appropriate rate and time for fertilizer application often results in inefficient fertilizer management (Walsh *et al*., 2018). The response of wheat to N fertilizer timing is not totally understandable. This could be due to the fact that fertilizer timing reflects the effect of seasonal variations of rainfall which directly influence the uptake and efficiency of N at several phases in plant, and the resulting fluctuations in soil residual N content before the new sowing season (López-Bellido *et al*., 2006). In addition, numerous other factors co-act in order to decrease the efficiency of N fertilizer management such as nitrate leaching, soil denitrification, and ammonia volatilization (Ravishankara *et al*., 2009; Reay *et al*., 2012).

Many studies have compared N efficiently in at-planting and split fertilizers. Under a sufficient amount and a regularity in the distribution of the rainfall during the cropping season, in-season fertilization enables matching the nitrogen supply with the plant needs leading to vital nutrients which improves efficient N fertilizer use (Walsh *et al*., 2009). However, pre-plant fertilization of N is considered more beneficial; both technically and economically, as it facilitates the allocation of farmers time and labor (Randall *et al*., 2003), in addition of the best exploitation of superior soil conditions (Bundy, 1986). Moreover, early fertilization has potential for minimizing N deficiency early in the growing season. However, single pre-plant N may result in nitrogen immobilization before plant uptake can take place (Wuest and Cassman, 1992). (López-Bellido *et al*., 2006) estimated that application of 100 kg N ha^{-1} before planting with sufficient rainfall in March and April resulted in higher grain yields than splitting supplies. But When rainfall quantities were low in the same period, split application of 150 kg N ha^{-1} gave higher yields compared to other fertilization strategies.

Substantial amounts of nitrogen are accumulated as nitrate in the soil, especially when high rates of fertilizer are used. With unsuitable rainfall, a considerable quantities of the nitrogen fertilizer not used by the plants in years may remain in the soil, and thus available to subsequent crops. Yearly variations in rainfall distribution over the previous growing season in our study may have prompted differences in the mineralization rate. Furthermore, (Stockdale *et al*., 1997) reported that Mediterranean vertisols are characterized by the clayey nature which give the soil a good moisture levels between October and December and an excess of soil water during the winter. The higher efficiency of N applications at-planting shown in Figure 1 could be in part explained by the greater concentration of fertilizer in the root area at higher N rates due to the application of NPK fertilizer (3x15) 7 days before sowing, thus stimulating development of a larger and more effective root system for the recovery of soil N, rather than to the effect of mineralization–immobilization turnover (Strong, 1995). The important contribution of soil nitrogen to the crop N accumulation is linked to the considerable residual levels of preplanting inorganic N and to mineralization. This could perfectly explain the higher grain yield obtained in our study with a single application of 200 q N at sowing since for both growing season the previous crop was wheat in which, a considerable amounts of N fertilizers are used. (López-Bellido *et al*., 2006) estimate that the

residual levels could to provide almost the same amount of N as the 150 kg N ha^{-1} rate applied as fertilizer. Furthermore, the total N fertilizer applied at sowing conduct to the best N nutrition of wheat at earlier stages.
Under a condition of an adequate moisture, the application of nitrogen fertilizer improve wheat yield due to the ease of N uptake (Sowers *et al*., 1994). These findings could explain the highest grain yield obtained with a single application of N fertilizer in December when the precipitations were abundant which gives a good moisture to the soil. Furthermore, N deficiency at early stages could result in stunted seedling growth negatively affecting tillering, leading to a grain yield reduction.
The amount and distribution of rainfall received between February and April are essential indicators when deciding the importance of top-dress N fertilizer application. (López-Bellido *et al*., 2006) estimate that single application of N fertilizer pre-plant accompanied by sufficient precipitation in the months of February and April resulted in maximum yields compared splits application, which is the case of our study since the site of study recorded 216.7 mm of rainfall for the mentioned period. Adequate soil moisture in spring could favored microbial activity providing N to the crop through mineralization during flowering and grain fill. This would minimize and perhaps eliminate the need for top-dress N.

The objective of the study carried out was to establish a nitrogen fertilization strategy adapted to the region of the plains of Constantine for durum wheat crop. The reasoning of the study focused mainly on nitrogen inputs to the soil and foliage modulated over time. The study was carried out under experimental conditions that should be noted. We observed a decrease in rainfall compared to previous years, a snowfall that lasted three weeks at the start of the vegetative cycle, hailfall during the month of January which led to a decrease in yields compared to previous campaigns.
The analysis of all the parameters studied made it possible to draw the following conclusions:

- Nitrogen fertilization has a positive effect whatever the method of application on all the parameters studied, apart for HI;
- the most efficient method was single application to the soil at the start of cultivation for all the parameters studied, except the length of the ear where the modalities with foliar supply provided the best results;
- Splitting N fertilizer resulted in intermediate values between the control and the modality with a single at-planting application. This can be explained by the losses of urea nitrogen brought to the surface;

Considering that studied agricultural seasons were characterized by rather delicate climatic conditions (temperatures down to -0.6 °C, an annual rainfall of 473 mm poorly distributed), and that these vary from year to year, it would be desirable to continue this study over several years in order to provide additional information and, possibly, to confirm our results.

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Conflict of interest

There is no actual or potential conflict of interest in relation to this article.

REFERENCES

Alcoz, M.M., Hons, F.M., Haby, V.A., (1993). Nitrogen fertilization timing effect on wheat production, nitrogen uptake efficiency, and residual soil nitrogen. *Agronomy Journal* 85, 1198–1203.

Bensemane, L., Bouzerzour, H., Benmahammed, A., Mimouni, H., (2011). Assessment of the phenotypic variation within two-and six-rowed barley (Hordeum vulgare L.) breeding lines grown under semi-arid conditions. *Advances in Environmental Biology* 1454–1461.

Blankenau, K., Olfs, H.-W., Kuhlmann, H., (2002). Strategies to improve the use efficiency of mineral fertilizer nitrogen applied to winter wheat. *Journal of Agronomy and Crop Science* 188, 146–154.

Bundy, L.G., (1986). Timing nitrogen applications to maximize fertilizer efficiency and crop response in conventional corn production. *Journal of Fertilizer Issues* 3, 99–106.

Chourghal, N., Lhomme, J.P., Huard, F., Aidaoui, A., (2016). Climate change in Algeria and its impact on durum wheat. *Regional environmental change* 16, 1623–1634.

Cline, W.R., (2007). Global warming and agriculture: Impact estimates by country. Peterson Institute.

Cui, Z., Zhang, F., Chen, X., Dou, Z., Li, J., (2010). In-season nitrogen management strategy for winter wheat: Maximizing yields, minimizing environmental impact in an over-fertilization context. *Field crops research* 116, 140–146.

Efretuei, A., Gooding, M., White, E., Spink, J., Hackett, R., (2016). Effect of nitrogen fertilizer application timing on nitrogen use efficiency and grain yield of winter wheat in Ireland. *Irish Journal of Agricultural and Food Research* 55, 63–73.

Field, C.B., Barros, V.R., (2014). *Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects*. Cambridge University Press.

Liu, D., Shi, Y., (2013). Effects of different nitrogen fertilizer on quality and yield in winter wheat. Advance *Journal of Food Science and Technology* 5, 646–649.

López-Bellido, L., López-Bellido, R.J., López-Bellido, F.J., 2006. Fertilizer nitrogen efficiency in durum wheat under rainfed Mediterranean conditions: Effect of split application. Agronomy journal 98, 55–62.

MADR, (2011). Agricultural statistics : areas and productions 2011, serie B.

Malki, M., Redjel, N., (2000). Durum wheat yield sustainability or ecosystem sustainability?: effects of state policies on farmers' behaviour in Algeria. Royo C, Nachit M, Di Fonzo N, Arau s JL (eds), Durum wheat improvement in the Mediterranean region: new challenges. Options Méditerranéennes: Série A. Séminaires Méditerranéens, CIHEAM Zaragoza 569–573.

Randall, G.W., Vetsch, J.A., Huffman, J.R., (2003). Corn production on a subsurface-drained mollisol as affected by time of nitrogen application and nitrapyrin. *Agronomy Journal* 95, 1213–1219.

Ravishankara, A.R., Daniel, J.S., Portmann, R.W., (2009). Nitrous oxide (N2O): the dominant ozone-depleting substance emitted in the 21st century. science 326, 123–125.

Reay, D.S., Davidson, E.A., Smith, K.A., Smith, P., Melillo, J.M., Dentener, F., Crutzen, P.J., (2012). Global agriculture and nitrous oxide emissions. *Nature climate change* 2, 410–416.

Sowers, K.E., Miller, B.C., Pan, W.L., (1994). Optimizing yield and grain protein in soft white winter wheat with split nitrogen applications. *Agronomy Journal* 86, 1020–1025.

Stockdale, E.A., Gaunt, J.L., Vos, J., (1997). Soil–plant nitrogen dynamics: what concepts are required?, in: Developments in Crop Science. *Elsevier*, pp. 201–215.

Strong, W.M., (1995). Nitrogen fertilization of upland crops. *Nitrogen fertilization in the environment* 129–169.

Tao, F., Zhang, Z., (2011). Impacts of climate change as a function of global mean temperature: maize productivity and water use in China. *Climatic Change* 105, 409–432.

Van Oosterom, E.J., Ceccarelli, S., Peacock, J.M., (1993). Yield response of barley to rainfall and temperature in Mediterranean environments. *The Journal of Agricultural Science* 121, 307–313.

Ventrella, D., Charfeddine, M., Moriondo, M., Rinaldi, M., Bindi, M., (2012). Agronomic adaptation strategies under climate change for winter durum wheat and tomato in southern Italy: irrigation and nitrogen fertilization. *Regional Environmental Change* 12, 407–419.

Walsh, O., Kanke, Y., Edmonds, D.E., Raun, W.R., (2009). Improving mid-season nitrogen recommendations for winter wheat using soil moisture data. *Better Crops Plant Food* 93, 26–27.

Walsh, O.S., Shafian, S., Christiaens, R.J., (2018). Nitrogen fertilizer management in dryland wheat cropping systems. *Plants* 7, 9.

Wuest, S.B., Cassman, K.G., (1992). Fertilizer-nitrogen use efficiency of irrigated wheat: II. Partitioning efficiency of preplant versus late-season application. *Agronomy Journal* 84, 689–694.

إدارة سماد النيتروجين في نظام القمح الأحادي في ظل الظروف المناخية لمنطقة البحر الأبيض المتوسط

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ملخص

إنتاج القمح الصلب في الجزائر بالكاد يكفي للطلب المتزايد على هذا المنتج. نتيجة للصعوبات المناخية، يُعزى متوسط المردود الوطني الذي لا يكاد يتجاوز 10 قنطار/هكتار، بشكل أساسي إلى عدم التمكن من تقنيات الإنتاج مثل التسميد المعدني، الحماية النباتية والري التكميلي. كان الهدف من التجربة التي تم إجراؤها هو تشكيل استراتيجية التسميد الآزوتي للقمح الصلب الذي يناسب منطقة سهول قسنطينة في الجزائر. بناءً على شكل السماد وطريقة التطبيق ووقته، استفادت التجربة من تربة جيدة وظروف مناخية جيدة. لذلك أنشأنا جهازًا تجريبيًا يتضمن طرقًا مختلفة للمساهمة: الأسمدة الآزوتية الأرضية والورقية، مقسمة أو مطبقة بالكامل عند الزراعة. أظهر تحليل عناصر النمو ومكونات المحصول أن أي مدخلات نيتروجين تؤدي إلى تحسينات مهما كان شكلها أو طريقة تطبيقها. بالإضافة إلى ذلك، كانت الطريقة ذات التطبيق الفردي للأسمدة النيتروجينية عند الزراعة على الأرض هي الأكثر فعالية لجميع العناصر المدروسة، باستثناء طول السنبلة حيث لاحظنا أفضل نتيجة مع الإمداد الورقي.

الكلمات الدالة: التسميد الآزوتي، التطبيق الأحادي، التطبيق المقسم، القمح الصلب، مناخ البحر المتوسط.