

Effect of Organic and Inorganic Fertilization on Yield and Quality Traits of Tritordeum, 'Bulel' Variety under Dry Conditions in Greece

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Abstract

Response of tritordeum, 'Bulel' variety, on organic and inorganic fertilization was observed through a field experiment in Greece. So as to evaluate, a field experiment was set up in Randomized Complete Block Design (RCBD) where blocks were four fertilizations (control, inorganic, manure, compost). Plant height was affected by fertilization. Thus height was ranged from 65 cm (control) to 71.75 cm (NPK). Concerning, kernel weight, control and the two organic fertilized did not differ. Both protein and gluten has a positive response to inorganic fertilization, values were 16.27 % and 33.45 % respectively. The increase in gluten is not a desirable trait as tritordeum is cultivated for lower gluten levels than wheat. Yield rised with fertilizers with the highest value of 4753.5 kg ha⁻¹. In brief, as first results, there was a positive response of tritordeum to fertilization in the dry conditions of Greece. As far as 'Bulel' variety recently became commercial, consequently a few years to further investigate are needed.

Keywords: tritordeum, Bulel variety, fertilization, protein content, gluten content

Introduction

Cereals are at the base of the food pyramid and are the center of a balanced diet. A new species is the tritordeum (*xTritordeum martinii* A. Pujadas, nothosp. nov.). The breeders of this new type of grain tried to maintain the properties of wild relatives of *Hordeum vulgare* (*Hordeum chilense* Roem. Et Schultz.) and cultivated durum wheat (*Triticum turgidum* ssp. *Durum* Desf). Feuillet *et al.*, in 2008 report that tritordeum failed to gain commercial acceptance. But three years later, the recording of the first commercial variety, 'Aucan' is done (2011) and five years after (2013) is released the second commercial cultivar, 'Bulel'. The newly-

created cereal is proper for human consumption and suitable for a wide range of cereal-based products in bakery and confectionery industry.

Tritordeum gained space due to improved quality and wheat bread characteristics. Vaquero *et al.* (2017), comparing the response of some volunteers to wheat bread and tritordeum bread, showed that tritordeum can restore wheat bread due to lower gluten levels.

The quality of cereals, except for genetic characteristics, are significantly influenced by cultivation techniques. Fertilization is one of these practices. De Santis *et al.* (2020) report that nitrate fertilization affects the quality of wheat

flour. Besides, Blandino *et al.* (2020) mention that late application of N fertilizer influenced gluten composition and increased protein content.

The purpose of this study was to create knowledge about the cultural care in tritordeum cultivation. Tritordeum is considered as a novel crop through Europe and Greece. Most researches on this new cereal concern breeding and the quality characteristics of seeds. Like all crops it is directly related to cultivation practices and climatic conditions. As a result, a knowledge gap was created and our study was set up. The effect of inorganic and organic fertilization was studied in non-irrigated tritordeum cultivation in Greece. The agronomic traits and yield of the amphiploid *Hordeum chilense* × *Triticum turgidum* conv. *durum* were observed under dry field conditions. Additionally, some quality characteristics, such as grain protein content, gluten, seed moisture capacity and seed fiber, have been studied in inorganic and organic fertilization.

Material and methods

Experimental design

A field experiment was set up in experimental field of Laboratory of Agronomy, in Agricultural University of Athens laboratory of Agronomy (37° 59'01.83"N, 23° 42'07.37" E and altitude 30 m). The soil is classified as a Clay Loam (35.9% sand, 29.8% clay and 34.3% silt), with pH 7.29 (1:1 water

H₂O) and 2.37% organic matter content (Wakley and Black, 1934). For chemical characterization of soil for control treatment, P_{olsen} = 25ppm, N-NH₄⁺ = 15ppm, N-NO₃⁻ = 11 ppm and K = 230 ppm. Weather data (rainfall and average temperature) of the experimental site are presented in Figure 1. Previous crop was cotton.

The field experiment was set up in Randomized Complete Block Design (RCBD) where blocks were fertilization. The treatments were control, NPK, (1250 kg ha⁻¹), compost (526 kg ha⁻¹) and ruminant manure (250 kg ha⁻¹). The NPK was ammonium sulfate (40-0-0). Chemical composition of manure is pH = 8.1, EC (dS m⁻¹) = 4.2, organic matter (%) = 31.3 and total nitrogen (%) = 0.93. Respectively, for compost was pH = 4.3, EC (dS m⁻¹) = 1.3, organic matter (%) = 43.1 and total nitrogen (%) = 1.35.

Supplementary fertilization was not applied. The surface of experimental area was 165 m², 4 blocks and 16 plots (6 m²). Sowing date was 10/01/2020. Seed rate was 410 seeds m⁻², with row spacing 15 cm soil. Implements for tillage were included primary chisel plow (depth of 40 cm), secondary disc harrow. Weed control was achieved handily. Harvest was done 161 DAS.

Plant material

'Bulel' is the second commercial cultivar of tritordeum (*xTritordeum martinii* A. Pujadas, nothosp. nov.) which was registered in 2013 in the CPVO (Community Plant Variety Office). It

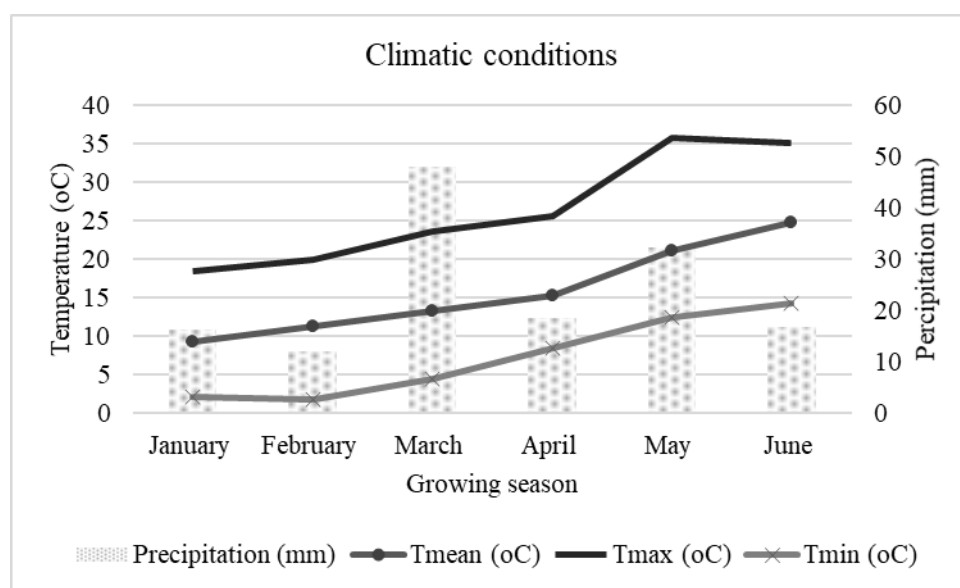


Figure 1: Meteorological data at experimental area for growing season 2020
The total precipitation was 144.2 mm for the growing season

is characterized by the improved bread-making quality and high protein content.

Sampling and analytical methods

Plant height was noticed 140 DAS, average three plants per plot. Total protein (%), seed moisture capacity (%), grain specific weight and gluten content (%) were determined using the Infratec™ 1241 Grain Analyzer (FOSS, Eden Prairie, MN, USA, Serial no. 12417239) after harvest. The scanning temperature was controlled from 21°-25°C. The absorption wavelength range of the samples was 850-1050 nm. The 1000-grain weight was determined from a subsample of the grain harvested from each plot. Crude fiber (%) was determined (AOAC, 1984).

Calculations and statistics

Analysis of variance was carried out on data using the Stat Soft (2011) logistic package as a Completely Randomized Block Design. The significance of differences between treatments was estimated by using Duncan test and probabilities equal to or less than 0.05 were considered significant.

Results and discussion

Plant height ranged from 65 cm (control) to 71.75 cm (NPK). Between organic fertilizations there was not observed significant difference. Similar results are noticed for the average internode length (cm). Plant height is lower than the wheat parent (Baro *et al.*, 1991). Karagoz *et al.* (2004) mentioned wheat plant height around 100 cm. Martin *et al.* (1999) mentioned that traits such as plant height and biomass yield have range variation. In addition, 1000 seed weight (g) varied between 27.5 g (control) and 31.96 g (NPK).

These values are close to Erlandsson (2010) who observed a range of 38 g to 44 g. This difference may be due to the seed moisture capacity, as Erlandsson (2010) reports seed moisture capacity at 14%.

Also, yield was significantly affected by fertilization. Yield was significant higher with inorganic fertilization. Maximum value was 4753.5 kg ha⁻¹ (NPK) whereas minimum was 3210.75 kg ha⁻¹ (control). Inorganic fertilization resulted in 30% more yield than organic fertilization. Yield was only between 20-40 % of that of wheat partially possibly due to the late heading date of tritordeum (Millán, 1988). Late anthesis date may cause lower yield under Mediterranean drought conditions (Millán *et al.*, 1988; Villegas *et al.*, 2010). In spite of sowing late, in our experiment yield was high. This can be explained by the combination of stable genotype and fertilization.

Inflorescence length did not statistically differ for three fertilizers, whereas yield differed for inorganic and organic fertilizers. Therefore, tritordeum inflorescence length does not mean higher yield. Villegas *et al.* (2010) use for yield components grain weight, spikes m⁻²; grains per spike.

Seed moisture capacity was not varied among fertilizations. The seed moisture capacity, for tritordeum seeds, 'Bulel' variety, was around 11%. Seed moisture capacity varies from harvest date depending the sowing date. Seed moisture capacity were 9.1% and 7.9% for experimental lines T-3 and T-9 (Alvarez *et al.*, 1992). Concerning gluten content, it was significant difference among fertilizations. Highest value was 33.45% (NPK) and lowest 27.62% (control). Gluten content in

Table 1. Mean values of height, 1000 seed weight, inflorescence length, average internode length, yield by fertilizers of variables measured in field experiments carried out during the 2020 season

Fertilization	Height (cm)	1000 seed weight (g)	Inflorescence length (cm) 115 DAS	Average internode length (cm)	Yield (kg ha ⁻¹)
Control	65a	27.52a	13.1a	14a	3210.75a
NPK	71.75b	31.9b	14.5b	15.3b	4753.5b
Compost	68c	29c	14.2b	14.6a	3665.5c
Manure	68.9c	29.8c	14.3b	14.6a	3806c

Note: Different letters within a column indicate significant differences at P<0.05 according to the Duncan test

Table 2. Mean values of protein, seed moisture capacity, Kernel weight, gluten, seed fiber concentrate, stem fiber concentrate by fertilizers of variables measured in field experiments carried out during the 2020 season

Fertilization	Protein (%)	Seed moisture capacity (%)	Kernel weight (kg hl ⁻¹)	Gluten (%)	Seed fiber concentrate (%)	Stem fiber concentrate (%)
Control	11a	10.7a	66.82a	27.62a	4.06a	35.37a
NPK	16.27b	11.025a	71.4b	33.45b	3.92b	36.25b
Compost	14.2c	11.025a	67.62a	31.2c	3.89b	36.46b
Manure	14.12c	11.025a	67.92a	31.7c	3.94b	34.63b

Note: Different letters within a column indicate significant differences at $P < 0.05$ according to the Duncan test

compost and manure did not differ, values were 31.2 and 31.7 respectively. Inorganic fertilization has a negative effect on gluten content as it increased the percentage as far as tritordeum is grown for less gluten than bread wheat.

Furthermore, there was no significant statistical difference between the two-organic fertilizations for protein content. Protein content was 14.6% higher in NPK fertilization compared to compost. Even in control, protein content was observed raised compared to bread wheat (Erlandsson, 2010). The high protein content, characteristic of primary tritordeum, is kept in improved lines (Millán, 1988). Tritordeum protein content can reach 25% (Gallardo and Fereres, 1993).

Kernel weight ranged from 66.8 (control) to 71.4 kg/hl (NPK). By Villegas *et al.* (2010) the highest value observed was 43.77 kg/hl. Alvarez *et al.* (1992) mention grain specific weight 44.9 kg/hl. This high difference may be explained by the genotype (Villegas *et al.*, 2010). Indeed, 'Bulel' variety which was used in this experiment has become commercial later compared to literature. Therefore, large differences in values can be explained by the improvement of genotype.

Besides fiber, seed concentration was higher in control. The highest value of control was explained due to the lowest seed moisture capacity (Tab. 2). Erlandsson (2010) was mentioned for dietary fiber 14.3 %. Seed fiber and stem fiber concentration did not statistically differ with inorganic and organic fertilization. Stem fiber concentration was a characteristic for fodder quality of tritordeum

before it being used in human diet. Daniels *et al.* (2000) mentioned that nitrogen fertilization had no effect on digestibility of forage and Collins *et al.* (1990) observed the same on neutral detergent fiber (NDF) or acid detergent fiber (ADF). On the contrary, in our experiment, fertilization was significantly affected by fertilization.

Conclusion

As first results, in Greece, tritordeum crop had a positive response to fertilization, especially in inorganic. Higher yield and protein content were observed under inorganic fertilization compared to organic. But gluten content increased with inorganic fertilization and this is a negative character as far as tritordeum is cultivated for lower levels of gluten. Gluten content was 5.5% higher under inorganic fertilization in comparison with compost. This study indicated that inflorescence length is not the factor affecting the yield of tritordeum. Additionally, seed moisture capacity, 161 DAS, 'Bulel' variety was around 11%. While it was noted that fertilization positively affected growth and quality characteristics of tritordeum, further study is needed because many characteristics are due to the genotype. In this study, although the sowing date was late comparatively to literature, the yield was observed raised up. Protein content was around 14% higher in inorganic fertilization compared to organic.

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