World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Evaluation of durum wheat cultivars under certified organic production in the Yaqui Valley, Sonora, Mexico

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World Journal of Advanced Research and Reviews, 2023, 19(01), 1219–1224

Publication history: Received on 12 June 2023; revised on 22 July 2023; accepted on 25 July 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.19.1.1473

Abstract

Durum wheat cultivars Don Lupe Oro C2020 and the regional check CIRNO C2008, and Baroyeca Oro C2013 and the check, were evaluated for grain yield during the crop seasons 2021-2022 and 2022-2023, respectively, in a plot with organic certification, at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Sonora, Mexico. For the first season, land preparation consisted of three passes of harrowing, leveling, and making beds 80 cm apart with three rows. Fertilizer was not applied since the previous crop was chickpea which had been fertilized with 5 t ha^{-1} of poultry manure. Sowing was carried out on December 2, 2021, with a seed density of 120 kg ha^{-1}; one pre-sowing and three complementary irrigations were applied. For 2022-2023, the land was managed as in the previous season, except for the application of the granulated compost BIDA. Sowing was carried out on November 23, 2022, with a seed density of 100 kg ha^{-1} in beds with two rows. One pre-sowing and four complementary irrigations were applied. Don Lupe Oro C2020 showed an average of 5.051 t ha^{-1}, while CIRNO C2008 5.641. Baroyeca Oro C2013 showed an average grain yield of 6.904 t ha^{-1}, while the check 8.056. Despite the lower yield of both cultivars in relation to CIRNO C2008, they are resistant to leaf rust and the average b Minolta value of the pigment of semolina is 30.8, therefore, they are good candidates to be cultivated under organic agriculture.

Keywords: *Triticum durum*; Durum wheat; Organic agriculture; Organic certification

1. Introduction

Wheat is the second most important cereal for human consumption in Mexico; durum wheat is used for pasta-making and represents 59.8% of all the wheat produced in the country, while bread wheat is used for bread making, confectionery and flour. Durum wheat complies with the domestic demand, while bread wheat is not sufficient and therefore, it has to be imported [1]. In the state of Sonora, 236,472 ha were harvested during the crop season fall-winter 2020-2021, with a production of 1,721,597 t and an average grain yield of 7.28 t ha^{-1}. In the Cajeme District which comprises the counties of Bácum, Cajeme, Etchojoa, Guaymas, Navojoa, Benito Juárez, and San Ignacio Río Muerto, 141,614 ha were harvested with a production of 1,050,613 t and an average grain yield of 7.42 t ha^{-1} [2]. The yields already mentioned are obtained under conventional agronomic management; however, in the Yaqui Valley, there has been research and technology transfer on some of the most important crops on certified organic production since the year 2000 [3]; however, wheat has received more attention since it occupies a large area and it is one of the crops most studied under organic agriculture. According to Costanzo [4], crop grain yield under organic agriculture is limited partly by the use of inappropriate cultivars. Organic agriculture adds more difficulties to the agronomic management by three main reasons: cultivars behave differently if they are cultivated under conventional or organic agriculture; with a minimum or nil use of external inputs like herbicides, mineral fertilizers, and insecticides, organic crops tend to differ

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among them more than under conventional agriculture; also, observations of experimental plots are less reliable while under organic agriculture than under conventional agriculture when the objective is to forecast grain yield at the commercial level. Ferguson [5], reported that to breed wheat specifically for use in organic farming could benefit conventional agriculture by leading to cultivars that require fewer chemicals, that is, their genetics could potentially be transferred into conventional agriculture. Organic agriculture for wheat implies a soil biology and levels of competition different to the agriculture system that uses chemical products, as well as different timing and availability of nutrients in the soil. Research studies on certified organic production have been conducted in the Yaqui Valley, where the results obtained under this production system were similar to those obtained under conventional production [6]; however, the release of wheat cultivars has been quite dynamic in the last few years, and therefore, it is needed to evaluate such cultivars under organic agriculture using a check which has been evaluated under organic agriculture. Since the selection of the wheat cultivar to use is a very important decision for farmers that are trying to get into organic agriculture, the objective of this work was to identify cultivars suitable for exploitation under organic systems with low inputs.

2. Material and methods

The evaluations were carried out during the crop seasons fall-winter 2021-2022 and 2022-2023 at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Sonora, Mexico (27°22'4.9'' N latitude and 109°55'36.86'' W longitude, 40 masl) in a soil with clay texture. This region has a warm climate (BW (h)) and extreme heat according to Koppen's classification, modified by García [7]. Durum wheat cultivars Don Lupe Oro C2020 [8] and the regional check CIRNO C2008 [9] were established during the crop season 2021-2022 in a plot with organic certification [10,11,12]). Land preparation consisted of three passes of harrowing, leveling, and making beds 80 cm apart with three rows. Fertilizer was not applied since the previous crop was chickpea (*Cicer arietinum* L.) which had been fertilized with 5 t ha^{-1} of poultry manure during the crop season 2020-2021. Sowing was carried out on December 2, 2021, with a seed density of 120 kg ha^{-1}; one pre-sowing and three complementary irrigations were applied. The experimental design was a randomized complete block with three replications and the experimental plots consisted of 2 beds 110 m long, while the experimental unit was one bed 3 m long. During the crop season 2022-2023, comparisons were made between Baroyeca Oro C2013 [13] and CIRNO C2008, also in a plot with organic certification [14,15]), which was managed as in the previous season, except for the application of the granulated compost BIDA [16], whose composition is described in Tables 1 and 2. Sowing was carried out on November 23, 2022, with a seed density of 100 kg ha^{-1} in beds with two rows. One pre-sowing and four complementary irrigations were applied. The experimental design was a randomized complete block with four replications and the experimental plots consisted of 2 beds 110 m long, while the experimental unit was one bed 1 m long. Weed control was done manually, as well as the harvest which was carried out with a hand sickle, and for threshing a stationary Pullman thresher was used. The variable evaluated was grain yield at 12% humidity.

Table 1 Guaranteed minimum composition of major and minor elements contained in the organic product Bida

Guaranteed composition	Content
Nitrogen (%)	2 -3
Phosphorus (%)	2 -3
Potassium (%)	2 -3
Sulfur (%)	0.5 – 1.5
Calcium (%)	6 – 8
Magnesium (%)	1 – 106
Iron (%)	0.4 – 1
Zinc (ppm)	400 – 700
Copper (ppm)	60 – 90
Manganese (ppm)	450 – 800
Boron (ppm)	40 - 100

Table 2 Fungal and bacterial content in the organic product Bida

Beneficial organism	CFU per ton*
Trichoderma sp.	3.8×10^{11}
Aspergillus sp.	6.3×10^{11}
Penicillium sp.	1.5×10^{11}
Pseudomonas fluorescens	8.4×10^{15}
Bacillus thuringiensis	5.7×10^{15}
Bacillus subtilis	6.4×10^{15}
Azotobacter sp.	3.7×10^{15}

*Colony forming units

3. Results and discussion

Crop season fall-winter 2021-2022. The durum wheat and regional check cultivar CIRNO C2008 had a grain yield range of 4.990 to 5.994 t ha^{-1}, with an average of 5.641 t ha^{-1} (Figure 1); while cultivar Don Lupe Oro C2020 showed a range of 4.571 to 5.822 t ha^{-1} with an average of 5.051 t ha^{-1}.

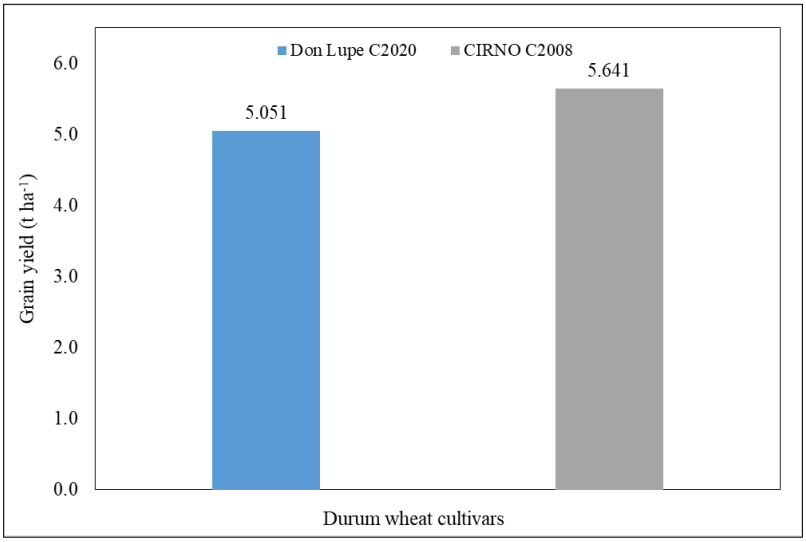

Figure 1 Grain yield of durum wheat cultivars Don Lupe Oro C2020 and CIRNO C2008 in a plot with organic certification, at the Norman E. Borlaug Experimental Station during the crop season fall-winter 2021-2022

The difference between these two cultivars was 590 kg. The low grain yields obtained in this trial were possibly due to the lack of fertilization, since previous studies where appropriate rates of fertilizer were applied under organic production, have shown grain yields similar to the regional average under conventional production [17,18]); for example, in crop season 2018-2019 CIRNO C2008 showed a maximum grain yield of 6.9 t ha^{-1} after fertilization with poultry manure. Crop season fall-winter 2022-2023. Significant statistical differences $p \leq 0.05$) were detected in grain yield between Baroyeca Oro C2013 and CIRNO C2008. The former cultivar showed a grain yield range of 6.172 to 7.200 t ha^{-1}, with an average of 6.904 t ha^{-1} (Figure 2), while the latter showed a grain yield range of 7.200 to 8.150 t ha^{-1}, with an average of 8.056 t ha^{-1}. The difference between these two cultivars was 1,152 kg.

Durum and bread wheat cultivars cultivated in the region have been evaluated under organic agriculture with low inputs to determine their performance under this system. Ortiz *et al.* [17) evaluated durum cultivars CIRNO C2008 and CENEB Oro C2017 [19] in which the latter overcame the grain yield of CIRNO C2006 by 17%; however, CENEB Oro C2017 is susceptible to lodging, even under low inputs, and therefore it was no longer used in other evaluations. Cortés *et al*. [20] reported that bread wheat cultivar Borlaug 100 [21] showed a grain yield of 4.040 t ha^{-1}. Despite that CIRNO C2008 has lost its resistance to the leaf rust race BBG/BP_CIRNO [22], caused by the fungus *Puccinia triticina* E., it is still

the most widely used cultivar by farmers in southern Sonora. The average area sown with this cultivar during the last three crop seasons has been 92% [23,24,25]). There has been a dynamic process releasing new durum wheat cultivars with resistance to leaf rust in order to replace CIRNO C2008; however, farmers have been reluctant to adopt them, since CIRNO C2008 has a high grain yield potential. During the crop season fall-winter 2021-2022, the percentage of the area sown with the durum wheat cultivars in southern Sonora was: CIRNO C2008 91.85%, Quetchehueca Oro C2013 [26] 3.97%, CENEB Oro C2017 1.93%, Baroyeca Oro C2013 1.06%, and Don Lupe Oro C2020 0.03% [25]. Despite the 1,152 kg difference in grain yield between CIRNO C2008 and Baroyeca Oro C2013, the latter is resistant to leaf rust and the average b Minolta value of the pigment of semolina is 30.2, therefore, it is a good candidate to be cultivated under organic agriculture. Evaluation of Quetchehueca Oro C2013 under organic agriculture is needed, since it is resistant to leaf rust and it is the second most sown cultivar in this region; in addition, the average b Minolta value of the pigment of semolina is 28.7. Although Don Lupe Oro C2020 showed susceptibility to lodging which affects grain yield and quality [27,28], it is a good prospect for organic agriculture since it is resistant to leaf rust, once appropriate seed density and fertilization rates are adjusted, and like Baroyeca Oro C2013, the average b Minolta value of the pigment is 31.4.

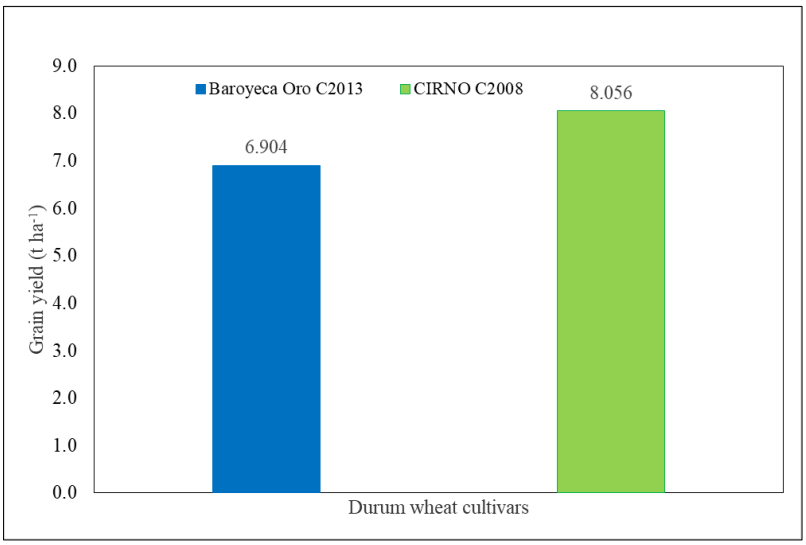

Figure 2 Grain yield of durum wheat cultivars Baroyeca Oro C2013 and CIRNO C2008 in a plot with organic certification, at the Norman E. Borlaug Experimental Station during the crop season fall-winter 2022-2023

4. Conclusion

Durum wheat cultivars Baroyeca Oro C2013 and Don Lupe Oro C2020 which are resistant to leaf rust and present high pigment values for semolina, are good options for organic agriculture, although the latter must be evaluated for appropriate seed density and fertilization rates in order to avoid lodging

Compliance with ethical standards

Acknowledgments

This research was financially supported by the Mexican National Institute for Forestry, Agriculture, and Livestock Research (INIFAP), Competitive SIGI Grant No. 124032365152.

Disclosure of conflict of interest

The authors declare that No conflict of interest.

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