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EVALUATION OF WHEAT GENOTYPES WITH DIFFERENT SEEDING DENSITIES IN SOUTHERN SONORA, MEXICO

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ABSTRACT

An evaluation of seeding density (60, 120, and 180 kg ha-1) with six durum wheat and two bread wheat genotypes, was carried out at the Norman E. Borlaug Experimental Station during the fall-winter 2021-2022 crop season. An experimental alpha lattice design was used with three replications; the plot size consisted of two beds five meters long, separated by 80 cm and with three rows. Highly significant statistical differences were found between seed densities and between the genotypes evaluated; the best seed densities ($p \leq 0.05$) were 120 and 180 kg ha-1, with grain yields of 7,319 and 7,425 kg ha-1, respectively. Genotypes with the highest grain yield were: STOT (STOT//ALTAR 84/ALD/3/PATKA_7/YAZI_1/4/SOMAT_3/PHAX_1//TILO_1/LOTUS_4/5/SOOTY_9/RASCON_37//WODUCK/CHAM_3/6/BAROYECAORO C2013/7/WID22202/4/SORA/2*PLATA_12//SOMAT_3/3/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/5/CF4-JS 21//TECA96/TILO_1, CDSS13B00720T-099Y-099M-1Y-4M-0Y) with 7,669 kg ha-1, followed by Noroeste C2021 (7,561), Don Lupe C2020 (7,463), Borlaug 100 (7,392), CIANO M2018 (7,296), TARRO (TARRO_1/2*YUAN_1//AJAIA_13/YAZI/3/SOMAT_3/PHAX_1//TILO_1/LOTUS_4/4/CANELO_8//SORA/2*PLATA_12/5/CBC 501CHILE/GUANAY/4/CNDO/PRIMADUR//HAI-OU_17/3/SNITAN/7/ALTAR84/BINTEPE85/3/STOT//ALTAR 84/ALD/4/POD_11/YAZI_1/5/VANRRIKSE_12/SNITAN/6/SOOTY_9/RASCON_, CDSS14B00835T-099Y-099M-5Y-1M-0Y) (7,282), CENEB Oro C2017 (7,271), while CIRNO C2008 the regional check, showed the lowest grain yield (6,019 kg ha-1).

Keywords: Wheat, Triticum Spp., Seeding Density.

1. INTRODUCTION

Wheat (*Triticum* spp.) is the cereal with the second highest world production. In Mexico, wheat has reached an approximate value of 12,000 M pesos (about USD $689,607,600), which ranks wheat as the 10th most important crop, since it contributes 2.9% to the value of the agricultural production. During the year 2018 and 2019, the national harvested wheat area was 522,000 ha, with an average grain yield of 6.02 t ha^{-1}, and a production volume of 3.15 M annual t (SIAP, 2020). During the fall-winter 2020-2021, the area grown with wheat in the country was reduced to 475,000 ha harvested, but the grain yield increased to 6.61 t ha^{-1} and the production volume was 3.14 M t (SIAP, 2022). During the crop season 2020-2021, 236,472 ha of wheat were harvested in the state of Sonora, with an average grain yield of 7.28 t ha^{-1} and a production of 1.72 M t, which represented 55% of the total national production (SIAP, 2022). CIRNO C2008

(Figueroa-López *et al*., 2010) is the most widely grown cultivar in the state of Sonora (Fuentes-Dávila *et al*., 2022), however, during the crop season 2016-2017, the new race of leaf rust (*Puccinia triticina* E.) BBG/BP_CIRNO overcame the genetic resistance of this cultivar (Pérez-Lopez *et al*., 2017), which was conferred by the gene LrCamayo in chromosome 6BL (Herrera-Foessel *et al*., 2014). In greenhouse tests, this new race did not affect some cultivars released previously like Samayoa C2004, Patronato Oro C2008, CEVY Oro C2008, Sawali Oro C2008, Movas C2009, CONASIST C2015, Barobampo C2015, and Norteño C2016 (Huerta-Espino *et al*., 2017). Since this disease is the most important in southern Sonora, a continuous effort is focused on the generation of new durum wheat cultivars like Don Lupe C2020 and Noroeste C2021, and therefore the agronomic management of such cultivars must be determined. The objective of this work was to evaluate seeding densities for four cultivars and two experimental lines of durum wheat as well as two bread wheat cultivars.

2. MATERIALS AND METHODS

The evaluation was carried out during the crop season fall-winter 2021-2022 at the Norman E. Borlaug Experimental Station located in block 910 in the Yaqui Valley, Sonora, Mexico. The durum wheat (*Triticum durum* Desf.) genotypes evaluated were cultivars CIRNO C2008 (as the regional check), CENEB Oro C2017 (Chávez-Villalba *et al*., 2018), Don Lupe C2020 (Borbón-Gracia *et al*., 2022), Noroeste C2021 (Borbón-Gracia *et al*., 2021), and the advanced lines STOT (STOT//ALTAR84/ALD/3/PATKA_7/YAZI_1/4/SOMAT_3/PHAX_1//TILO_1/ LOTUS_4/5/SOOTY_9/RASCON_37//WODUCK/CHAM_3/6/BAROYECAOROC2013/7/WID22202/4/SORA/2*PLATA_12//SOMAT_3/3/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/5/CF4-JS 21//TECA96/TILO_1, CDSS13B00 720T-099Y-099M-1Y-4M-0Y), and TARRO (TARRO_1/2*YUAN_1//AJAIA_13/YAZI/3/SOMAT_3/PHAX_1//TILO_1/ LOTUS_4/4/CANELO_8//SORA/2*PLATA_12/5/CBC501CHILE/GUANAY/4/CNDO/PRIMADUR//HAI-OU_17/3/SNITAN/7/ALTAR84/BINTEPE85/3/STOT//ALTAR84/ALD/4/ POD_11/YAZI_1/5/VANRRIKSE_12/SNITAN/6/SOOTY_9/RASCON_, CDSS14B00835T-099Y-099M-5Y-1M-0Y), while the bread wheat (*Triticum aestivum* L.) genotypes were cultivars Borlaug 100 (Chávez-Villalba *et al*., 2021b) and CIANO M2018 (Chávez-Villalba *et al*., 2021a). Seed densities were 60, 120, and 180 kg ha^{-1}, using two beds five meters long, separated by 80 cm and with three rows (8 m^2). The sowing date was December 14, 2021, in moist soil; fertilization consisted of the formula 241-52-00, applying 103-52-00 before sowing and 138-00-00 before the first complementary irrigation. Four complementary irrigations were applied as recommended by Figueroa *et al*. (2011). Weed control was carried out with Situi XP 30 g c.p./ha and Axial XL 1 L c.p./ha, and for control of aphids Muralla Max was applied at 250 mL c.p./ha. For rust control on cultivar CIRNO C2008, Velficur 25 EW was applied at 0.6 L/ha; no preventive or curative fungicides were applied to the rest of the genotypes since they are resistance to leaf rust and stripe or yellow rust (*Puccinia striiformis* f. sp. *tritici* Eriks.). An experimental alpha lattice design was used with three replications. The entire experimental plots were harvested with a wintersteiger type Nr:1540-46 classic cereal thresher. Other variables evaluated were: days to flowering, plant height, days to physiological maturity, and harvest index.

3. RESULTS AND DISCUSSION

Significant statistical differences ($p \leq 0.05$) were observed for grain yield, while harvest index and plant height were similar for all seeding densities (Table 1). The lowest seeding density (60 kg ha^{-1}) showed the lowest grain yield, while the other two showed grain yields greater than 7.3 t ha^{-1}. Similar results were obtained by Beres *et al*. (2011) who reported that as the number of seeds increased per m^2, the greater the grain yield obtained. The average harvest index for all seeding densities was 51.4 and plant height was 85.8 cm.

Table 1. Grain yield, harvest index, and plant height of six durum wheat and two bread wheat genotypes, evaluated under three seed density regimes at the Norman E, Borlaug Experimental Station, in the Yaqui Valley, Sonora, Mexico, during the fall-winter 2021-2022 crop season.

Seed density (kg ha^{-1})	Harvest index	Plant height (cm)	Grain yield (kg ha^{-1})
60	51.3 a	85.2 a	6,989 b
120	51.4 a	85.8 a	7,319 a
180	51.7 a	86.6 a	7,425 a
CV	6.02	3.41	5.06
LSD	1.50	1.42	177.5

CV= coefficient of variation; LSD= least significance difference ($p \leq 0.05$).

The durum wheat experimental line STOT showed the highest grain yield with 7,669 kg ha^{-1} which is the average yield of the three seeding densities (Table 2), followed by durum wheat cultivars Noroeste C2021 and Don Lupe C2020; bread wheat cultivars Borlaug 100 and CIANO M2018 ranked fourth and fifth in average grain yield; CIRNO C2008 had the lowest average grain yield with 6,019 kg ha^{-1}.

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Table 2. Grain yield (GY), harvest index (HI), plant height (PH), days to flowering (DF), and days to physiological maturity (DPH) of six durum wheat and two bread wheat genotypes, evaluated under three seed density regimes at the Norman E, Borlaug Experimental Station, in the Yaqui Valley, Sonora, Mexico, during the fall-winter 2021-2022 crop season.

Genotype	GY (kg ha^{-1})	HI	PH (cm)	DF	DPH
STOT	7,669 a	51.4 bc	86.2 b	78	122
Noroeste C2021	7,561 ab	52.1 ab	82.4 cd	76	121
Don Lupe C2020	7,463 ab	54.7 a	84.3 bcd	75	120
Borlaug 100	7,392 ab	49.5 bc	92.6 a	77	119
CIANO M2018	7,296 ab	48.4 c	91.6 a	85	123
TARRO	7,282 b	50.8 bc	83.2 bcd	73	117
CENEB Oro C2017	7,271 b	54.6 a	85.1 bc	74	119
CIRNO C2008	6,019 c	50.5 bc	81.6 d	76	118
CV	5.06	6.02	3.41		
LSD	376.67	3.18	3.01		

CV= coefficient of variation; LSD= least significance difference ($p \leq 0.05$).

For five of the genotypes evaluated, the highest grain yield was obtained with the highest seeding density of 180 kg ha^{-1} (Table 3); STOT showed a maximum yield of 7,892 kg ha^{-1}, Borlaug 100 7,837, Noroeste C2021 7,718, Don Lupe C2020 7,683, and CIRNO C2008 6,382. The other genotypes CIANO M2018, TARRO, and CENEB Oro C2017 responded better with a seeding density of 120 kg ha^{-1}, obtaining a maximum yield of 7,668, 7,468, and 7,388 kg ha^{-1}, respectively.

Table 3. Grain yield of six durum wheat and two bread wheat genotypes, evaluated under three seed density regimes at the Norman E, Borlaug Experimental Station, in the Yaqui Valley, Sonora, Mexico, during the fall-winter 2021-2022 crop season.

Genotype	Seed density (kg ha^{-1})		
	60	120	180
STOT	7,494	7,622	7,892
Borlaug 100	7,018	7,322	7,837
Noroeste C2021	7,403	7,562	7,718
Don Lupe C2020	7,324	7,384	7,683
CIANO M2018	6,894	7,668	7,327
TARRO	7,094	7,468	7,285
CENEB Oro C2017	7,146	7,388	7,281
CIRNO C2008	5,532	6,142	6,382

The range of the differential response between the lowest seeding density, which in all genotypes showed the lowest grain yield, and the density in which the highest yield was obtained varied from 3.27 to 10.45% with an average of 6.99 (Figure 1). The highest differential response was shown by CIRNO C2008, followed by Borlaug 100 and CIANO M2018. Moreno-Ramos *et al*. (2010) reported that two bread wheat (Rayón F89 and Oasis F86) and two durum wheat (Altar C2004 and Aconchi C89) cultivars maintained a rather constant grain yield after the seeding density reached a maximum of 210,000 plants per ha, which it would be approximately 10 kg ha^{-1}; the average grain yield of those cultivars was 6,092, 6,090, 6,408, and 6,274 kg ha^{-1}, respectively. However, in our work, all the genotypes evaluated showed a positive response as the seeding density increased. It is noteworthy that the number of plants per ha is highly different than those evaluated by Moreno-Ramos *et al*. Pirez *et al*. (2013) reported that the adjustment of seeding rates is one of the crop management techniques that most influences grain yield components. Using ten genotypes sown in five different seeding densities in three locations, they found that genotypes with reduced tillering ability expressed an increase in grain yield with an increase in seeding density, however, they showed a reduction in ear weight. The number of grains per ear did not affect grain yield, but it was highly influenced by the seeding density. The compensatory effect was expressed by the weight of a thousand grains as a function of the experimental conditions in which the genotypes were evaluated, regardless of the seeding density used. There were differences among the genotypes evaluated, in specific locations and years. Bastos *et al*. (2020) reported that grain yield response to plant density is inconsistent in *Triticum*

Vol. 08, No. 04; 2023

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aestivum and that the mechanisms leading to this response are not clear. They indicated that high the tillering potential reduces the agronomic optimum plant density mainly in high and low yield environments; at canopy-scale, both final number of ears and kernels per square meter were the main factors improving yield response to plant density under high tillering potential; and that under varying yield environments, at per-plant-scale, a compensation between ears per plant and kernels per ear was the main factor contributing to yield with different tillering potential. The harvest index of durum wheat cultivars Don Lupe C2020, CENEB C2017, and Noroeste C2021 was statistically different and greater than the rest of genotypes, while plant height was greater for Borlaug 100 and CIANO M2018 (Table 2).

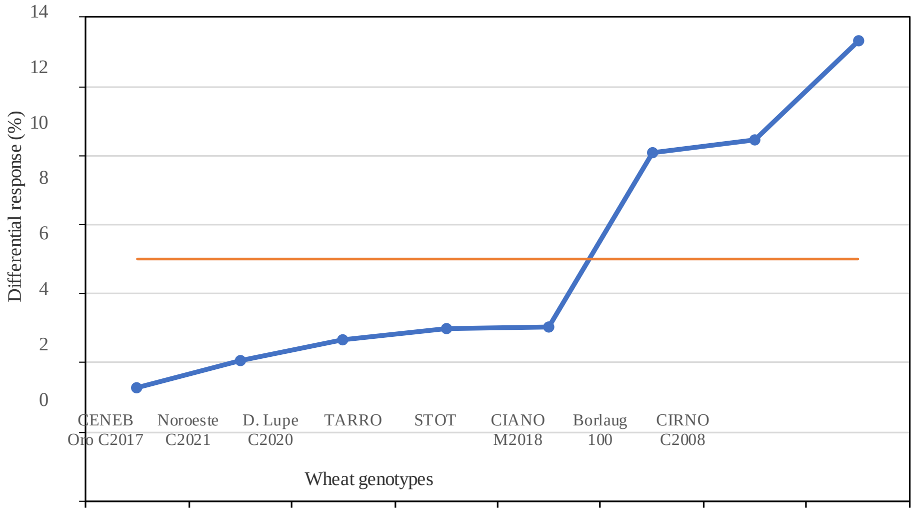

Figure 1. Differential response (%) in grain yield, between the lowest seeding density and the density in which the highest yield was obtained from six durum wheat and two bread wheat genotypes, evaluated under three seed density regimes at the Norman E, Borlaug Experimental Station, in the Yaqui Valley, Sonora, Mexico, during the fall-winter 2021-2022 crop season.

4. CONCLUSIONS

Six durum wheat and two bread wheat genotypes had a positive response in grain yield as the seeding density increased. STOT, Borlaug 100, Noroeste C2021, Don Lupe C2020, and CIRNO C2008 increased grain yield as the seeding density increased from 60 to 180 kg ha^{-1}, while CIANO M2018, TARRO, and CENEB Oro C2017 responded better with a seeding density of 120 kg ha^{-1}. With the exception of CIRNO C2008, all genotypes had an average grain yield greater than 7,000 kg ha^{-1}; the highest average grain yield was shown by STOT with 7,669 kg ha^{-1}.

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