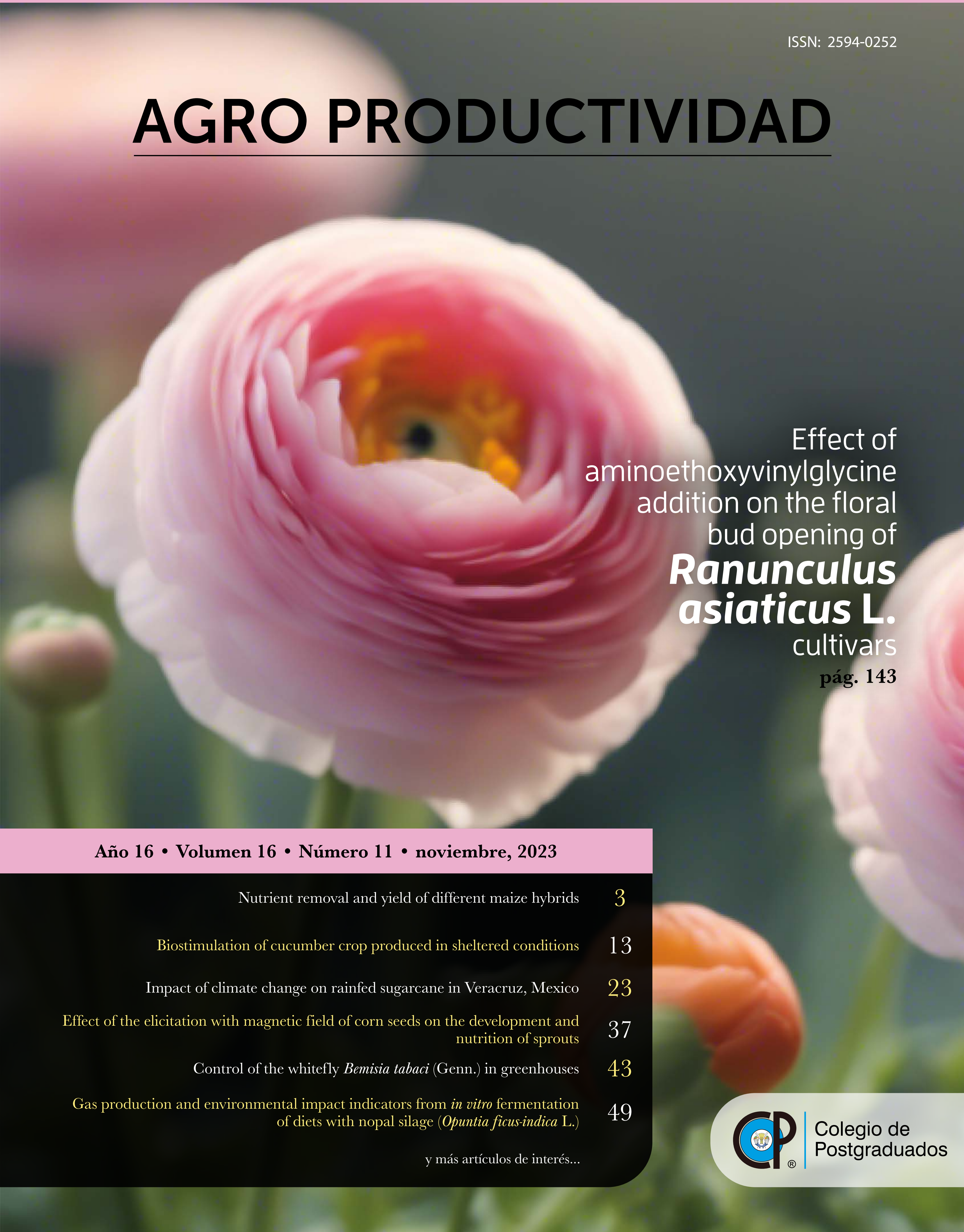

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Effect of aminoethoxyvinylglycine addition on the floral bud opening of ***Ranunculus asiaticus* L.** cultivars

pág. 143

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Nitrogen fertilization in wheat, in clay soils at the Mexicali valley, Baja California, Mexico

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ABSTRACT

The national and international markets' demand for wheat commercialization is conditioned by quality standards, among which the protein content and percentage of vitreous grain, without white belly, stand out. In them, nitrogen plays an important role in the yield and quality of the wheat grain. For these reasons, the objective of this research was to determine the effect that nitrogen has on yield, grain protein, and the vitreous grain percentage. A field experiment, planted on December 16, 2009, was conducted at the Institute of Agricultural Sciences of the Universidad Autónoma de Baja California. The experimental design was of complete randomized blocks with four repetitions. The assessed treatments were 0, 105, 210, 315, and 340 kg of N ha^{-1} (N_0, N_{105}, N_{210}, N_{315} and N_{340}, respectively). The sown seed was Aconchi F-76 variety crystal wheat. The evaluated variables were grain yield, protein content, and vitreous grain quantity (without white belly). The results indicated that the 210, 315, and 340 kg of N ha^{-1} treatments affected the yield, protein content, and white belly decrease in the grain. Grain quality is therefore improved with these nitrogen doses, in relation to the quality of the harvested grain in the plots with 0 kg ha^{-1} and those cultivated with 105 kg ha^{-1}.

Keywords: nitrogen fertilization, white belly, vitreous grain.

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INTRODUCTION

Worldwide, wheat (*Tritticum vulgare*) is the most utilized cereal in human nutrition. The wheat importance in the human diet mainly lies in its high energy value, plus containing more protein than corn and rice (Peña *et al.*, 2007). According to Evans (1993), worldwide, digestible energy (83.7%) and protein (65%) for human diets come directly from crops, out of which, cereals contribute more than half of the energy diet. After corn and beans, wheat is the third source of nutrients in the Mexican diet, mainly in low-economic urban and rural populations (Peña *et al.*, 2007).

In Mexico, wheat is grown in more than 20 states. However, 80% of the production is generated in the northwest area (Sonora and Baja California) and the state of Guanajuato in the autumn-winter (A-W) cycle with irrigation; the rest is generated, for the most part, in regions of the central states and the central highlands during the spring-summer (S-S) cycle in rainfed conditions (Peña *et al.*, 2007). During the 2006-2007 to 2010- 2011 period,

on average, the nationwide planted area was almost 618 thousand hectares, from which a production of 3.51 million tons was obtained (SIAP, 2012). In the 2007 agricultural cycle case, the states of Sonora, Guanajuato, and Baja California contributed 48, 15, and 15% of the total national production, respectively, (SIAP, 2007).

The national cereal yield average was 5.79 t ha^{-1} during the same period. Considering the average yields per hectare, in 2007 the main producing states were above the national average: Sonora (22%), Baja California (18%), and Guanajuato (7%) (SIAP, 2007). The above denotes that Baja California has favorable environmental conditions for wheat to express a yield potential similar to that obtained in Sonora, but higher compared to the potential yield in Guanajuato states.

Yield potential and protein content of the plant occur when there are adequate soil fertility, climate, water, and other effectively controllable stress problems conditions (Evans, 1993; Kraljevié *et al.*, 1982; Lloveras *et al.*, 2001; Rharrabti *et al.*, 2001; Liu *et al.*, 2003; Guttieri *et al.*, 2005; Peña *et al.*, 2007). However, to maintain the sustainability of this cereal under variable climatic conditions, adequate management of the plants and soil is necessary. In it, adequate nitrogen fertilization doseing has an important influence (Sarkar and Kar, 2008). Nitrogen deficiency in soils decreases grain protein concentration (Fowler *et al.*, 1989; Ottman *et al.*, 2000; Rharrabti *et al.*, 2001). Where protein content is an indicator of soil fertilization or fertility, this deficiency occurs when the plant does not have enough nitrogen in the grain-filling phase (Peña *et al.*, 2007). The grain protein content is an indirect indicator of the amount of protein in the gluten present in semolina and flour, this is important because the gluten content defines the cooking quality of pasta and baking quality (Peña *et al.*, 2007).

Zepeda *et al.* (2007) determined that nitrogen application modified in different proportions the tortilla dough and tortilla quality of different corn used. On the other hand, Guttieri *et al.* (2005) determined that the highest grain yield was obtained with 303 kg of N ha^{-1}; the highest flour and grain protein quality was obtained with 314 kg of N ha^{-1}.

The protein content in grain has great variability (7.1 to 14.7%), from this, it is inferred that the nitrogen fertilization criterion, in quantity or in application times to plants, is not unique, causing the quality of the grain to also vary (Peña *et al.*, 2007). To achieve maximum quality potential expression, plants must be adequately nitrogen supplied (Mengel and Kirkby, 1987).

National and international wheat markets demand this cereal meet quality standards, among which the protein content and percentage of vitreous grain (without white belly) stand out since a high incidence of white belly in the grain is a sign of a low protein content in it (Peña *et al.*, 2007). In this regard, Solís and Díaz (2001) consider that low nitrogen fertilization favors the percentage of white belly in grain. The low protein content is commonly reflected as a white belly problem (Fowler *et al.*, 1989), which in turn causes the industry to pressure farmers on the grain price (Robinson *et al.*, 1979).

To meet the grain wheat quality standards, applying an adequate nitrogen dose for the conditions of the Mexicali Valley, Baja California, is necessary. This research aimed to determine the effect of different nitrogen doses on the yield, grain protein, and percentage of vitreous grain, to recommend the one that most increases grain yield and quality.

MATERIALS AND METHODS

Experiment location

The experiment was conducted in the Experimental Field of the Instituto de Ciencias Agrícolas of the Universidad Autónoma de Baja California, at the Nuevo León ejido, Mexicali, Baja California, Mexico. Located at 32° 24' 14" north latitude and 115° 12' 02" longitude west, 12 meters (m) above mean sea level.

Environment at the experimental area

The climate in the area is warm arid, and extreme, with a mean annual temperature of 22.9 °C, 48.5 °C maximum, and −7.0 °C minimum during winter, mean annual precipitation of 60 mm (García, 1988). The soil in the experiment had a clay texture, 4.0 dS m^{-1} electrical conductivity, and a pH of 8.0. Sowing was done in flat terrain with 200 kg ha^{-1} of Aconchi F-76 crystal wheat seed variety.

Vegetative evaluation

The experimental design was of complete randomized blocks with four repetitions in 100 m^2 experimental plots. The treatments were 0, 105, 210, 315, and 340 kg of N ha^{-1} (N_0, N_{105}, N_{210}, N_{315}, and N_{340}, respectively), from urea [$CO\ (NH_2)_2$], monoammonium phosphate [$(NH_4)\ H_2PO_4$] and anhydrous ammonia (NH_3). Pre-planting fertilization included 20% of the total applied nitrogen, plus 78 kg of P_2O_5 ha^{-1} in monoammonium phosphate form; in the first and second relief irrigation, 60% more nitrogen was applied, divided into 30% each irrigation, while the remaining 20% was applied during the third relief irrigation.

The harvest took place on June 3, 2010; the grain yield (Yg) was determined in a 2.0 m^2 harvested area based at the center of the experimental plot. The total nitrogen content was assessed following the Kjendhal method, while the protein content was estimated by multiplying the total nitrogen value by 5.7 (Rharrabti *et al.*, 2001). The vitreous grain (without white belly) percentage was obtained from a 100 g grain sample from one seed kilogram processed through the Boerner homogenizer; The grains with white belly were separated from normal ones; The fraction of grains with white belly was weighed and their percentage was determined; the vitreous grain percentage was estimated by subtracting the white belly percentage from one hundred percent.

The data were statistically analyzed using the PROC GLM (SAS Institute, 1996). The comparison of means was determined with the Tukey test ($\alpha \leq 0.05$). The relationship of protein percentage with nitrogen dose and glassy grain percentage was analyzed using the linear regression model.

RESULTS AND DISCUSSION

Nitrogen dosing effect on grain yield

Grain yield occurred with highly significant differences ($P \leq 0.01$). The means comparison indicates that N_0 reported the lowest grain per surface (2.76 Mg ha^{-1}); while the N_{210}, N_{315}, and N_{340} treatments induced similar effects to each other (Figure 1), but the

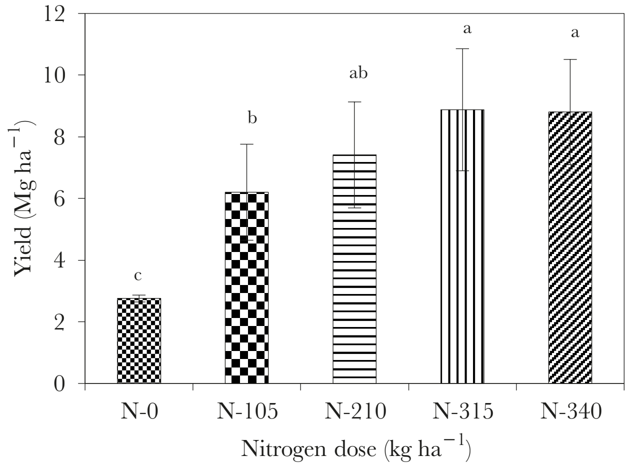

Figure 1. Wheat grain yield relation to nitrogen dosing.

N_{315} and N_{340} treatments increased up to 2.63 Mg ha^{-1} compared to the N_{105} treatment yield, and much higher to that of N0.

Similar results were obtained by Solís and Díaz de León (2001), who reported that as the nitrogen doses increased, from 0 to 120 and from 120 to 240 kg of N ha^{-1} yield also increased, with a maximum of 240 kg of N ha^{-1}. The aforementioned response was also noted (Johnson *et al.*, 1973; Limon *et al.*, 2000; Ottman *et al.*, 2000; López *et al.*, 2002; Guttieri *et al.*, 2005; López *et al.*, 2007; Takahashi *et al.*, 2007, and Ziadi *et al.*, 2008); however, it is also noted that finding an adequate nitrogen dose for wheat cultivation will depend on various factors, such as soil fertility, cultivar, application time, and irrigation and climatic variables. That researchers concluded that the yield response reaches a maximum when applying various nitrogen doses, after which a decrease occurs due to a nutritional imbalance in the plants.

Grain quality (protein)

The grain protein content was highly significant ($P \leq 0.01$) in the N_{210}, N_{315}, and N_{340} treatments compared to the N_0 and N_{105} (Figure 2).

Although no significant differences between the averages among the first three treatments, in absolute values, as more nitrogen was applied, the protein content also increased, such that the N_{340} increased by 5.29, 4.48, 0.67, and 0.39. % in relation to N_0, N_{105}, N_{210} and N_{315}, respectively.

The applied nitrogen doses had a positive linear effect on the protein percentage (Figure 3). This coincides with results by Johnson *et al.* (1973) in three-year research with different nitrogen doses (0 to 135 kg of N ha^{-1}), where the protein content had a positive linear trend to the applied nitrogen doses; likewise, with the results by Fowler *et al.* (1989), Ottman *et al.* (2000), Takahashi *et al.* (2007). However, the same researchers also report that protein content can be affected by various factors related to wheat plants' growth and development since plants in stress conditions due to nitrogen deficiency decreased their grain protein content in response to low nitrogen availability.

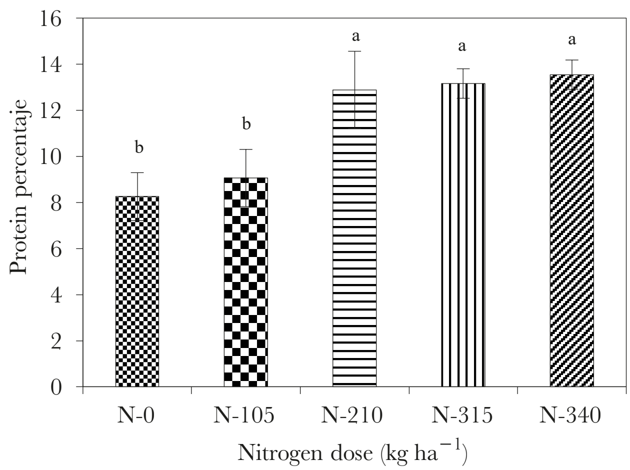

Figure 2. Wheat grain protein percentage relation to nitrogen dose.

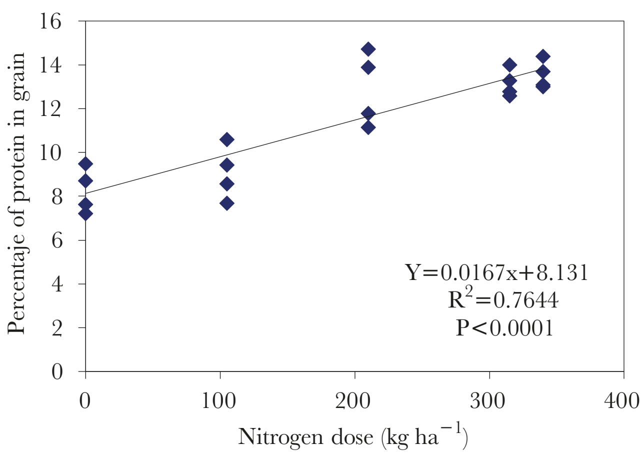

Figure 3. Grain protein content relation to nitrogen dose.

Vitreous grain (without white belly)

The percentage of grains with no white belly had high significant differences ($P \leq 0.01$), so nitrogen dose variation induced grain quality changes; however, the averages of grain without white belly, obtained in the plots fertilized with 210, 315 or 340 kg of N ha^{-1}, were statistically higher than those obtained with 0 or 105 kg N ha^{-1} (Figure 4). In the three highest nitrogen doses cultivated plots, the grain without white belly percentages ranged from 96.93 to 98.78%; still, in the N_0 plot, where wheat was grown with 105 kg N ha^{-1} the percentages were 11.05 and 35.18%, respectively, Thus, according to Peña *et al.* (2007), the increasing percentage of grains without white belly suppose high semolina yields during milling.

The percentage of grains without white belly increased with the nitrogen dose (Figure 5), in such a way that when the percentage of protein increased, the percentage of grains without white belly also increased; That is, as the protein content in the grain decreased,

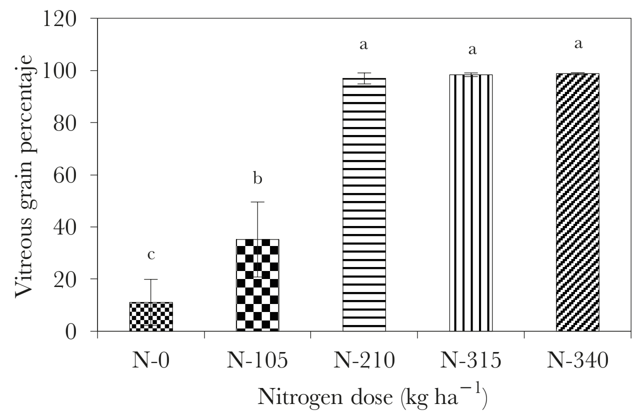

Figure 4. Percentages of grains without white belly relation to nitrogen dose.

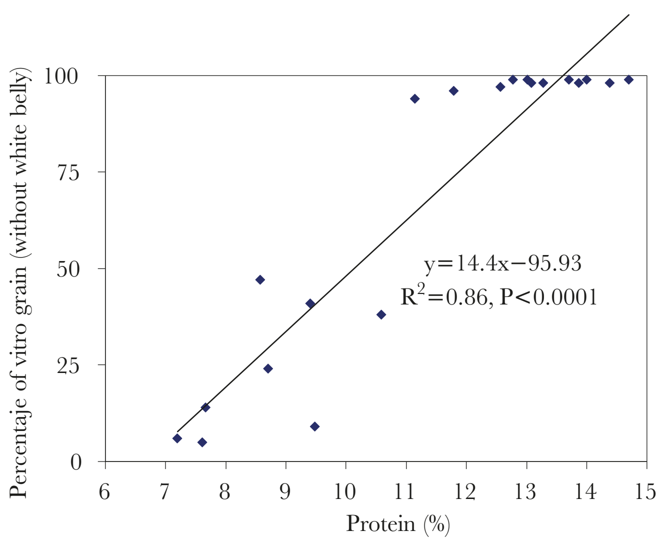

Figure 5. Percentage of vitreous grain (without white belly) relation to wheat grain protein percentage.

the percentage of white belly grains increases. The above coincides with Fowler *et al.* (1989) and Peña *et al.* (2007), since they report that a high incidence of grains with white bellies is a low protein content sign. Likewise, results by Solís *et al.* (2001), reported that the number of irrigations influences the increases in grains with white belly when wheat is fertilized with less than 240 kg of N ha^{-1} since in fertilization with said nitrogen dose, the percentage of grains with white belly decreases to 7%, while in N_0 can obtain up to 70% of white belly grains.

CONCLUSIONS

The 210 to 340 kg of N ha^{-1} doses applied in wheat cultivation allowed greater yield expression, protein content, and grains without white belly so that the grain increased compared to that from grain cultivated with a lower nitrogen amount.

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