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Agronomic Traits Associated to Yield and Quality in Oat Seeds

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Abstract: This study aimed the evaluation of the role of plant density and fertilization on yield and quality of oat seeds. Factors as plant density and type of fertilization (nitrogen and phosphoric) were evaluated in the study. Measurements of yield, vigor, germination, volumetric weight, weight of 1000 seeds and protein content were determined in oat seeds. Present results showed that in order to increase yield and seed quality in oat, it is necessary a plant density of 40 kg ha^{-1}, as well as nitrogen fertilization of 60 kg ha^{-1}. Besides, phosphoric fertilization of 80-120 kg ha^{-1} increased both yield and seed quality.

Key words: Density, nitrogen, phosphorous, protein, vigor

INTRODUCTION

Oat is an important crop worldwide, with a cultivated surface of 18 million ha being Russia, United States and European Union as the main producers. In México, 316 ha are cultivated, however it is considered as an emergent crop with lacking of a technological package for its complete and adequate management (Espitia *et al.*, 2001). Several problems are presented with this crop especially poor seed quality and production (López, 1994; Cortéz- Baheza, 2000). Plant density and fertilization has been mentioned as main factors in order to improve seed quality and production in crops (Vela, 1997; Spies, 2008). Nitrogen fertilization has been reported elsewhere to improve yield and germination in crops as wheat and oat (Amado and Ortíz, 2001; Vela, 1997; Zimdahl, 2004). Additionally, Amado and Ortiz (2001) have reported increased yield in oat production using from 40 to 80 kg ha^{-1} of phosphoric fertilization. Oat seeds present differences in protein content depending on the environmental conditions, plant nutrition, processing and intrinsic variability among cultivars (Shewry, 1999). Seed vigor is one of the most important factors in order to determine seed quality, due to its relationship with fast and uniform germination, as well as improved plantlets production as showed in wheat and oat crops (Delouche, 2002). This study aimed to determine appropriate levels of plant density related to nitrogen and phosphoric fertilization on production and quality of oat seeds.

MATERIALS AND METHODS

Experimentation: The study was carried out during the years 2003 and 2004 and consisted in three sections: agronomic, seed quality and protein quantification. Agronomic evaluation was carried out in the experimental station located at Instituto Tecnologico de Roque. The soil in which the study was carried out corresponded to type vertisol, pH 6.91, field capacity 42%, inorganic nitrogen content of 9.44 ppm, phosphorous 76.9 ppm and potassium 1166 ppm.

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Seed quality assessment: Three factors were evaluated in the study: plant density (D): 40, 80 and 120 kg ha^{-1}; nitrogen fertilization (N): 60, 100, 140 and 180 kg ha^{-1} and phosphoric fertilization (P): 40, 80, 120 and 160 kg ha^{-1}. As experimental control (T) it was included a treatment without fertilization. There were established four furrows of 5 m as experimental unit. Sowing was carried out in furrows of 75 cm in double line with a spacing of 20 cm among lines. As nitrogen source, urea (46% nitrogen) and triple superphosphate (46% P_2O_5) as phosphoric fertilizer were used (EDNA del Bajío S.A de CV; Celaya, Gto, México). Irrigation was carried out five times during the study with differences of 20-30 days each other. Response variables evaluated were seed yield (Y), vigor (V) and germination (G), volumetric weight (VW) and one thousand seeds weight (1000 SW).

Protein content: Protein content was carried out using lyophilized samples and the micro-Kjeldahl methodology as proposed elsewhere (Villegas, 1971).

Statistical analysis: The study was carried out using a random blocks design in a factorial arrangement 3×4×4, with three repetitions. The results were processed according to general lineal model method according to SAS Institute (Anaya-López *et al*., 2003).

RESULTS AND DISCUSSION

Plant density: Regarding plant density, oat seed yields obtained ranged from 1.62 to 2.67 t ha^{-1}. Plant densities of 40 and 80 kg ha^{-1} were statistically better than other ones evaluated (Table 1). These treatments improved in 40% the control; meanwhile, plant density of 120 kg ha^{-1} slightly reduced yields to 2.39 t ha^{-1}. Vigor and seed germination displayed three different statistical groups being 40 kg ha^{-1} the best one. As in the case of yield, volumetric weight showed that plant densities of 40 and 80 kg ha^{-1} were the best treatments for this factor (Table 1).

Nitrogen fertilization: In general, nitrogen fertilization showed yields from 1.62 t in control to 3.033 t when fertilized with 60 kg ha^{-1}. On the other hand, seed vigor displayed an increased percentage (72.89%). Seed germination was better in fertilization ranking from 60 to 140 kg ha^{-1}, displaying 89.31 and 88.86%, respectively. Regarding volumetric weight, the best fertilization treatment was 180 kg ha^{-1}. Additionally, the best treatment with the weight of 1000 seeds was 180 kg ha^{-1} (Table 2).

Table 1: Treatments average by effect of plant density in oat

Density (kg ha^{-1})	Yield (t ha^{-1})	Vigor (%)	Germination (%)	VW (kg hL^{-1})	1000 SW (g)
40	2.67a	68.58a	89.29a	42.17b	19.27c
80	2.58a	63.08b	86.65b	42.63a	19.67b
120	2.39b	64.42b	86.71b	42.85a	19.96a
80 ctr	1.62c	37.30c	84.00c	40.30c	19.30c

Different letter(s) indicates statistical differences (p>0.05), Tukey 5%. VW = Volumetric weight; 1000 SW = Weight of 1000 seeds, ctr = Control plant without fertilization

Table 2: Treatments average by simple effect of fertilization nitrogen in different variables in oats seed

Nitrogen (kg ha^{-1})	Yield (t ha^{-1})	Vigor (%)	Germination (%)	VW (kg hL^{-1})	1000 SW (g)
60	3.033a	62.56c	89.31a	42.08b	19.03b
100	2.781b	72.89a	88.33a	42.53b	19.31b
140	2.246c	67.67b	88.86a	42.52b	19.97a
180	2.139d	58.33d	83.69b	43.06a	20.22a
ctr	1.620e	37.30e	84.00b	40.30c	19.30b

Different letter(s) indicates statistical differences (p>0.05), Tukey 5%. VW = Volumetric weight; 1000 SW = Weight of 1000 seeds, ctr = Control plant without fertilization

Table 3: Treatments average by simple effect of phosphorous fertilization in oats seed

Phosphorus (kg ha^{-1})	Yield (t ha^{-1})	Vigor (%)	Germination (%)	VW (kg hL^{-1})	1000 SW (g)
40	2.44c	60.00c	86.33b	42.41a	19.53b
80	2.61a	63.56b	87.33b	42.72a	19.39b
120	2.61a	68.89a	87.14b	42.35a	19.61b
160	2.54b	69.00a	89.39a	42.71a	20.00a
ctr	1.62d	37.30d	84.00c	40.30b	19.30b

Different letter(s) indicates statistical differences (p>0.05), Tukey 5%. VW = Volumetric weight; 1000 SW = Weight of 1000 seeds, ctr = Control plant without fertilization

Phosphoric fertilization: Oat seeds yield was significantly improved in treatments of 80 and 120 kg ha^{-1} . Vigor of oat seeds was improved at levels of phosphoric fertilization from 120 to 160 kg ha^{-1} with values of 68.89 and 69.0, respectively. In the case of germination, the best treatment was 160 kg ha^{-1}, while volumetric weight was not significantly influenced by the different treatments of this type of fertilization, although all of them were statistically different from control. Finally, the treatment of 160 kg ha^{-1} was the best one in the case of weight of 1000 seeds (Table 3).

Interactions between plant density and type of fertilization: Plant density and nitrogen fertilization interaction displayed that 40 kg ha^{-1} was the best one; however it tended to diminish when plant density increased (Fig. 1). On the other hand, the interaction between plant density and phosphoric fertilization, the lowest plant density and 80 and 120 kg ha^{-1} showed the best yield (Fig. 2). Interaction between both nitrogen and phosphoric fertilization showed that phosphorus was stable when 60 and 100 kg ha^{-1} of nitrogen was applied;

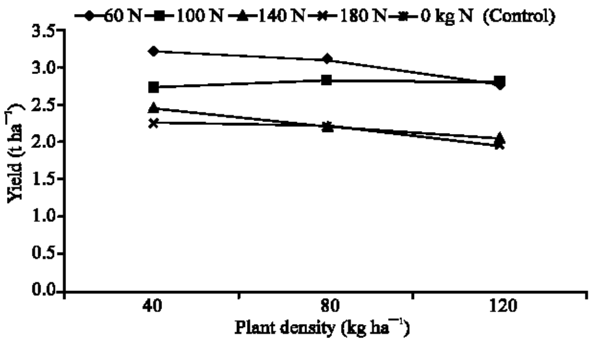

Fig. 1: Interaction response between plant density and nitrogen fertilization on the yield of oats seed

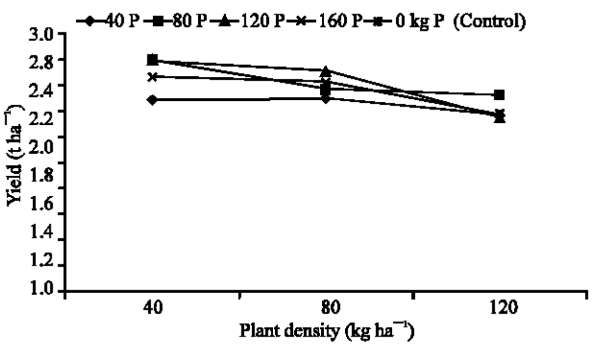

Fig. 2: Interaction response between plant density and the phosphoric fertilization on the yield of oats seed

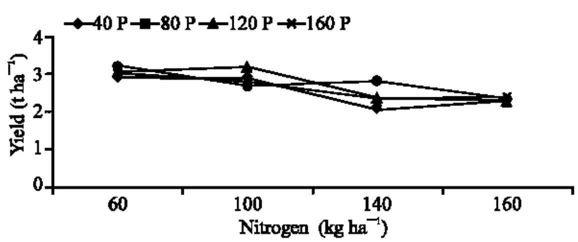

Fig. 3: Interaction between nitrogen and phosphoric fertilization on yield oats seed

however, when levels of both fertilizers increased the yield became diminished (Fig. 3). Seed vigor was clearly influenced by the lowest plant density and 100 kg ha^{-1} of nitrogen fertilization or 120 and 160 kg ha^{-1} of phosphoric fertilization (Fig. 4, 5). According to linear regression analysis an increase in levels of plant density and type of fertilization, the lower were yield and seed vigor the higher were volumetric weight and the weight of one thousand seeds (data not shown). Both fertilizers displayed an

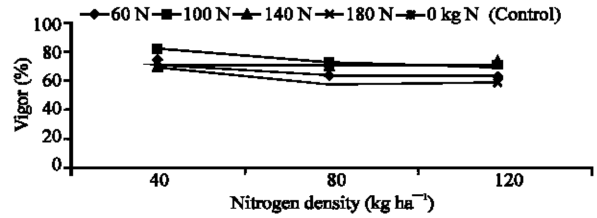

Fig. 4: Interaction response between plant density and nitrogen fertilization on percentage of vigor oat seeds

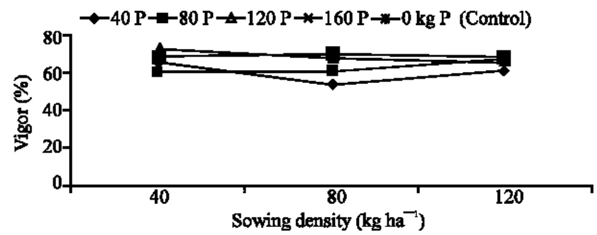

Fig. 5: Interaction in sowing density and the phosphoric fertilization in vigor oats Saias seed

increase in protein content within seeds, as well as the higher the protein content within seeds the higher the seed vigor (data not shown).

According to present results, in order to increase yields in seeds production in oat plant densities of 40 and 80 kg ha^{-1} is recommended which agree with similar reports elsewhere (Rivera *et al*., 1997; Vela *et al*., 1997). Low levels of nitrogen applications (60 kg ha^{-1}) were detected as necessary to increase seed production, which agree with Amado and Ortíz (2001) and Anton (2008), who reported that an increase in nitrogen fertilization levels diminished the seed yield in oat and wheat respectively. Regarding phosphoric fertilization, oat seed yield was improved with 80 and 120 kg ha^{-1}; this data disagreed with those reported by Vela *et al*. (1997) and Díaz de León (1991), who recommended lower levels of this fertilizer in barley seeds production. In this case there are no reports in oat, however, as a cereal; barley could be a good reference in this sense. In present study, it was observed a relationship between nitrogen fertilization and plant density on oat seed production, which disagreed with other reports elsewhere (Benbi *et al*., 1993). This situation could be explained based on the fact that plant density and low levels of nitrogen fertilization has been shown to improve seed quality (Lopez, 1994). In this sense, phosphoric fertilization and plant density also displayed a good interaction to produce oat seeds, which is similar to data reported by Amado and Ortíz (2001). On the whole, the oat seed quality was improved in low plant densities and fertilization levels. In other cereals, similar results when evaluating nitrogen and phosphoric fertilization have been reported elsewhere regarding seed quality and production (Zimdahl, 2004). In present study, the protein content in oat seed was important to improve vigor in germination; this result was similar to that reported by Carneiro *et al.* (1999) who mentioned that protein storage in seeds is important when emerging plantlets.

CONCLUSION

Taking together, present results displayed a high importance of plant density and type of fertilization (nitrogen and phosphoric) in order to improve oat seeds production and quality. Thus, in order to increase yield and seed quality in oat, our results displayed that a plant density of 40 kg ha^{-1}, nitrogen fertilization of 60 kg ha^{-1} and phosphoric fertilization of 80-120 kg ha^{-1}, significantly increased both yield and seed quality.

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