**Indications that the fertilization balance can improve the generation of gladioluscorm and cormels in México**

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**Abstract**

In regions of Puebla State (Mexico), gladiolus (*Gladiolus grandiflorus* Hort.) production has had asexual propagation problems causing losses to producers who mostly produce their own vegetative seeds. The aim of this study was to evaluate some physical quality and health characteristics in corms and cormels generated at different fertilization doses (FD). From a field experiment (2009), 240 corms with their cormels of two varieties and produced at four different FD were harvested. As for physical characteristics in corms, the corm fresh weight (CFW), number of cormels generated (Nc) and their total weight (TW) were assessed; and in cormels, their size (mm) and total weight were evaluated for each FD. Cormel´s health was analyzed in 160 random disinfested pieces that were plated in agar medium with or without splitting. Percentage of identified fungus incidence was recorded. It was observed that CFW and Nc were characteristic of varieties with statistical variations of 96 and 69 % respectively; and in 31 %, FD2 in Borrega Roja induced the highest Nc. FD1 and FD2 were the best for TW in both varieties. In cormels, the size 6-8 mm registered the highest weight in the same FD. The best cormel’s health was with FD2. In both varieties in average, the lowest percentage of *Fusarium* was isolated with 17.5 % in external tissue and 0.0 % in internal tissue. These observations were opposite to the blank results which showed a percentage of *F. oxysporum* of 70 and 30 % respectively. Thus FD2 generated a better corm and cormels. Thus the findings indicate that apply research should be conducted in commercial gladiolus fields.

**Keywords**: ornamental, macronutrients, micronutrients, interactions, nutrient balance.

**Introduction**

Gladiolus (*Gladiolus grandiflorus* Hort.) is an important ornamental plant in the world (Halder et al., 2007) in which the corms are used as asexual propagation. A corm originates a plant and as product of the underground stem tuber a new corm is formed and at its base it produces cormels. These both structures serve as vegetative seeds. In Mexico there are 3,600 ha of gladiolus plantations and Puebla State is the leading producer with 38 % of the national production (AFIS, 2012).

The main gladiolus varieties grown in the San Martin Texmelucan (SMT) region (Puebla) are Borrega Blanca, Borrega Roja, Espuma and Grand Prix among others. Most farmers there reproduce their own seeds; therefore, 10 % of the total surface is devoted to cormels and corms production. One of the main problems in this region, is the use of vegetative seeds which are stored under uncontrolled conditions (humidity and temperature) reducing its quality with consequent health loss during the growth period (Cohat, 1993). Also during crop development, corms can get various diseases from soil fungi or from the same propagules, which leads to loss estimates of 40 to 70 % by plant mortality. Then the own asexual seed contributes to the spread of diseases in the field (González- Pérez et al., 2009).

In some studies, fertilization is one of the best practices to improve the overall quality of the gladiolus vegetative seed. To help increase the quality of the plant and the number of cormels per corm (Khan and Ahmad, 2004; Halder et al., 2007), a proper nutrients balance of nitrogen, phosphorus, potassium and micronutrients such as boron (B) is necessary. Previous field studies in SMT showed that adding B and S to traditional fertilization did not affect plant phenology but it did reduce plant mortality caused by corm diseases (González- Pérez et al., 2011). Based on the above, the aim of this study was to evaluate some physical quality and health characteristics in gladiolus corms and cormels, which were generated at different fertilization doses, assuming that adequate fertilization doses produce better gladiolus vegetative seeds that the current ones used by farmers in the study area.

**Materials and Methods**

**Study area**

The study was carried out in SMT, Puebla, at the Tlacotepec de José Manzo community, El Verde municipality (19º 12' 18'' NL; 98º 26' 54'' WL; 2,425 m), with Cw type climate (Garcia, 2004), soil is a clay loam and slightly acidic, pH 5.8 (González- Pérez et al., 2011).

**Plant material and treatments**

From a previous field experiment carried out in July, 2009, 240 corms and cormels from Borrega Roja and Espuma varieties were harvested from fertilization doses experiments (FD), and evaluated. Treatments were four FD in a factorial experiment and a randomized complete block design with four replications. The fertilizer sources used were agricultural lime, ammonium nitrate, borax, di-ammonium phosphate, magnesium sulfate, potassium chloride, potassium nitrate and in four FD (kg ha-1): 65N- 14.9P- 171K- 16.6Mg- 31.2Ca (FD1), 40.5N- 24P- 171K- 23Mg- 37.2Ca- 0.2B- 8.5S (FD2), 81N- 24P- 171K- 23Mg- 37.2Ca- 0.2B (FD3) and the blank (dose used in the region) 81N- 24P- 171K- 23Mg- 37.2Ca (FD4).

**Corm analysis**

During harvest, 30 mother corms (MC) with their cormels were randomly selected depending on their treatment (FD), variety (Borrega Roja or Espuma) and repetition number. In the MC the variables evaluated were: fresh weight (CFW, g), number of cormels produced per corm (NcMC) and total fresh weight of cormels (TW, g).

**Cormels analysis**

In the cormels separated from the MC, the size (in mm), TW and health were assessed. In order to determine the cormels size, these were sieved through sieves of 50x 80cm of different diameters (mm). Cormels were classified according to the mesh size used, and their TW was determined by size.

**Health**

This parameter was evaluated in 160 random cormels (20 per treatment and variety). Each of the cormel tunics was removed and rinsed in running water during 20 min (soil removal) and dried over sterile towels inside a laminar flow chamber. The cormels were disinfested with a 1.5 % sodium hypochlorite solution during 3 min and they were dried as mentioned above. Then they were rinsed three times with sterile distilled water and re-dried inside the chamber. Eighty cormels were planted directly in Petri dishes with PDA (potato-dextrose-agar; Bioxon©, Mexico) and the remainder were split longitudinally and seeded in the same medium with the inner side in contact with the medium. All the Petri dishes were incubated during 12 days at 21°C in continuous 40 W white light. As for fungal colonies developed, the incidence rate per cormel was recorded. The colonies were identified with the same methodology described in González- Pérez et al. (2008; 2009). Also, literature techniques and descriptions were used for the main *Fusarium* species that cause rotten corms.

**Statistical analysis**

Variance analysis and mean comparisons by Tukey (*p* ≤ 0.05) were done to the obtained data by using the Statistical Analysis System software (SAS, 2009).

**Results and Discussion**

**Corm physical quality**

Differences between varieties for CFW and number of cormels were observed. In the FD experiments there were only differences in the TW (*p* ≤ 0.05) (Table 1). The CFW showed 96 % of the total variation due to different varieties effect. Espuma variety, accumulated the double in CFW (10.9 g) than Borrega Roja (5.5 g), and there was no difference between fertilization doses (*p* ≤ 0.05) (Table 1). The highest weight accumulation in Espuma variety may be due to plant genetics. This can be said based on previous observations where (in this variety) the corm weight increase starts at the flowering stage, while in Borrega Roja variety such weight increase occurs after this step. Therefore, photosynthates in Espuma variety are devoted to the new corm formation and in the other variety they are devoted to the cormels generation (González- Pérez et al., 2011).

As for the NcMC, 69 % of the variation effect was due to variety differences and 26 % due to FD (*p* ≤ 0.05). Borrega Roja was the best to generate on average 47 cormels per each MC and where FD1 and FD2 were the best treatments with the same results in this variety. Espuma, in contrast, only produced 21 cormels (50 % less) on average. In both varieties, FD2 was the best dose, as it produced 46 cormels per each MC, followed by the FD1 and FD3 with 36 and 30 cormels respectively. The blank experiment (FD4) only stimulated the generation of 24 cormels (Table 1). The highest cormels number (FD2) in both varieties is attributed to the B presence at this dose. According to Halder et al. (2007), B is essential throughout the plant’s life to help the sugars transfer to the reserve zone (corm) and when it is in balance with phosphorus and potassium it promotes the formation of a higher NcMC as long as it doesn’t exceed the 2 kg ha-1 of B tolerance limit (Yau and Ryan, 2008). In Espuma variety, the lowest NcMC in the blank was associated with high N concentrations, which -in this variety- produces higher leaf area (González-Pérez et al., 2011) and corm size (Table 1), causing reduction in the number of cormels.

As for TW, no difference between varieties was observed but FD showed 96 % of the variation (*p* ≤ 0.05). On average, FD1 and FD2 were the best to generate a weight of 169.3 and 160.6 g, in contrast to FD3 and FD4 (blank) that showed the lowest weight (82.6 and 63.8 g) in both varieties. In the last two treatments, the high N concentration (81 kg ha-1) improved the leaf development and mother corm size, but the number of cormels and TW decreased. Similar results were reported by Pant (2005) and Butt (2005), who observed higher corm and cormel weight with lower N doses (50 kg ha-1), and at higher doses (100 kg ha-1) they observed less amount and cormels weight.

**Cormels physical quality**

The generated cormels were classified into five sizes and TW varied depending on the size (Table 2). In both varieties, 6-8 size showed the higher weight with 57.2 % for Borrega Roja and 64.5 % for Espuma. In contrast, the lowest percentage was recorded in the 2-4 size (1 %). There were no significant differences between varieties for size 6-8, both had an average weight of 71.5 and 72.9 g (Table 2). On the other hand, FD showed differences (*p* ≤ 0.05): 99 % of the variation was due to the treatments. On average, FD1 and FD2 were the best to generate a total weight of 108.5 and 120.9 g respectively, while FD3 and FD4 (blank) registered the lowest weight (28.3 and 31.0 g). As for 10-12 size (considered ideal propagation), there were differences only between varieties (*p* ≤ 0.05), Borrega Roja showed on average 53 % more fresh weight than Espuma (Table 2) but this wasn’t higher than the blank (control).

TW was generally in direct proportion to the number of cormels generated by each MC. The highest weight on FD1 and FD2 was attributed to a low N amount in both FD or to the B and S presence in FD2. In other studies, Hernandez et al. (2008) and Khan and Ahmad (2004), reported that the highest accumulated weight in vegetative seeds (corms and cormels) was due to a proper N balance, and besides this nutrient, Halder et al. (2007) showed that other important nutrients such as B (which stimulates the optimal corm and cormels development) also must be considered.

**Cormels health**

**External tissue.** From the cormels seeded without split, *Fusarium* spp*.* and *Penicillium* spp. were isolated from external tissue in 15-75 % and 8.8-36.3 %, respectively (Table 3). The lower incidence of *Fusarium* was observed in FD2 for both varieties with an average of 17.5 %, meanwhile in the blank dose the highest percentage, 69.4 %, was observed. The presence of these fungi on the external surface tissue demonstrates that they were living on the soil where the cormels were produced. However such cormels didn’t show symptoms of external rot as previously observed in other studies reported by González- Pérez et al. (2009) in the same area of study.

**Internal tissue.** In the four FD, *F. oxysporum* and *Penicillium* spp. were isolated with 0-40 % and 5-15 %, respectively (Table 3). There was no incidence of *Fusarium,* 0.0 %, in FD1 and FD2 for both varieties; in FD3 there was only 5 % incidence in Borrega Roja. In contrast, FD4 (blank) showed the highest percentage, 20-40 % of *F. oxysporum* (Booth, 1971; González- Pérez et al., 2009). FD2 and FD3 had in common the presence of B, which according to Engelhard (1989), this is an element that reduces the incidence of soil pathogenic fungi that causes rot in various crops. This also was demonstrated by González- Pérez et al. (2011) in a field study where the gladiolus MC, FD2 added with B and S, decreased by 48 % the MC rot by *F. oxysporum* f. sp. *gladioli,* main soilborne pathogen in this region (González- Pérez et al., 2011). Moreover, Chandel and Deepika (2010) observed that when a sulphur source is incorporated to the gladiolus cultivation, the number of diseased corms is reduced and the number of healthy plants with good formation of corms is increased.

FD1 and FD2 treatments had lower N concentration (65 and 40.5 kg ha-1 respectively) compared to the blank (81 kg ha-1). Thus, several authors (Daughtrey and Benson, 2005; Engelhard, 1989; González- Pérez et al., 2011) recommended the use of low N doses (60 kg ha-1) and B incorporation for disease management in different cultivars, because if the N concentration mentioned above is exceed, then the presence of various *Fusarium* species is favored. Adding S, for the nutritional balance of FD2, was an additional contribution, and it is generally recommended for the control of fungal diseases (Chandel and Deepika, 2010; Daughtrey and Benson, 2005; Engelhard, 1989). On the other hand, Mg could also act on disease control in balanced combinations of N in FD1. In this regard, Jones et al. (1983) mentioned that the application of Mg in foliar form or directly to the soil has a beneficial effect on the plants as it helps them reduce the development of fungal diseases and other pathogens.

As it was previously shown from the analysis of mother corm weight and number of cormels (96 and 69 % variation respectively due to the varieties), these physical qualities of the vegetative seeds depend on the variety of gladiolus. FD1 and FD2 were the best treatments in other physical quality components analyzed. Although, when analyzing in more detail, FD2 was better as cormels external and internal tissues were healthier in this case (Table 3) and this treatment was also well supported by previous field studies (González- Pérez et al., 2011). FD2 strength relies on its N lower dose and the B and S addition. On the other hand for FD1, probably *Fusarium* was not possible to isolate from internal tissues due to Mg presence. However, it was isolated from external tissue in almost equal percentage than the blank treatment. A proper Mg balance should be determined in further studies.

**Conclusions**

In conclusion, the physical and health quality of the vegetative seed was enhanced by the balanced interaction between N, B and S in FD2, and the blank fertilization dose was at a disadvantage. The cormels number and weight of the mother corm were mainly, or in greater extent, influenced by the variety. Apparently this is the first study reporting the interaction and influence of the N, B and S elements that provide better vegetative seed generation in this ornamental plant. Thus these studies indicate that application research should be conducted in commercial gladiolus fields with this generated basic information.

**Acknowledgements**

Thanks to Ing. Hector Sanchez for providing plant material and advice on the agronomic crop management. To Colegio de Postgraduados-Campus Montecillo for the facilities provided for the development of this study and to the National Council for Science and Technology (CONACYT) for the financial support.

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