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TOLERANCE AND RESPONSE OF HYBRID CORN TO DIFFERENT OIL CONCENTRATIONS

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Abstract: This study evaluated the effect of contamination by crude oil at different concentrations (0, 0.5, 1, 2, 4 and 8% w/w) in 3 lines of the corn plant (Zea mays) Creole, hybrids H384A and H386A. Variables such as germination, height, stem diameter, and leaf length-width were evaluated at 7, 10, 14 days after sowing (DDS). For each concentration of crude oil, three repetitions were made to obtain 54 experimental units, 18 for each of the lines studied (Criollo, H-384A, H-386A). In the present work we found that the Creole corn and the hybrid H386A, reached 100% germination at 5 DDS, while the hybrid H384A at 4 DDS at the different concentrations. Plant height, stem diameter and leaf size were affected in their development at higher concentrations of crude oil. The hybrid H384A showed a better response compared to the native corn and the hybrid H386A against contamination by crude oil. However, the native corn showed a favorable response to the different hydrocarbon concentrations. It is necessary to carry out more studies related to native maize races, to know the response to environmental contingencies such as oil spills.
Keywords: Phytotoxicity, hydrocarbon, cultivation, germination, contamination.

INTRODUCTION

The main reason for the presence of oil, not only in soils intended for planting, but also in various ecosystems, is due to accidental spills generated by the oil industry. These spills affect the soil and various crops around the world. The effects can be both direct or indirect, oil can inhibit the enzymatic activity of the soil, germination, the outbreak of meristems, as well as the decrease in root elongation and photosynthesis in plants. The inhibition of germination, the decrease in plant growth and the death of plants are indicators of the toxicity of hydrocarbons (Arias et al., 2017). They indirectly generate toxic minerals in the soil available to be absorbed, in addition, it leads to a deterioration of the soil structure; loss of organic matter content; and loss of mineral nutrients from the soil, such as potassium, sodium, sulfate, phosphate, and nitrate" in the same way, the soil is exposed to leaching and erosion (Serrano et al., 2013).

Corn (Zea mays) is one of the most representative agricultural crops in Mexico due to its economic, social and cultural importance, around 64 races have been cultivated in Mexico (CONABIO, 2019). For an optimal cultivation of the corn plant, various factors are required in the soil, such as: a pH between 6 to 7, deep soils rich in organic matter, moisture being of vital importance since water stress or Drought can cause losses during the early stages of the crop, as well as alter the development of the plant. (Deras, 2012). The aforementioned factors can be modified by external components such as oil from spills. The presence of oil in the soil has been shown to cause alterations in corn, Marín-Velásquez, (2016) reports that the greater the amount of oil, the lower the percentage of germination of Zea mays, and from 50 mL no germination occurred, due to changes in soil properties.

Mexico presents extensive areas of soil contaminated by hydrocarbons due to the different oil activities such as exploration, extraction, refining, maintenance of wells and pipelines, among others, due to climatic and environmental effects, currently various corn hybrids have been developed that present greater resistance to these adverse conditions of the plant, which suggests that they could have a greater resistance when hydrocarbon spill events occur, the Hybrids H-384A and H-386A have been recently obtained (SAGARPA, 2018), for Therefore, there are few studies that relate the response or tolerance to oil by these hybrids, so the objective of this study was to evaluate the phytotoxicological effect of oil at different concentrations on the germination and development of hybrid corn H-384A and H-386A and their possible tolerance to oil concentrations.

MATERIALS AND METHODS

The following lines were used as a study model for this work: Hybrids H-384A and H-386A developed by INIFAP and Creole corn from the Cardel Veracruz region, Mexico.

The soil used for this experiment was classified as Andosol, which was dried, ground and sieved to a particle size of 5 mm.

A mixture was made with 450 g of the soil and 50 g of agrolite, the mixture was contaminated with Olmec oil at the following concentrations: 0%, 0.5%, 1%, 2%, 4% and 8% p/p and in triplicate to obtain 18 experimental units for each of the lines studied (Criollo, H-384A, H-386A) thus obtaining a total of 54 experimental units (pots), in which 5 seeds were sown respectively, the pots were placed in a ECOSHEL brand artificial climatic chamber model C1000D, 16/8 light/dark at 25°C and 60% humidity. The variables evaluated were: germination, plant height, diameter, leaf width-length and dry biomass at 7, 10, 14 and 21 days after sowing (DDS), at the end of the experiment (21 DDS) we proceeded to evaluate the fresh and dry biomass of the root and the aerial part of the plant. Data were analyzed by one-way ANOVA analysis of variance, and the multiple comparison test (Tukey) was applied to determine specific differences between treatments, for $p < 0.05$. All analyzes were performed with GraphPad Prism 6.0.

RESULTS ANSD DISCUSSION

OIL EFFECT ON GERMINATION

The results found in this study show that the hybrid H384A and H386A began to germinate on the third day, while the Creole maize after four days. Creole corn and hybrid H386A, reached 100% germination at 5 DDS, while hybrid H384A at 4 DDS at different concentrations, it can be seen in the three lines that germination is delayed at higher oil concentration. Previous studies with everta creole corn and light grade oil reported that contamination of 4%, 6%, 8%, 10 and 12% of crude oil, even with sowing 7 days after soil contamination, represented a decrease of 46%, 67%, 73%, 100%, 100% respectively in the germination of corn seeds (Velásquez, 2016). In other studies carried out on Creole corn, a delay in its germination is also reported, going from an average of 5 days to 15 days to achieve germination in concentrations of 10 and 12% (Méndez-Natera et al., 2004). Germination can be affected by volatile fractions of hydrocarbons, which penetrate and damage the embryo of the seeds, which affects the emergence, another effect of oil is the reduction and delay of seed germination due to the effect of entry from the hydrocarbon to the grain, which alters the metabolic reactions with the possibility of completely damaging the embryo due to toxicity (Quiñones-Aguilar et al., 2003). Observing the germination data of other authors, we can suggest that there is a better resistance of the hybrids used in this work, since they present a better tolerance to the presence of the hydrocarbon.

EFFECT OF OIL ON PLANT DEVELOPMENT

After seven days of sowing, it is observed that the height of the Creole corn presents significant differences between the treatments, observing a smaller size in the plants exposed to 8% of oil, this same effect could be seen at 10, 14 and 21 days of cultivation. planting. In the case of the hybrids H-384A and H-386A, no differences were observed between the treatments after seven and 10 days, but on days 14 and 21 the hybrid H-386A showed a smaller size at a higher oil concentration (8

%), (figure 1). In the case of the diameter of the plant, no differences were observed in the three lines at 7 days, however, at 10, 14 and 21 days, both the Creole and the hybrid H-386A showed a decrease in their diameter at higher concentrations. of oil (4 and 8%). Both the length and width of the leaves did not present significant differences in the three lines under study at 7, 10, 14 and 21 days after sowing, however, it must be noted that the hybrids presented a larger size in their leaves.

As can be seen, the seedlings were affected by higher concentrations of crude oil, which coincides with that reported by other authors (Rivera-Cruz et al, 2005). Among the possible causative factors can be considered the alteration in the availability of water, nutrients and the physical and chemical properties of the soil when in contact with crude oil (Adams and Morales-García, 2008). The inhibition of plant growth shows a direct relationship with the increase in the concentration of hydrocarbons, since high concentrations of hydrocarbons prevent the absorption of water and beneficial elements for the plant due to the formation of a hydrophobic layer on the roots (Quiñones, et al., 2003). It has also been seen that hydrocarbon molecules can damage cell membranes causing spillage of cell contents and blockage of intercellular spaces reducing metabolite transport and respiration rate. However, the hybrid H384A showed a better response compared to the native maize and the hybrid H386A against contamination by crude oil, this could be attributed to the genetic improvement acquired by the hybridization. On the other hand, the Creole corn and the hybrid H386A showed a decrease in diameter as the oil concentration increased. Other works with hydrocarbons report thinner stems at higher oil concentrations (Mujica Blanco et al., 2006).

Decreases in plant characters have been observed in different species at high concentrations of oil in the soil. Rivera-Cruz et al, (2005) evaluated four legumes at different concentrations of oil in the soil and found that the vegetative growth of the four legumes was affected, including plant height with 8%, 10% and 15%. at 15% the plants failed to survive. In another study Rivera-Cruz et al, (2005) observed that at 5, 10 and 15% of crude oil, the plants Cyperus articulatus, Cyperus sp. and Mimosa pigra reduced their growth, root length and biomass.

The presence of oil was also observed to affect leaf length in hybrids H-384A and H-386A. Studies indicate that oil can affect photosynthesis and chlorophyll content in vegetation, which could lead to low aerial biomass production. The presence of hydrocarbons can inhibit the foliar growth of plants, which prevents them from taking advantage of the greater amount of their resources and energy to consolidate their radical fraction (Arias-Trinidad et al, 2017).

After 21 days of exposure to different concentrations of crude oil, the aerial dry biomass and the root biomass of the Creole corn seedlings showed significant differences $p<0.05$, this being lower in the treatments with the highest concentration of crude oil, both the aerial dry biomass as the root of the hybrid H-384A plants subjected to the different concentrations of oil did not show significant differences between the treatments throughout the 21 days of exposure. The biomass of the hybrid H-386A did not show differences in the aerial biomass, but in the radicular $p< 0.05$.

In figure 2. Creole corn seedlings, hybrid H-384A and 386A are shown after 21 days of exposure to different concentrations of oil.

It has been found that high concentrations of hydrocarbons cause severe damage and inhibit meristem regrowth, decrease root elongation and growth, and prevent cellular oxygen diffusion due to anoxic soil

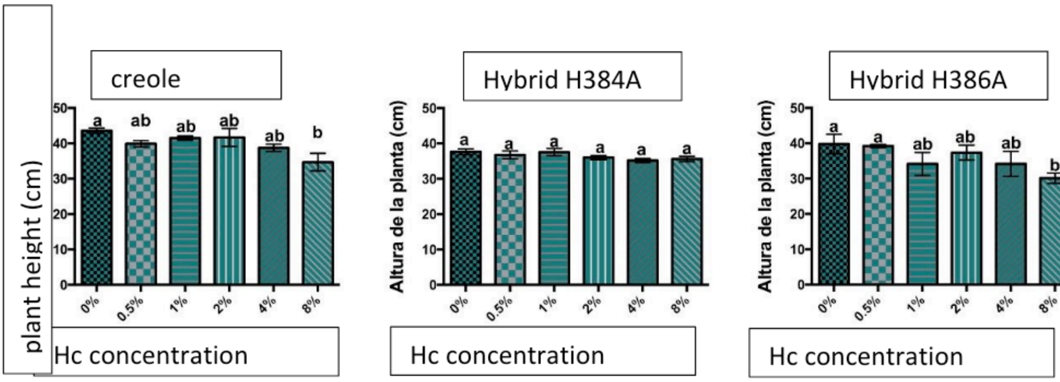

Figure 1. Plant height 21 days after sowing (21 DDS). The lines indicate the standard error. Different lowercase letters indicate significant differences between treatments p<0.05.

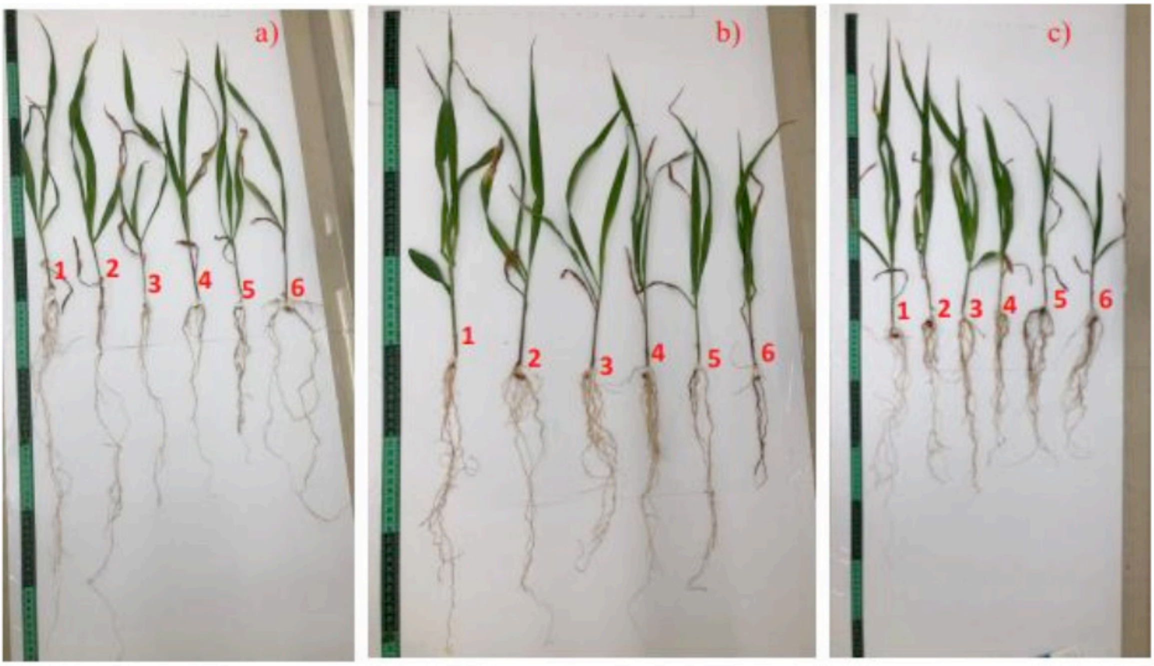

Figure 2. Maize seedlings a) creole, b) H-384A, c) H-386A. Exposed to 0, 0.5, 1,2,4 and 8% crude oil, the progressive numbers represent the different concentrations respectively.

conditions. This coincides with Reynoso-Cuevas et al, (2008), who identified a decrease in root length as hydrocarbon concentration increases. This effect can be attributed to the fact that the oil forms a layer that limits the absorption of water and nutrients by the root (Quiñones Aguilar et al, 2003), which can affect subsequent development.

There are several studies that report that the presence of some type of hydrocarbon in the soil reduces the root length of plants. In this regard, a decrease in root volume has been found in German grass plants (Echinochloa polystachya), this may be due to the fact that oil forms a hydrophobic layer on the root, which limits the absorption of water and nutrients (Quiñones Aguilar et al., 2003). The results of our study showed that, in the three maize lines studied, root growth decreased when the oil concentration increased, the roots grew very short and thick in the 8% concentration, mainly in the native maize and the hybrids. H-386A. The results obtained confirm that the greatest damage occurs on the root biomass due to contact with the oil.

Studies of various hybrid lines of maize and races of native maize, as well as in other stages of development, would be of great relevance to have more possibilities in the face of environmental contingencies such as oil spills.

CONCLUSIONS

The hybrid H-384A showed a higher tolerance to contamination by crude oil, since it has better adaptability to water stress conditions and to situations that limit germination and development.

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