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Content

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Determination of periods of greater sensitivity to thermal stress due to high temperatures in the reproductive stage of cotton cultivars

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ABSTRACT

The phenomenon of climate change is currently observed in a wide range of ecosystems and species in all regions of the world in response to increasing temperatures. This increase in temperature has been recorded from pre-industrial times to the present, with negative effects associated with crop yield losses, as well as significant changes in the distribution of phenology and species. The reproductive period is a critical period in the face of high temperatures in cotton cultivation. It is unknown which is the reproductive subperiod with greater susceptibility to stress due to high temperatures in cotton cultivars. The objective was to determine in the reproductive stage the subperiods susceptible to thermal stress. due to high temperatures in Cotton cultivars, with special emphasis on: I) development and growth parameters; II) performance and its components; III) fiber quality parameters. The treatments consisted of two subperiods of thermal stress i) budding ii) at 50% flowering in both phenological moments, the tents were installed to achieve the increase in temperature, said tents made of transparent polyethylene material for 14 days in each subperiod.

The development and growth of plants with thermal stress showed a differential response depending on the spatial configuration and high temperatures. Thermal stress due to high temperatures had a more negative impact on underground planting due to less rainfall.

In the three cultivars, the period of greatest susceptibility to stress due to high temperatures is at the beginning of the reproductive period, causing greater losses in yield.

INTRODUCTION

High temperatures in the last century have increased due to the higher concentration of greenhouse gases. These gases retain part of the heat emitted by the planet's surface after having been heated by sunlight, raising the temperature on the surface (Meehl et al., 2007). These gases are increasing, at the current rate of gas emissions and population increase (Singh et al., 2004). Climate change caused an increase in temperature and is expected to rise further, causing substantial losses in the productivity of cotton cultivation (Al-Khatib and Pausen, 1999).

High daytime temperatures, i.e. above 32°C, can occur during the flowering and fruit development stages in many cotton-producing regions around the world. These elevated temperatures can compromise the fixation of reproductive organs and fiber yield (Reddy et al., 2004).

The reproductive period is a critical period in the general reproductive development of cotton, where a white flower opens in the early morning (Stewart, 1986), pollination occurs approximately between 7 and 11 hours (Pundir, 1972) and germination of the pollen within 30 minutes after pollination (Stewart, 1986). Successful growth of the living pollen tube and subsequent fertilization of the ovule is a prerequisite for the formation of cotton seeds; seeds and their associated fibers are the basic components of yield.

It is unknown which reproductive subperiod is most susceptible to stress due to high temperatures in cotton cultivars.

METHODOLOGY

The experiment was carried out in the town of Presidencia Roque Sáenz Peña, at the INTA Agricultural Experimental Station. On a factorial arrangement using a divided plot design with three repetitions, (i) in the main plot the application of a thermal level will be combined (ii) in the sub-plot of three cultivars (DP 402, DP 1238 and NuOpal RR. The Thermal levels will be achieved with polyethylene tents (3 m² surface) that will allow the temperature to be raised during the day, in which temperatures will be recorded with sensors connected to data-loggers. The tents were installed at 35 DAS (days after sowing) 1 stress at 52 DAS (2 stress). The treatments were harvested and the yield per hectare was calculated, and the number of seeds was also counted.

RESULTS

Figures 1, 2 and 3 show how the first stress (35 DDS) affects the three cultivars compared to the second stress (52 DDS) where yields are higher. With respect to the number of seeds, a relationship is observed between yield and number of seeds since the latter is a performance factor associated with yield.

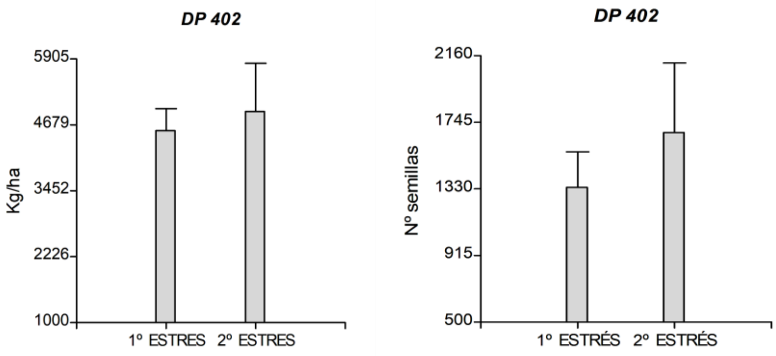

Figure 1 Yield (kg/hectare) and number of seeds in two subperiods of the reproductive period of the DP 402 variety

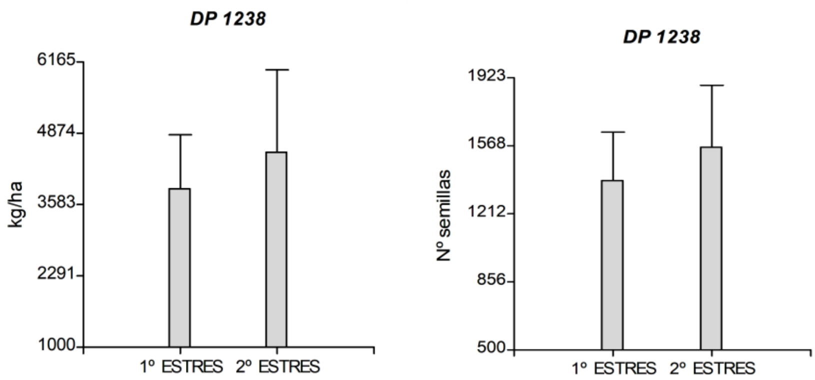

Figure 2 Yield kg/hectare and number of seeds in two subperiods of the reproductive period of the variety DP 1238

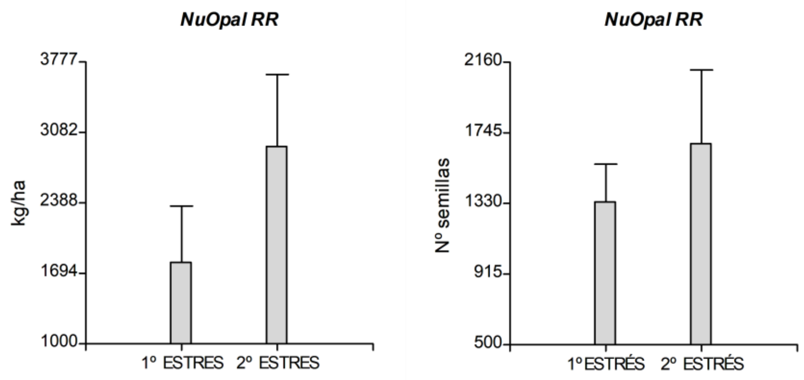

Figure 3 Yield kg/hectare and number of seeds in two subperiods of the reproductive period of the NuOpal RR variety

CONCLUSION

In the three cultivars, the period of greatest susceptibility to stress due to high temperatures is at the beginning of the reproductive period, causing greater losses in yield.

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Evaluation of lint yield of cotton genotypes in different growing seasons in Santa Fe, Argentina

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INTRODUCTION

Cotton (Gossypium hirsutum L.) is a very important crop for the economy of the state of Santa Fe, in Argentina. This state is the third largest cotton-producing area in the country, covering approximately 180,000 hectares. The region is home to both small-scale producers with less than 400 hectares and large-scale producers with over 3,000 hectares. Average yields in the area range from 500 to 1000 kg ha-1 of lint according to the region and year.

In Argentina, a limited number of cotton genotypes are available on the market, all of which have been genetically modified to enhance weed and pest control. The evaluation of the performance of different commercial varieties is an ongoing process that has been conducted over multiple growing seasons in our region, located in northern Santa Fe. This analysis is crucial, as environmental conditions have a direct impact on productivity. They vary across seasons and within the same growing season, with sowing date playing a pivotal role in determining the main growing condition for each genotype.

Lint cotton yield is influenced by three main factors and their interactions: genotype selected, agronomic management practices applied, and environmental conditions registered. So, the study of commercial cotton varieties over multiple growing seasons provides valuable data on different aspects such us: phenological stages duration, cotton yields, and fiber quality. This kind of experiment allows us to assess how different varieties adapt to different environmental conditions. Additionally, analyzing several sowing dates is essential to understand genotypes' plasticity, being this, the ability to adjust their growth and development based on planting date.

Among the commercial cotton varieties available in Argentina, there are short mid, and full maturity types. Currently, full maturity varieties are the most popular choice among growers in Santa Fe due to their higher yield potential. However, recent studies have indicated an important genotype-environment interaction, suggesting that full maturity varieties are generally preferent placed in early planting dates, while early-maturity varieties might adapt more effectively to later planting dates. In our region, though, these patterns are not always consistent, and yields can vary significantly.

The objective of this study was to evaluate the impact of environmental conditions on cotton yield of various genotypes across different environments in Santa Fe, Argentina.

MATERIALS AND METHODS

The evaluation of commercial varieties was carried out at the INTA Reconquista Experimental Station from 2017 to 2024, considering different sowing dates and years as different environments. In each growing season, either two or three sowings were carried out at different times to distinguish between the different environments. This corresponds to a total of 17 environments.

The commercial genotypes included in these studies are presented in the following table (Table 1):

Table 1. Genotypes and their main characteristics used in the experiment.

Genotype	Maturity and seed protection
DP 1238	Full maturity. Bollgard Roundup Ready (BGRR)
Guazuncho 2000	Mid maturity. Roundup Ready (RR). Refuge genotype
Guaraní	Short maturity. BGRR
Guazuncho 4	Short mid maturity. BGRR
NuOpal	Full mid maturity. BGRR
Porá 3	Short mid maturity. BGRR
DP 402	Short maturity. BGRR

Across the different growing seasons, each trial was conducted in a completely randomized block design with 4 replicates per treatment. Each plot consisted of 8 narrow rows separated by 0.52 m, with a length of 5 m and an approximate density of 10 to 12 plants per linear meter. At the end of the cycle, hand-harvest were made from a representative sample of each plot (3 m2), collecting the two central rows and estimating lint yield per hectare (LY).

Daily meteorological data records were registered at the INTA Reconquista Agrometeorological Station. The variables recorded were air temperature, solar radiation, relative humidity, wind speed, precipitation and vapor pressure.

STATISTICAL ANALYSIS

First, the genotypes were evaluated using boxplots to observe the distribution of LY in each group. A comparison between the genotypes was made using Fisher's LSD test at a significance level of $\alpha = 0.05$. Also, an analysis of variance was performed to observe how the LY varied in the different environments.

Subsequently, the analysis of LY in cotton was performed using a conditional inference tree, a nonparametric statistical technique that allowed the identification of environmental variables that significantly affected yield. This method divided the data into homogeneous groups using cut-off points in the explanatory variables. It generated internal nodes representing the partition criteria and terminal nodes grouping observations with similar yield values.

For this analysis, primary meteorological variables were first aggregated (cumulative or averaged) at a daily scale. Then, the secondary meteorological variable growing degree days was derived on a daily scale assuming a base temperature of 12 °C. GDD, planting and harvest dates were then used to segment the cotton growing season on each trial into six developmental stages of interest. The stages and GDD required were emergence (0-86 GDD), vegetative (86-666 GDD), squaring (666-1111 GDD), flowering (1111-1558 GDD), cut-out (1558-2184 GDD), and boll opening (2184- GDD). Finally, for each trial and developmental stage, summarized meteorological variables were calculated as either the mean (temperature and vapor pressure) or sum (precipitation and solar radiation) of primary meteorological variables, and the duration (in days) of each developmental stage, for each stage and across the growing season. A total of 93 summarized meteorological variables were generated at this step and used for environmental characterization.

Each node contained a box plot showing the distribution of LY in the corresponding group. The box plots allowed a visual comparison of the groups and showed the differences in variables. The differences between the variables were evaluated at a significance level of α = 0.05; groups represented by the same letter did not have statistically significant differences between them. This analysis was performed using the Rstudio software and the corresponding statistical package for conditional inference trees.

RESULTS AND DISCUSSION

Figure 1 shows the lint yields (LY) of different cotton genotypes in all environments. Significant differences were observed between the genotypes, however, there is no clear separation indicating a major superiority of one variety over the others. Significant differences were observed between Guarani (800.7 kg ha-1) which presented the highest value in LY, and NuOpal (708.0 kg ha-1) and DP402 (715.5 kg ha-1), which presented the lowest LY values.

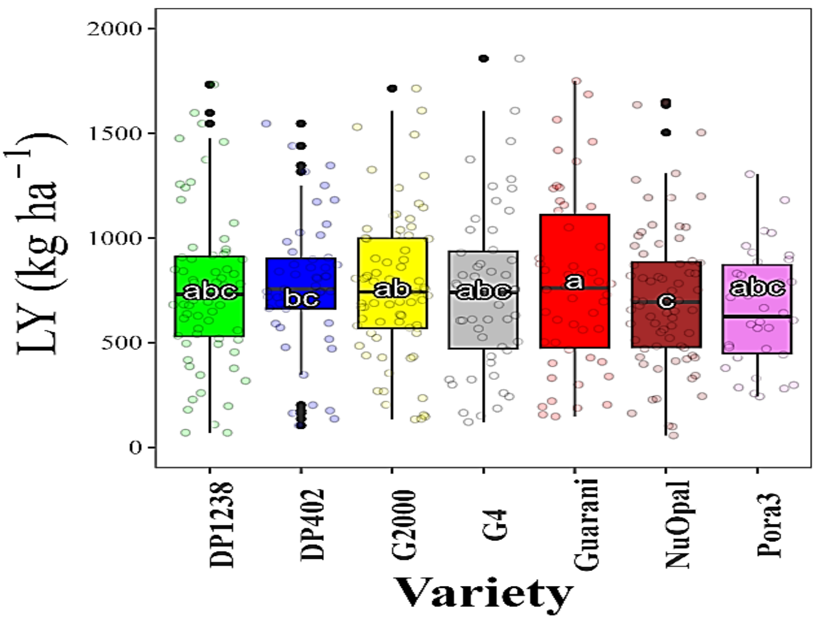

Figure 1 Boxplot analysis of lint yield (LY) in different cotton genotypes across 17 environments in Santa Fe, Argentina. Similar letters indicate non-statistical differences (alpha = 0.05).

Figure 2 shows the lint yield by environment. The LY differences among the environments were higher than among the genotypes (p-value < 0.0001), showing a strong influence of environment on cotton LY. Environments 8 and 9 presented significantly higher LY than the rest of the environments, while environment 11 presented significantly lower LY than the rest of the environments.

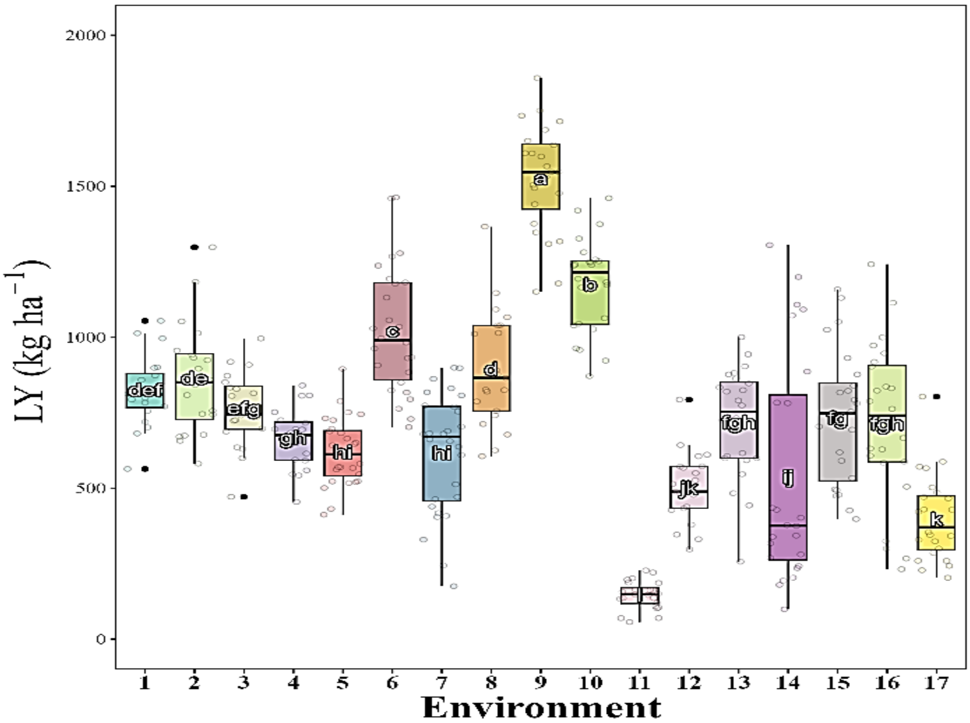

Figure 2 Boxplot analysis for lint yield (LY) of 17 different environments, determined by growing seasons and planting date in Santa Fe, Argentina. Similar letters indicate non-statistical differences (alpha = 0.05).

The results shown above suggest that LY in cotton is more influenced by environmental factors than by genetics. Although the genotypes have statistically significant differences in some cases, these differences are much smaller compared to the variation observed between the different environments. This indicates that adaptation to environmental conditions is the key to yield improvement. The choice of the planting date is a key agricultural management practice as an alternative to optimize the availability of resources in the environment.

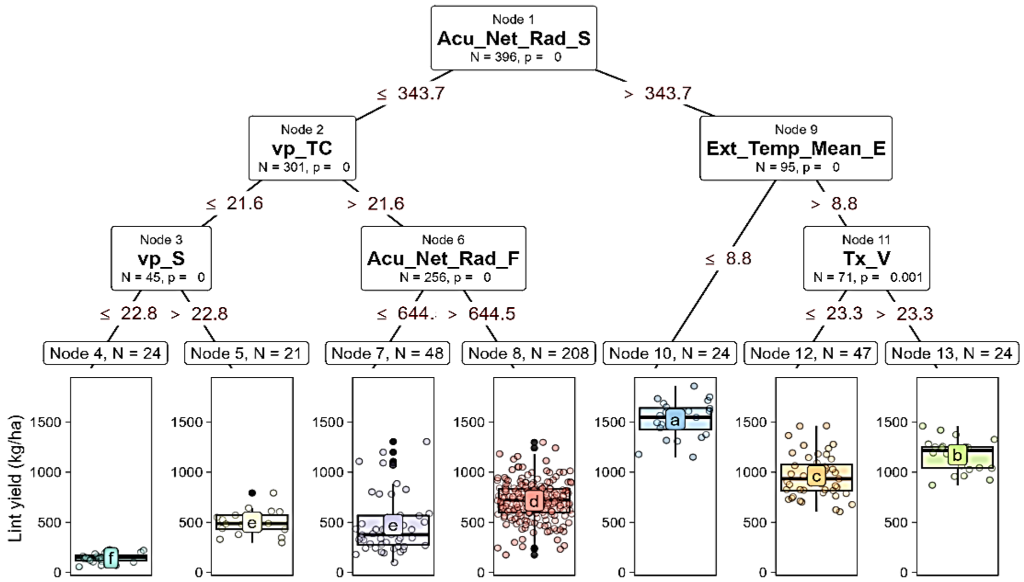

Figure 3. Conditional inference tree for cotton lint yield (kg ha-1) across all environments as affected by net solar radiation accumulation during squaring (Acu_Net_Rad_S), vapor pressure during total cycle (vp_TC), mean external temperature during emergence (Ext_Temp_Mean_E), vapor pressure during squaring (vp_S), net solar radiation accumulation during flowering (Acu_Net_Rad_F), and mean temperature during vegetative stage. Boxplots show data distribution in each terminal node. Boxplots followed by the same letter are not significantly different at alpha = 0.05.

To identify and associate the response variables with both the meteorological conditions in each environment and with crop cycle and phenological stage duration, a conditional inference tree was performed on all the studied response variables each as a function of 93 explanatory variables (Figure 3). According to our conditional inference tree criterion for splits and minimum number of observations at the terminal nodes, the highest LY values was observed when the net solar accumulation during squaring (Acu_Net_Rad_S) was higher than 343.7 MJ m-2 and the mean external temperature during emergence (Ext_Temp_Mean_E) was lower than 8.8 °C. The lowest LY was observed when Acu_Net_Rad_S was lower than 343.7 MJ m-2, and the vapor pressure was lower than 21.6 and 22.8 in the total cycle and squaring stage, respectively. These results indicate the importance of solar radiation at squaring and flowering, which is crucial for reproductive development and photosynthesis, while adequate vapor pressure and moderate temperatures at emergence contribute to a better LY.

CONCLUSION

These analyses of LY in different genotypes and environments emphasize the importance of environmental factors in cotton productivity, highlighting the need for agronomic management strategies that optimize environmental conditions to increase yield. These analyses have important implications for cotton crop management in Argentina. Since the variability in yield is determined more by the environment than by genetics, it is essential that producers pay attention to the specific conditions of each year and adjust their management practices, such as planting date, based on the expected environmental conditions. Meteorological variables like net solar radiation, vapor pressure, and temperature were the most important variables that explained yield variation across the environments. This suggests that management practices that optimize solar radiation and control temperature and humidity conditions could be key to improving cotton lint productivity in this region of Santa Fe.

Spodoptera complex caterpillars on cotton in Argentina

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SPODOPTERA COMPLEX IN THE SANTA FE REGION

The cotton crop attracts a large number of organisms, most of them insects, which can act as either pests or beneficials depending on their modes of action. Among the main pests, cutting insects are notable in the early stages of the crop, sucking insects such as aphids and thrips during the vegetative stage, defoliating species like bollworm caterpillars, and armyworms; as well as other economically significant species, such as the cotton boll weevil, throughout the entire reproductive stage of the crop.

For several years, in the north of Santa Fe, damage to leaves and fruits caused by different Spodoptera caterpillars has been observed in both conventional (non-Bt) and Bt insect-resistant cotton crops. Due to its abundance, S. cosmioides has gained greater significance since 2018, followed by S. frugiperda, and to a lesser extent S. eridania and S. albula, which are considered secondary or sporadic pests (Fig. 1a, b, c, and d).

Figure 1. Larvae of the Spodoptera complex. a) Spodoptera frugiperda; b) S. cosmioides; c) S. eridania; d) S. albula

Spodoptera frugiperda, commonly known as the fall armyworm, corn cutworm, or late season armyworm, belongs to the Noctuidae family. It is a primary pest of maize and a secondary pest of cotton, rice, some vegetables, and other crops in various parts of the world. It exhibits significant variability in its biological parameters, between regions (tropical and subtropical), and even within the same regions, as a response to both biotic and abiotic environmental conditions.

In the early developmental stages of the crop, this species feeds on cotton, acting as a cutter on seedlings and later on shoots, flower buds, and developing capsules.

In the north of the Santa Fe province, the species exhibits two biotypes (maize and rice), which are morphologically identical but differ in genetic composition and feeding preference. In this region, rice biotype caterpillars have been found in cotton, wheat, sugarcane, and other grasses.

The typical damage caused by this species in cotton includes feeding holes on the leaves, although they rarely defoliate the entire leaf due to their ability to detect and reject Bt toxins. They also attack reproductive structures, such as buds, flowers, and capsules, with greater voracity, as the concentration of Bt toxin in these organs is lower than in the leaves (Fig. 2).

Figure 2. Damage caused by Spodoptera on cotton leaves and capsule

In a laboratory study, biological parameters of *S. frugiperda* were evaluated by feeding them with maize (Bt and non-Bt) and cotton varieties (Bt and non-Bt). The results showed higher survival rates on non-Bt maize (94%) compared to Bt cotton (71%). However, the longest larval stage occurred on Bt cotton (28 days) compared to non-Bt maize (14 days).

Among the pest management strategies, Bt cotton acts as a biological insecticide. The cotton varieties used in Argentina contain only the Cry1Ac toxin, which has low efficacy in controlling armyworms. However, despite its low effectiveness against these species, the implementation of refuges (a portion of the field planted with non-Bt cotton) is necessary. This reduces selection pressure and allows the survival of susceptible individuals, which, when mating with insects exposed to the toxins, help delay the onset of resistance in both *Spodoptera* and other pests such as the pink bollworm (*Pectinophora gossypiella*) and cotton leafworm (*Alabama argillacea*).

In the case of armyworms, the action threshold is considered when 5 to 10% of the reproductive organs show damage. As a cultural practice, it is recommended to keep the fields free of weeds, especially grasses and certain broadleaf plants such as pigweed (*Amaranthus sp.*) and purslane (*Portulacca oleracea*), as these caterpillars may initially feed on these plants and then move on to attack the crop.

BEHAVIOR OF THE COMPLEX IN OTHER REGIONS OF ARGENTINA AND THE AMERICAS

In the province of Chaco, Argentina, a pattern similar to that of Santa Fe was observed regarding the increase of certain species from the *Spodoptera* complex, such as *S. albula*. Its appearance in cotton crops has always been sporadic; however, in recent seasons (2022/23), it was recorded feeding on leaves, flowers, and capsules of various cotton varieties. Despite its high voracity and reproductive capacity, *S. albula* is tolerant to several chemical insecticides and the Cry1Ac toxin. In laboratory conditions, similar survival rates were observed in caterpillars fed with Bt cotton (70%) and non-Bt cotton (60%).

In the province of Santiago del Estero (Argentina), the *Spodoptera* complex is mainly represented by *S. frugiperda*, and to a lesser extent *S. cosmioides*, with *S. eridania* and *S. albula* appearing very sporadically. The damage attributed to these species primarily occurs during the maturation phase, with caterpillars feeding on leaves, flowers, and destroying large capsules.

In Brazil, *S. frugiperda*, *S. cosmioides*, and *S. eridania* affect cotton crops, acting as defoliators from the flowering bud stage to capsule maturation. Mainly, caterpillars of *S. cosmioides* and *S. eridania* feed on leaves and bracts and can damage floral buds; additionally, *S. frugiperda* may attack cotton seedlings, acting as a cutter. In Peru, although cotton crops are affected by a large number of pest species, similar to those reported in our region, the presence of *S. frugiperda* is almost nonexistent. In Colombia, in addition to *S. frugiperda*, *S. ornithogalli* and *S. sunia* are mentioned as affecting leaves and flowers. Historically, demographic explosions of *S. frugiperda* have been recorded in cotton crops in various departments across the country, without a particular pattern. These population changes are likely influenced by the heterogeneity of cotton agroecosystems. In Mexico, *S. frugiperda* is the primary species of the complex, with no reproducible spatial pattern year after year.

PRESENT AND FUTURE

The incidence of species from the *Spodoptera* complex in cotton in the north-central region of Argentina is advancing towards an increasing population, where several factors are likely interacting to transform these secondary pest species into primary pests in both transgenic and conventional cotton crops.

In recent seasons, a high proportion of *S. cosmioides* has been recurrently observed in cotton crops in the north of Santa Fe, with abundances higher than those of other defoliating caterpillars in the crop.

It is essential to understand the behavior, distribution, and occurrence of species that could be considered pests in regional crops, within the framework of integrated pest management, as well as the implementation of crop refuges for managing the resistance of these insects.

Integrated Pest Management (IPM) is key to achieving sustainable and efficient management in agroecosystems, aiming for long-term productivity and profitability, preserving natural resources, and improving people's quality of life. It is necessary to consider all available tools to discourage the development of pest populations while promoting crop growth with minimal disruption to agroecosystems. This approach must take into account the specific agricultural situations and their complexities, adapting IPM and crop protection to each regional reality.

Three-year analysis of cotton boll weevil (Anthonomus grandis Boheman) captures and their relationship with meteorological factors in an experimental field in the central Chaco region

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ABSTRACT

Cotton boll weevil, Anthonomus grandis B. (Coleoptera: Curculionidae) is the most damaging pest of the cotton crop in the Americas. This insect species causes high yield losses mainly due to the feeding activity and oviposition damage occasioned by the adult insects in the reproductive structures of cotton plants. One of the Integrated Pest Management tactics currently applied to monitoring the population dynamics and control this pest species involves the use of pheromone traps. Previous studies have demonstrated that climatic variables of the growing area affect the boll weevil population dynamics. The aims of this study are to analyze the results of monitoring the cotton boll weevil traps located in the experimental field of the Estación Experimental Agropecuaria Saenz Peña (Chaco province, Argentina) during the last three years and evaluate the incidence of the main meteorological variables on the insect capture data obtained over time. Eighteen pheromone traps were installed in strategic points of the experimental field and weekly revised. In parallel, meteorological variables of the period August 2021 to September 2024 were registered and analyzed. Our results evidenced

that the boll weevil population dynamic appeared directly related to the temperature and relative humidity, in addition to the presence of cotton crop. In fact, during the last year analyzed we observed a decrease in the average monthly number of captures per trap, particularly in the month of May likely associated with the unstable prevailing climatic conditions with an unexpected drop in the temperature. The evaluation of the climate variables in conjunction with the monitoring of the boll weevil population dynamics allows improving the criterion to predict a high pest population growth in the cotton fields, and this information should be considered for programming the next cotton season.

INTRODUCTION

Cotton boll weevil, Anthonomus grandis B. (Coleoptera: Curculionidae) is one of the most damaging pests of the cotton crop, Gossypium hirsutum L. (Malvaceae). It is native to tropical lowlands of Meso-America (southern and southeastern Mexico) and has distributed along the American continent (Burke et al. 1986; Scataglini et al. 2000; Lanteri et al. 2003). The damages caused by this insect include large declines in cotton yields and cotton acreage and occur from both oviposition and feeding on reproductive structures of the cotton plant (buds or squares, flowers and small bolls) (Showler and Cantú, 2005). All immature stages develop inside the reproductive structure of cotton, making their control difficult and inefficient (Oliveira, 2006). With the objective to implement a national boll weevil eradication program an Integrated Pest Management (IPM) strategy has been applied in the field, including the use of bait traps (male aggregation pheromone Grandlure) to monitor the weevil dynamics, and insecticide and bait traps to control pest populations (Dickerson, 1986; Grilli et al. 2012). Pheromone scout traps resulted a powerful tool to detect the presence and movements of the insect from the winter refuges to the crop, in the period prior to sowing and the first 30 days of the crop; and from the crop to the winter refuges, from the end of effective flowering to harvest (Sosa et al., 2009). Interestingly, periodic measurements registered of traps can be used to analyze the fluctuation of weevil populations and thus predict future focal point of high population density that could occur in the next growing season (Trochez, 1994).

The development, dispersal and survival of the boll weevil in commercial cotton fields are mainly influenced by environmental conditions such as temperature and relative humidity, which play a preponderant role, not only in stimulating the onset of diapause, but also in conditioning weevil survival (Parajulee et al., 1996; Rummel & Summy, 1997; Mas et al., 2002/03).

The aims of this study are to analyze the results of monitoring the cotton boll weevil traps located in the experimental field of the Estación Experimental Agropecuaria Saenz Peña during the last three years and to evaluate the incidence of the main meteorological variables on the insect capture data obtained over time.

MATERIALS AND METHODS

The experimental field of INTA Sáenz Peña is located near the city of Presidencia Roque Sáenz Peña (Chaco province, Argentina; 26° 50'37"S; 60° 25'36"W), covering an area of 95 hectares. Eighteen Grandlure attraction pheromone traps (scout type; T01 to T18, Figure 1) were installed and located in strategic points of the experimental field on stakes at a height of approximately 1.50 m (Figure1).

Figure 1: Spatial arrangement of the 18 pheromone traps located in the experimental field of the EEA Sáenz Peña, Chaco.

Traps were inspected every seven days and rebaited every 15 days throughout the analyzed period (from August 2021 to September 2024). The number of weevils collected per trap were registered, and then, averages were calculated for the total number of traps in the field. Trap maintenance consisted of cleaning, removing weeds in the surrounding area, and replacing broken or overturned devices.

The analysis of the monitoring activities was carried out together with data from the meteorological station of INTA Sáenz Peña (62° 52' 13.006"S; 60° 26' 56.49"W), thus obtaining measurements of the main variables to characterize the climate of the area under study (subtropical climate with dry season). The meteorological variables considered for the study were as follows: Mean Temperature (°C); Mean Maximum Temperature (°C); Mean Minimum Temperature (°C), Precipitation (mm) and Relative Humidity (%). Monthly averages were obtained for each variable corresponding to the three periods under study. A historical monthly average was calculated considering records from 1930 to 2023 for Mean Temperature (°C); Mean Maximum Temperature (°C); Mean Minimum Temperature (°C); records from 1924 to 2023 for Precipitation (mm); and records from 1965 to 2023 for Relative Humidity (%). To obtain the monthly averages, data from three daily observations (9 am, 3 pm and 9 pm) were used. The weather station is equipped with the following instruments: A precision maximum thermometer, Thermo Schneider minimum thermometer (both under meteorological shelter), Thermo Schneider dry bulb and Siap humidity thermometers (for calculating relative humidity) in vertical position on a psychrometric support and type A rain gauge at 50 cm.

RESULTS AND DISCUSSION

The boll weevil population dynamics assessed in the experimental field of INTA Saenz Peña (Chaco) by the analysis of insects captured in the 18 traps together with the meteorological variables during the period of three consecutive years (Figure 2) was found directly related to the temperature and relative humidity, in addition to the presence of cotton crop, as was previously reported by Casuso (2012). Besides, our findings agreed with Grossman (1930), who determined that a temperature of 27-28 °C together with a humidity of 50-60% make up the ideal environment for the boll weevil development. Particularly, we observed that a decrease in temperature (average monthly mean temperature, Figure 2b) seemed to be associated with an increase in the average monthly number of captures per trap (Figure 2a). This result showed a correspondence with pre- and post-harvest periods of the crop (April and May), when the boll weevil moves from the crop to the overwintering sites.

Precipitations seemed to show a different dynamic in relation to the insect captures, we observed an increase in accumulated monthly rainfall (Figure 2c) likely associated with an increase in the number of average monthly captures per trap (Figure 2a), in agreement with the authors who point out that cotton boll weevil populations increase their number in wetter periods (Grossman, 1930).

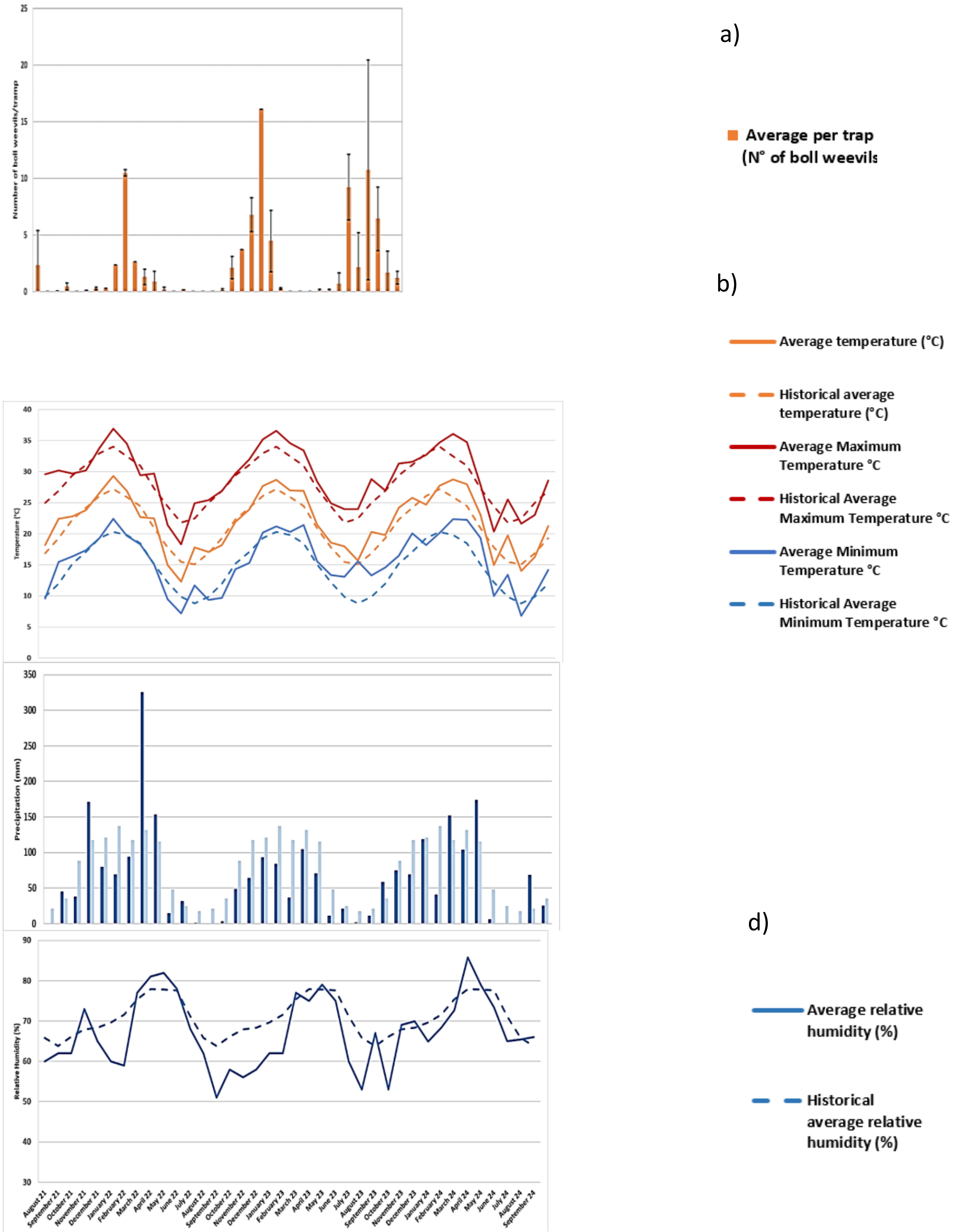

Figure 2: a) Monthly average of weevil captures in pheromone traps, together with their corresponding standard deviations. b) Maximum, mean and minimum temperature data (monthly averages and historical monthly averages) for the three years under study. c) Accumulated monthly and historical monthly precipitation for the three years under study. d) Monthly average relative humidity and historical monthly average relative humidity for the three years under study.

The peaks of average monthly boll weevil catches (Figure 2a) seemed to correspond with periods of relative humidity above 70% (average monthly relative humidity Figure 2d). Our results agree with Grossman (1930) in relation to the ideal conditions of temperature and relative humidity for the boll weevil development.

The data analysis of the whole period of three years (August 2021 - September 2024) evidenced the greatest variability for the number of catches in June 2024 (Figure 2a; standard deviation bars in black line). This result is possibly reflecting unstable climatic conditions during this last period. In addition, we observed a high drop in weevil counts during the month of May 2024 (Figure 2a) also showing changing climatic conditions, particularly a temperature decrease during that month (Figure 2b).

Our study showed that capture peaks occurred from the month of March onwards (Figure 2a) with maximum values in the month of May for the first season and in July for the second season. The last season (2023/2024) showed a different dynamics of boll weevils collected per trap. We observed two catch peaks during the months of April and June. The catch peak in April coincides with the pre-harvest and harvest period of the crop (Figure 2a). This effect has been previously documented for the boll weevil dynamics (Arias de Lavalle et al., 1994). These authors also described a decrease in trap captures during the flowering period, probably due to a competition among synthetic compounds of the traps, volatiles produced by plants and pheromones produced by males. As a result, a lower number of boll weevils were caught in traps.

CONCLUSION

The evaluation of the meteorological variables in conjunction with the monitoring of the boll weevil population dynamics is necessary to efficiently predict a high pest population growth in the cotton fields. The use of pheromone traps 60 days prior to planting, and the later inspection of the damage occasioned in plants during flowering is essential to assist adequately the Integrated Pest Management tactics adapted to each agricultural region. Particularly, the winter captures of the last season (2023-2024) should be taken into account for the programming of the next cotton season.

Although the purpose of this study was to relate the dynamics of the cotton boll weevil population with local meteorological conditions, it is essential to complement the information obtained by analyzing the influence of stubble control management carried out at regional level.

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