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PERFORMANCE EVALUATION OF POTATO (*Solanum tuberosum* L.) BEHAVIOR AS TEMPERATURES

Evaluación del rendimiento en papa (*Solanum tuberosum*, L.) a partir del comportamiento de las temperaturas

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ABSTRACT. The work was developed at the National Institute of Agricultural Sciences in order to evaluate the responses elicited in product yield variations in temperature during the crop cycle. Plants of three varieties of potatoes Call White, Santana and Spunta harvested during the years 2010, 2011 and 2012 respectively were used. The behavior of minimum temperatures, average of temperature and maximum temperature, amplitude of these and accumulated temperature too, were evaluated. The average of yield per plant in kilograms and inferred in t.ha^{-1} were determined. All statistical processing was performed with the use of the program Statgraphycs v5.1 and graphics were performed with the program Sigma Plot v3.1.

Key words: potato, performance, temperature

RESUMEN. El trabajo se desarrolló en el Instituto Nacional de Ciencias Agrícolas (INCA) con el objetivo de evaluar las respuestas provocadas en el rendimiento, producto de las variaciones de las temperaturas durante el ciclo del cultivo. Se utilizaron plantas de tres variedades de papa Call White, Spunta y Santana cosechadas durante los años 2010, 2011 y 2012, respectivamente. Se evaluó el comportamiento de las temperaturas mínimas, medias y máximas así como la amplitud de estas, además se determinó el rendimiento promedio por planta en kilogramos y se infirió en t.ha^{-1}. Todo el procesamiento estadístico se realizó con el empleo del programa Statgraphycs v5.1 y los gráficos se realizaron con el programa Sigma Plot v3.1.

Palabras clave: papa, rendimiento, temperatura

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the fourth most important food crop worldwide, after wheat, rice and corn. It is among the top ten staple foods produced in developing countries (1). In Cuba, it ranks the first place among roots and tubers; thus, around 7515 hectares are planted every year, reaching an average yield of 22.02 t ha^{-1} and an annual output of 165 508.6 ton[A]. It is a highly valuable food in the diet of Cuban population, so that it makes scientists and producers achieve greater production with higher crop quality.

Although it is planted in many geographic areas due to its great ecological plasticity (2), the most suitable conditions for its production in Cuba are comprised in a short period of time, from December to April, when temperatures are the lowest. In fact, its soil and climatic requirements should be considered, since this effect also counteracts to some extent for locating production areas in the most productive soils within the coldest season of the year, also taking into account the requirements of the technical instructions; nevertheless, crop cycle is reduced under these conditions (3).

In other regions, high yields depend on the productive potential of cultivated varieties and the agrotechnical management applied; however, in our region, the temperature is a determining factor for crop physiological development, so it is necessary to evaluate yield performance, considering temperature variations every year, which is the purpose of this paper.

MATERIALS AND METHODS

The work was conducted in potato (*Solanum tuberosum* L.) plantations from the experimental areas of the National Institute of Agricultural Sciences (INCA) during 2010, 2011 and 2012. Three varieties were used: Call White, Spunta and Santana, with imported

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[A]Manso, F. Informe Técnico de campaña de papa 2010-2011. MINAGRI. 2011. 11 pp.

seed tubers derived from Canada and the Netherlands, sized over 45 mm and planted at 0.30 x 0.90 m using a sampling design. Mechanized sprinkle irrigation was applied by Central Pivot machinery; the other cultural practices followed the Technical Instructions for this crop (3).

Minimum, average and maximum temperatures were measured from the data recorded in the nearby meteorological station to the experimental area, also determining its variations through the difference between daily maximum and minimum temperatures. The effective temperature above 10 ^{o}C was estimated from average temperatures and then the sum of temperatures was calculated per phase, considering Phase 1 from planting up to 30 days (tuber initiation), Phase 2 from tuber initiation up to 70 days (end of foliage growth) and Phase 3 from that moment until harvest (4).

At the end of harvest, the average yield per plant was determined in kilograms whereas total yield was estimated in t ha^{-1}. All statistical processing was performed by Statgraphics v5.1 program and figures were drawn by Sigma Plot v3.1 program.

RESULTS AND DISCUSSION

Figure 1A and B shows the total and marketable yield of tubers sized over 35 mm, respectively, during the years evaluated. It can be seen that the highest total yield was recorded by the variety Call White (58.0 t ha^{-1}), followed by Spunta and Santana (35.6 and 32.3 t ha^{-1}, respectively). Significant differences are denoted with respect to other varieties, thus demonstrating its high production potential upon the others. Similar values were achieved by this variety in previous studies (5).

Regarding marketable yield (Figure 1B), the variety Call White presented significant differences in 2010 and 2012; however, in 2011, differences were only marked with respect to the variety Santana. In both variables, a yield decrease became evident during the years of study.

Taking into account that temperatures constitute a significant factor under current climatic conditions and that they also have a great influence on yield behavior, a lower influence was denoted on the variety Call White, as it showed the highest yields all the time.

As shown in Figure 2, maximum temperatures showed lower values in 2010, and they stayed longer under that condition, favoring crop development and allowing it, in turn, to achieve higher yields than within the other years evaluated.

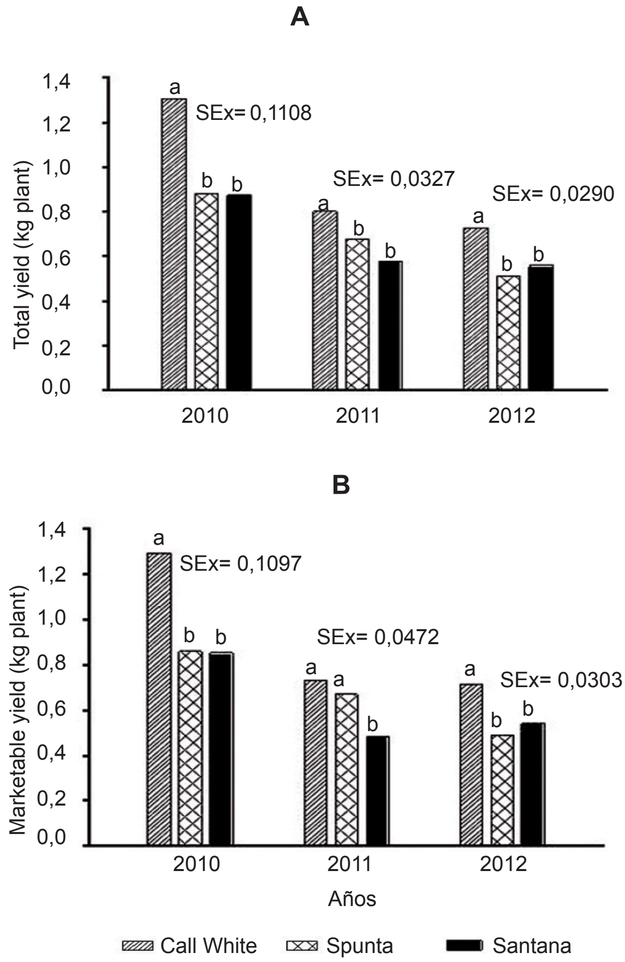


Figure 1. Behavior of total (A) and marketable (B) yields during the years of study

However, the most significant behavior of temperatures was recorded in 2010 (Figure 2), since they were favorable not only at tuber-developing stage but at their formation and growth as well (18-22 ^{o}C). As it is also shown, average temperatures for 2011 and 2012 exceeded those established as optimal, 15-20 ^{0}C (6, 7, 8); even though some varieties yielded the maximum at higher temperatures (9, 10), which is not the case of the varieties studied, considering their origin.

Some studies performed to evaluate the effect of temperatures on yield (11, 12) show that an increase in temperature above the aforementioned values reduces photosynthesis and increases respiration; consequently, the stored carbohydrates in tubers are consumed. The effect of such increase can range from an increase up to a marked decrease of yield and dry matter content of tubers. Also, it was proved that high temperatures induce late tuber formation, smaller leaves and taller plants, with a negative result in crop yield (13).

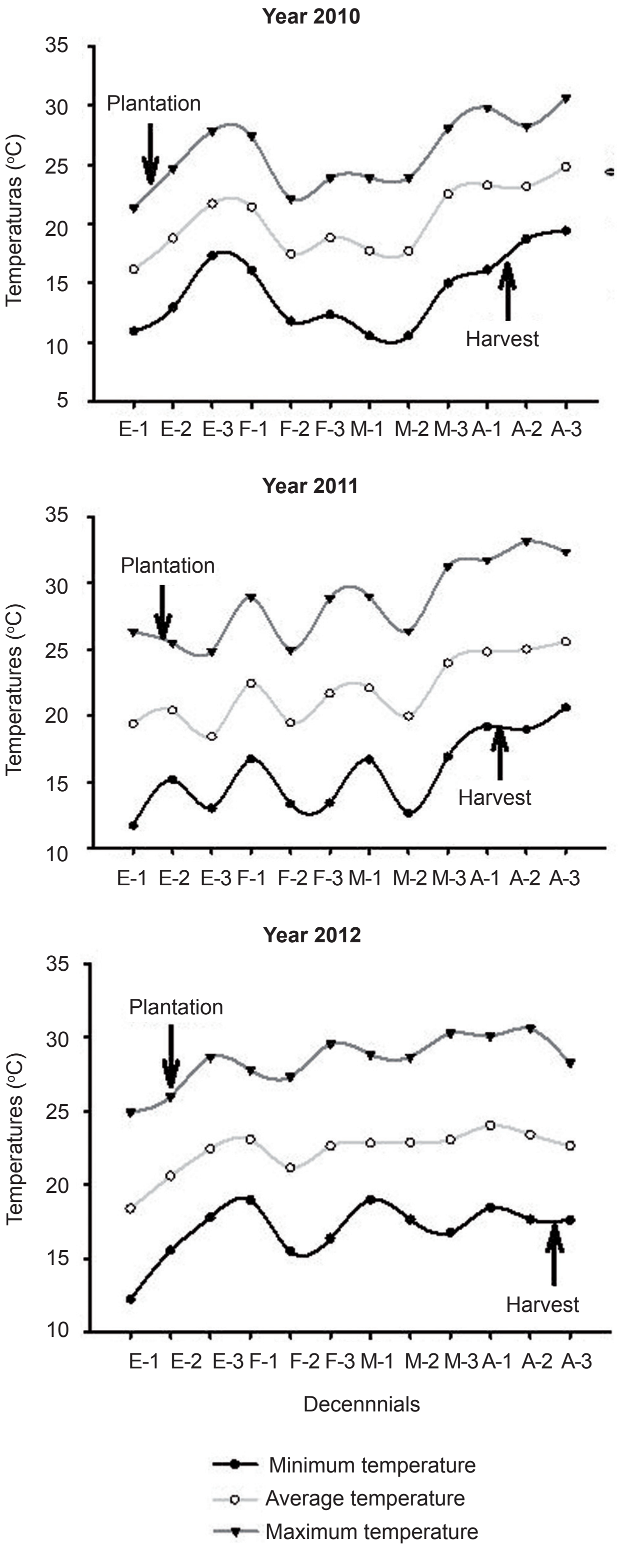


Figure 2. Behavior of temperatures during the three years of study

On the other hand, it suggests that sudden changes in temperature, as it occurred in 2011 and 2012 compared to 2010, affect the overall crop behavior, resulting in lower yields (14).

The greatest influence of this meteorological variable on the crop lies in the range of variations between maximum and minimum temperatures (Figure 3); the years evaluated presented a good behavior of this indicator, highlighting 2010, as it remained stable during tuber growth and development, favoring the yields achieved.

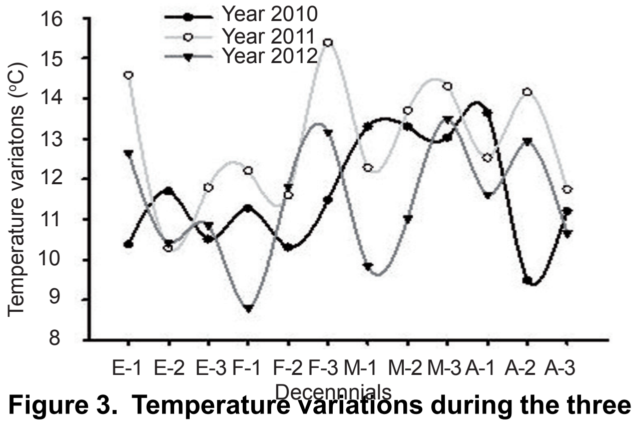
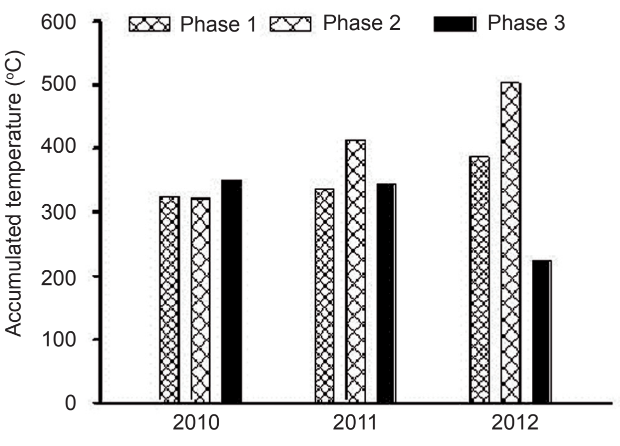


Figure 3. Temperature variations during the three years of study

In Figure 3, it can be inferred that a wider range of temperatures during the corresponding period towards the end of crop cycle allowed to a greater translocation of dry matter to tubers, favoring yield increase in 2010, as it had already been analyzed.

This figure also shows the trend in 2011 and 2012 to a greater temperature variability compared to 2010, which was more stable mainly in the early stages of crop cycle, enabling to achieve higher yields in that year. In some studies made on the climatic change in Latin America and its influence on agriculture, particularly on potato production, the productivity of this crop for 2010-2040 is expected to be reduced from 10 to 19 %, if measures of adaptation are not employed (15), an aspect that other authors also agree with (16).

Assuming that each stage of crop development requires an accumulated minimal temperature to reach its term, so that the plant can proceed to the next phase; Figure 4 presents the sums of temperature accumulated for each phenological phase in the three years of study.



(Phase 1 from planting up to 30 days (tuber initiation)
Phase 2 from tuber initiation up to 70 days (end of foliage growth
Phase 3 from that moment until harvest)

Figure 4. Accumulated temperature per crop phase during the years of study

During 2011 and 2012, a different behavior was denoted from 2010, in terms of the accumulated temperature range over each of the phases considered. Therefore, in 2010, the accumulated values were similar between phases, also corresponding to the year of higher yields reached by the varieties studied. The fact of registering higher temperatures at the second phase in 2011 and 2012, led to a greater accumulation; however, this situation affects tuber growth, an aspect that has been noted by other authors (4), who have indicated that high temperatures (28-30 °C) inhibit tuber growth, since the plant spends by respiration the highest amount of matter produced in the photosynthetic process.

Moreover, it is pointed out that both temperature and photoperiod (17) are the most influencing ecological factors on growth and development processes that lead to the final yield of a given genotype. Similarly, other investigators (18, 19, 20), studying other crops such as basil (Ocimum basilicum L.) and corn (Zea mays L.), have shown that temperature is one of the most important physical factors influencing directly on plant growth and length during its growth cycle, which is coupled to yield decreases in any species if the optimal growth is not reached.

CONCLUSIONS

During work development, it was proved that despite planting was conducted within the same season every year, temperatures showed a different behavior in 2011 and 2012 compared to 2010, for its decisive influence on the lower yields achieved in both years, an environmental condition that largely determines the yields of this crop. There is another element related to the behavior of temperatures that enabled to reach higher yields in the first planting, which was the fact that during the period of tuber growth, temperatures remained low for longer time than the other two, where decennial variations were greater.

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