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GROWTH PERFORMANCE AND YIELD OF WHEAT (*Triticum aestivum* L.) ON THREE PLANTING DATES

Comportamiento del crecimiento y rendimiento del cultivo del trigo (*Triticum aestivum* L.) en tres fechas de siembra

Naivy Hernández Córdova✉**, Francisco Soto Carreño and Rodolfo Plana Llerena**

ABSTRACT. Wheat (*Triticum aestivum* L.) is considered the oldest agricultural species cultivated by man and is currently the most widely cultivated cereal in the world. Each passing day, matures on earth, at least this important cereal crop, demonstrating the ability to grow and produce in environments and soil conditions very dissimilar. The present study was to evaluate the influence of three planting dates on growth and yield of this crop. The same was developed at the National Institute of Agricultural Sciences, at 23^0 01' N and 82^0 08' W and 138 m s. n. m.; were studied three planting dates: November 2008, December 2009 and January 2010, using a seed rate of 100 kg ha^{-1} seed. Destructive samplings were performed every 7 days from emerged plants until harvest, total dry weight (TDW) of the aerial partand Leaf Area Index (LAI) were determined, adjusting the data to an exponential model of the second degree, coefficients of determination (R^2) being between 0,90 and 0,99; where from regression equations calculated the absolute growth rate of dry mass of the aerial part (TAC), being a greater accumulation of dry matter in the sowing date January 2010 which was maintained throughout the cycle crop breeding. The dynamics of LAI and TDW showed a similar behavior of the dry mass, indicating that maximum values of these indicators and especially they are held for a longer period of time involving higher yields.

Key words: growth analysis, wheat, yield

RESUMEN. El trigo (*Triticum aestivum* L.) es considerado la especie agrícola más antigua cultivada por el hombre y es, en la actualidad, el cereal más cultivado en el mundo. Cada día que pasa, madura sobre la tierra, al menos una cosecha de este importante cereal, evidenciando la capacidad de crecer y producir en ambientes y condiciones edáficas muy disímiles. El presente trabajo tuvo como objetivo evaluar la influencia de tres fechas de siembra (tres condiciones de clima) sobre el crecimiento y rendimiento de este cultivo. El mismo se desarrolló en el Instituto Nacional de Ciencias Agrícolas, situado a los 23^0 01' N y a los 82^0 08' W, a 138 m s. n. m., en un suelo Ferralítico rojo compactado hidratado; se estudiaron tres fechas de siembra: noviembre de 2008, diciembre de 2009 y enero de 2010, utilizándose una densidad de siembra de 100 kg ha^{-1} de semillas. Se realizaron muestreos destructivos semanalmente después de emergidas las plantas hasta la cosecha, determinándoseles la masa seca total de la parte aérea, el Índice de Área Foliar (IAF) y el rendimiento, ajustándose los datos a una modelo exponencial polinómica de segundo grado, estando los coeficientes de determinación (R^2) entre 0,90 y 0,99; a partir de las ecuaciones de regresión se calculó la tasa absoluta de crecimiento (TAC) de masa seca de la parte aérea, encontrándose una mayor acumulación de materia seca en la fecha de siembra de enero de 2010, la cual fue mantenida durante todo el ciclo reproductivo del cultivo. La dinámica del IAF y la TAC mostraron un comportamiento similar al de la masa seca, indicando que valores máximos de estos indicadores y sobre todo que estos se mantengan durante mayor período de tiempo implican mayores rendimientos.

Palabras clave: análisis del crecimiento, trigo, rendimiento

INTRODUCTION

The yield of a crop depends on its capacity for growing and producing assimilates and of what part of them goes to the organs of economic interest. Its growth results from the use of sunlight in manufacturing constituent and functional components of the various

Instituto Nacional de Ciencias Agrícolas (INCA), gaveta postal 1, San José de las Lajas, Mayabeque, Cuba. CP 32 700.

✉ naivy@inca.edu.cu

plant organs. Therefore, it is directly related to the ability of foliage to capture the influencing light. The consequences of modifying the time of crop establishment on growth result from the effect of temperature, solar radiation and photoperiod on its phenology, leaf area development and dry matter accumulation (1).

Crop productivity is governed by complex interactions between climate and the ecophysiological processes they involve. The productive success not only depends on the intensity of climatic stimuli but also on their seasonal timing during crop life cycle (2).

Thus, variations in the sowing date significantly affect crop growth and development, since various stages of yield generation are situated under different conditions of solar radiation, temperature and rainfall (3, 4).

Wheat is a species having a wide range of adaptation, as it grows and develops under very different environments and can be grown in both winter and spring, which together with its high consumption, has allowed to be spread to many parts of the world and it is now regarded as one of the four largest cereal producers along with corn, rice and barley (5, 6). It is grown in more than 200 million hectares of land worldwide and it provides about one fifth of the total caloric input of the world's population (7).

In Cuba, the production of this kind of grain is possible, which has been proved by several researches (8, 9). There are references indicating the possible existence of a Cuban acclimated or adapted wheat cultivar since the colonial times, at the early nineteenth century; furthermore, between 1958 and 1965 the wheat variety "Cuba C-204" was developed through a process of an individual selection made in the variety BH-1146 from Brazil. Another study reviewing the development of wheat in tropical and subtropical warm and humid countries noted that it can grow under the conditions of this region (10).

The efficiency of cultivated plants with regard to yield and production can be measured by using growth rates, which indicate the effectiveness of plants to take advantage of the environmental factors where they grow and how plants distribute their assimilates (11). Thus, this study was aimed at evaluating the influence of three sowing dates (three climatic conditions) on wheat growth and yield.

MATERIALS AND METHODS

This work was conducted in the experimental area of the National Institute of Agricultural Sciences (INCA), located in San José de las Lajas, Mayabeque, at 138 m over sea level. To study different climatic conditions and using a sampling design, three sowing dates were established in plots of 200 m^2 (November 18, 2008, December 19, 2009 and January 26, 2010) on a hydrated compacted red Ferralitic soil (12). Wheat cv. 10-TH4 was seeded at 0.70 m using a sowing density of 100 kg ha^{-1} seeds.

Through weekly visual observations, some phenological phases were identified, namely: flag leaf emergence, spike emission, grain formation and physiological maturity. Every week, 15 days after emergence (DAE) and until harvest, 10 plants were evaluated per each plot, determining the following indicators by destructive samplings:

- ♦♦Dry mass of the aerial part (g m^2) by removing different plant organs and drying them in a forced circulation oven at 80 ^oC, up to a constant weight.
- ♦♦ Leaf area index (LAI) by estimating leaf area through the disk method based on dry mass.
- ♦♦Dry grain yield (t ha^{-1}).

Data of growth indicators were fit to a second degree polynomial exponential model, considering the regression coefficient and the biological behavior of the variable; the statistical program Statgraphics Plus 5.0 was used to calculate the absolute growth rate (AGR) of the dry mass (g m^2 day^{-1}) from these equations.

Data from average air temperature were taken at the meteorological station of Tapaste, nearby the experimental site (Figure 1).

RESULTS AND DISCUSSION

Figure 2 shows the different performance of the total dry mass of the aerial part between sowing dates. January 2010 is highlighted by a greater accumulation until 90 days after emergence, this period corresponding to the stage of grain formation, whereas a lower accumulation is recorded in November 2008. On the other hand, December 2009, which even occupies an intermediate position for about 80 days, since that moment on it continues to increase dry matter accumulation, reaching its maximum value at 105 days, it corresponding with the physiological maturity stage.

This becomes apparent when observing Figure 3, in which the performance of total dry mass is shown in every phenological phase; it can be seen that from flag leaf emergence until grain formation, the highest dry mass value was reached in January 2010, whereas the lowest one was recorded in November 2008.

The relationship between total biomass accumulation and grain production has been generally demonstrated in various studies, and in absence of crop limitations, the higher the biomass the higher the yield (13, 14).

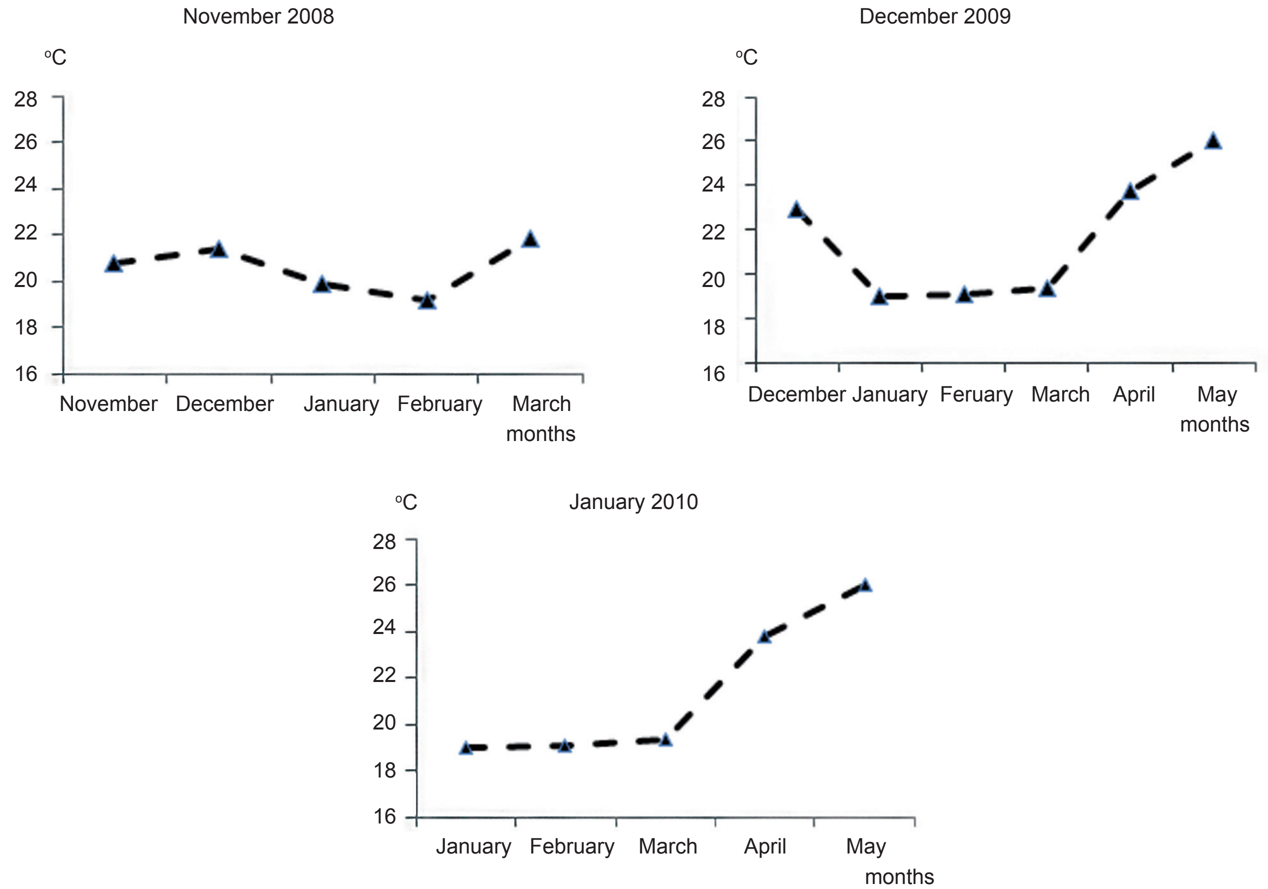
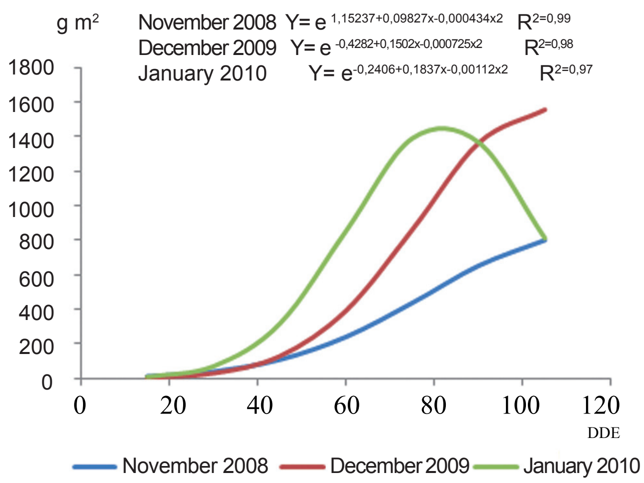


Figure 1. Performance of the average temperature at three sowing dates



(DAE: days after emergence)

Figura 2. Dynamics of total dry mass of the aerial part of plants at three sowing dates

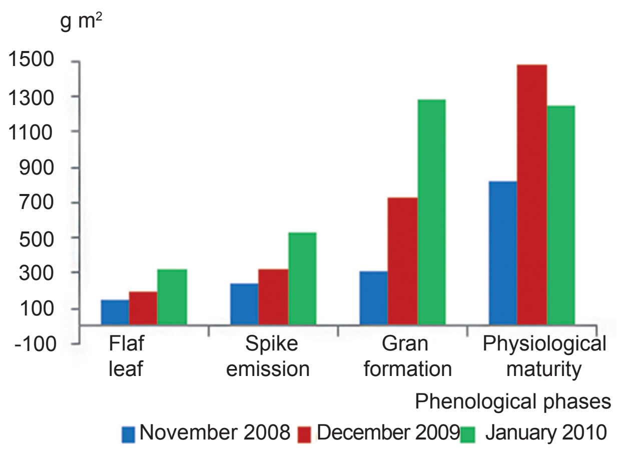


Figure 3. Performance of total dry mass of the aerial parts of plants in different phenological phases at three sowing dates

Figure 1 shows the performance of average temperature in each sowing date during the experimental period; it can be seen that in January, even though at the beginning average temperature was relatively low, three months after crop establishment this meteorological variable was increasing until reaching its maximum value at the end of the experimental period; in December, even though the average temperature was also increasing, it happened a month later; in the case of November, average temperature values remained relatively low during a large portion of crop cycle. The increase or decrease of crop growth period caused by variations in the performance of environmental conditions, essentially temperature, can affect crop yield (15).

As it is known, temperature is one of the most influencing meteorological variables on plant physiology (16, 17). The greater the temperature, the higher the rate of plant growth until reaching an optimal value, above which an increase in temperature causes its decrease. The main reason is the effect of temperature on the enzymatic reactions, because the greater the temperature, the higher the kinetic energy of molecules, thus increasing the speed of reactions. However, low temperatures affect physiological processes, decreasing the speed of enzymatic reactions. A decrease of a few degrees causes a significant change in growth rate. The effects of temperature on each of the processes determine its global effect on plant growth; in general, low temperatures reduce every stage of plant life cycle (18).

Studies on soybean crop point out that temperature is important for photosynthesis, thereby for plant growth, which in the period of higher temperature under the environmental conditions of Cuba allows to a greater dry mass accumulation[A]. However, achieving maximum yields will be directly related to a maximum net photosynthesis, it occurring within a fairly long time, so that a wider leaf area and length at the reproductive stage could lead to higher yields (19).

When analyzing the dynamics of LAI (Figure 4), the highest values are shown in January 2010, whereas the lower ones in November 2008, meanwhile December 2009 is at an intermediate position. By observing the performance of this indicator per phenological phase (Figure 5), it is evident that from flag leaf emergence up to grain formation, the greatest value of LAI was reached in January 2010, and the lowest one in November 2008. At the physiological maturity stage, values of December 2009 and January 2010 were similar.

[A]Cruz, O. Influencia de los factores agrometerológicos sobre la fenología, el crecimiento y el rendimiento de la soya (*Glicynemax* (L.) Merr.) variedad G7-R315. [Tesis de Doctorado]. 1991. 123 pp .

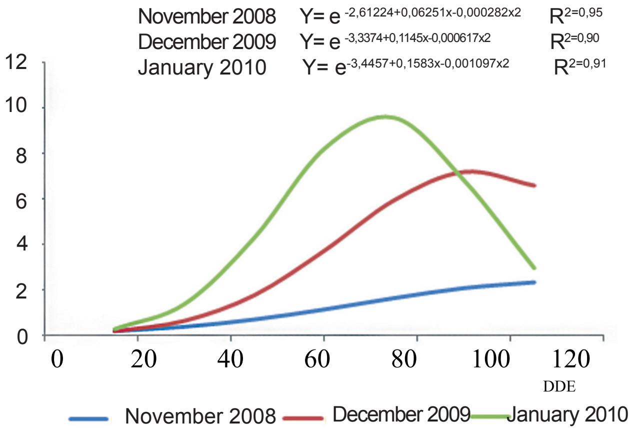


Figura 4. Dynamics of leaf area index at three sowing dates

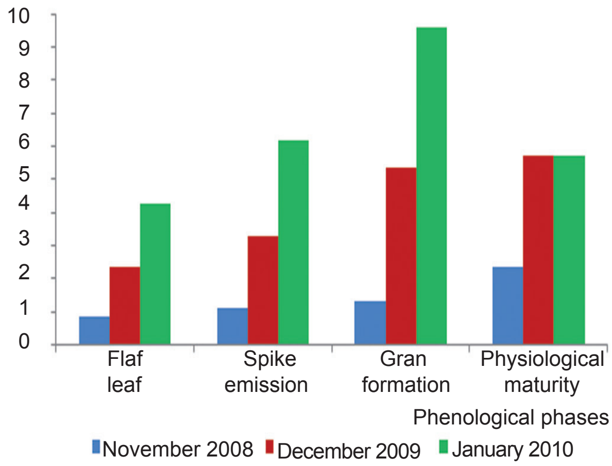


Figure 5. Performance of leaf area index in different phenological phases at three sowing dates

Dry matter production is related to leaf area; thus, when the latter is wide, a high dry matter accumulation is expected and if it lasts longer, extending to the reproductive phase, it is very important for obtaining good yields (20), so that the significant implications of leaf area extension for plant growth and dry matter production as well as its persistence must be taken into account, since it determines a greater or lower uptake of light energy during the growth process (21).

Absolute growth rate (AGR) constitutes an important indicator in determining the increasing rate of dry mass. In Figure 6, the dynamics of this indicator is observed during three sowing dates, which shows how the date of November 2008 lasted longer and reached the lowest values (14.52 g m^2 day^{-1}) with regard to the dates of December 2009 and January 2010; concerning the latter, it is important to note that the highest values of AGR (42.08 m^2 g day^{-1}) occurred during a shorter period of time, since the plants on this date reached the period of senescence at about

84 days, meanwhile in those seeded in November 2008 and December 2009, this period occurred 100 days after emergence.

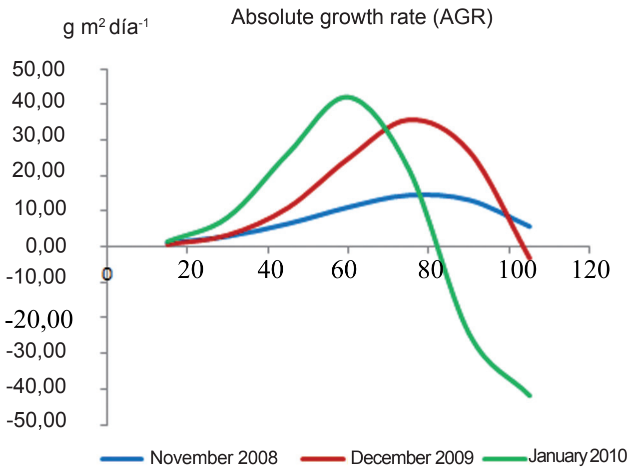


Figure 6. Dynamics of absolute growth rate (AGR) of the dry mass of plant aerial parts at three sowing dates

When analyzing the dynamics of this indicator, it greatly shows the importance of achieving high values of dry mass and leaf area index, and that they may remain high until the stage of grain formation.

Figure 7 shows the rate of dry mass accumulation per phenological phase; it can be seen how the maximum values of this index have different values according to sowing dates, resulting that January 2010 has the highest values, throughout the whole reproductive phase, except at the phase corresponding to grain formation, which shows lower values but very similar to the date of December 2009; whereas in November 2008, throughout its whole cycle, it showed a lower AGR increase with regard to the crops mentioned above, indicating that a higher dry matter accumulation and especially if it lasts until the reproductive phase should involve a greater yield.

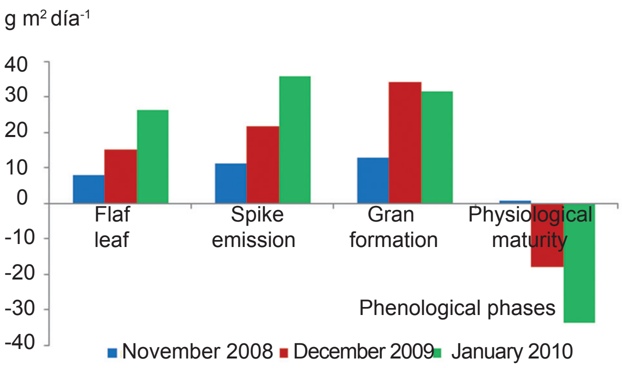


Figure 7. Performance of absolute growth rate (AGR) of the dry mass of plant aerial parts in different phenological phases at three sowing dates

Figure 8 presents the yields from three sowing dates; the significant performance of growth indicators, such as dry mass accumulation, LAI and AGR, can be appreciated, as it was previously observed on grain production. This highlights plant needs to reach its highest growth during the yield-forming stages, so as to achieve satisfactory results; therefore, the greatest agricultural yields are associated to an earlier and larger growth, based on the dry mass of plant aerial parts per unit area (22).

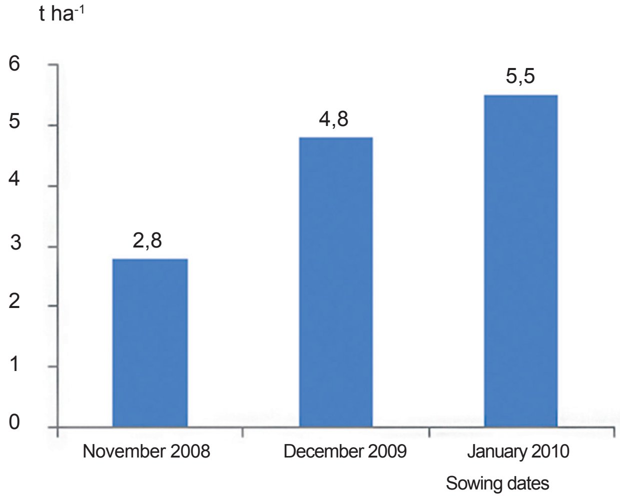


Figure 8. Agricultural yield of wheat reached at the three sowing dates evaluated

In this sense, different authors have made some observations on total biomass accumulation and grain production and, in case of corn grown under the conditions of Cuba, the higher the total biomass production, the higher the yield (13). Concerning beans, it has been shown that dry mass accumulation next to harvest and LAI are indicators related to yields (22).

CONCLUSIONS

- With regard to wheat crop, yield and growth cycle length are influenced by temperature, besides that the latter is one of the key factors determining crop yield.
- Biomass production is the result of how much efficiently plants have used solar radiation and the length such efficiency has been held.
- A greater leaf area index and its length, as well as dry matter accumulation at the reproductive stage, besides an adequate distribution of assimilates lead to higher yields.

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