Thermal Requirements and Productivity of Squash (*Cucurbita moschata* Duch.) in the Cerrado-Amazon Transition

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Summary

The thermal requirements for the phenological stages of squash cv. 'Menina Brasileira Precoce' were evaluated. The experiment was conducted in a Red-Yellow Dystrophic Oxil soil and Tropical Climate (Aw), with six winter/spring planting dates (June 5, 15, 25 and July 5, 15 and 25, 2013). The determination of accumulated degree days (GDD) was given considering the minimum and maximum basal temperatures of 12 and 35 °C. The average duration of phenological stages were 6.4, 29.2, 48.2, 60.9, 63.0 and 69.6 days, with demands for thermal time of 88.2; 401.9; 661.5; 832.5; 858.6 and 985.5 GDD for phases to emergence, emission of first male button and first female button, first male flower and first female flower and early harvest. The proportion of female/male flowers ranged from 1:8.4 to 1:18.1. The smaller proportions of female/male flower provided a lower number of fruits per plant and productivity. The timing of fruit harvest should be set when fruit development reaches 100 GDD (8.0 days after the female flower emission).

Keywords: *Curcubita moschata,* degree days, flowering, phenology

Necesidades térmicas y productividad de calabacín (*Cucurbita moschata* Duch.) en la transición Cerrado-Amazónica

Resumen

Se evaluaron las necesidades térmicas de las diferentes etapas de crecimiento del calabacín cv. «Menina Brasileira Precoce». El experimento se realizó en un suelo Oxisol Distrófico rojo-amarillo y en clima tropical, en los cultivos de invierno/primavera, con seis siembras (5, 15, 25 de junio y 5, 15 y 25 de julio de 2013). La determinación de los grados acumulados (GDD) se hizo considerando las temperaturas mínima y máxima basales de 12 y 35 °C. La duración promedio de las etapas fenológicas fue de 6,4; 29,2; 48,2; 60,9; 63,0 y 69,6 días, con demandas de tiempo térmico de 88,2; 401,9; 661,5; 832,5; 858,6 y 985,5 GDD para las fases de emergencia, primeros capullos de las flores masculinas y femeninas, primeras flores masculinas y femeninas y cosecha precoz. La proporción de flores femeninas/masculinas fue de 1:8,4 a 1:18,1. Las proporciones más bajas de flores femeninas:masculinas generaron un menor número de frutos por planta y menor productividad de la planta. El momento de cosecha de la fruta debe fijarse cuando el desarrollo del fruto alcance 100 GDD (8,0 días después de la emisión de flores femeninas).

Palabras clave: *Cucurbita moschata*, grados día, floración, fenología

Introduction

Pumpkins belong to the Cucurbitaceae family, genus *Cucurbita*, are important crops in different Brazilian regions. Overall, the *C. moschata* (Duch.), *C. maxima* (Duch.), *C. pepo* (L.), *C. mixta* (Pangalo) and *C. ficifolia* (Bouche) species are cultivated in Brazil. The species *C. moschata* is considered to be the most important pumpkin species in Tropical America due to the large areas cultivated with it and to its variability (Mascarenhas et al., 2007).

This pumpkin is an annual plant with indeterminate growth. Vegetative, flowering and fruiting parts present concomitant development (Filgueira, 2008; Côrrea and Cardoso, 2016). Its culture is characterized by monoecy, as well as by large and showy flowers. Male flowers emerge above the leaves canopy, at the end of long petioles. The female flowers have prominent inferior ovaries, and they anticipate the size of the future fruit (Carpes et al., 2008). The number of male and female flowers differ in *C. moschata*, as the number of female flowers is quite smaller in comparison to the number of the male ones (Salata, Bertolini and Cardoso, 2008).

This pumpkin is a tropical plant, and its growth and development are favored by mean temperatures ranging from 18 to 24 °C, although the species also tolerates higher temperatures (Maynard, 2007). The species of the genus *Cucurbita* are monoecious and they depend on biotic vectors to ensure pollination. Flowering is the most sensitive period to environmental effects during the phenological phases of species belonging to this genus (Zehtab-Salmasi, 2006). According to Maynard (2007), high temperatures promote male flowers and delay female flower development. The exposure to daytime temperatures of 32 °C and to night temperatures of 21 °C causes the death of female flower buds (Maynard, 2007; Carpes et al., 2008).

Cucurbita moschata Duch. is one of the most consumed pumpkins worldwide; it represents an important food source in many countries. This species has great social and economic importance in Brazil since it is the basic food for many low-income families. The Northeastern region presents the highest variability of this species, which is easily accepted by the market and is widely produced (Ramos et al., 2010). *Cucurbita moschata* Duch. is significantly important to the Brazilian agriculture, mainly to traditional and/or family agriculture farms, since it has different regional uses and its applications depend on nutritional, cultural and social values (Ramos et al., 2010; Carvalho, Peixoto and Ferreira, 2011).

In Brazil, the species *C. moschata* can be consumed in its immature stage squash or when it is fully mature. Some features such as rusticity, precocity, yield potential, yield stability, fruit size and color uniformity, excellent sensory qualities (texture, flavor and reduced cooking time) and good post-harvest conservation, make the different cultivars and/or squash hybrids greatly accepted for consumption (Resende, Borges and Gonçalves, 2013; Pôrto et al., 2014).

Although *C. moschata* is a widespread culture in the Brazilian scenario, it is necessary to know the possible effects of production technique changes (fertilization and/or mulching planting, irrigation, fruit thinning and phytosanitary treatments), definition the growing seasons, crop planning of production cycles, the storage and disposal, among others depending on the genetic diversity, as well as the soil type and climatic requirements (Blank et al., 2013).

Mato Grosso State presents socio-economic dynamics and complex spatial configuration based on the agricultural activity, despite its growing urbanization and great natural resources (water, forests, etc.). Therefore, supplying certain vegetables is a huge problem due to the high transportation costs and to the loss of *in natura* product quality, mainly when the cargo goes to regions located in the North of the State. Besides the distance from the production sites, there is few scientific research related to physiologic responses and/or the production yield of horticultural crops in this region.

The Northern region of Mato Grosso State presents two well-defined seasons: the rainy season (from October to April) and the dry season (from May to September). There is a narrow annual temperature amplitude (monthly averages ranging from 22 to 26 °C) and a greater temperature range in winter (Souza et al., 2013; Santos et al., 2013). The regional water conditions favor the cultivation of this vegetable. Irrigation in the dry season is demanding due to the reduction in foliar diseases; however, air temperature variations can lead to changes in the phenology and productive performance of the plant. The aim of the current study is to assess the phenological stage thermal requirements (accumulated degree days) of squash cv. 'Menina Brasileira Precoce', in six winter crops sowing dates (with ten-day intervals) under Sinop climatic conditions, in Mato Grosso State, Brazil.

Materials and Methods

The experiment was conducted from June to December 2013 in the experimental area of Plant Production Sector at Federal University of Mato Grosso, Sinop Campus, which is located 11º85 'S and 55º38'57' W, at 345 m altitude. The soil is classified as Yellow Dystrophic Oxisol and presents the following chemical characteristics in the 0 to 0.20 m depth: pH (H_2O) = 5.11; OM, sand, silt and clay = 45.07; 383; 146 and 471 g dm^{-3}; P and K = 2.48 and 65.0 mg dm^{-3}; Ca, Mg, H+Al = 1.02; 0.27 and 5.2 $cmol_c$ dm^{-3}; SB = 1.46 $cmol_c$ dm^{-3}; Base saturation (%) = 21.9. According to the Koppen classification, the climate is Aw (Tropical climate), with two well-defined water seasons: the dry (May to September) and rainy (October to April) seasons. The mean monthly temperature ranges from 22.96 to 25.76 °C. The annual rainfall and evapotranspiration are approximately 1974 and 1327 mm $year^{-1}$, respectively (Souza et al., 2013).

The herein used squash cultivar Menina Brasileira Precoce (*Cucurbita moschata*, Duch.) has cylindrical neck shape, light green color with dark green streaks and its harvest takes place between 60-70 days, a fact that highlights its precocity. The planting holes were 0.40 x 0.40 x 0.40 m (length, width and depth) and 2.0 x 2.0 m spacing (between plants and lines). Three (3) seeds, originated from the company Feltrin Seeds, were sown per hole at the depth of 0.04 m. Thereafter, fifteen (15) days after sowing (DAS), thinnings were performed in order to keep one plant per hole. Liming and fertilization were done in the pit using 4.2 t ha^{-1} Filler limestone and 150 kg ha^{-1} P_2O_5, 60 kg ha^{-1} K_2O and 60 kg ha^{-1} N, as it is recommended by Mascarenhas et al. (2007) for squash cv. Menina Brasileira. The P_2O_5 was applied all at once, whereas K_2O and N were applied in 40 and 30 % fractions in the base, and the remaining 60 and 70 % were divided into two fertilization covers (30 and 55 days after emergence (DAE), respectively. Soybean mulch was applied (30 t ha^{-1}) at 10 DAE to minimize the effect of spontaneous vegetation. Whenever necessary, the phytosanitary treatments against pests and diseases were applied using recommended products and doses. The water supplementation of 4.0 mm day^{-1} was adopted as a reference (Souza et al., 2013).

Plants were daily inspected in the morning shift to identify phenological phases (emergence, first male flower bud, first female flower bud, first male flower, first female flower, fructification, and harvest) and the number of fully expanded leaves. The number of male and female opened flowers per plant was quantified 30 days after flowering. Twenty-five (25) flowers (after opening) were selected and identified by sowing epochs to determine fruit growth rates; the performed measurements were flower length, and open flower ovarian longitudinal and equatorial diameters. This is a fruit cultivar which is prolonged after fertilization. The length and diameter of the squash neck (1.0 cm apart from the stalk) and bulge (hole with seeds) were measured at two-day intervals, until harvesting. Harvest was manually done at the time the fruits had a length between 0.22-0.27 m, were still green (immature) and sensitive to pressure.

During the experimental period, the meteorological data were collected by an automatic station through CR 1000 data acquisition system and global solar radiation (pyranometer CS300), wind speed and direction (anemometer, 03002-L RM YOUNG) sensors, as well as through a psychrometer with thermometer shelter (CS 215) and a rain sensor (TE 525). The meteorological measurements were collected at 5 minutes intervals and stored according to hourly and daily scales. The minimum (Tb) and maximum (TB) basal temperatures of 12 and 35 °C respectively (Mota et al., 1977), were used to find the thermal sums (accumulated degree days, GDD) for squash. The proposal by Ometto (1981) was adopted due to cases that were seen as possible, depending on the local weather conditions, as it was recommended by Souza et al. (2011).

Case 1: Tm > Tb; TB > TM

$$GDD = [(TM - TB)^2]/2 + (Tm - Tb) \qquad \text{(eq. 1)}$$

Case 2: Tm d» Tb < TM ; TB > TM

$$GDD = [(TM - TB)^2]/[2(TM-Tm)] \qquad \text{(eq. 2)}$$

Case 3: Tb < Tm; TB < TM

$$GDD = 2[(TM\ Tm)\ (Tm - Tb)] + [(TM - Tm)^2] - [(TM - TB)^2] / (2[TM - Tm)] \qquad \text{(eq. 3)}$$

Case 4: Tb > Tm; TB < TM

$$GDD = 0.5\ [(TM - Tb)^2] - [(TM - TB)^2)] / (TM - Tm) \qquad \text{(eq. 4)}$$

where: TM and Tm = maximum and minimum are daily temperatures (°C). Tb and TB = minimum and maximum basal temperature.

The experiment was conducted in randomized blocks with six treatments (sowing epochs with ten-days intervals in winter, on June 05, 15th, 25th, and July 05, 15th, 25th of 2013) and four repetitions of five plants each. The variables assessed in the present experiment were subjected to variance analysis (ANOVA) through F-test, which considered the seeding epochs as variation source. The means were compared through Tukey test ($p \leq 0.05$).

Results and Discussion

Minimal air temperatures of 10.13, 11.01 and 11.35 °C were observed in July 24th and 25th, as well as on November 8th, 2013, respectively. The Tm was higher than Tb in the other periods and TB was lower than TM in August and

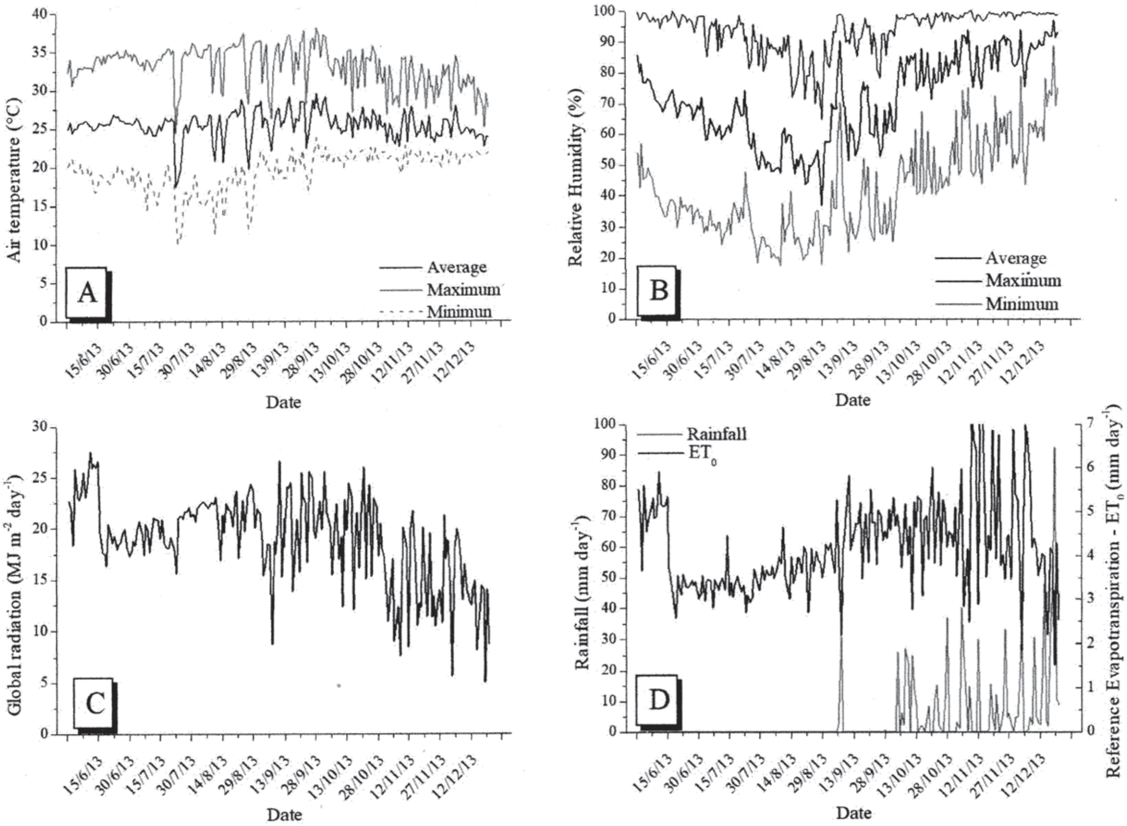

Figure 1. (A) Air temperature variations, (B) air relative humidity, (C) global solar radiation and (D) precipitation and reference evapotranspiration from June.05 to December.23, 2013, in Sinop, Mato Grosso State, Brazil.

September 2013 (23 days). Figure 1 shows daily temperature range reduction and global radiation caused by the rainfall period which goes from March 10 to December 21, 2013, with rainfall accumulations of 34.4; 224.4; 219.8 and 364.8 mm from September to December.

Such climatic behavior allowed obtaining optimal conditions to assess the floral biology of this culture. According to Pacini et al. (1997), for *C. pepo*, the male flowers are prevalent and have short lifetime during high-temperature periods. These flowers open before dawn and close in mid-morning.

There were significant variations in the duration (number of days) and thermal requirements (GDD) of the phenological phases linked to flowering depending on the different sowing dates (Table 1). Similar results were found by Paula et al. (2005) in a study conducted in a potato crop. Trentin et al. (2008) conducted a study in a watermelon crop and found variations in the duration of the development stages rather than in the GDD. According to these authors, such result regards the mean air temperature throughout the cycle, which did not exceed the optimum temperature for culture development.

This behavior is often expected since the degree-days method assumes a linear link between temperature and plant development; however, such connotation is only true into the cardinal temperature range of the plant – minimum base temperature Tb; optimum temperature – Topt; and maximum base temperature TB (Fagundes et al., 2010; Cardoso, 2011; Souza et al., 2011). The coefficient of variation (CV %) could be used to measure the duration variability (days or degree days) on the developmental phases of cultures grown at different times (Cardoso, 2011). Regarding the total squash cycle (sowing-harvest), the highest CV values (%) were found when the time was expressed in degree days, rather than in the civil calendar. This result corroborates the one found by Paula et al. (2005) in their study conducted in a potato crop. As for the duration of the developmental sub-periods in GDD, the CV values (%) ranged from 9.3 to 14.2 %.

The greatest changes between sowing dates were seen in the emission of the first male and female flower buds and in the openings of male and female flowers. Such result suggests that the induction of reproductive stages presents more variation than the GDD definition. The proximity between the CV percentage found in the duration of the developmental sub-periods (in days) and the thermal time may be a good method to describe the biological time of the plant (Trentin et al., 2008; Paula et al., 2005).

The emergence of squash seedlings in different sowing times demanded from 75.1 to 91.4 degree-days (5.3 to 7.3 days). The cucurbit seeds depend on well-defined temperature limits in order to germinate. Temperatures below 15 °C delay the germination rate (Nascimento, 2005). The recorded maximum temperatures increased from 35.9 °C (T1 - June.05) to 37.8 °C (T6 - July.25). It was noticed that the plant developmental cycle in the last planting season was prolonged when TM exceeded TB (Cardoso, 2011) (Table 1).

According to Miranda and Campelo Junior (2010), higher temperatures can reduce the vegetative growth of this plant, thus they delay the developmental stages. However, Bueno et al. (2012) studied the variability effects on the thermal range in orange growth (*Citrus sinensis* L. Osb.) and found that thermal range reduction negatively interfered in the vegetative growth. There was first male and female flower bud emission delay (Carpes et al., 2008); therefore, they were affected by the lower daily thermal conditions and by the reduced daily accumulated GDD. Thus, they demanded longer time to accumulate the same thermal sum and to, subsequently, change the reproductive stages in squash plants. The female sowing-flowering period demanded from 763.4 to 993.1 GDD (56-76 DAS). There was an early male flower opening trend in comparison to the female flowers.

According to Salata, Bertolini, and Cardoso (2008), male flowers often appear before the female ones, in squash crops. According to Côrrea and Cardoso (2016), squash is a monoecious plant, i.e., it has male and female flowers in different places. Pollination problems may occur due to lack of synchronicity between the opening of the first male and female flowers in the same plant (Salata, Bertolini and

Table 1. Time duration and thermal requirements on phenological stages of squash cv. Menina Brasileira Precoce, in different planting dates in winter, Sinop, MT.

Sowing	Emergence	FMFB	FFFB	FMF	FFF	Harvest
Necessary time to phenological phase onset (days)						
June.05 (1)	6.3 b	22.8 a	46.8 ab	56.4 a	57.8 a	65.3 ab
June.15 (2)	5.3 a	24.8 a	43.4 a	53.7 a	56.1 a	62.7 a
June.25 (3)	5.4 a	32.8 b	49.1 b	70.0 c	66.8 b	74.9 bc
July.05 (4)	6.8 bc	30.3 b	51.4 b	62.0 abc	62.8 ab	68.9 ab
July.15 (5)	7.0 bc	30.0 b	46.9 a b	58.1 ab	57.7 a	63.9 a
July.25 (6)	7.3 c	34.4 b	51.4 b	65.2 bc	76.5 c	81.9 c
Mean	6.3	29.2	48.2	60.9	63.0	69.6
CV (%)	9.7	13.2	7.7	10.8	11.3	12.1
Accumulated thermal sum (Degree days)						
June.05 (1)	89.5 c	380.7 a	696.4 bc	786.5 ab	876.4 ab	974.5 ab
June.15 (2)	75.1 a	355.4 a	598.8 a	736.1 a	763.4 a	850.7 a
June.25 (3)	81.4 ab	448.0 b	658.8 abc	951.3 c	892.3 ab	1021.0 b
July.05 (4)	91.9 cd	398.3 ab	683.4 abc	831.2 abc	842.4 ab	932.1 ab
July.15 (5)	99.8 d	370.2 a	620.8 ab	787.2 ab	783.6 a	908.9 ab
July.25 (6)	91.4 bcd	458.9 b	710.6 c	902.6 bc	993.8 b	1225.5 c
Means	88.2	401.9	661.5	832.6	858.6	985.5
CV (%)	9.2	13.1	10.7	11.5	14.1	13.7

Means within each column followed by the same letter do not differ statistically by Tukey's test at 5 % probability. First male flower bud (FMFB), first female flower bud (FFFB), first male flower (FMF), first female flower (FFF).

Table 2. Male and female flowers number per plant of squash cv. Menina Brasileira Precoce, in different planting dates in winter, Sinop-MT.

Sowing date	Male flowers	Female flowers	Proportion (fem/mal)
June.05 (1)	321.36 ab	21.73 abc	1:18.10 b
June.15 (2)	371.73 a	28.27 a	1:13.70 ab
June.25 (3)	214.73 c	26.18 ab	1:8.41 a
July.05 (4)	226.73 bc	19.09 bc	1:12.84 ab
July.15 (5)	197.36 c	16 c	1:13.31 ab
July.25 (6)	83.36 d	4.81 d	1:13.36 ab

Means followed by the same letter do not differ statistically by Tukey at 5 % probability.

Cardoso, 2008). Overall, pollination failures may be due to the absence of pollinating insects, continuous rains or low temperatures (Lattaro and Malerbo-Souza, 2006).

The number of squash female flowers opening daily is usually smaller than the number of male flowers, thus influencing the intensity of pollination and fruit formation. Female and male flower proportions ranged from 1: 8.4 to 1: 18 (Table 2), and only significant differences were observed between the sowing of June.05 and June.25.

Lattaro and Malerbo-Souza (2006) found ratios between female:male flowers of 1: 3.2 in *Cucurbita mixta* (hillbilly zucchini), whereas Amaral and Mitidieri (1966), in their study about the pollination of *Cucurbita moschata,* found 1: 17.7. Thus, their results corroborated those findings in the current study. Fruit development starts after the squash flower is pollinated. The harvesting point can be the mature or green stages depending on the consumption rate. The fruits would remain in the field during this period.

Sowing time does not influence the fruit growing rates. It was found that 15.7 % of the assessed fruits were harvested six days (70.7 GDA) after flower opening (DAF). These fruits' fresh mass was 0.4343 kg (Table 3), on average; approximately 100 and 127.3 GDD (8 and 10 DAF). Harvesting percentages were higher than 66.7 % and 87.6 %. However, it was observed that fruits required 179 GDD to reach the harvesting point; they showed no massive increase in comparison to fruits harvested in earlier GDD stages.

The fast growth of immature squash fruits is justified by the localized distribution of flowers and fruits in the reproductive phase of cucurbits (Floss, 2006). Braga et al. (2011) found that the higher dry matter accumulation in the aerial part of watermelon plants occurs at fruit onset and that the fruits are responsible for 63 % of the accumulated mass.

Harvest time duration did not significantly differ between different sowing times (Table 3). Harvest times lasted from 72 to 83-day intervals and from 1.5 to 2.4 fruits per harvest, on average. Table 4 shows the physical characteristics of fruits harvested at different sowing times.

The mean fruit length varied from 242.8 to 277.5 mm, whereas the apex diameters (near the peduncle) ranged from 48.2 to 58.6 mm, and the bulge diameter from 66.8 to

Table 3. Productive compounds of squash cv. Menina Brasileira Precoce, in different planting dates in winter, Sinop-MT.

Sowing date	NH	HTD (days)	AFPP	PP (kg)	PROD(ton ha^{-1})
June.05 (1)	13.27 a	78.27 a	19.54 a	10.10 a	25.26 a
June.15 (2)	17.45 bc	80.73 a	28.82 bc	15.92 b	39.79 b
June.25 (3)	18.18 c	83.09 a	32.09 c	19.22 b	48.06 b
July.05 (4)	13.82 ab	81.09 a	26.27 abc	16.93 b	42.31 b
July.15 (5)	12.27 a	76.18 a	27.73 bc	18.13 b	45.32 b
July.25 (6)	10.00 a	72.27 a	24.09 ab	17.16 b	42.90 b

Means followed by the same letter do not differ statistically by Tukey test at 5 % probability. Number of harvest (NH), harvest time duration (HTD), average number of fruits per plant (AFPP), production per plant (PP), productivity in Mg ha^{-1} (PROD).

Table 4. Lenght, diameter, and fruits fresh mass of squash cv. Menina Brasileira Precoce, in different planting dates in winter, Sinop-MT.

Sowing	Fruits length (mm)	Apex diameter (mm)	Bulge diameter (mm)	Fresh mass of fruits (kg)
June.05 (1)	246.98 a	50.18 ab	66.83 a	0.5288 a
June.15 (2)	242.83 a	48.20 a	73.55 a	0.5462 a
June.25 (3)	259.74 ab	49.84 a	69.70 a	0.5971 ab
July.05 (4)	263.07 ab	55.99 ab	72.34 a	0.6504 bc
July.15 (5)	260.14 ab	52.25 ab	76.33 a	0.6548 bc
July.25 (6)	277.49 b	58.58 b	69.60 a	0.7155 c

Means followed by the same letter do not differ statistically by Tukey test at 5 % probability.

76.3 mm. As for the relationship between the bulge and apex diameters, it was observed that the planting dates influenced fruit shape and length. Longer length fruits had greater apex and bulge diameters; however, the diametric relations were lower (more elongated and thinner fruits). The mean of fresh mass of each fruit ranged from 0.5288 to 0.7155 kg. The sowing in July.25 led to greater dimension and fresh mass fruits, as well as to smaller harvest number (10). With sowing at August.02.2013, Côrrea and Cardoso (2016) found mean values of 73.0 mm; 51.0 mm and 310 mm for bulge diameter, apex diameter, and length of squash fruit cv. Menina Brasileira, in hot humid temperate climate (mesothermal) in Brazil.

In general, with increases of the fruit numbers per harvest, occurs reduction of the size and fresh mass of the fruit, because the plant directs the new photo-assimilates produced for the formation of new fruits (source-sink dynamics). The sowing performed in June.05 showed significant differences in production per plant and productivity; it led to lower production rates per plant and productivity (10.10 kg plant^{-1} and 25.26 ton ha^{-1}). Overall, the mean production values ranged from 15.92 to 19.22 kg plant^{-1}, whereas the mean yield ranged from 39.79 to 48.06 ton ha^{-1}. Côrrea and Cardoso (2016) found mean values of 627.0 g (fresh mass of fruit), 7,3 fruits per plant and 4.54 kg of fresh mass per plant, in mesothermal climate.

According to Mascarenhas et al. (2007), squash hybrids can produce approximately 20-24 ton ha^{-1} of fruit. However, regardless the planting season, the current study found better yields, a fact that suggests the great potential of this crop under Sinop- MT soil and weather conditions. An increasing production per plant (kg plant^{-1}) and productivity (ton ha^{-1}) trend are associated to later sowing dates. Such a trend may be due to the beginning of the rainy season in the region (September/October) at the time of fruit production.

The rainfall reduces the solid particle concentrations (aerosols, burned waste, dust, and others) in the air, and provides increased incidence of direct radiation on these plants, consequently, generating more radiation availability in the photosynthetic processes. However, according to Lattaro and Malerbo-Souza (2006), the rains also reduce the insect pollinators, indicating that plantations in the rainy season in the Sinop-MT region may not always indicate higher productivity for squash. According to Larcher (2004), the plant productivity increases due to the intercepted and absorbed radiation. The assimilation period and the type of assimilative capacity of cucurbit crops sowed between the third and tenth day of June showed greater yield.

Conclusions

The highest productivity levels of squash in the Sinop-MT region, for winter planting, are obtained with sowing dates in July. Later sowing dates do not influence the thermal requirements of fruit growth but increase the size and fresh mass of squash fruit. Squash developmental stages were 48 and 69.6 days, on average, and the accumulated thermal sums were 661.5 and 985.5 GDD for the first female button emission and the early harvest, respectively.

The proportion of male and female flowers influenced the harvest number, the fruits per plant and productivity. Greater male and female flower proportions resulted in smaller agronomic performance. The fruit of squash cv. Menina Brasileira Precoce should be harvested at 100 GDD (8 days) after the female flower opening.

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