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Production performance of sunflower genotypes in Campo Novo do Parecis, Brazil´s main producing region of the oleaginous plant

Flávio Carlos Dalchiavon[1*], Anderson Morais Kimecz[1], Marcelo Marchesini[1], Diego Hahn Machado[1], Wellington Junior Candido da Silva[1], Rosivaldo Hiolanda[1] and Claudio Guilherme Portela de Carvalho[2]

[1]Department of Agronomy, Federal Institute of Education, Science and Technology of Mato Grosso (IFMT), 78360-000, P. O. Box 100, Campo Novo do Parecis MT Brazil.
[2]Brazilian Agricultural Research Corporation, Embrapa Soybean, 86001-970, Londrina - PR, Brazil.

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Sunflower crops have a wide adaptability to several edaphoclimatic conditions, with possible alternative for a second harvest. Crops are diversified and extra profit is collected by the producer. Current assay determines the agronomic characteristics of the sunflower genotype planted in second harvest in Campo Novo do Parecis MT Brazil, the main sunflower producing region in Brazil. The assay was conducted on the experimental field of the Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso, Campus Campo Novo do Parecis MT Brazil, in the agricultural year 2016-2017. Experimental design comprised randomized blocks with 4 replications and 5 treatments from hybrids SYN 045, BRS G40, BRS G49, BRS G50 and BRS G51. The sunflower´s vegetative and reproductive characteristics were evaluated. Hybrids SYN 045, BRS G51 and BRS G40 had good performance in grain and oil. Hybrid BRS G51 showed good performance in grains and oil with reduced cycle and size.

Key words: Production components, performance of varieties, *Helianthus annuus.*

INTRODUCTION

The sunflower (*Helianthus annuus*) is an annual dicotyledon plant of the family Asteraceae, known for its adaptability to different edaphoclimatic conditions making possible its cultivation in all continents. The crop is employed for the production of edible oil and animal feed, among others (Souza et al., 2015; Carvalho et al., 2019).

It is highly common in Brazil to have a second summer harvest in February, when the main crop, planted between October and the start November, is harvested (Porto et al., 2008; Dalchiavon et al., 2015). Sunflower is one of the crops suitable as the second summer crop, mainly cultivated in the central-western region, especially in Campo Novo do Parecis, state of Mato Grosso, Brazil. The area cultivated in Brazil in 2017-18 reached 95.5 thousand hectares, of which 60.5 thousand hectares were in the state of Mato Grosso (CONAB, 2018). In

*Corresponding author. E-mail: flavio.dalchiavon@cnp.ifmt.edu.br. Tel: +00 55 65 996175059.

these areas, the Brazilian production totaled 142.2 thousand tons, with 101.9 thousand tons mainly produced in Campo Novo do Parecis. The region is characterized by adequate temperature and well-defined dry season (Dalchiavon et al., 2016a, b).

Current agricultural system in Campo Novo do Parecis scarcely employs crop rotation, with the subsequent occurrence of pests and diseases. The sunflower is an oleaginous plant, with greater resistance against draught, cold and heat than most of the species cultivated in Brazil. In fact, it features great adaptability to different soil-climate conditions, practically not affected by latitude, altitude and photoperiod (Porto et al., 2008). Consequently, it is a good option in crop rotation systems in the region of Campo Novo do Parecis, since it contributes towards agricultural diversity (Dalchiavon et al., 2016a,b).

Research-based data have been decisive for the technological basis of the crop´s development in Brazil, with greater productivity and competitive economical profits (Dalchiavon et al., 2019). The proper selection of cultivars is one of the main components of the crop´s production system among the several technologies developed for the production of sunflower (Porto et al., 2007; Souza et al., 2014). Cultivars should be adapted to regions and should have features that facilitate cultural practices, decrease risks of production loss and increase the producer´s profits (Dalchiavon et al., 2016a). Current assay determines the agronomic characteristics of the sunflower genotype planted in the second summer harvest in Campo Novo do Parecis MT Brazil.

MATERIALS AND METHODS

The experiment was developed within the experimental area of the Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso (IFMT) - campus Campo Novo do Parecis, during the harvest of the agricultural year 2016-2017, at 13°40'37''S and 57°47'30''W, altitude 564 m. According to the Brazilian Classification of Soils (EMBRAPA, 2013), the region´s soil is typical Red-Yellow Dystrophic Latosol. Initial fertility characteristics for the 0- 0.20 m layer had the following features: pH ($CaCl_2$) = 4.97; MO = 27.02 g dm^{-3}; K^+ = 0.05 $cmol_c$ dm^{-3}; Ca^{+2} = 2.17 $cmol_c dm^{-3}$, Mg^{+2} = 0.85 $cmol_c dm^{-3}$; H^+ = 4.61; H+Al = 4.61 $cmol_c$ dm^{-3}; P = 7.47 mg dm^{-3}; Cu = 1.03 mg dm^{-3}; Zn = 4.19 mg dm^{-3}; Fe = 189.53 mg dm^{-3}; Mn = 15.76 mg dm^{-3}, with V = 39.98%.

According to Köppen´s classification, local climate, referred by Vianello and Alves (2004), is Aw, or rather, tropical climate with a well-defined dry season between May and September. Dry and rainy seasons are well-defined: dry between May and September and rainy between October and April (Dallacort et al., 2011). Figure 1 shows mean rainfall and temperatures during the experimental period. Mean rates comprised 31.0; 23.3 and 18.4°C respectively for maximum, mean and minimum temperatures, with rainfall at 510.4 mm, perfectly fitting the crop´s water demand between 500 and 700 mm, regularly distributed throughout the cycle (Castro and Farias, 2005).

Experimental design comprised randomized blocks with 5 treatments and 4 replications. Treatments consisted of hybrids SYN 045 (control), BRS G40, BRS G49, BRS G50 and BRS G51. Tested hybrids were simple hybrids developed by Embrapa´s improvement program. Experimental plots were formed by four 6 m rows, with 0.45 m spaces and a population of 45,000 plants ha^{-1}. Useful area was defined by two 5.0 m central rows, taking off 0.5 m from each edge, as border, and side rows.

Prior to seeding, the area was sprayed with herbicide Paraquat (20% i.a.) at 1.5 L ha^{-1} to eliminate infesting plants on the experimental area. Seeding, with three seeds per hole, was performed with a sowing rack on 10th March 2017. Thinning occurred 10 days after emergence (DAE) so that only one plant/hole would remain. Base fertilization followed Leite et al. (2007) with a chemical analysis of the soil to attend to crop needs: 10 kg ha^{-1} N; 70 kg ha^{-1} P_2O_5; 60 kg ha^{-1} K_2O; 2 kg ha^{-1} B, distributed previously with seeding, at a row below the seeds, with a 7-row sower. Cover fertilization was done 30 DAE, at 60 kg ha^{-1} N, with urea, and 0.5 L ha^{-1} Boron through the leaves, with borosol (14.6% Boron), with application volume at 200 L ha^{-1}.

Weeds were eliminated by hand at 7, 20 and 35 DAE. Pest and disease controls were undertaken by constant monitoring of the area. Two applications of Tiametoxan + Lambda Cialotrina (141 g L^{-1} + 106 g L^{-1} i.a., respectively), at dose 250 ml ha^{-1}, were undertaken for the control of the cucurbit beetle (*Diabrotica speciosa*), sunflower patch (*Chlosyne lacinia*) and the *Cyclocephala melanocephala* beetle, when plant reached V4 stage (four true leaves) and V6 (six true leaves); an application of Alpha-cypermethrin (1000 g L^{-1} i.a.) at 100 ml ha^{-1} when sunflower reached R1 (visible inflorescence); and one application of acephate (750 g kg^{-1} i.a.) at 1 kg ha^{-1} when the sunflower reached R5 (start of anthesis). Two doses of Difeconazol (250 g L^{-1} i.a.) at 0.3 L ha^{-1} were applied for disease control of plant pathogen *Alternaria helianthi*) when crop reached V6 and R1. Applications were done by shoulder-strapped pump with CO_2, at a constant pressure of 60 pounds.

Hand harvest was undertaken within the useful area when the crop reached the phenological stage of physiological maturity (R9) on June 30th 2017. A mechanized trailer (Maqtron – B 350 STD) was employed to separate achenes from the head and send for laboratory analysis. Achenes were weighed and humidity corrected to 11% (b.u.), following Dalchiavon et al. (2016a).

Evaluated agronomic characteristics at R5.5 (full florescence), in five plants per plot, comprised plant height (PH; m), measured by tape and taking soil level as the highest section of the plant; stalk diameter (SD; mm), measured by digital caliper at 5 cm from soil level; fresh mass of aerial section (FMA; t ha^{-1}) and of root (MFR, t ha^{-1}) and dry mass of the aerial sector (DMA; t ha^{-1}) and of root (DMR, t ha^{-1}), after weighing and drying of plants in a buffer at 105°C. Harvest of fresh and dry mass of the aerial sector was divided into stalk, leaves and head.

Assessment of the following in five head was undertaken at R9: head diameter (HD; cm), measuring its extremities by tape; number of achenes per head (NAH), by grain counter (Model NV-C/01); mass of head (MH; g) and mass of achenes per head (MAH; g) by semi-analytic scale (0.01 g); harvest index (HI), by dividing the mass of achenes by the mass of the head; mass of 1000 achenes (MTA; g) and the productivity of achenes (PA; kg ha^{-1}), based on the harvest of plants of the plot´s useful area.

Assessment was also made for initial florescence days (IFD) and days for physiological maturity (DPM), till plants reached stage R4 (initial florescence) and R9 (physiological maturing), respectively; number of broken plants (NBP) and number of lodging plants (NLP) within the plot´s useful area (R9), for hectare; oil rate (OR; %), forecast by spectroscopy (Grunvald et al., 2014) and oil productivity (OP, kg ha^{-1}), calculated by the product of oil rate of achenes (%) and the productivity of achenes (kg ha^{-1}) / 100. When data complied with the presuppositions of homogeneity and residues´ constant variance, they underwent analysis of variance; when F was significant ($p<0.05$), Tukey´s mean test was applied by SISVAR (Ferreira, 2011); Pearson´s co-relationship analysis was employed between characteristics, by Excel.

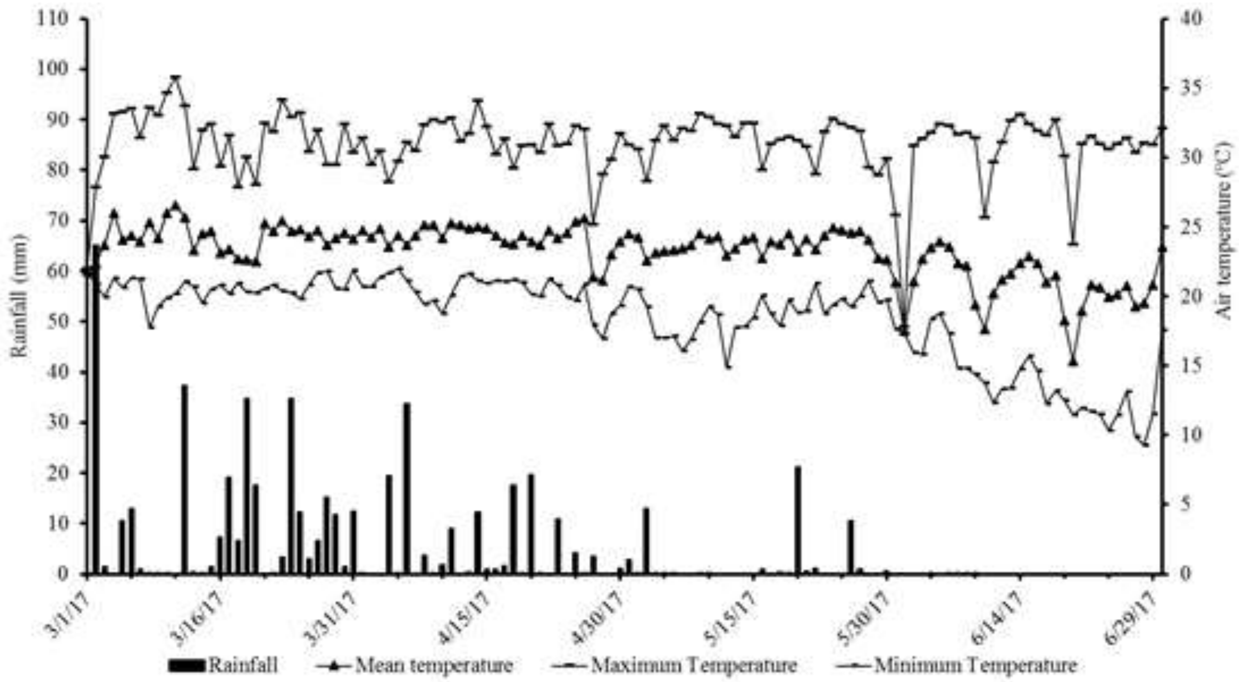

Figure 1. Rainfall and mean temperature in the experimental region between March and June, 2017.

RESULTS AND DISCUSSION

There was significant difference ($p<0.05$) among the characteristics evaluated for physiological maturing days, height of plants, stalk diameter, number of lodging plants, mass of one thousand achenes, mass of achenes per head and productivity of achenes (Table 1). The physiological maturing of genotypes had a general average of 107 days (Table 1). However, the latest material was SYN 045, with 113 days (Table 2), whereas the others did not statistically differ from one another, varying between 105 and 107 days. An assay by Carvalho et al. (2016), conducted in Tangará da Serra MT Brazil, a town with similar edaphoclimatic conditions as that in current study, proved SYN 045 to be the latest, with 106 days, whereas hydrids BRS G40, BRS G49, BRS G50 and BRS G51 did not differ among themselves, with rates between 93 and 94 days. Difference in the hybrid cycle among studies may be the result of severe draught in the municipality of Tangará da Serra. In fact, sowing dates were similar, or rather, March 9th, 2016 for Tangara da Serra and 10th March 2017 for Campo Novo do Parecis. According to Dalchiavon et al. (2016b), very early hybrids are less prone to the occurrence of insect pests, diseases and water deficit in second harvest crop when compared to late hydrids. Risk in production loss and grain quality may be reduced if the management of these factors is not efficient.

According to Kaya et al. (2007), there is a significant co-relationship between physiological maturing and plant height. In current study (Table 2), the latest hybrid (SYN 045) was the highest. Dalchiavon et al. (2016b) also reported such co-relationship in their study in which Genotype GNZ Neon was the latest, featuring 99 days, and the highest, featuring 199.00 cm. Highest averages in plant height were reported for SYN 045 (164.1 cm), BRS G40 (164.7 cm) and BRS G51 (131.9 cm). The first two hybrids differed statistically from the others (Table 2), with averages below 125.8 cm (BRS G50 and BRS G49), corroborating data by Carvalho et al. (2016), who registered SYN 045 as the highest (114 cm) and BRS G50 and BRS G49 as the shortest, featuring 88.0 and 81.0 cm, respectively, and by Dalchiavon et al. (2016a) who also registered highest average for SYN 045 (198.5 cm). The above proved that the hybrid had the plant´s highest height. Plant height is an important characteristic when mechanized agriculture is taken into account since higher plants may make difficult mechanized operations. Shorter and more uniform plants are required for an adequate mechanized harvest, with fewer losses (Pivetta et al., 2012; Dalchiavon et al., 2016a,b; Hiolanda et al., 2018).

With the exception of BRS G49 (16.5 mm), all hybrids had a stalk diameter greater than 18.0 mm and did not differ statistically from control SYN 045 ($p<0.05$) (Table 2). Stalk diameter is an important characteristic for crops. According to Biscaro et al. (2008), their good development causes less lodging, making easier crop treatments and mechanized harvest. In current assay, there was a decrease in final population: 0 (SYN 045); 1.03 (BRS G50); 2.06 (BRS G51) and 3.09% (BRS G49) when compared to initial population of 45,000 plants ha^{-1},

Table 1. Analysis of variance for the characteristics of the sunflower under analysis (Campo Novo do Parecis MT Brazil, 2017).

Characteristics[1]	F[2]	CV (%)[3]	GM[4]
IFD	0.4	5.4	57.0
DPM	6.2*	2.5	107.0
PH	10.8*	8.3	139.4
SD	4.7*	9.4	19.3
NLP	6.8*	76.6	1157.5
NBP	1.1	111.2	1111.2
HD	2.1	9.2	17.8
FMR	1.9	16.9	3.5
FMA	1.8	17.3	36.3
DMR	2.0	20.6	1.7
DMA	0.8	12.4	6.1
MTA	7.8*	18.4	70.5
NAH	1.3	15.8	715.0
MAH	3.8*	27.0	45.7
HI	2.5	7.9	0.6
PA	7.5*	13.0	2185.8
OR	0.9	4.02	41.9
OP	4.61*	13.4	855.7

[1]IFD = initial florescence days (days), DPM = days for physiological maturing (days), PH = plant height (cm), SD = stalk diameter (mm), NLP = number of lodging plants (plants ha^{-1}), NBP = number of broken plants (plants ha^{-1}), HD = head diameter (cm), FMR = fresh mass of roots (t ha^{-1}), FMA = fresh mass of aerial sector (t ha^{-1}), DMR = dry mass of root (t ha^{-1}), DMA = dry mass of aerial sector (t ha^{-1}), MTA = mass of one thousand achenes (g), NAH = number of achenes per head, MAH = mass of achenes per head (g), HI = harvest index, PA = productivity of achenes (kg ha^{-1}), OR = oil rate; OP = oil productivity; [2]* significant at 5%; [3]CV = coefficient of variation; [4] GM = general means.

Table 2. Average of characteristics: days for physiological maturing (DPM, days), plant height (PH, cm), stalk diameter (SD, mm) and the number of lodging plants (NLP, plants ha^{-1}) (Campo Novo do Parecis MT Brazil, 2017).

Genotype	DPM	PH	SD	NLP
SYN 045(T)	113.0[a]	164.1[a]	21.8[a]	0.0[b]
BRS G40	105.0[b]	154.7[ab]	19.0[ab]	3009.5[a]
BRS G49	105.0[b]	120.4[c]	16.4[b]	1389.0[ab]
BRS G50	107.0[b]	125.8[c]	18.8[ab]	463.0[b]
BRS G51	107.0[b]	131.9[bc]	20.0[ab]	926.0[b]
DMS	5.9	26.1	4.0	1998.8

*Different letters differ by Tukey´s test at 5% probability. T = control.

due to lodging plants. Against Biscaro et al. (2008), albeit with similar SD, the hybrid BRS G40 had the greatest NLP (6.69% lodging) when compared to SYN 045, BRS G50 and BRS 51. On the other hand, the hybrid BRS G49 had similar NLP when compared to SYN 045, with the lowest SD.

Hybrids BRS G40 (82.1 and 46.6 g) and BRS G51 (80.4 and 46.4 g) provided the mass of 1000 achenes (MTA) and mass of achenes per head (MAH) similar to SYN 045 (86.7 and 64.7 g) ($p<0.05$) (Table 3). On the other hand, hybrid BRS G50 (44.5 and 36.8 g) had lower average rates to control for the two characteristics. Co-relation between MTA and the productivity of achenes (PA) (r = 0.647**) and between MAC and PA (r = 0.649**) were significant and positive, corroborating assays by Amorim et al. (2008), Pivetta et al. (2012) and Stasiak et al. (2018). Results for MTA and MAC may explain the productivity difference between the genotypes, since other characteristics such as the number of achenes per head and head diameter failed to showed any statistical difference between the genotypes.

The productivity of achenes varied between 1731.1 and 2499.3 kg ha^{-1} (Table 3). Rates are above average for Brazil for the 2017-2018 harvest, with 1489 kg ha^{-1}

Table 3. Average of characteristics: mass of 1000 achenes (MTA, g), mass of achenes per head (MAH, g), productivity of achenes (PA, kg ha^{-1}) and productivity of oil (OP) (Campo Novo do Parecis MT Brazil, 2017).

Genotype	MTA	MAH	PA	OP
SYN 045(T)	86.7^{a}	64.7^{a}	2499.3^{a}	1012.2^{a}
BRS G40	82.1^{a}	46.6^{ab}	2427.8^{ab}	912.4^{ab}
BRS G49	58.5^{ab}	33.8^{b}	1731.1^{c}	682.8^{b}
BRS G50	44.5^{b}	36.8^{b}	1792.7^{bc}	689.3^{b}
BRS G51	80.4^{a}	46.4^{ab}	2477.7^{a}	987.5^{a}
DMS	29.2	27.8	640.3	258.8

*Different letters differ by Tukey´s test at 5% probability. T = control.

(CONAB, 2018). SYN 045, BRS G51 and BRS G40 were highlighted, with achene productivity over 2400 kg ha^{-1}. SYN 045 (2499.3 kg ha^{-1}) average was 19 and 29% higher than that given by Dalchiavon et al. (2016a) and Hiolanda et al. (2018), respectively. The two had the same genotype, sown during the same period and in the same region as BRS G40 with 16% higher in achene productivity by Poletine et al. (2013) in an assay in Umuarama PR Brazil, during the 2011-2012 harvest. The existence of positive co-relationships between PA and PH were reported by Kaya et al. (2007) (r = 0.235**), Dalchiavon et al. (2016b) (r = 0.610*) and Stasiak et al. (2018) (r = 0.240*), and also in current assay (r = 0.621**). In fact, SYN 045 provided the highest plant and the highest rate in achene productivity (Tables 2 and 3), whereas hybrids of the shortest plants (BRS G49 and BRS G50) had the lowest averages in achene productivity. However, even with positive co-relationship between PH and PA, the hybrid BRS G51 had the smallest size, with PA similar to SYN 045.

According to Castro and Farias (2005), late cycle genotypes had a greater time period for grain filling and tended towards greater achene productivity rates. Hybrid SYN 045 was the latest and the most productive in absolute value. However, BRS G51 had PA similar to control ($p<0.05$), albeit earliest and shortest.

In current study, there was no significant difference between the hybrids´ oil rates, with a 41.9% average. This rate is higher than that desired by industries (over 40%). In fact, some industries forecast a depreciation of the product when rates are below those expected, or a bonus when rates are above (Porto et al., 2008). Since there was no difference between oil rates, the hybrids (SYN 045, BRS G51 and BRS G40) with greater grain yield were also those with highest oil yield.

Conclusion

(1) Hybrids tested showed similar performances for flowering, number of lodging plants, number of broken plants, head diameter, fresh and dry mass of root and aerial sector, number of achenes per head, mass of achenes per head and harvest index.
(2) Hybrid BRS G51 has good grain and oil yield, adequate plant´s cycle and height when cultivated in Campo Novo do Parecis, the main producing region in Brazil.
(3) As a proposition of this initial study, it is recommended to repeat it in time and in different places.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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