

Full Length Research Paper

Phenology of “Niagara Rosada” grapevines grafted on different rootstocks grown on Cerrado (Brazilian savanna) of Goiás State, Brazil

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The purpose of this experiment was to study the phenological stages from pruning to harvest of the ‘Niagara Rosada’ grapevine grafted on different rootstocks grown on Cerrado conditions (Brazilian savanna) at the Goiás State, in the middle west of Brazil. The trial was carried out in Mineiros County, to evaluate phenological stages of ‘Niagara Rosada’ grapevines grafted on three rootstocks (‘Ripária do Traviú’, ‘IAC-766 - Campinas’ and ‘IAC-572 - Jales’ and cultivated on climate and soil conditions of Cerrado (Brazilian savanna). The results showed that the cycle (from pruning to harvest) of ‘Niagara Rosada’ had differences on number of days according to the rootstock: 109 days on ‘Ripária do Traviú’, 112 days on ‘IAC-766’, and 113 on ‘IAC-572’, and the thermal summation requirements to complete the phenological cycle of ‘Niagara Rosada’ were 1,167.4, 1,197.9 and 1,207.4 degree-days, respectively. It can be concluded that climate and soil of Cerrado provided cycle reduction of ‘Niagara Rosada’.

Key words: *Vitis vinifera*, rootstock, phenological characterization, Brazilian savanna.

INTRODUCTION

The viticulture is a traditional and important agricultural trade worldwide. In Brazil, grape yield was 1.77 million tonnes obtained from 78,273 hectares in 2007 (FAO, 2009). In 2008 in Brazilian regions, crops were mainly at the States of Rio Grande do Sul (776,964 tonnes), São Paulo (193,534 tonnes), Pernambuco (165,075 tonnes), Paraná (101,500 tonnes), Bahia (97,481 tonnes), Santa Catarina (58,330 tonnes), Minas Gerais (13,711 tonnes) and Goiás (5,619 tonnes) (IBGE, 2009). Studies of grapevine phenology have been developed in these regions (Leão and Silva, 2003) and have contributed

significantly to grape yield development.

Recently, other Brazilian locations have planted grapevines, as in the Middle-Western region; however these places need researches and technologies in order to develop the viticulture activities (Silva et al., 2006). Within this region, State of Goiás has large area on the Cerrado biome (Brazilian savanna) where viticulture has been installed since early 1990s. Cerrado has predominantly acid and low fertile soil, two definite seasons (dry and rain) and high temperatures all the year.

The study of plant phenology in agriculture is essential to know the behavior and biology of cultivated plants under diverse environmental conditions, mainly their relationship with edafoclimatic conditions, primordial to develop the viticultural techniques (McIntyre et al., 1982; Jones and Davies, 2000a,b; Jones et al., 2005a; Silva et al.,

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Table 1. Chemical and physical characteristics of soil at experimental site location.

pH	P	K	Ca	Mg	Al	S	O.M.	Clay	Silte	Sand
(CaCl ₂)	mmol _c dm ⁻³				(Mg dm ⁻³)		g dm ⁻³			
4.2	10.0	0.5	5.0	2.0	5.0	5.0	14.0	160	20	820

2006).

The phases of grapevine phenology are basically growth (from sprouting to growth end), reproduction (from blooming to fruit maturation), tissue maturation (from stopping growth to stem maturation), vegetative (grapevine bleeding to leaf fall) and dormancy (phase between two cycles) (Galet, 1983). On the other hand, phenological phases of grapevines were also fragmented at several stages (1 to 47) for each pruning-leaf fall cycle (Lorenz et al., 1995).

The phonological stages of grapevines can be useful to determine adequate time and number of operations for several viticultural practices as fertilization, pruning, plant regulators and agrochemicals application, thinning and harvest date (Murakami et al., 2002; Roberto et al., 2005).

Several factors influence the grapevine phenological. One of these factors is the use of rootstock, which exercises strong effect on the growth and development of plants (Ezzahouani and Williams, 1996; Pauletto et al., 2001; Gonçalves et al., 2002; Pedro et al., 2006; Sato et al., 2008b). 'Ripária do Traviú' is adapted to fresh soils, it has considerable dry resistance, and in the same time, it is adapted to wet and clay lands (Nogueira, 1984). 'IAC-766' which is adapted to climate of São Paulo State, Brazil, is medially vigorous, has high fungus disease resistance, its cuttings show a high rooting percentage and demonstrates dormancy under mild temperatures (Camargo, 1998; Pommer, 2001). 'IAC-572 is highly vigorous, adapted to several soils and tropical climate, has high resistance to the main diseases, its cuttings show excellent rooting percentage and has been used on South-West region of Brazil (Camargo, 1998; Pommer, 2001). However, phenology of 'Niagara Rosada' grapevines grafted on the different rootstocks and cultivated on Cerrado (Brazilian savanna) has not been studied yet.

The objective of this experiment was to evaluate the phenological phases of the 'Niagara Rosada' grapevines grafted on three different rootstocks planted on Cerrado biome (Brazilian savanna) at the State of Goiás, Middle Western region of Brazil.

MATERIALS AND METHODS

The experiment was carried out in the vineyard of the Institute of Agricultural Researches of the Fimes (IPAF) located in the Institute of Agricultural Sciences (ICA) of the Integrated Faculties of Mineiros belonging to the Municipal Integrated Foundation of Graduates (Fimes) located in Mineiros, South-Western region of Goiás State, Brazil (17°34'S and 52°33'W, 800 m a.s.l.) and Quartzipsamment soil. Soil analysis was made by Soil Analysis Laboratory of IPAF (Table

1). The climate on this region is classified as tropical Aw according to Köppen classification, showing high temperatures during the year and mild temperatures from June to July, with minimum temperatures of 15°C and maximum higher than 22°C.

The trail was carried out in a five years old 'Niagara Rosada' grapevines (*Vitis vinifera*) grafted on three different rootstocks: 'Ripária do Traviú' (*Vitis riparia* x *Vitis rupestris* x *Vitis cordifolia* 106-8), "IAC-766" - Campinas' [(*V. riparia* x *V. rupestris* x *V. cordifolia* 106-8 Mgt) x *Vitis caribea*] and "IAC-572" - Jales' [*V. caribea* · (*V. riparia* x *V. rupestris*)]. The grapevines were trained on vertical trellis system using unilateral 2-bud spur-pruned cordon and spaced in 1.2 x 2.2 m.

The vineyard was irrigated by a microsprinkler system based on the average evapotranspiration in accordance with grapevine's water requirements for the climate and soil conditions. The grapevines were pruned on 11st August 2006 and soon after the buds were treated with dormex® (49% of hydrogen cyanamide) at 7%. The experiment design was completely randomized blocks design with three treatments composed of rootstocks ('Ripária do Traviú', 'IAC-572' and 'IAC-766'), seven replicates and one-plant plot.

Data were obtained by daily visual observation between 8:00 and 9:00 h according to sixteen phenological stages (Lorenz et al., 1995): 01 - bud dormant; 02 - bud swelling; 03 - wool stage; 05 - bud burst (green shoot); 07 - first leaf unfolded and spread away from shoot; 09 - two to three leaves unfolded; 12 - five to six leaves unfolded; inflorescence visible.; 15 - inflorescence swelling; flowers closely pressed together; 17 - inflorescence fully developed; flowers separating; 19 - beginning to ending of flowering; 27 - fruit set; 29 - pellet-like berry; 31 - berry pea-sized; 33 - beginning of berry touch; 35 - beginning of ripening (veraison); 38 - fruit ripening for harvest, harvest date (1 day) was defined as when 100% berries showed intensive coloring. Each grapevine was set on specific phenological stage when 50% of the stems were in this phase, and each treatment were set when four table grapes of the replication were in the specific stage (Schiedeck et al., 1997; Murakami et al., 2002; Ferreira et al., 2004; Roberto et al., 2004; Roberto et al., 2005).

Temperature data (Figure 1) were obtained from Cptec/INPE Website (Centre of Weather Forecast and Climate Studies/National Institute of Space Studies). Thermal summation requirements were taken in growing degree-days in °C units (DD) according to the following equation (Villa et al., 1972):

$$DD = (T_{\text{MIN}} - T_B) + (T_{\text{MAX}} - T_{\text{MIN}}) / 2, \text{ to } T_{\text{MIN}} > T_B ;$$

$$DD = (T_{\text{MIN}} - T_B)^2 / 2(T_{\text{MAX}} - T_{\text{MIN}}), \text{ to } T_{\text{MIN}} < T_B ;$$

$$DD = 0, \text{ to } T_B > T_{\text{MAX}}$$

Where DD = degree-days; T_{max} = maximum temperature daily (°C); T_{min} = minimum temperature daily (°C); T_b = base temperature (°C).

The base temperature for 'Niagara Rosada' grapevine is 10°C according to Pedro et al. (1994).

RESULTS

There were differences in the number of days and

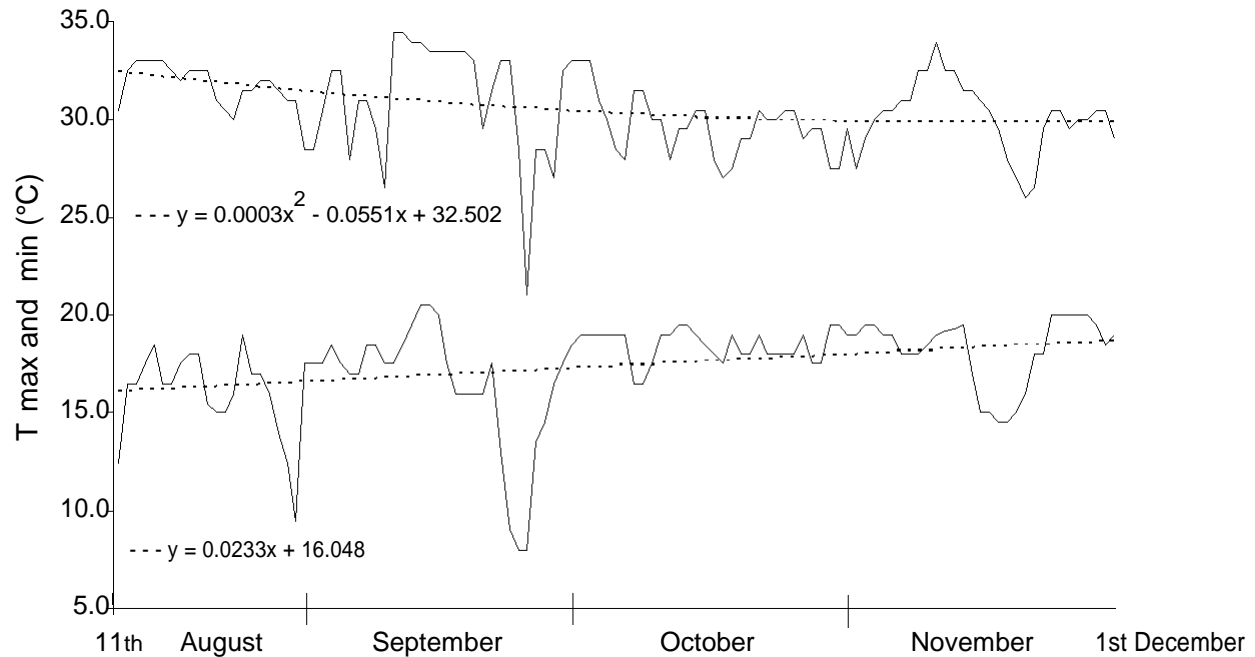


Figure 1. Daily maximum and minimum temperatures obtained during experimental period (11th August to 1st December, 2006).

thermal summation requirements for several phenological stages according to grapevine rootstock (Tables 2 and 3). In general, the 'IAC-766' and 'IAC-572' rootstocks showed a similar phenological behavior, cycle duration and thermal summation requirement for the 'Niagara Rosada' grapevines, while 'Ripária do Traviú' presented the largest length of phenological stages (Tables 2 and 3).

The differences in phenological stages that verified in this trial were expected once plant phenology is strongly influenced by gene of each cultivar and according to edaphoclimatic relationship (Murakami et al., 2002; Pedro Júnior et al., 1993; Leão and Silva, 2003; Lebon et al., 2005), thus the grapevine rootstock cultivars possibly influenced growth and development of 'Niagara Rosada' grapevines because the results showed cycle reduction on this table grape on site conditions. The similar behavior observed on 'Niagara Rosada' grafted on 'IAC-766' and 'IAC-572' could be explained by the genotypic relationship between these two rootstocks (Pommer, 2001), which promotes similar influence on the growth and development of grapevine. The vegetative vigor of rootstock is the main factor that influences grapevine growth. The influence of the rootstocks 'Ripária do Traviú', 'IAC-766' and 'IAC-572', on 'Niagara Rosada' phenology stages was also reported by Alvarenga et al. (2002) in a previous study developed in Caldas, State of Minas Gerais, Brazil (21°S, 40°W, altitude at 1,150 m).

The cycle of the 'Niagara Rosada' grapevine from pruning to harvest, was 109 days when grafted on the 'Ripária do Traviú' rootstock, 112 days on the 'IAC-766' and 113 days on the 'IAC-572' (Table 2). It was only in

the dormancy period (stages 01), that inflorescence fully developed; flowers separating (stage 17), and beginning to ending of flowering (stage 19) showed the same number of days, independently of the grapevine rootstock. On the other hand, there were differences between two and eleven days on some phenological stages. 'Ripária do Traviú' increased some phenological phases, mainly in stage 09 (two to three leaves unfolded), stage 33 (beginning of berry ripening) and 35 (beginning of ripening - veraison) (Table 2).

The similar duration of bud dormancy (stage 02) of 'Niagara Rosada' grapevines, independently of rootstock, can be explained by the same application of hydrogen cyanamide that induced homogeneous bud break. The identical periods of phenology also verified inflorescence fully developed; flowers separating (stage 17), and beginning to ending of flowering (stage 19) could be related to the physiologic phenomenon within these stages, for fertilization which is a brief, critical and delicate phase of grapevines need constant and optimum conditions to happen normally. The similar development of grapevine inflorescence was reported by Lebon et al. (2005) on 'Gewurztraminer' and 'Pinot Noir' grapevines that also verified an equal behavior on stages before early bloom.

The longest phenological stage was beginning of berry touch (stage 33), independently to the rootstock, with average of 40.2 days (Table 2). On the other hand, the shortest stage has fully developed inflorescence (stage 17) and beginning to ending of flowering (stage 19) with average of 2.0 days (Table 2). It is interesting to emphasize that grapevine phenology between berry touch

Table 2. Number of days of phonological stages of 'Niagara Rosada' grapevines grafted on different rootstocks on Brazilian savanna conditions, Goiás State, Brazil.

Stage ¹	Rootstock						Average	
	'Ripária do Traviú'		'IAC-766'		'IAC-572'		XND	XNAD
	ND	NAD	ND	NAD	ND	NAD		
Pruning	0	0	0	0	0	0	0.0	0.0
01	5	5	5	5	5	5	5.0	5.0
02	4	9	5	10	5	10	4.7	9.7
03	5	14	5	15	4	14	4.7	14.3
05	3	17	2	17	3	17	2.7	17.0
07	2	19	3	20	2	19	2.3	19.3
09	8	27	2	22	2	21	4.0	23.3
12	4	31	6	28	9	30	6.3	29.7
15	4	35	6	34	5	35	5.0	34.7
17	2	37	2	36	2	37	2.0	36.7
19	2	39	2	38	2	39	2.0	38.7
27	6	45	6	44	5	44	5.7	44.3
29	7	52	9	53	8	52	8.0	52.3
31	3	55	5	58	6	58	4.7	57.0
33	47	102	38	96	37	95	40.7	97.7
35	6	108	15	111	17	112	12.7	110.3
38 (harvest date)	1	109	1	112	1	113	1	111.3

¹ 01 - Bud dormant; 02 - bud swelling; 03 - wool stage; 05 - bud burst (green shoot); 07 - first leaf unfolded and spread away from shoot; 09 - two to three leaves unfolded; 12 - five to six leaves unfolded; inflorescence visible.; 15 - inflorescence swelling, flowers closely pressed together; 17 - inflorescence fully developed, flowers separating; 19 - beginning to ending of flowering; 27 - fruit set; 29 - pellet-like berry; 31 - berry pea-sized; 33 - beginning of berry touch; 35 - beginning of ripening (veraison) ; 38 - fruit ripening for harvest. ND - number of days of the each phonologic stage; NAD - number of accumulated days; XND -average number of day; XNAD - average number of accumulated days.

beginning stage and berry growth ending demanded a long period before early berry coloring. Leão and Silva et al. (2003) also found long period for beginning to touch berry of 'Superior Seedless' ('Festival'), 'Thompson Seedless', 'Catalunha', 'Perlette' and 'Marroo Seedless' grapevines, both grafted on 'IAC-572' and cultivated in Petrolina (9°09'S, 40°22'W, 365 m a.s.l.), State of Pernambuco, Brazil.

The relationship between rootstock genotype and environment was probably the most important factor that influenced the phonological stages of 'Niagara Rosada'. According to Jones and Davis (2000), the interactions between the climate, soil and site location play an important role on the behavior and yield of grapevines. Nogueira (1984) reported that 'Ripária do Traviú' delayed fruit ripening in a few days of 'Itália' table grapes (*V. vinifera*). Alvarenga et al. (2002) carried out an experiment in Caldas (Minas Gerais State, Brazil) to study the behavior of 'Niagara Rosada' grafted on the rootstocks 'Ripária do Traviú', 'IAC-766' and 'IAC-572', and verified longer cycles: 144.0, 141.9 and 148.2 days, respectively. Pedro et al. (1993) also studied cycle duration of 'Niagara Rosada' grapevines in several Brazilian cities of São Paulo State: 145 days in Jundiá, 130 days in Mococa, 152 days in Monte Alegre do Sul, 178 days in São Roque and 135 days in Tietê. While Ferreira et al. (2004) observed

a cycle of 147 days from pruning to harvest of 'Niagara Rosada' grafted on 'RR 101-14' (*V. riparia* x *V. rupestris* 101-14 Mgt) rootstock in Caldas, Minas Gerais State, Brazil. The high temperatures during the experiment (Figure 1) contributed to reduce 'Niagara Rosada' (Pedro, 2001). Sato et al. (2008b) studying phenological and productive behavior of the 'Jacquez' grapevine (*Vitis bourquina*) in northern Paraná state, Brazil in two cycle (2003/2004 and 2004/2005), also observed that the high temperature occurrence in 2003/2004 promoted its cycle reduction (pruning to harvest). The phenological cycle reduction on grapevines ('Niagara Branca' and 'Concord' cultivars) by high temperatures was also verified by Anzanello et al. (2008) between two harvests by season. Additionally, the rootstock characteristics are the primary factors that provided reduction of 'Niagara Rosada' cycles (Pedro, 2001; Jones and Davis, 2000a, 2000b; Alvarenga et al., 2002; Jones et al., 2005a, 2005b; Jones, 2006).

Thermal summation requirements for 'Niagara Rosada' grapevine was 1,167.4 DD grafted on 'Ripária do Traviú' rootstock; 1,197.9 DD on 'IAC-766' and 1,207.4 DD on 'IAC-572' (Table 3). These results are in accordance with Sato et al. (2008a) that verified phonological cycle reduction of 'Isabel' cultivar grafted on 'IAC-766 Campinas' and 'IAC 572 Jales' rootstocks in relation to grafting on '420-A' rootstock, was when cycles of 142, 148 and 167

days for pruning to harvest on the respective rootstocks was observed.

This present work showed that 'Niagara Rosada' requested average of 1,190.9 DD to complete its cycle from pruning to harvest on climate and soil conditions of Brazilian Savanna. The highest thermal summation requirement occurred within beginning to ending of flowering (stage 33) with average of 405.7 DD. On the other hand, the phase of two to three leaves unfolded (stage 09) requested the lowest average degree-days (13.2) (Table 3).

This experiment showed that 'Niagara Rosada' grapevines cultivated on Brazilian savanna conditions needs lower degree-days to complete phenological cycle than other Brazilian locations. It is possible because climate on experimental site location is warming subtropical and it has high average temperatures and daylight length (data not shown). Pedro et al. (1994) defined 1,549.0 degree-days as total amount of thermal summation necessary to complete the cycle of 'Niagara Rosada' (pruning-harvest) in city Jundiá, São Paulo State, Brazil (23°12'S, 46°53'W, altitude at 715 m).

The highest thermal requirement for 'Niagara Rosada' phenological stages was obtained for beginning berry touch (stage 33) on the three rootstocks (467.3 DD on 'Ripária do Traviú', 380.3 DD on 'IAC-766' and 369.5 DD on 'IAC-572'), while the lowest thermal summation occurred to the phases of two to three leaves unfolded (stage 09) on 'IAC-766' and 'IAC-572' (11.9 DD and 13.2 DD, respectively) and to the phase of first leaf unfolded and spread away from shoot (stage 07) on 'Ripária do Traviú' (21.8 DD) (Table 3). The highest average thermal summation was obtained to the phase of beginning of berry touch (stage 33) and the lowest average was to the beginning to ending of flowering (stage 19). The highest thermal requirement necessary to beginning of berry touch verified in this work was probably related to intensive berry expansion that requires high carbohydrate accumulation (photosynthesis), transportation and accumulation. In addition, the low maximum temperatures occurred during berry touching (October to November, 2006) (Figure 1) and possibly contributed to extend this phenological stage. Dantas et al. (2007) reported that lower temperatures, radiation and sunstroke during fruit set to growth berry provided period elongation on 'Syhah' grapevine cultivated in São Francisco River Valley.

It can be concluded that 'Niagara Rosada' table grape showed different phenological behavior according to rootstock and environment conditions. The 'Ripária do Traviú', 'IAC-766' and 'IAC-572' added to climate and soil conditions of Cerrado, provided cycle reduction of 'Niagara Rosada' grapevines, suggesting more annual harvest dates in this region.

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