Original Article

PERFORMANCE OF MANGO CULTIVARS UNDER SUBTROPICAL CONDITIONS IN THE STATE OF SÃO PAULO

DESEMPENHO DE CULTIVARES DE MANGUEIRA EM CONDIÇÕES SUBTROPICAS DO ESTADO DE SÃO PAULO

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ABSTRACT: Mango is quite popular among tropical fruits, and has traits of a fast-expanding market. There is a huge variety of mango cultivars and their potential should be studied in order to be introduced in new producing regions with favourable edaphoclimatic characteristics for planting. The current study aimed to evaluate mango productive performance under subtropical conditions in the state of São Paulo, Brazil. The experiment was conducted with 'Espada Vermelha', 'Keitt' and 'Palmer' cultivars grafted onto rootstock 'Espada' over three crop cycles 2012-2013, 2013-2014 and 2014-2015. The experimental design was a randomized complete block, consisting of 3x3 factorial design, in which the first factor corresponds to the cultivars and the second factor to the evaluated crop cycles, with 10 replications and one plant per plot. The following variables were evaluated: number of fruits per panicle, number of fruits per plant, panicles percentage to the full aborted fruits, fruit fresh weight, production, yield, canopy volume, production efficiency and crop seasonality. Data analysis by Tukey test and Pearson´s correlation coefficients. Among the evaluated cultivars, Palmer has stood out with the best productive performance under the experiment conditions in the three evaluated crop cycles. The seasonal availability of cultivars should be explored so that there are fruit productions over a longer period of time. Correlations among productive traits varies according to the cultivar.

KEYWORDS: *Mangifera indica* L.. Alternate bearing. Yield. Crop seasonality. Correlation.

INTRODUCTION

Mango tree (*Mangifera indica* L.) comes from either the Indian center or Indo-Malayan sub-center (VAVILOV, 1951). Mango is among the most popular tropical fruits in the world, mainly due to its characteristic flavour, aroma, attractive colour and nutritional properties (NUNES et al., 2007). India is the world´s largest mango producing country; while Brazil is the 7th largest (FAOSTAT, 2016), with approximately 1.16 million tons in 2013.

'Tommy Atkins' is the main cultivar produced in Brazil (SABATO et al., 2009). Mango-traded market is growing rapidly, as the demand for traditional varieties in western markets is increasing. There is a huge variety of mango cultivars and their potential should be studied (JHA et al., 2010). Thus, introducing these crops in new producing regions become promising, especially areas that present edaphoclimatic relevant characteristics to the development thereof.

Evaluation of mango cultivars in various regions is a crucial tool for the Brazilian mango production, mainly due to the great diversity of cultivars and hybrids availability for planting. Additionally, in Brazil they are different soils and climatic conditions that directly and indirectly influence growth and development of plants. These data are crucial for a number of reasons including better crop management; increased yield; fruit quality; consumer acceptance and fruit market life. Therefore, this type of study makes possible to select the best varieties for each region.

In the world, there have been carried several studies on this matter, such as Kobra et al. (2012) that evaluated 12 mango cultivars in three regions of Bangladesh, showing that is possible to grow mango in all these regions whether the right cultivar is chosen. While Singh et al. (2013) studied 20 mango cultivars in a particular Indian area, reported that only eight cultivars suited to local conditions. Similarly, Iqbal et al. (2012) conducted a study with 10 mango cultivars in Pakistan; noticed that only two cultivars adapted well in the studied area due to better production performance.

In Brazil, Carvalho et al. (2004) evaluated various mango cultivars during two crop cycles (i.e. 2001-2002; 2002-2003) in Votuporanga (state of São Paulo); showing that 'Espada Vermelha' was the least productive; whilst Palmer was the most productive. The authors highlighted that the following cultivars: 'Votupa', 'Van Dyke' and 'Tommy Atkins' presented intermediate

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productions. However, Haden 2H cultivar exhibited tendency of alternate bearing.

In mango crops, alternate bearing must be considered, as it can be an issue during crop management, since fruit production increases in one year, but decreases in the following year (Davenport, 2007). Probably due to non-uniform flowering in mangoes, since canopy branches develop at different times, thus showing that flower bud induction and differentiation are directly linked to the apical bud (age) (RAMÍREZ; DAVENPORT, 2010)

In Brazil, mangoes production is mainly concentrated in the Northeast or consolidated existing crops in the Southeast. However, there are a few studies on this crop in other areas. Given the above, the current study aimed to evaluate the performance of mango cultivars grown under subtropical conditions in Brazil.

MATERIAL AND METHODS

The experiment was conducted in the Sao Manuel Experimental Farm, Botucatu School of Agronomy, UNESP (22°44'28"S, 48°34'37"O; 740m m altitude). According to Köppen's classification, the climate type is Cwa, i.e. mesothermal climate (dry winter/wet summer pattern associated with humid subtropical climate). The mean annual rainfall of São Manuel is 1376.70 mm; and the mean annual temperature of the warmest month is above 22°C (CUNHA; MARTINS, 2009). The regional climate data of the experimental set-up is shown in Figure 1.

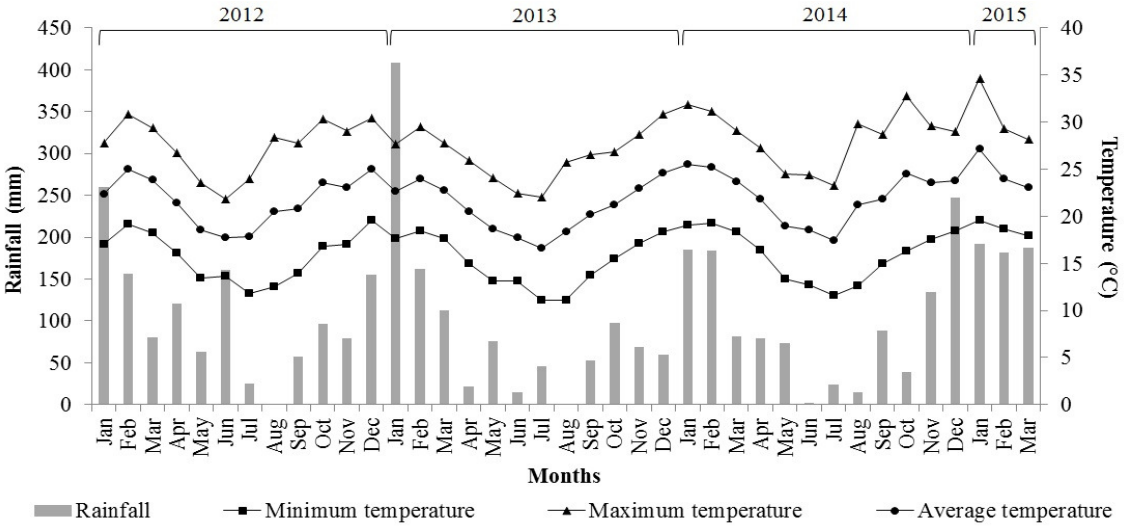


Figure 1. Average, maximum and minimum temperatures; and rainfall between January 2012 and March 2015 in the city of São Manuel (state of São Paulo).

On January 5, 2008, orchard was installed by keeping a plant density of 417 plants per hectare at six meters spacing between rows and at four meters spacing between plants. Espada Vermelha, Keitt and Palmer cultivars were all grafted onto rootstock 'Espada'. 'Keitt' and 'Palmer' are cultivars of the Indian group (monoembryonic); 'Espada Vermelha' and 'Espada'' rootstock belong to the Philippine group (polyembryonic). The experiment was conducted over three agricultural cycles: 2012-2013 (5-year-old plants with full production capacity at this period), 2013-2014 and 2014-2015. Technical guideline recommendations for the crop were followed in rainfed agriculture and plants flowered spontaneously. Fertilizer recommendations were based on soil analysis prior to the experiment (Tables 1 and 2), as recommended by Raij et al. (1997).

Table 1. Soil macronutrients levels of the experimental area in the following years: 2012, 2013 and 2014.

Sample (cm)	pH $CaCL_2$	M.O. $g.dm^{-3}$	P resin $mg.dm^{-3}$	H+Al	K	Ca	Mg	SB	CTC	V%
				-------$mmolc.dm^{-3}$-------						
2012										
0 - 20	5.5	14	59	18	1.6	22	8	32	50	64
20 - 40	5.5	12	64	16	1.4	25	8	34	50	67

2013										
0 - 20	5.2	15	55	20	2. 7	20	8	30	48	56
20 - 40	5.2	14	68	23	1.9	24	7	32	52	66
2014										
0 - 20	4.9	15	50	23	3.6	12	6	31	54	58
20 - 40	4.9	15	68	26	2.8	23	8	34	59	67

Source: Laboratory of Soil Fertility. DCS-FCA. 2012, 2013, 2014.

Table 2. Soil micronutrients levels of the experimental area in the following years: 2012, 2013 and 2014.

Sample (cm)	B	Cu	Fe	Mn	Zn
	---------- mg.dm^{-3}----------				
2012					
0 – 20	0.42	1.4	36	20.4	3.0
20 – 40	0.33	1.2	29	16.2	2.5
2013					
0 – 20	0.37	1.6	36	18.3	2.4
20 – 40	0.32	1.5	25	12.8	1.9
2014					
0 – 20	0.40	2.2	30	21.7	2.8
20 – 40	0.33	2.0	23	18.1	2.1

Source: Laboratory of Soil Fertility. DCS-FCA. 2012, 2013, 2014.

The experimental design was a randomized complete block in a 3x3 factorial design, consisting of two factors (i.e. three cultivars and three agricultural cycles), with 10 replications and one plant per plot.

By evaluating the yield performance, the following variables were considered: number of fruits per panicle, by cutting the fruits of 50 marked panicles in each evaluated plants at 10 days before harvest; number of fruits per plant, counted individually; percentage of panicles to full aborted fruits, prior harvesting 50 panicles were marked in each plant, then the panicle that aborted all fruits were counted at the beginning of harvesting and the numbers were converted into percent; fruit fresh weight by weighing the fruits in digital scale, expressed in grams; production by obtaining the number of harvested fruits and fruit average weight per plant, expressed in kilograms; yield, based on one stand of 417 plants per hectare by the number of plants and the amount produced per plant, expressed in tonnes per hectare; canopy volume according to the methodology described by Mendel (1956), wherein $V=2/3\ \pi R^2H$, V is the volume (m^3), R is the canopy radius (m) and H is plant height(m); production efficiency by obtaining the ratio between production and canopy volume, expressed in kg m^{-3}; and crop seasonality by considering the start, the end and each cultivar harvest period.

After obtaining all the data, they were submitted to analysis of variance test at 1 and 5% probability level. When there was significant variance, averages were compared by Tukey test at 5%. Pearson´s correlation coefficients was also evaluated among all production traits in each cultivar.

RESULTS AND DISCUSSION

Based on data analysis, there was a significant interaction between cultivars and crop cycles for the following variables: number of fruits per panicle; percentage of panicle to full aborted fruits; number of fruits per plant; and fruit fresh weight. However, each cultivar responded differently according to the assessed cycle. Furthermore, an isolation effect was observed for production; yield; canopy volume; and production efficiency from each factor (Table 3).

With regard to the number of fruits per panicle, Palmer and Espada Vermelha cultivars showed the highest averages, independently of crop cycle. However, there was no significant difference between the cultivars during 2013/2014 season. ‘Palmer’ and ‘Keitt’ presented lower averages in the second cycle than the first and third cycles (Table 4). Regarding to the percentage of panicles to full aborted fruits, ‘Espada Vermelha’ showed the highest percentage of abortions over the three crop cycles. Additionally, there was no average percentage difference in abortion among ‘Espada Vermelha’ cycles. However, ‘Keitt’ and ‘Palmer’

presented the highest abortion percentage during 2013/2014 season (Table 4).

Table 3. F test values , coefficient of variation and average number of fruits per panicle (NFP), percentage of panicles to full aborted fruit (PPFAF), number of fruits per plant (NFPL), fruit fresh weight (FFW) production (PROD), yield (YIELD), canopy volume (CV) and productive efficiency (PE) of mango cultivars under subtropical conditions in the state of São Paulo, 2016.

FV	NFP	PPFAF (%)	NFPL	FFW (g)	PROD (kg)	YIELD ($t.ha^{-1}$)	CV (m^3)	PE ($kg.m^{-3}$)
Block	1.5^{ns}	1.2^{ns}	1.1^{ns}	0.9^{ns}	1.5^{ns}	1.5^{ns}	4.6^{**}	1.0^{ns}
Cultivar (A)	10.9^{**}	62.0^{**}	32.7^{**}	221.3^{**}	46.4^{**}	46.4^{**}	19.8^{**}	70.0^{**}
Crop cycle (B)	43.0^{**}	18.0^{**}	94.5^{**}	67.5^{**}	44.0^{**}	44.0^{**}	7.8^{**}	30.0^{**}
A x B	2.7^{*}	2.1^{*}	3.9^{**}	15.8^{**}	1.6^{ns}	1.6^{ns}	0.3^{ns}	1.9^{ns}
CV (%)	20.5	23.6	32.6	17.9	36.2	36.2	18.5	40.7
Average	1.9	46.5	98.9	515.8	43.9	18.3	10.0	4.9

^{ns} Not significant, * Significant at 5% probability, ** Significant at 1% probability.

Table 4. Number of fruits per panicle and percentage of panicles to full aborted fruits over three crop cycles, according to three cultivars, under subtropical conditions in the state of São Paulo, 2016.

Cultivars	Number of fruits per panicle			Percentage of panicles to full aborted fruits (%)		
	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15
Esp. Vermelha	1.88 abB	1.52 aB	2.38 aA	60.67 aA	66.47 aA	63.97 aA
Keitt	1.75 bA	1.32 aB	1.91 bA	35.33 bB	55.53 bA	38.83 bB
Palmer	2.19 aB	1.43 aC	2.78 aA	23.33 cB	46.20 bA	28.57 bB

Identical lower case letter in the columns (cultivars) and identical upper case letter in rows (Crop cycle) do not differ using Tukey's test ($p \leq 0.05$)

These characteristics have already demonstrated the biennial bearing behaviour of mangoes, wherein years of high and low production alternate; therefore, the least number of fruit per panicle reflects a lesser number of fruits per plant; consequently, reducing production and yield. Fruits abortion is more common in certain fruits like mango, generally only one-three fruits per panicle reach full maturation (CUNHA et al. 2002). According to Pereira et al. (2005) and Manica et al. (2001) alternate bearing in fruits like mango may be influenced by several factors, such as biological (i.e. flowers structure, pollination, flowering); physiological (i.e. hormonal balance, nutritional depletion of the plant); plant protection (i.e. the occurrence of disease); and edaphoclimatic (i.e. in the absence of well-defined dry season; heavy rainfall during flowering; low temperatures after flowering; and strong winds).

Regarding to the number of fruits per plant, Palmer cultivar excelled with the highest average in the first and third cycle, i.e. 146.7 and 203.0 fruits, respectively. During 2013/2014 cycle, it was not observed any difference among cultivars in which all of them performed lower average in the number of fruits per plant (Table 5). In 2013/2014 cycle, it was obtained the lowest number of fruits per plant, probably due to the heavy rainfall in July at the time that plants were in full bloom (i.e. affecting pollination); and lower temperatures, as the first and third cycle presented higher temperatures during the same period, in other words, low temperatures affect fruit set after flowering, according to Pereira et al. (2005).

For fruit fresh weight, the highest averages were observed for Keitt cultivar over the three cycles, 624.01, 996.16 and 626.61 g, respectively. For 'Palmer', the averages were 447.65, 774.91 and 422.81 g, respectively. Espada Vermelha cultivar presented the lowest averages over the three crop cycles, 235.53, 256.57 and 258.27 g, respectively. Therefore, it seems that 'Keitt' and 'Palmer' had

higher averages for fruit fresh weight during the second cycle, while 'Espada Vermelha' did not present any significant difference over the three-cycles (Table 5). It was expected the difference in the cultivars, as each carries a specific genetic factor. However, the highest average of fresh weight of 'Keitt' and 'Palmer' during 2013/2014 cycle could be explained by the lowest number of fruits per plant in the same cycle for both cultivars. Therefore, it is believed that these cultivars are more vulnerable to climate changes during flowering and fruit set.

Table 5. Number of fruits per plant and fruit fresh weight over three crop cycles, according to three cultivars under subtropical conditions in the state of São Paulo, 2016.

Cultivars	Number of fruits per plant			Fruit fresh weight (g)		
	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15
Esp. Vermelha	89.90 bB	47.67 aC	152.50 bA	235.53 cA	256.57 cA	258.27 cA
Keitt	80.40 bA	17.20 aB	101.58 cA	624.01 aB	996.16 aA	626.61 aB
Palmer	146.70 aB	51.00 aC	203.00 aA	447.65 bB	774.91 bA	422.81 bB

Identical lower case letter in the columns (cultivars) and identical upper case letter in rows (Crop cycle) do not differ using Tukey's test ($p \leq 0.05$)

With regard to the fruit fresh weight of Espada Vermelha cultivar, the result is similar to those found by Jilani et al. (2010), while evaluated other cultivars in Pakistan. Although, 'Espada Vermelha' averages were lower than 'Palmer' and 'Keitt', similarly results were found on other cultivars by Iqbal et al. (2012), Das (2013) and Kau et al. (2014). Fresh weight and fruit size (diameter) are used to identify the maturity of fruits (CHITARRA and CHITARRA, 2005). Whereas, mango fruits must not be weighed less than 200g to be canned in syrup, according to Medina (1996). Thus, all fruits from the cultivars weighed greater than prior recommendations; therefore, fruits were suitable for canning in syrup.

As stated before, there was no interaction between both cultivars and crop cycles for production and yield, however there was an isolation effect of those factors, meaning that there were differences in each cultivar, independently of the cycles; and in each cycle, independently of the cultivar.

By comparing production per plant and yield among three cultivars, 'Palmer' has stood out with an average of 63.86 kg plant^{-1} and 26.63 t ha^{-1}, respectively. While 'Espada Vermelha' presented the lowest production and yield average, 24.35 kg plant^{-1} and 10.15 t ha^{-1}, respectively (Table 6). In 2013, the global yield of 'Palmer' and 'Keitt' mango fruits were 8.03t ha^{-1}; while 16.53t ha^{-1} in Brazil (FAOSTAT, 2016); therefore, both yields were below the current study averages.

In literature, it was found higher averages in yield per plant. In Pakistan, Iqbal et al. (2012) found averages ranging 85-140 kg.plant^{-1}. In India, Kaur et al. (2014), while evaluated several cultivars, reported averages between 44.04 and 148.90kg.plant^{-1}. In India, Singh et al. (2013) found similar results from the current study, i.e. 6.81 and 69.81kg.plant^{-1}. In Brazil, lower results were also found in an agroecological farming system for 'Palmer' and 'Keitt' in the city of Teresina (State of Piauí) by Souza et al. (2004); and for 'Palmer' in the city of Ipameri (State of Goiás) by Peixoto et al. (2005). However, beyond the different genetic materials, one must consider the age of the plant, as it affects the canopy size; and the region/locality, as it results in different weather conditions and management practice. Therefore, all these factors indirectly interfere on production of the plants.

Regarding to the crop cycles, there were lower average for production and yield in 2013/2014 cycle (23.91kg.plant^{-1} and 10.00t ha^{-1}), and higher averages in 2014/2015 cycle, followed by 2012/2013 cycle (Table 6). This result has highlighted the alternate bearing pattern concerning the production of these three cultivars. This pattern was observed in the number of fruits per plant, as the cultivars showed lower fruit production in 2013/2014, but higher in the other cycles.

Thus, it is evident that production and yield are more affected by the number of fruits per plant than average fruit fresh weight, since the greater the fruits fresh weight were, the lower the production and yield were. In other words, fruit fresh weight increased, because of the lower number of fruits per plant; therefore, allowing fruits to receive higher amount of assimilates and nutrients.

After flowering becomes the most critical period for mangoes from the productive point of

view, as most of fruit abortion occurs and deserve more attention to control disease. As stated before, in 2013/2014 cycle, precisely in July, there was a heavier rainfall than the other two cycles, probably affecting fruit set.

For canopy volume, Palmer cultivar demonstrated the lowest average (8.23 m^3). On the other hand, 'Espada Vermelha' and 'Keitt' showed 10.96 and 10.66 m^3, but not statistically different from each other (Table 6). In India, Singh et al. (2013) reported similar averages for several mango cultivars, 28 years of age, at a spacing of 10m. With regard to the 'Palmer' lowest average, one can say that 'Palmer' can be grown in smaller spacing between plants than 'Espada Vermelha' and 'Keitt'.

With regard to the crop cycles, an increase in canopy volume average was obtained in 2013/2014 and 2014/2015 cycles (Table 6). During the second cycle, canopy volume increased more vigorous and intense (i.e. more vegetative development of the plants), contributing to lower production and yield, which can be explained by the heavy rainfall prior to flowering (i.e. January to June) over the 2013/2014 cycle (Figure 1), thus inducing vegetative growth of the plants. Additionally, mango trees can be induced to flower by prolonged exposure to low temperatures and a moderate water stress, according to Ramírez and Davenport (2010).

By considering production efficiency, the highest average was obtained for 'Palmer' (8.16 $kg.m^{-3}$), followed by 'Keitt' (4.17 $kg.m^{-3}$) and 'Espada Vermelha' (2.25 $kg.m^{-3}$) (Table 6). Therefore, 'Palmer' can produce more fruits than the other cultivars in a specific canopy volume. However, by assessing production efficiency due to the crop cycles, the 2013/2014 cycle presented the lowest average (2.64 $kg.m^{-3}$), while the highest average (i.e. 6.42 $kg.m^{-3}$) was obtained in 2014/2015 cycle (Table 6). Bearing in mind the weather conditions, since all the management practice were exactly the same over the three cycles, it seemed that 2014/2015 cycle presented a moderate amount of rainfall prior to flowering, thus controlling plants vegetative growth, besides the driest month of June and low temperatures that may have favoured flowering. Additionally, this cycle also had a regular and high rainfall over the growth period and fruit ripening (September to March).

Table 6. Production, yield, canopy volume and production efficiency over three crop cycles, according to three cultivars, under subtropical conditions in the state of São Paulo, 2016.

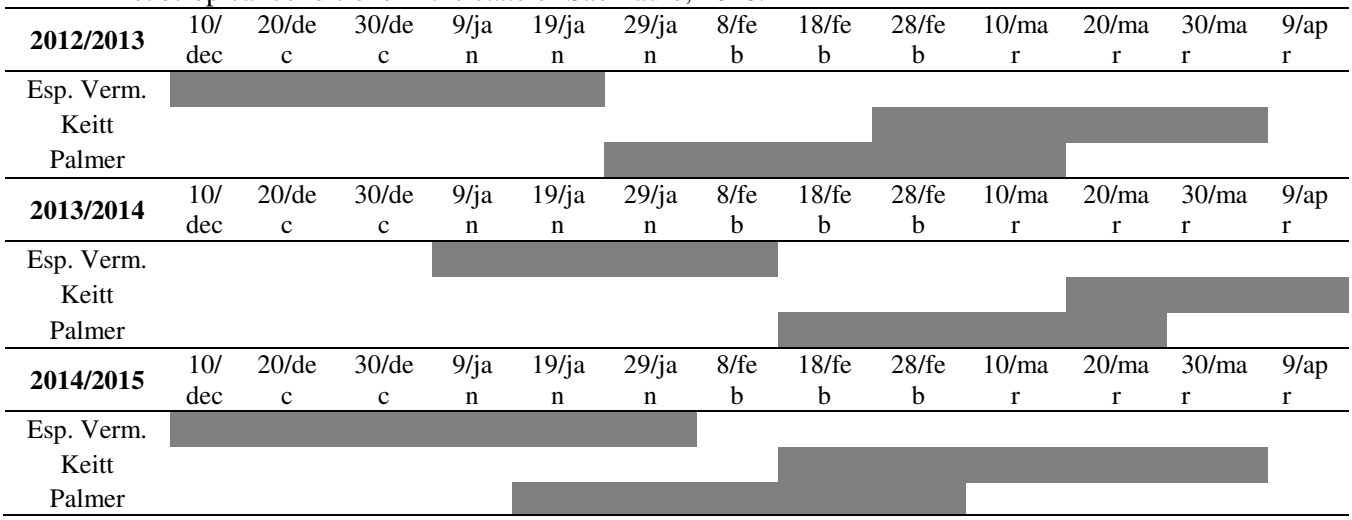
Cultivars	Production (kg)	Yield ($t.ha^{-1}$)	Canopy Volume (m^3)	Production efficency ($kg.m^3$)
Esp. Vermelha	24.35 c	10.15 c	10.96 b	2.25 c
Keitt	43.51 b	18.15 b	10.66 b	4.17 b
Palmer	63.86 a	26.63 a	8.23 a	8.16 a
Crop cycle				
2012/2013	45.56 b	19.00 b	8.89 b	5.51 a
2013/2014	23.91 c	10.00 c	10.30 a	2.64 b
2014/2015	62.25 a	25.96 a	10.66 a	6.42 a

Means followed by different letters are significantly different using Tukey's test ($p \leq 0.05$).

About crop seasonilty, which was evaluated in number of days between the beginning and the end of harvesting, 'Espada Vermelha' presented an early harvest than the others over the three cycles. Thus, 'Palmer' and 'Keitt' were considered late (Table 7). Also, Carvalho et al. (2004) rated Palmer cultivar late compared to 'Espada Vermelha', 'Votupa', 'Haden', 'Tommy Atkins' and 'Van Dyke'. By the time that a cultivar starts producing when a previous production has ended, enables producer diversify their crops with more varieties, as their fruit production extends over longer period of time; therefore, increasing in market supply and in price at times of fruits scarcity; consequently, increasing their income.

It is noticed that the first and third evaluated crop cycle of three cultivars showed early production compared to the second cycle (Table 7). This result is probably due to the intensity of rainfall prior to flowering, which ended up delaying the issue of panicles by plants, in addition to lower temperatures during fruit development; consequently, decreasing the thermal time and changing on plants phenology. Finally, it seemed that the crop seasonality was lower in all the cultivars during 2013/2014 cycle; therefore, lower production and yield.

Table 7. Crop seasonality of mango cultivars over three crop cycles (2012/2013, 2013/2014 and 2014/2015), subtropical conditions in the state of São Paulo, 2016.



Results from correlation analyses showed variations among the cultivars. 'Palmer' presented more significant correlations than the other cultivars, but only canopy volume showed no correlation significance with number of fruits per panicle, number of fruits per plant, fruit fresh weight, production and yield (Table 8). 'Espada Vermelha' showed less significant correlations than the others, such as number of fruits per panicle indicated significant correlation with number of fruits per plant, production, yield and productive efficiency; as well as number of fruits per plant with production, yield and productive efficiency; fruit fresh weight with canopy volume; production with yield, canopy volume and productive efficiency; and yield with canopy volume and productive efficiency (Table 8).

In 'Keitt', number of fruits per panicle showed a significant correlation with panicles percentage to the full aborted fruits, number of fruits per plant and fruit fresh weight; panicles percentage to the full aborted fruits with number of fruits per plant, fruit fresh weight, production, yield and productive efficiency; number of fruits per plants with production, yield and productive efficiency; production with yield and productive efficiency; and yield with productive efficiency.

It is important to consider not only the results, but also direction (positive or negative) and magnitudes of the coefficients when evaluating correlations between traits. Therefore, a positive correlation indicates that the value of one variable increases, the other also increases; whilst a negative correlation means that as one variable increases, the other decreases (NOGUEIRA et al.,2012).

There was a significant negative correlation between panicles percentage to the full aborted fruits and the other traits in all cultivars. Additionally, there was also a negative correlation between number of fruits per plant and fruit fresh weight in 'Keitt' and 'Palmer'. Therefore, the higher the averages of fruit fresh matter, the fewer the number of fruits during the agricultural cycle of 2013-2014. Moreover, Palmer cultivar also presented negative correlation, i.e. fruit fresh weight with production, yield and productive efficiency; and canopy volume with productive efficiency (Table 8).

The greatest magnitude (i.e. greater than 0.7) was evenly observed in the three cultivars; therefore, number of fruits showed a significant correlation with production, yield and productive efficiency; as well as production with yield and productive efficiency; and yield with productive efficiency. Although the only exception was the high magnitude observed between number of fruits per plant and fruit fresh weight in 'Palmer' (Table 8).

It was already expected the correlation between number of fruits per panicle and number of fruits per plant in those cultivars, since the highest number of fruits per panicle is directed linked to the final number of fruits per plant, as well as the correlation coefficients whose magnitude were high among production, yield and productive efficiency, since they are all intermingled.

In 'Espada Vermelha' and 'Keitt', there was a lack of correlation of fruit fresh weight with production, yield and productive efficiency. Although, Palmer showed a negative significant correlation for those traits; while presented a positive significant correlation whose magnitude was high between number of fruits per plant and productive characteristics; in other words, it is more

relevant plants with higher number of fruits per plant than fruit fresh weight when considering higher production and yields. Therefore, the averages of production and yield were higher in 'Palmer' than 'Keitt' whose fruits presented higher fresh weight.

Table 8. Pearson´s correlation coefficients among the traits of productive cycle from different mango cultivars under subtropical conditions of the state of São Paulo.

	PPA	NFP	FFW	PR	YL	CV	PE
	Espada Vermelha						
NFPN	0.011^{NS}	0.619^{**}	-0.034^{NS}	0.581^{**}	0.581^{**}	0.055^{NS}	0.578^{*}
PPA		-0.018^{NS}	0.150^{NS}	-0.003^{NS}	-0.003^{NS}	0.193^{NS}	-0.180^{NS}
NFP			0.123^{NS}	0.980^{**}	0.980^{**}	0.348^{NS}	0.861^{*}
FFW				0.304^{NS}	0.304^{NS}	0.379^{*}	0.090^{NS}
PR					1.000^{**}	0.402^{*}	0.843^{*}
YL						0.402^{*}	0.843^{*}
CV							-0.087^{NS}
	Keitt						
NFPN	-0.376^{*}	0.373^{*}	-0.407^{*}	0.263^{NS}	0.263^{NS}	0.054^{NS}	0.234^{NS}
PPA		-0.680^{**}	0.483^{**}	-0.557^{**}	-0.557^{**}	0.295^{NS}	-0.575^{**}
NFP			-0.655^{**}	0.903^{**}	0.903^{**}	-0.107^{NS}	0.876^{**}
FFW				-0.332^{NS}	-0.332^{NS}	0.172^{NS}	-0.326^{NS}
PR					1.000^{**}	-0.110^{NS}	0.976^{**}
YL						-0.110^{NS}	0.976^{**}
CV							-0.300^{NS}
	Palmer						
NFPN	-0.416^{**}	0.719^{**}	-0.636^{**}	0.594^{**}	0.594^{**}	-0.042^{NS}	0.555^{**}
PPA		-0.467^{**}	0.515^{**}	-0.386^{*}	-0.386^{*}	0.605^{**}	-0.631^{**}
NFP			-0.767^{**}	0.928^{**}	0.928^{**}	0.147^{NS}	0.711^{**}
FFW				-0.510^{**}	-0.510^{**}	-0.002^{NS}	-0.448^{*}
PR					1.000^{**}	0.143^{NS}	0.768^{**}
YL						0.143^{NS}	0.768^{**}
CV							-0.473^{**}

NS = not significant; * = significant at 5%; ** = significant at 1% by the F test.
NFPN: Number of fruits per panicle. PPA: Percentage of panicles to full aborted fruits. NFP: Number of fruits per plant. FFW: Fruit fresh weight. PR: Production. YL: Yield. CV: Canopy volume. PE: Production efficiency.

Similarly, Pimentel et al. (2008) studied the early selection of passion fruit by using correlation, observed a significant positive correlation between plants production and the number of fruits within two agricultural cycles, while the correlation between production and fruit weight was not significant. Likewise, Duenhas et al. (2002), who evaluated production and quality of 'Valencia' orange, reported that the plant yield was more affected by the number of fruits per plant than by the fruit fresh weight.

Furthermore, canopy volume showed a positive correlation with fruit fresh weight, production and yield only in 'Espada Vermelha'. Thus, higher canopy volume does not necessarily result in higher production and yield averages; in the current study, lower canopy volume indicated higher production and yield in 'Palmer'.

CONCLUSIONS

Palmer cultivar presented the best productive performance under subtropical conditions.

Crop seasonality of the three cultivars could be considered in order to increase fruit production over longer period of time.

Correlations between traits varies according to the cultivar.

The number of fruits per plant is more significant than fruit weight in order to promote greater production and yield in the three cultivars under subtropical conditions.

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Development (CNPq) and the Coordination for the Improvement of Higher Education Personnel (CAPES) to scholarship granted for the studies.

RESUMO: A manga é uma das frutas tropicais mais apreciadas e seu mercado está em expansão. Existe uma grande variedade de cultivares de mangueira e seu potencial deve ser estudado, sendo importante a introdução do cultivo desta frutífera em novas regiões produtoras, principalmente em locais que apresentem características edafoclimáticas favoráveis para seu cultivo. Desta forma, objetivou-se com este trabalho, avaliar o desempenho produtivo de três cultivares de mangueira nas condições subtropicais do estado de São Paulo, Brasil. O experimento foi conduzido em três ciclos agrícolas, (2012-2013, 2013-2014 e 2014-2015) com as cultivares Espada Vermelha, Keitt e Palmer enxertadas sobre a cultivar Espada. O delineamento experimental foi em blocos casualizados com esquema fatorial 3 x 3, em que o primeiro fator corresponde às cultivares e o segundo fator aos ciclos agrícolas avaliados. Utilizaram-se 10 repetições e uma planta por parcela. As seguintes variáveis foram avaliadas: número de frutos por panícula, número de frutos por planta, porcentagem de panículas com abortamento total de frutos, massa fresca do fruto, produção, produtividade, volume da copa, eficiência produtiva e sazonalidade de colheita. Os dados obtidos foram analisados por meio do teste Tukey e correlação de Pearson. Dentre as cultivares avaliadas a Palmer destaca-se com o melhor desempenho produtivo independente do ciclo agrícola avaliado. As correlações entre as características produtivas avaliadas variam conforme a cultivar.

PALAVRAS-CHAVE: *Mangifera indica* L.. Alternância produtiva. Produtividade. Sazonalidade. Correlação.

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