PERFORMANCE OF NEW *Hevea* CLONES FROM IAC 400 SERIES

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ABSTRACT: The *Hevea* breeding program of Instituto Agronômico de Campinas (IAC) has completed clonal evaluation on the following series: IAC 100, IAC 200 and IAC 300. The performance of 22 clones of *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg., evolved at IAC, over a period of eleven years was evaluated in the Western Central part of the São Paulo State, Brazil. Among these 22 new clones, six were intraspecific hybrid clones (IAC 400, IAC 404, IAC 405, IAC 406, IAC 410, IAC 412) and the remaining are primary those resulted from selected ortets within half-sib progenies. An old popular clone RRIM 600, of Malaysian origin, was used as the control. The trial was laid out in a randomized block design with three replications. Yield performance over a period of four years, mean girth at the 11th year, girth increment before tapping and on tapping, thermal property of natural rubber produced, bark thickness, number of latex vessel rows in seven year virgin bark, percentage incidence of tapping panel dryness, wind damage and diseases like leaf and panel anthracnose have been observed. Sixty one percent of the clones were superior in relation to the control for yield. The clone IAC 400 recorded the highest yield (97.40 g tree^{-1} tap^{-1}) over four years of tapping, followed by IAC 411 (78.87 tree^{-1} tap^{-1}), whereas the control clone RRIM 600 recorded 50.86 g tree^{-1} tap^{-1}. All selected clones were vigorous in growth. Girth increment of these clones was average to above average. Except for IAC 423, other clones had thick virgin bark at opening ranging from 4.84 mm for IAC 401 to 6.38 mm for IAC 416. The natural rubbers from IAC clones have shown good thermal stability up to 300^{o}C and no differences in the thermal behavior among rubber from clones of the IAC series and the clone RRIM 600 were found in inert atmosphere.
Key words: *Hevea brasiliensis*, yield, vigour, brown bast, bark thickness

PERFOMANCE DE NOVOS CLONES DE *Hevea* DA SÉRIE IAC 400

RESUMO: O programa de melhoramento de *Hevea* do Instituto Agronômico de Campinas (IAC) completou a avaliação dos clones da série IAC 100, IAC 200 e IAC 300. O desempenho médio em torno de 22 clones de [*Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg.], desenvolvidos pelo IAC, por um período de 11 anos foi avaliado na região Centro Oeste do estado de São Paulo. Dentre os 22 novos clones, seis são resultantes de hibridação intraespecífica (IAC 400, IAC 404, IAC 405, IAC 406, IAC 410, IAC 412) e o restante, clones primários resultantes de ortetes selecionados dentro de progênies de meios irmãos. O clone RRIM 600, de origem Malaia, foi usado como testemunha. O experimento foi conduzido sob delineamento de blocos ao acaso com três repetições. Desempenho da produção sob o período de quatro anos, média do perímetro do caule no décimo primeiro ano, incremento médio anual do perímetro antes e durante a sangria, espessura de casca, número de anéis de vasos laticíferos no sétimo ano de casca virgem, análise por termogravimetria da borracha produzida, percentagem de incidência de seca do painel de sangria, danos causados pelo vento e doenças como antracnose do painel e das folhas foram observados. A maioria dos clones foi superior em produção em relação ao clone RRIM 600. O clone IAC 400 registrou a mais alta produção (97,40 g árvore^{-1} sangria^{-1}) em quatro anos de sangria o qual foi seguido pelo IAC 411 (78,87 g árvore^{-1} sangria^{-1}) visto que o clone testemunha registrou 50,36 g árvore^{-1} sangria^{-1}. Todos os clones selecionados tiveram crescimento vigoroso. Incrementos do perímetro do caule estiveram acima da média. Exceto o IAC 423, outros clones apresentaram espessura de casca virgem na abertura do painel (mm) variando de 4.84mm (IAC 401) a 6.38 mm (IAC 416). As borrachas estudadas apresentaram boa estabilidade térmica até cerca de 300^{o}C e não foram observadas diferenças no comportamento térmico entre as amostras dos clones da série IAC e as do clone RRIM 600.
Palavras-chave: *Hevea brasiliensis*, produção, vigor, secamento do painel, espessura de casca

INTRODUCTION

The "Instituto Agronômico" (IAC) started in 1942 a breeding and selection program for *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg. clonal cultivars. Since then, the institute has tested about 366 clones in small-scale clone trials and 43 clones in large-scale clone trials (Gonçalves, 2002). In addition, IAC has also carried out tests on clones produced by other research organizations within and outside the country. IAC has now completed the clonal evaluation of the following series, IAC 100, IAC 200 and IAC 300 (first selection). Currently, field tests on the new, IAC 400 series clones are being carried out.

For *Hevea*, selective hybridization between superior clones as well as ortet selection (plus tree selection) followed by vegetative multiplication and evaluation, could produce many promising clones. Improved clones evolved by adopting these two techniques are used as planting materials since 1958 in the São Paulo State (Cunha, 1963a; 1963b; 1966, Gonçalves et al., 1997; Gonçalves, 2002). The experimental evaluation of clones is very elaborate, involving three stages of which the small scale trial is the second stage.

Attempts were made to extend rubber cultivation to the non-traditional regions of Brazil in which near tropical climatic conditions prevail (Ortolani, et al., 1998). One such region identified is South Western Brazil (19 to 23ºS) where the continental up land of the region is an escape area of South American Leaf Blight (SALB) (Camargo et al., 1967; Ortolani et al., 1983; Gasparotto & Lima, 1991) and the daily and monthly high rainfall or continuous water excess are not related to high latex production. The crop yield models described for this continental plateau for soybeans (Camargo et al., 1986) and for oranges (Camargo et al., 1995) indicate surplus as penalization factor for development and production.

In the present study, the performance of twenty-two IAC 400 series clones along with RRIM 600 an old popular clone taken as control, is presented for the first time, in a small scale trial carried out over a period of 11 years.

MATERIAL AND METHODS

The experiment was carried out in Jaú, Western Central São Paulo State, Brazil (22º17'S; 48º34'W and 580m elevation), mean annual rainfall 1,344mm, on a Kandiudox of good nutrient status and physical structure. This location represents the most important continental area of non traditional rubber production in Brazil.

Genetic materials used in the experiment were 22 *Hevea* genotypes (clones) evolved by IAC and one developed by the Rubber Research Institute of Malaysia (RRIM 600) taken as control. The clones were budded on established GT 1 clonal rootstocks in a nursery. One-and-a-half-year-old rootstock seedlings raised in nurseries were used to budgraft the clonal materials. The successful budgrafts were uprooted and planted in plastic bags. The experiment was planted in the field after the first flush of leaves.

The small scale trial consisted of a randomized complete block design with three replications, using ten trees per row, with 7.0 m × 3.0 m spacing. Missing plants were replaced with spares during the first two years after planting to maintain plantation density, but were not scored. One row of the clone RRIM 600, acquired from a commercial nursery, was planted around the plot. Annual fertilizations consisted of 400g of 10-10-10 formula NPK per plant, according to Bataglia & Gonçalves (2003).

The trees were opened for tapping at the seventh year. The followed tapping system was the half spiral four daily tapping system (seven tappings per month), 11 month per year. Important characters recorded were dry rubber yield tree^{-1} tap^{-1} in grams over four years, girth of the trees eleven years after planting, girth increment before and on tapping, thickness as well as latex vessel rows of seven years virgin bark, per cent incidence of wind damage, tapping panel dryness and major diseases under normal prophylactic conditions for annual latex production.

Attempts were made to record four annual yields after panel opening. Yield recording was made by the cup coagulation method on two normal tapping days per month i.e., by coagulating the latex from individual trees accumulated in collecting cups by adding 2% acetic acid solution and stirring. The coagulated rubber was pressed into a cylinder, hand-dried for 30 days, and weighed for calculation of the dry rubber mass.

Girth of each tree was recorded once a year at a height of 120 cm above the bud union with a tailors' tape. The first measurement at 12 months consisted of diameters, since the plants were too small to measure girth. Plant diameter was measured 0.50 cm above ground level with a slide clipper. This measurement was converted to girth, assuming that the stem was cylindrical. Thickness of the bark was measured with a Scheliper's guage. To record the number of latex vessel rows, bark samples were sectioned in the radial plane, stained with Sudan III and the number of latex vessel rows was counted using a light microscope. The incidence of diseases was assessed by visual observation. Data on yield, yield depression, girth, bark thickness and latex vessel rows were statistically analyzed.

For the panel anthracnose evaluation caused by the *Colletotrichum gloeosporioides* (Penz.) Sacc., the system of severity degree was used to quantify the intensity of symptoms of the disease in the panels. The evaluation was made using a gradual grade scale varying from 1 to 5 (1. low; 2. below average; 3 average; 4. above average; 5. high). Data were transformed in infection indexes according to Bajungu (1977).

Thermogravimetric analysis of the rubber from the clones IAC 400, 401, 402, 403, 404, and RRIM 600 was obtained in a TA instrument model Q500, in the temperature range of 25°C to 800°C, at a heating rate of 10 degree/min, in a nitrogen atmosphere.

All statistical analyses were performed using the Genes computer program, windows version, 2001 (Cruz, 2001).

RESULTS AND DISCUSSION

The annual combined analyses for variance for rubber yield and annual girth increment showed genetic variation among clones and years. This difference indicates good perspectives for the selection of clones. The experimental coefficients of variation were higher for girth increment. The low coefficient of variation for rubber yield suggests the need of a greater accuracy in the field. The year effect yielded significant values for both characters. The effect of the clones × year interaction was also significant showing that these characters were affected by the variation between years.

Yield

Two methods of comparing yield for all the clones were used (Table 1). Each method has its particular value. First, the mean yield per tree per tapping allows a comparison of the yield potential of the trees and does not take into consideration differences in the numbers of trees in relation to tapping. The mean yield is calculated from the yields of all recorded trees in tapping during the year. Second, the actual yields per hectare per year give a comparison in which a clone with high yield per tree, but with a low number of trees under tapping, may appear to be of the same productive value as another clone with a low yield per tree but a higher number of trees under tapping. To assess the value of a clone both types of yield, records need to be examined together. However, in the early years of tapping the yield per tree is a better indication of the yield potential than is the yield per hectare because of the wide differences in tappability or tappable stand per hectare among clones at opening (Tan, 1987).

Mean yield for the first four years, annual mean, percentage control and relative rank are given in Table 1. The yield potential of these clones over first three years has already been reported by Gonçalves (2006). Yield figures for the first year period indicated that 70% of the clones were numerically superior to the control and that IAC 400 had the highest yield of 69.89 g $tree^{-1}$ tap^{-1}. The next highest in yield were IAC 406 and IAC 405 with 56.65 g and 56.13 g, respectively. The control clone RRIM 600 yielded on average 32.03 g. During the period of second, third and fourth years of tapping, clones IAC 405 and IAC 406 yielded 70.00 g, 75.48 g, 77.35 g, 68.30 g, 75.73 g, and 88.13 g of dry rubber per tree tapping, respectively. The control clone RRIM 600 yielded on average 54.54 g, 52.07 g, and 64.78 g, respectively.

The mean yield over four years of exploitation had shown differences in rubber yield. Clones IAC 400 and IAC 411, over four years of exploitation, out yielded all other clones recording 97.40 g and 78.87 g, which means 192% and 155% superior to the clone control, respectively. The yield of the control clone RRIM 600 was only 50.86 g. Fourteen clones were superior to the control in this aspect. Gonçalves (2006) also reported that IAC 406, IAC 405, IAC 410, IAC 412 and IAC 413 were the top yielders over the period of three years. Analysis of winter yield depression has indicated that most of the clones are superior to the control regarding summer yield. IAC 400 had remarkable months (8.30%).

Secondary characters

Girth at 7^{th} and 10^{th} year, mean girth increment before and on tapping, and mean bark thickness, number of latex vessel rows of seven years virgin bark tappability were separately ranked within the selected clones (Table 2).

Vigour

The high yielding clone IAC 413 recorded the highest girth (62.33 cm) at the 10^{th} year, while the control clone, RRIM 600, presented only 52.14 cm. The lowest girth was noticed in another high yielding clone, IAC 420 (47.43 cm). This is in agreement with the statement that high yield needs not necessarily to be associated with high girth increment (Gonçalves et al., 2006). The percentage of tappable trees varied between 29% (IAC 411) to 82% (IAC 423), at opening. As mentioned earlier, the trials were opened for tapping at different ages varying from five and a half to seven years. Clones are also not uniformly present in the trial. Therefore, it is necessary to standardize the age in the trial, in order to make a fair comparison of the girths between the clones. Mean girths at the first three years

Table 1 - Estimates of annual yield of dry rubber and rank compared with the control (RRIM 600) of 22 new *Hevea* clones from IAC 400 series evaluated in small scale clone trial in the Western Central part of São Paulo State, Brazil.

Clone	Parentage	First year			Second year			Third year			Fourth year			Mean			Winter yield depression as percentage of mean yield
		g t^{-1} t^{-1}	Rank	kg ha^{-1} y^{-1}	g t^{-1} t^{-1}	Rank	kg ha^{-1} y^{-1}	g t^{-1} t^{-1}	Rank	kg ha^{-1} y^{-1}	g t^{-1} t^{-1}	Rank	kg ha^{-1} y^{-1}	g t^{-1} t^{-1}	Rank	kg ha^{-1} y^{-1}	
IAC 400	GT 711 x RRIM 600	69.89	1	1,207.70	89.71	2	2,196.18	101.69	1	2,782.33	128.31	1	3,695.33	97.40	1	2,470.39	8.30
IAC 401	RRIM 600 ill.	51.34	4	887.21	57.41	9	1,405.48	85.65	3	2,343.38	99.70	2	2,871.36	73.53	3	1,876.86	27.44
IAC 402	GT 711 ill.	45.22	5	781.34	58.04	8	1,420.90	68.69	8	1,879.27	64.00	14	1,843.20	58.99	10	1,481.18	23.48
IAC 403	GT 711 ill.	40.50	7	699.84	56.91	10	1,393.08	71.18	6	1,947.39	68.58	11	1,975.10	59.29	9	1,503.85	14.20
IAC 404	PB 5/63 × AVROS 363	44.19	6	763.60	55.58	11	1,360.52	57.85	12	1,582.78	87.94	6	2,532.67	61.39	7	1,559.89	5.82
IAC 405	Tjir 1 × RRIM 623	56.13	3	969.98	70.00	3	1,713.60	75.48	5	2,065.13	77.35	8	2,227.68	69.74	5	1,744.10	1.96
IAC 406	IAN 873 × RRIM 600	56.65	2	978.97	68.30	5	1,671.98	75.73	4	2.071,97	88.13	5	2,538.14	72.20	4	1,815.20	23.01
IAC 407	RRIM 600 ill.	28.44	22	491.00	54.09	13	1,324.04	37.27	22	1,019.80	87.50	7	2,520.00	51.83	13	1,338.71	32.03
IAC 408	RRIM 513 ill.	38.25	12	660.96	46.97	17	1,149.91	43.18	21	1,181.40	56.13	21	1,616.54	46.13	20	1,152.18	19.95
IAC 409	Fx 2784 ill.	26.14	23	451.70	52.16	15	1,276.80	63.58	9	1,739.64	71.92	9	2,071.30	53.45	12	1,384.86	24.08
IAC 410	PB 86 x PB 235	40.72	9	703.64	68.00	6	1,664.04	62.71	10	1.715.75	67.83	12	1,953.50	59.82	8	1,509.38	22.76
IAC 411	GT 711 ill.	40.60	10	701.57	90.71	1	2,220.58	90.00	2	2,462.40	94.17	3	2,712.10	78.87	2	2,024.16	29.55
IAC 412	IAN 873 × GT 711	39.92	8	689.82	60.00	7	1,468.80	59.80	11	1,636.13	70.08	10	2,018.30	57.45	11	1,453.26	18.54
IAC 413	IAN 873 ill.	38.41	11	663.72	53.00	14	1,297.44	44.33	18	1,212.87	61.30	18	1,765.44	49.26	17	1,234.87	23.99
IAC 414	IAC 126 ill.	34.04	13	588.27	50.00	16	1,224.00	54.92	13	2,736.00	61.10	19	1,759.68	50.02	16	1,268.64	22.76
IAC 416	RRIM 600 ill.	29.30	21	506.30	46.18	18	1,130.49	46.98	17	1,285.28	61.90	17	1,782.72	46.09	19	1,117.62	24.00
IAC 417	RRIM 600 ill.	33.75	14	583.20	45.76	19	1,120.20	70.83	7	1,938.00	91.08	4	2,623.10	60.36	6	1,566.10	19.92
IAC 418	RRIM 600 ill.	33.02	15	570.53	69.97	4	1,717.87	48.56	16	1,328.60	55.67	22	1,603.30	51.81	14	1,303.82	18.17
IAC 420	IAN 873 ill.	32.44	16	560.56	40.02	23	979.69	43.72	19	1,196.18	63.15	15	1,818.72	44.83	21	1,113.88	20.12
IAC 421	IAC 157 ill.	31.79	18	549.33	43.73	20	1,070.51	36.17	23	989.61	52.60	23	1,514.88	41.07	23	1,031.08	25.82
IAC 422	RRIM 513 ill.	31.24	19	539.83	43.71	21	1,070.02	52.16	14	1,427.10	62.95	16	1,812.96	47.52	18	1,212.48	18.00
IAC 423	IAC 90 ill.	30.70	20	530.55	42.13	22	1,031.04	43.66	20	1,194.54	58.68	20	1,689.98	43.79	22	1,111.60	23.50
RRIM 600	Tjir 1 × PB 86	32.03	17	553.54	54.54	12	1,335.14	52.07	15	1,424.64	64.78	13	1,865.66	50.86	15	1,297.74	30.55
General mean		39.34		679.72	57.26		1,401.66	60.27		1,648.99	73.69		2,122.20	57.64		1,463.15	
S.E.		10.69		184.81	13.67		334.68	17.47		478.16	18.13		522.02	13.37		340.45	
C.V.%		27.18		27.19	23.88		23.88	29.00		29.00	24.60		24.60	23.19		23.19	

In the first, second, third and fourth year of tapping it was considered 240, 340, 380 and 400 trees/hectare respectively. Tapping system: 1/2S d/4.5d/7.11m/y.ET 2.5% Pa. 10/y.

Table 2 - Some secondary characters of 22 new *Hevea* clones from IAC 400 series clones compared with the control (RRIM 600) in small scale clone trial evaluated in the Western Central part of São Paulo State, Brazil.

Clones	Girth				Girth increment average				Trees tappable		Virgin bark		Latex vessel rows	
	At opening	Rank	At 10th year	Rank	Before tapping	Rank	On tapping	Rank	At opening	Rank	At opening	Rank	At opening	Rank
	cm								%		mm			
IAC 400	41.63	10	56.99	5	5.95	10	5.12	3	81	2	5.32	14	12.31	17
IAC 401	40.93	12	51.69	14	5.85	12	3.59	21	43	17	4.84	23	12.28	19
IAC 402	41.14	11	52.00	12	5.88	11	3.62	20	45	16	5.95	4	13.69	7
IAC 403	35.86	19	49.20	20	5.12	18	4.11	13	77	3	5.25	15	12.83	11
IAC 404	42.03	9	53.27	10	6.00	9	3.74	18	58	9	5.50	13	14.39	4
IAC 405	38.36	14	51.07	15	5.48	14	4.23	10	56	10	5.61	12	13.14	9
IAC 406	43.27	5	56.50	6	6.18	5	4.41	7	67	5	5.08	20	11.69	22
IAC 407	35.56	20	49.87	17	5.08	19	4.77	4	53	14	5.68	11	13.67	8
IAC 408	31.33	23	49.27	19	4.48	23	4.31	8	77	4	5.71	8	12.50	12
IAC 409	34.75	22	48.75	21	4.97	22	4.00	14	32	22	5.81	6	12.33	16
IAC 410	37.22	17	48.27	22	5.32	16	3.68	19	40	19	5.70	10	10.46	23
IAC 411	46.16	3	58.67	3	6.59	3	4.17	12	29	23	5.24	16	11.75	21
IAC 412	46.74	2	57.28	4	6.68	2	3.51	23	43	18	5.70	9	13.79	6
IAC 413	46.95	1	62.33	1	6.71	1	5.13	2	51	15	4.91	21	12.17	20
IAC 414	38.52	13	51.97	13	5.50	13	4.48	6	55	11	4.86	22	12.29	18
IAC 416	37.94	16	49.95	15	5.42	15	4.00	15	61	7	6.38	2	13.00	10
IAC 417	36.44	18	49.31	18	5.21	17	4.29	9	55	13	5.22	17	12.33	15
IAC 418	43.11	6	60.53	2	6.16	6	5.81	1	65	6	5.11	18	12.50	13
IAC 420	35.41	21	47.43	23	5.06	20	4.00	16	36	21	5.11	19	12.50	14
IAC 421	42.36	7	54.89	8	6.05	7	4.18	11	55	12	5.82	5	15.00	1
IAC 422	42.16	8	53.55	9	6.03	8	3.80	17	60	8	5.97	3	14.11	5
IAC 423	44.23	4	55.00	7	6.32	4	3.59	22	82	1	6.48	1	14.75	3
RRIM 600	38.14	15	52.14	11	5.06	21	4.67	5	40	20	5.79	7	14.78	2
General mean	40.01		52.04		5.70		4.23		54.04		5.52		12.97	
S.E.	4.17		4.11		0.61		0.58		15.21		0.45		1.14	
C.V.%	10.42		7.74		10.68		13.63		28.06		8.20		8.78	

have been found to be highly correlated with mean girths at opening (Sultam, 1973). Hence, the former is used in preference for the assessment of the clones.

Girth increment

Mean girth increment per year before tapping ranged from a minimum of 4.48 cm (IAC 408) to a maximum of 6.71 cm (IAC 413). Gonçalves (2006) reported the highest girth at opening for IAC 413. The control clone RRIM 600 recorded mean girth increment of 5.06 cm before tapping. The rate of girth increment during the tapping period, over three years also varied among the clones. The clones IAC 418 and IAC 413 showed the highest girth increment of 5.81 cm and 5.13 cm per year, respectively, followed by IAC 400 (5.12 cm), IAC 407 (4.77 cm) and IAC 414 (4.48 cm), which were found to be very poor in this regard when compared to other clones. Girthing rate on tapping is important when considering future yield and wind damage (Tan, 1987). In addition, good girthing in tapping according to Tan (1987) sustains yield and a reduce wind damage losses through trunk snap.

Bark thickness

In the case of bark thickness of seven-year virgin bark, all the clones were also found to be similar to the control. IAC 423 (6.48 mm) recorded the highest bark thickness while IAC 401 (4.84 mm) recorded the lowest. Tan (1987) reports that thick bark is very important because it minimizes wounding incidence, which is known to affect yield productivity on later panels.

Number of latex vessels rings

At opening, in relation to virgin bark, only IAC 421 clone was superior to the control and was found ranging from 10.46 (IAC 410) to 15.00 (IAC 421). In the control, the number was 14.78 rings. The number of vessel rings according to Henon & Nicolas (1989) appeared to be the best parameter, among others, that influence the latex production. Its correlation with yield established by means of the Morris-Mann test for early tapping of seedlings is very good (r = 0.64). Tixier (1953) examined the same relation in ten six-year-old clones and obtained a correlation coefficient r of 0.75. However, observation of AVROS 226, a low-yielding clone with many latex vessel rings, led him to take into account other criteria, such as girth and bark thickness, in the evaluation of rubber yield.

Wind damage

Only trees lost through trunk snap, uprooting and those that were stumped above 2 m were considered as losses due to wind damage. The incidence of wind damage occurring in different forms of trunk snap, branch snap and uprooting, up to the 10th year of growth, was recorded and is given in Table 3. All the clones were affected by wind and the incidence varied from 1.03% (IAC 400) to 10.15% (IAC 416). The control clone RRIM 600 recorded 3.20% wind damage. Tolerance to wind minimizes losses ensuring a good tapping stand throughout the economic life of the crop that may be associated with branching habit, three height, long latex flow or low plugging index, leading to an adverse partition and hence an imbalance between crown and trunk components (Tan, 1987).

Dry trees

Only genuine cases of dry trees have been considered; trees that became dry as consequence of wind damage have been excluded. Dry tree incidences were also recorded (Table 3) over one-and-a-half years of tapping. As mentioned earlier, all trial trees were uniformly tapped on S/2 d/4. However, clonal susceptibility to dryness can be better assessed only after several years of tapping, (Sultan, 1973). Incidence of tapping panel dryness was noticed in almost all the clones. IAC 407 was the most susceptible clone, which recorded 3.67% incidence of dryness, followed by IAC 403 (3.65%) and IAC 405 (3.52%).

Disease susceptibility

All clones were found to be more or less susceptible to Anthracnose leaf and panel disease caused by *Colletrichum gloeosporioides* (Panz.) Sacc. within which six viz. IAC 402, IAC 403, IAC 404, IAC 405, IAC 406 and IAC 420, showed comparatively low incidence under normal prophylactic conditions (Table 3). Other clones were severely affected by this malady. Anthracnose panel disease also affected all clones with intensity varying from high to low. Based on the present study, four clones viz. IAC 406, IAC 410, IAC 412 and IAC 413 were found to be superior with respect to the Antracnose panel disease. According to Gonçalves et al. (1999) only recently, Anthracnose panel disease incidence was detected in tapping panels of the clone RRIM 600 by Silveira et al. (1992), on which where genetic studies were initiated. This disease has since assumed epidemic proportions in many rubber plantations in the São Paulo State (Trindade & Furtado, 1997).

Thermal properties

Typical curves TG/DTG obtained for raw rubber from the IAC series 400 clones in inert atmosphere (Figures 1 and 2) show that the TG curve has only one large plateau and the DTG curve has one degradation peak, indicating that thermal degradation of raw natural rubber of the IAC clones is a one-stage reaction. The temperature of the maximum mass loss rate

Table 3 - Percentages of wind damage, tapping panel dryness and incidence of anthracnose leaf and panel disease in 22 new clones from IAC 400 series in small scale trial evaluation in the Western Central part of São Paulo State.

Clones	Wind damage	Tapping panel dryness	Anthracnose disease incidence	
			Leaf	Panel
	---------------------- %	----------------------		
IAC 400	1.03	2.82	Below average	Below average
IAC 401	4.22	3.48	Below average	Above average
IAC 402	3.44	1.29	Low	Above average
IAC 403	6.20	3.65	Low	Above average
IAC 404	3.31	3.43	Low	Above average
IAC 405	2.10	3.52	Low	Below average
IAC 406	2.10	2.66	Low	Low
IAC 407	5.93	3.67	High	Above average
IAC 408	4.67	2.54	High	Above average
IAC 409	9.32	2.57	Average	Average
IAC 410	2.28	2.38	Below average	Low
IAC 411	4.61	0.81	Average	Average
IAC 412	1.22	1.61	Average	Low
IAC 413	2.18	2.83	Average	Low
IAC 414	3.12	1.61	Below average	Below average
IAC 416	10.15	2.81	Above average	Above average
IAC 417	5.14	2.38	Above average	Above average
IAC 418	4.70	2.54	Below average	Average
IAC 420	3.10	0.00	Low	Average
IAC 421	9.83	2.57	High	Average
IAC 422	5.61	1.29	Below average	Average
IAC 423	4.81	2.80	Below average	Average
RRIM 600	3.20	3.11	Average	Average

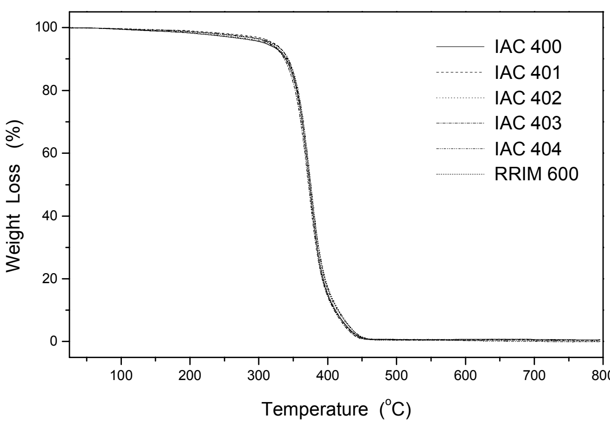

Figure 1 - TG curves of the IAC 400 series, and RRIM 600 clones in inert atmosphere. 10°C/min.

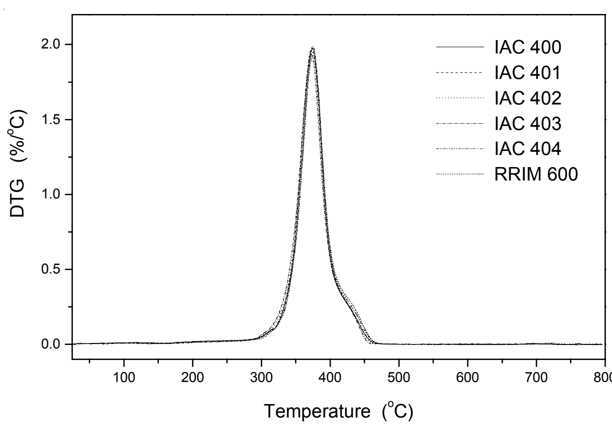

Figure 2 - DTG curves of the IAC 400 series, and RRIM 600 clones in inert atmosphere. 10°C/min.

or the peak temperature of the DTG curve is around 375°C, and at 800°C the content of residues was insignificant for all clones. This lower content of residues indicates that few impurities have been added during the extraction process of the latex in the plantation. A small shoulder can be observed at approximately 430°C attributed to the slow decomposition of the most entanglement or crosslinked chains (Rippel, 2005). The temperature at which 50% decomposition occurs is generally considered as an index of thermal stability (Menon et al., 1996), and our results have shown that this temperature for the rubber from IAC clones is about 375°C indicating good thermal stability. TG and DTG curves of all clones have shown similar behavior, suggesting that the thermal decomposition mechanism is the same.

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