Indian Journal of Natural Rubber Research, **16** (1 & 2) : 75-80, 2003

GENETIC PARAMETERS AND HETEROSIS IN RUBBER (*HEVEA BRASILIENSIS*) MUELL. ARG. : V. HYBRID VIGOUR FOR YIELD AND YIELD COMPONENTS AMONG THE RRII 400 SERIES CLONES IN SMALL SCALE EVALUATION

J. Licy, C.K. Saraswathyamma, D. Premakumari, T. Meenakumari, J. Rajeswari Meenattoor and M.A. Nazeer

Licy, J., Saraswathyamma, C.K., Premakumari, D., Meenakumari, T., Meenattoor, R.J. and Nazeer, M.A. (2003). Genetic parameters and heterosis in rubber (*Hevea brasiliensis*) Muell. Arg. : V. Hybrid vigour for yield and yield components among the RRII 400 series clones in smallscale evaluation. *Indian Journal of Natural Rubber Research*, **16** (1 & 2) : 75-80.

Performance of twenty three hybrid clones of rubber (*Hevea brasiliensis*) resultant of the cross RRII 105 x RRIC 100 was evaluated during the mature phase. The hybrid clones exhibited significant clonal variation for annual yield over seven years and for the yield components *viz.*, total volume of latex, dry rubber content, initial rate of latex flow, plugging index, girth at opening, girth increment on tapping, number of latex vessel rows and thickness of virgin and renewed bark, indicating sufficient variability for selection. Out of the 23 hybrid clones tested, 10 showed better potential for crop improvement in rubber as evidenced by estimates of standard heterosis.

Key words: Clonal variation, Hybrid clones, Standard heterosis.

J. Licy, C.K. Saraswathyamma (for correspondence), D. Premakumari, T. Meenakumari, J. Rajeswari Meenattoor and M.A. Nazeer, Rubber Research Institute of India, Kottayam-686 009, India. (E-mail : rrii@vsnl.com, info@rubberboard.org.in)

INTRODUCTION

The primary goal of any plant breeding programme is essentially to improve the genetic potential of the crop, particularly the productivity of a genotype. This is being achieved in several ways, the most attractive and achievable one being heterosis breeding. Heterosis has been exploited since quite long in cross-pollinated crops and cross-pollination is the rule rather than an exception in rubber. The present study deals with heterosis for yield and yield components among a set of twenty three hybrid clones of the cross RRII 105 x RRIC 100 under small-scale evaluation. Early evaluation of these clones at the immature phase had resulted in the identification of 15 clones having heterotic improvement for yield over the standard clone RRII 105 (Licy *et al.*, 1992). Further studies have also indicated the association of yield and yield attributes in these clones both in the early and mature phases (Licy, 1998; Licy *et al.*, 1993a, 1993b, 1998).

MATERIALS AND METHODS

The materials comprised twenty-five clones of *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell. Arg. which constituted twenty-three hybrid clones resultant of a biparental cross of RRII 105 x RRIC 100, and the two parental clones. The field experiment was laid out at the Rubber Research Institute of India, Kottayam in 1985 as a small scale evaluation trial. A randomised block design with three replications and four plants per plot was adopted with a spacing of 3.4 x 6.7 m. All cultural operations were carried out uniformly as recommended by the Rubber Board. The clones were opened for early tapping at four and a half years after field planting in order to evaluate the early performance in the immature growth phase. The trees were opened for regular tapping in 1993 following 1/2 S d/3 system. Yield was recorded as gram per tree per tap by cup coagulation method. The characters under observation included (1) annual mean dry rubber yield (g/t/t) over the first seven years of tapping, (2) volume of latex (ml/tap), (3) initial rate of latex flow , (4) dry rubber content (%), (5) plugging index over the first three years of tapping, (6) girth at opening (cm), (7) girth increment on tapping (cm) over the first 6 years of tapping, (8) number of latex vessel rows in virgin bark at opening year and during the 3rd year of tapping, (9) virgin bark thickness (mm) at opening and during the 3rd year of tapping, (10) number of latex vessel rows in renewed bark, (11) renewed bark thickness (mm) after six years renewal, and (12) wintering. Analysis of variance and heterotic values for all the characters were worked out as per the standard procedure.

RESULTS AND DISCUSSION

Analysis of variance revealed significant clonal variation for all the characters studied (Table 1). These observations suggest the presence of inherent genetic variability in the population which would enhance selection programme, wherein selection pressure can profitably be exerted on those characters. The results are in agreement with the findings of Mydin (1992) and Premakumari (1992). Ranges of variation in yield and yield components were in conformity with the result reported by Gilbert *et al.*, (1973), Nga and Subramaniam (1974), Tan *et al.*, (1975) and Licy *et al.*, (1992). Although Saraswathy amma and Sethuraj (1975) have reported clonal variations for latex flow characters and yield, ranges of variation observed in the present study for bark thickness, plugging index, girth increment and DRC were low, indicating limited scope for selection based on these characters.

Heterosis for growth and dry rubber yield

Mean girth at opening of seven clones *viz*, RRII 404, RRII 405, RRII 407, RRII 408, RRII 414, RRII 420 and RRII 429 were significantly superior to RRII 105 (Table 1) and the clone RRII 429 exhibited maximum standard heterosis (27.99%). This result shows the effectiveness of heterosis breeding for growth improvement. Mydin *et al.*, (1990) also recorded high estimates of heterosis for juvenile girth in certain hybrid *Hevea* clones. Early vigour facilitates early tapping. High girth in some of these hybrid clones render scope for early exploitation, by a reduction of the immaturity period. The value addition in terms of improved vigour combined with good latex yield is a unique feature of these clones. Twelve clones were found to show better girth increment over six years of tapping than RRII 105 of which RRII 407 (standard heterosis of 66.39%) was found to be significantly superior to RRII 105. High girth increment on tapping is a good sign of possible yield increase on tapping.

Mean dry rubber yield data shows that 10 hybrid clones out yielded RRII 105, the check variety, which is also the female parent. Two clones *viz.*, RRII 414 (81.11 g/t/t) and RRII 429 (80.22 g/t/t) were found to be significantly superior to RRII 105 in terms of yield (Table 1). This indicates that these hybrids have got higher potential for yield than the commercially popular variety, RRII 105 which points towards future promise. The hybrid clones exhibited standard heterosis estimates varying from 0.08 to 45.61% (Table 2). Heterosis of more than 20% for yield, is considered to be adequate for commercial exploitation of crop varieties (Rai, 1979). In the present study, standard heterosis observed in clones RRII 403, RRII 407, RRII 414, RRII 417, RRII 421, RRII 422, RRII 429 and RRII 430 offer promise for further improvement.

Heterosis for physiological yield components

Nine clones *viz.*, RRII 403, RRII 404, RRII 410, RRII 414, RRII 417, RRII 422, RRII 427, RRII 429 and RRII 430 were found to exhibit positive standard heterosis rang-

Table 1. **Growth and yield attributes of RRII 400 series clones along with the parents**

Clones	Girth at opening (cm)	Girth increment (cm)	Dry rubber yield* (g/t/t)	Volume of latex ** (ml/t/t)	Rate of flow	Plugging index	Dry rubber content (%)	Bark thickness			No. of latex vessel rows		
								In virgin bark		In renewed bark	In virgin bark		In renewed bark
								at opening	at 3rd year of tapping		at opening	at 3rd year of tapping	
RRII 403	54.54	10.18	71.60	199.83	28.8 0	2.63	34.00	6.17	7.50	7.29	11.50	18.25	13.50
RRII 404	58.69	11.22	66.60	199.47	32.76	2.87	31.00	6.27	7.88	6.95	8.11	14.72	17.55
RRII 405	57.54	12.11	32.90	96.83	24.28	4.67	32.07	6.40	7.79	7.29	9.83	13.83	13.55
RRII 407	56.34	20.65	68.90	173.31	22.52	2.63	28.19	6.78	8.04	8.25	7.28	15.39	16.73
RRII 408	56.84	18.08	32.90	105.74	21.61	4.46	31.60	7.29	8.67	8.92	9.78	18.05	17.17
RRII 410	53.52	16.27	55.60	188.70	44.76	3.81	32.58	6.67	7.84	8.54	8.75	19.58	17.38
RRII 411	51.38	17.20	43.80	120.43	31.59	4.92	36.74	5.97	7.28	7.33	10.50	17.05	16.61
RRII 414	57.49	17.02	81.11	280.12	43.55	2.59	30.64	7.14	8.61	7.85	11.77	21.76	19.83
RRII 415	50.39	15.96	25.90	63.65	22.40	5.03	34.68	6.26	7.18	6.74	6.74	12.05	9.49
RRII 417	54.73	10.76	71.35	209.63	40.19	3.42	34.63	6.71	8.09	8.34	13.00	20.49	18.93
RRII 418	51.30	3.84	37.80	132.30	31.21	3.70	34.21	6.84	8.00	7.42	8.00	16.00	13.13
RRII 419	51.04	13.45	24.60	91.70	15.50	3.32	27.10	6.27	7.21	6.92	5.28	9.33	8.94
RRII 420	57.24	17.42	39.00	94.49	16.19	3.26	30.63	6.02	7.29	7.29	9.28	14.16	15.94
RRII 421	50.64	5.99	70.90	173.70	32.85	2.97	36.65	6.70	8.39	7.55	13.45	20.44	15.91
RRII 422	52.40	8.71	72.52	237.49	39.47	2.82	34.27	6.89	8.18	7.67	14.62	21.66	24.86
RRII 423	50.59	14.78	51.30	138.37	31.92	3.75	33.53	6.51	7.52	7.70	7.39	15.44	14.03
RRII 424	49.59	14.11	51.50	174.90	30.58	2.88	31.06	6.50	7.57	7.58	9.84	16.55	16.67
RRII 425	52.08	11.17	52.30	183.64	32.01	2.77	28.51	6.94	8.21	7.63	6.78	17.44	15.33
RRII 426	49.68	12.98	49.50	154.77	29.96	2.92	30.02	6.38	7.58	7.33	9.39	17.22	16.39
RRII 427	52.79	6.02	56.90	222.48	35.43	2.47	29.88	7.05	8.18	7.34	8.22	16.72	14.01
RRII 428	52.40	10.70	44.40	132.97	37.74	4.02	32.60	6.25	7.40	7.18	9.62	15.77	14.72
RRII 429	62.77	14.33	80.22	237.16	31.40	2.33	28.81	6.19	7.89	7.68	12.95	22.00	21.64
RRII 430	53.42	8.44	69.22	223.84	53.00	3.90	35.26	6.63	7.92	7.38	11.73	18.32	11.83
RRII 105	49.04	12.41	55.70	185.76	45.21	3.60	33.46	7.00	8.17	8.00	10.58	15.21	19.38
RRIC 100	50.78	5.88	37.60	121.40	28.54	3.59	31.15	6.26	7.11	6.61	7.80	15.55	12.88
G. Mean	53.49	12.39	53.76	165.71	32.15	3.41	32.13	6.56	7.83	7.55	9.69	16.92	15.90
CD (P= 0.05)	6.50	5.76	17.64	55.23	7.29	0.83	3.72	0.73	0.93	1.04	3.36	4.27	3.99
F ratio	2.27**	0.74*	7.38**	7.95**	12.61**	7.02**	3.97**	2.01*	1.83*	2.21**	4.01*	4.13**	6.78**

* mean over 7 years ** mean over 3 years

Table 2. **Estimates of standard heterosis for growth and yield attributes of RRII 400 series clones**

Clones	Girth at opening (cm)	Girth increment (cm)	Dry rubber yield*** (g/t/t)	Volume of latex † (ml/t/t)	Rate of flow	Plugging index	Dry rubber content (%)	Bark thickness: In virgin bark at opening	Bark thickness: In virgin bark at 3rd year of tapping	Bark thickness: In renewed bark	No. of latex vessel rows: In virgin bark at opening	No. of latex vessel rows: In virgin bark at 3rd year of tapping	No. of latex vessel rows: In renewed bark
RRII 403	11.22	-17.96	28.55	7.57	-36.72	-26.94**	1.61	-11.85	-8.20	-0.87	8.69	19.98	-30.34
RRII 404	19.68 **	-9.58	19.56	7.38	-28.02	-20.27*	-7.35	-10.42	-3.55	-13.13	-23.35	-3.22	-9.44
RRII 405	17.33 **	-2.42	-40.93	-47.87	-46.65	29.72	-4.15	-8.57	-4.66	-8.88	-7.08	-9.07	-30.08
RRII 407	14.89 *	66.39 *	23.69	-6.70	-50.51	-26.94**	-15.75	-3.14	-1.59	3.13	-31.19	1.18	-13.67
RRII 408	15.91 *	45.68	-40.93	-43.08	-52.52	23.88	-5.56	4.14	6.12	11.5	-7.56	18.67	-11.40
RRII 410	9.14	31.10	-0.01	1.58	-1.65	5.83	-2.63	-4.71	-4.04	6.75	-17.29	28.73 *	-10.32
RRII 411	4.77	38.59	-21.36	-35.16	-30.59	36.67	9.80	-14.71	-10.89	-8.38	-0.75	12.09	-14.29
RRII 414	17.23 *	37.15	45.61**	50.79**	-4.31	-28.05**	-8.43	2.00	5.39	-1.88	11.24	43.06 **	2.32
RRII 415	2.75	28.61	-53.50	-65.74	-50.78	39.72	3.65	-10.57	-12.12	-15.77	-36.29	-20.78	-51.03
RRII 417	11.6	-13.2	28.09	12.85	-11.69	-5.00	3.49	-4.14	-0.98	4.25	22.87	34.71 *	-2.32
RRII 418	4.61	-69.05	-32.13	-28.78	-31.42	2.78	2.24	-2.28	-2.08	-7.25	-24.39	5.19	-32.25
RRII 419	4.08	8.38	-55.83	-50.63	-65.94	-7.78	-19.01	-10.42	-11.75	-13.5	-50.09	-38.66	-53.86
RRII 420	16.72 *	40.37	-29.98	-49.13	-64.43	-9.44	-8.46	-14.00	-10.77	-8.88	-12.28	-6.90	-17.75
RRII 421	3.26	-51.73	27.28	-6.49	-27.82	-17.50	9.53	-4.28	2.69	-5.63	27.13	34.39 *	-17.19
RRII 422	6.85	-29.81	30.19	27.85	-13.27	-21.67*	2.42	-1.57	0.12	-4.13	38.18 *	42.41 **	33.44 **
RRII 423	3.16	19.09	-7.89	-25.51	-29.86	4.17	0.21	-7.00	-7.96	-3.75	-12.29	1.51	-27.61
RRII 424	1.12	13.69	-7.54	-5.85	-32.81	-20.00	-6.24	-7.14	-5.14	-5.25	-6.99	8.81	-13.98
RRII 425	6.19	-9.99	-6.10	-1.14	-29.66	-23.06*	-14.79	-0.85	4.89	-4.63	-35.92	14.66	-20.89
RRII 426	1.31	0.05	-11.13	-16.68	-34.17	-18.89	-10.28	-8.85	-7.22	-8.38	-11.25	13.21	-15.43
RRII 427	7.65	-51.49	0.08	19.77	-22.15	-31.39**	-10.69	-0.71	1.22	-8.28	-22.31	9.93	-27.71
RRII 428	2.18	-13.78	-20.28	-28.42	-17.07	11.67	-2.57	-10.71	-9.42	-10.25	-9.07	3.68	-24.05
RRII 429	27.99 **	15.47	44.02**	27.67	-31.00	-35.28**	-13.89	-11.57	-3.43	-4.00	22.40	44.64 **	11.66
RRII 430	8.93	-31.99	24.27	20.49	16.46*	8.33	5.38	-5.28	-3.06	-7.75	10.86	20.45	-38.96
CD (P=0.05)	6.50	5.76	17.64	55.23	7.29	0.83	3.72	0.73	0.93	1.04	3.36	4.27	3.99
CD (P=0.01)	8.67	8.97	23.39	73.63	9.72	1.11	4.96	0.97	1.24	1.39	4.46	5.70	5.32

* Significant at P≤0.05 ** Significant at P≤0.01 *** mean over 7 years † mean over 3 years

ing from 1.58 to 50.79% for volume of latex (Table 2). Heterosis for latex volume of *Hevea* clones has been reported earlier (Licy, 1998). Only one clone RRII 414, having a heterosis of 50.79% was found to be significantly superior to RRII 105. Very high estimates of heterosis for latex yield of *Hevea* was observed by Olapade (1988) which is supportive of the results obtained in the present study.

Only one clone i.e., RRII 430 exhibited superiority over RRII 105 (with a heterosis of 16.46%) for initial rate of latex flow. With respect to dry rubber content, none of the clones were significantly superior to RRII 105 and the hybrid vigour for this trait was not significant. Plugging index values for many of the hybrid clones were found to be comparable to that of the parents. Eight clones exhibited significant negative heterosis for plugging index.

Heterosis for structural attributes

The bark thickness of none of the hybrid clones showed any significant improvement over RRII 105 and heterosis for this trait was relatively low in the case of both virgin and renewed bark (Tables 1 & 2). The number of latex vessel rows at the time of opening for tapping was higher in seven clones *viz.*, RRII 403, RRII 414, RRII 415, RRII 417, RRII 421, RRII 422, RRII 429 and RRII 430 than that for the standard clone RRII 105. Only one clone (RRII 422) showed significant superiority over RRII 105 (Table1). For number of latex vessel rows in virgin bark in the third year of tapping, 18 clones exhibited positive standard heterosis ranging from 1.18 to 44.64%. Among these, six clones RRII 410, RRII 414, RRII 417, RRII 421, RRII 422 and RRII 429 were significantly superior to RRII 105 and the clone RRII 429 exhibited maximum standard heterosis (Table 2). For the same trait with respect to the renewed bark (after six years bark renewal), standard heterosis showed a range from 2.32 to 33.44% (Table 2). Number of latex vessel rows is a clonal character (Bobilioff, 1923; Sanderson and Sutcliffe, 1929 and Vischer, 1921, 1922) and frequency of laticifer differentiation is genetically controlled. The above results suggest the immense potentiality of these clones for crop improvement in rubber, especially for using as parents in breeding programmes aimed at component level improvement of characters.

The rubber tree is deciduous and wintering takes place during the period December to February in South India. Wintering observations of the ten promising selections revealed that in four selections (RRII 407, RRII 414, RRII 421 and RRII 422) leaf shedding was completed before the end of December (early wintering) and in six selections (RRII 403, RRII 410, RRII 417, RRII 427, RRII 429 and RRII 430) leaf shedding was completed only by the end of January (late wintering).

Examination of heterotic response for yield and its components in general revealed that majority of the hybrids displaying significant hybrid vigour for yield also possessed marked heterotic advantages in one or more components. According to Graffius (1959) there cannot be any gene system for yield *per se* and yield is an end product of multiple interactions between the yield components. This would mean that heterosis for yield is the reflection of heterosis for one or more of the individual yield components as observed in the present investigation. Present study indicates that all the 23 hybrid clones possess greater potential either in terms of yield or in terms of any of the yield components. It provides scope for using these clones as parents for component wise breeding objectives.

The realization of good estimates of heterosis for yield and yield attributes in the clonal materials used for the present study shows that the cross RRII 105 x RRIC 100 could be better exploited for yield improvement in rubber (Licy *et al.* 1992, 1993a and

1993b). The parents have been identified as genetically distant, the genetic distance being 0.614 as evidenced by the studies using random amplified polymorphic DNA markers (Varghese *et al.*, 1996). Judging from the results discussed, a good number of the hybrid clones (RRII 403, RRII 407, RRII 410, RRII 414, RRII 417, RRII 421, RRII 422, RRII 427, RRII 429 and RRII 430) which were identified as either on par with or superior to RRII 105 in performance, seem to offer better potential towards improving the productivity of rubber.

ACKNOWLEDGEMENT

The authors are grateful to Dr. N.M. Mathew, Director, Rubber Research Institute of India, for encouragement and providing facilities for conducting the study.

REFERENCES

Boblioff, W.C. (1923). *Anatomy and physiology of Hevea brasiliensis:* 1. *Anatomy of Hevea brasiliensis.* Zurich, Art. Institute Orell Fussli, 150 p.

Gilbert, N.E., Dodds, K.S. and Subramaniam, S. (1973). Progress of breeding investigations with *Hevea brasiliensis*: 5. Analysis of data from earlier crosses. *Journal of the Rubber Research Institute of Malaya*, **23** : 365-380.

Graffius, J.E. (1959). Heterosis in barley. *Agronomy Journal*, 51: 551-554.

Licy, J. (1998). *Variability, correlations and heterosis for yield and yield components in certain hybrid clones of the para rubber tree Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell Arg. Ph.D Thesis, University of Kerala, Thiruvananthapuram, India, 158 p.

Licy, J., Panikkar, A.O.N., Premakumari, D., Varghese, Y.A. and Nazeer, M.A. (1992). Genetic parameters and heterosis in *Hevea brasiliensis*: 1. Hybrid clones of RRII 105 x RRIC 100. *Indian Journal of Natural Rubber Research*, **5**(1&2) : 51-56.

Licy, J., Thomas, M., Panikkar, A.O.N., Abraham, J., Saraswathyamma, C.K. and Sethuraj, M.R. (1993a). Genetic parameters and heterosis in rubber (*Hevea brasiliensis*): 2. Association for yield and certain yield attributes. Placrosym X, Kasaragod, India, 1992. *Journal of Plantation Crops*, **21** (Supplement): 264-267.

Licy, J., Panikkar, A.O.N., Premakumari, D., Nazeer, M.A., Varghese, Y.A., Saraswathyamma, C.K. and Sethuraj, M.R. (1993b). Genetic parameters and heterosis in rubber (*Hevea brasiliensis* Muell. Arg.): 3. Variability and hybrid vigour for yield and certain yield attributes. *Golden Jubilee Symposium, Horticulture Research : Changing Scenario*, 24-28 May 1993, Bangalore, India.

Licy, J., Panikkar, A.O.N., Premakumari, D., Saraswathyamma, C.K., Nazeer, M.A and Sethuraj, M.R. (1998). Genetic parameters and heterosis in rubber (*Hevea brasiliensis*) Muell Arg.: 4. Early versus mature performance of hybrid clones. *Developments in Plantation Crops Research*, (Eds. N.M. Mathew and C. Kuruvilla Jacob) Allied Publishers Limited, New Delhi, pp.9-15.

Mydin, K.K. (1992). *Genetic divergence, prepotency and inbreeding depression in para rubber (Hevea brasiliensis) Muell. Arg.* Ph.D Thesis, Kerala Agricultural University, Trichur, India, 321 p.

Mydin K.K., Nazeer, M.A. and Saraswathyamma, C.K. (1990). Heterosis for juvenile vigour in *Hevea brasiliensis. Indian Journal of Natural Rubber Research*, **3**(1): 69-72.

Nga, B.H. and Subramaniam, S. (1974). Variation in *Hevea brasiliensis*: 1. Yield and girth data of the 1937 hand pollinated seedlings. *Journal of the Rubber Research Institute of Malaysia*, **24**(2) : 69-74.

Olapade, S. (1988). Estimates of heterosis in *Hevea brasiliensis. Compte Render du Collogue Exploitation: Physiologic et Amelioration de I' Hevea*, 1988, Paris, France, pp.377-384.

Premakumari, D. (1992). *Variability, correlations and path coefficient analysis for yield in relation to anatomical characters in Hevea brasiliensis* (Willd. ex Adr. de Juss.) *Muell. Arg.* Ph.D Thesis, University of Kerala, Trivandrum, India, 260p.

Rai, B. (1979). Heterosis breeding. Agrobiological Publications, Azad Nagar, New Delhi, pp.193.

Sanderson, A.R. and Sutchiffe, H. (1929). Vegetative characters and yield of *Hevea. Rubber Research Institute of Malaya Quarterly Journal*, **1**: 75-90.

Saraswathyamma, C.K. and Sethuraj, M.R. (1975). Clonal variation in latex flow characteristics and yield in rubber tree (*Hevea brasiliensis*). *Journal of Plantation Crops*, **3**: 14-15.

Tan H., Mukherjee, T.K. and Subramaniam, S. (1975). Estimates of genetic parameters of certain characters in *Hevea brasiliensis*. *Theoretical and Applied Genetics*, **46**: 181-190.

Varghese, Y.A., Knaak, C., Ecke, W. and Sethuraj, M.R. (1996). Evaluation of RAPD markers in *Hevea* breeding. *Second International Crop Science Congress*, November 1996, New Delhi, India.

Vischer, W. (1921). Results obtained with budded trees of *Hevea brasiliensis* Pasir Waringen estate. *Archiefvoor de Rubbercultur*, 5: 17.

Vischer, W. (1922). Resultaten bereikt met oculaties van *Hevea brasiliensis* op de onderneming pasir waringer, un bijdrge tot de vraag, in hoeverre aantal latex vaaten en productivietit vasken marken zijin. *Archief voor de Rubbercultur*, 6 : 426.