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SEASONAL AND CLONAL VARIATIONS IN PROPERTIES OF RUBBER PRODUCED IN NORTH EAST INDIA

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The properties of rubber produced are influenced by the climatic conditions of North East India where these variations are more pronounced than in the traditional regions. The seasonal effect on the properties of rubber from seven clones was studied. The impact of season and clone on different physical and technological parameters of rubber is discussed. Season was found to have a strong influence on dry rubber content (DRC) and total solids content (TSC) in North East India. The DRC and TSC levels decreased from summer to winter. Most of the clones under study gave medium to hard rubbers in terms of plasticity, Mooney viscosity and gel content. The lowest initial Wallace plasticity (P_0) and Mooney viscosity were shown by RRII 430 and the highest by RRII 417. All the clones under study produced relatively low viscosity rubber with low P_0 during winter season. The best processing properties in terms of Mooney viscosity (in the range of 60-70 units) and low P_0 were obtained in winter season. Good correlation was observed between Mooney viscosity and P_0 for all the clones. Correlation between P_0 and accelerated storage hardening test (ASHT) was also significant. The study revealed that in North East India, low winter temperature had profound influence on the properties of latex.

Keywords: Clonal variation, Dry rubber properties, *Hevea brasiliensis*, Latex properties, North East India, Seasonal variation.

INTRODUCTION

Rubber (*Hevea brasiliensis*) is predominantly cultivated in India in the hinterlands of the South West coast comprising Kerala State and adjoining districts of Tamil Nadu. The agroclimatic conditions of North East India are unique but, they are also suitable for rubber cultivation. Among the north-eastern states, Tripura ranks first with 37846 ha of plantation and 18705 t rubber production as on 2006-07 (Rubber Board, 2009). North East India experiences very severe winter unlike traditional rubber growing region in the South.

Natural Rubber (NR) is harvested from the tree in the form of latex and the dry rubber content (DRC) in the latex varies from 30-45 per cent. Rubber breeders are aiming to produce high yielding clones with vigorous growth and resistance to biotic and abiotic stresses. A high yielding clone with vigorous

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growth may not always produce latex (rubber) of desirable properties and therefore, in breeding programmes it is necessary to consider the latex properties also. A major source of variability within and among NR grades probably is the clone from which the latex is derived (Fuller, 1988). The physical and technological properties of rubber could be uniform within a clone, but clonewise differences do occur (Martin, 1961). Environmental and soil factors may also influence the properties of latex (Ebi and Kolawole, 1992).

Latex also contains a variety of non-rubber constituents like lipids, proteins, carbohydrates, fatty acids, amines and some inorganic substances which may affect the properties of rubber derived from it. Clonal variations also may influence the non-rubber constituents which, in turn, affect the properties of latex and the rubber derived from it. RRIM 600 is the most popular clone cultivated in North East India and the present study was to evaluate the effect of seasons on technological properties of rubber from RRIM 600 and five new clones of RRII 400 series along with RRII 105, the most popular clone in the traditional region.

MATERIALS AND METHODS

The experiment was conducted at the Regional Research Station, Agartala (23°53′N 91°15′E, 20 m above MSL) of Rubber Research Institute of India. The climate is sub-humid with an annual rainfall of 1969 mm. The average maximum and minimum temperatures for 21 years were 30.5 and 19.8 °C respectively. About 60 per cent of the annual rainfall is received between May and September. Summer starts in March and continues up to May and is followed by rainy season and then winter.

Seven clones RRII 414, RRII 417, RRII 422, RRII 429, RRII 430, RRII 105 and RRIM 600 were planted in the farm at Agartala in randomized block design. Latex samples were collected from those trees in four replications in monthly intervals and analysed. For the characterisation of dry rubber, latex samples collected in three seasons *viz.* summer (April–May), rainy (August-September) and winter (December–January) were processed into sheet rubber and analysed for different technological properties. February and March were rest period for tapping.

Different latex properties like total solids content (TSC), dry rubber content (DRC), ash content, nitrogen content and magnesium content were analysed as per Bureau of Indian Standards (BIS) test methods. Dry rubber properties like initial Wallace plasticity (P_0), plasticity retention index (PRI), accelerated storage hardening test (ASHT) and Mooney viscosity were also tested as per ASTM D 3194-04. Gel content of the rubber samples were measured as per ASTM D-2765-84. A known weight of rubber was allowed to swell in toluene, filtered through a sieve and evaporated to dryness. Weight of the gel remained was taken and the gel content was estimated.

RESULTS AND DISCUSSION

The DRC of latex was found to vary depending on various factors. When the tree is opened for tapping it produces unstable latex with high DRC. As the tapping progresses the latex gets stabilised and the average DRC falls to a steady level. The annual average DRC was 35.23 per cent, which was low compared to the traditional region (George *et al.*, 2004). DRC varied between 22 and 44 per cent with low values

Table 1. **Clonal variation in dry rubber content of latex**

Clone	Dry rubber content (%)										
	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Mean
RRII 414	43.07	42.65	42.48	42.39	41.24	37.38	33.12	30.05	22.46	22.11	35.70
RRII 417	43.06	42.71	42.49	42.36	41.82	36.40	33.65	29.16	22.03	22.59	35.63
RRII 422	42.30	40.66	40.60	40.04	40.59	36.83	33.75	31.36	22.86	23.21	35.22
RRII 429	43.11	40.75	40.55	40.21	39.33	36.86	33.61	30.20	23.48	23.97	35.21
RRII 430	41.91	40.69	40.29	39.12	38.35	36.89	33.63	30.67	24.60	24.83	35.10
RRII 105	41.86	39.20	39.01	38.28	37.60	36.36	32.97	32.61	24.20	24.14	34.62
RRIM 600	43.62	41.36	41.15	40.53	39.60	36.91	33.27	30.97	22.71	21.40	35.15
Mean	42.70	41.15	40.94	40.42	39.79	36.80	33.43	30.71	23.19	23.18	35.23
CD (P = 0.01)	Clone - 0.940 ; Month - 0.119 ; Clone x Month - 0.3160										

in winter and high in summer. Clonal, monthly and clone to month interactions were observed to be significant (Table 1). Clonal characteristics, age of the tree, length of the tapping cut, frequency of tapping, application of stimulant, time of tapping and environmental conditions are some of the factors that affect DRC of latex (Dey *et al.*, 2004).

Total solids content is a measure of rubber and other non-rubber solids and minerals. It is measured by drying a known-weight of latex at 100°C. The latex was allowed to dry along with the other solids. The annual average value was 38.93 per cent and the monthly average values ranged from 26.76 to 46.64 per cent. The low value of TSC during winter season was due to the low rubber content. It was observed that DRC and TSC were positively correlated (R^2 = 0.94) and clonal, monthly and clone to month interactions were significant (Table 2).

Non-rubber constituents (NRC) are the solid constituents other than rubber present

Table 2. **Clonal variation in total solids content of latex**

Clone	Total solids content (%)										
	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Mean
RRII 414	47.17	46.01	46.17	45.99	44.82	40.88	37.07	33.26	25.63	25.76	39.28
RRII 417	46.87	46.35	46.21	46.13	45.12	39.55	37.18	33.14	27.07	26.46	39.41
RRII 422	46.42	44.82	44.73	44.53	43.19	39.00	37.30	35.25	26.25	26.52	38.80
RRII 429	46.84	44.77	44.39	44.20	43.23	40.18	37.04	34.02	27.23	27.35	38.93
RRII 430	45.91	45.01	44.92	43.50	42.72	40.60	37.04	32.79	28.18	28.31	38.90
RRII 105	45.71	43.05	42.93	42.09	41.09	39.78	36.16	36.35	27.92	28.23	38.33
RRIM 600	47.53	45.42	45.18	44.62	42.55	40.42	37.50	34.59	26.12	24.67	38.86
Mean	46.64	45.06	44.93	44.44	43.25	40.06	37.04	34.20	26.91	26.76	38.93
CD (P = 0.01)	Clone - 0.066 ; Month - 0.076 ; Clone x Month - 0.210										

Table 3. **Clonal variation in non-rubber content of latex**

Clone	Non-rubber content (%)										
	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Mean
RRII 414	4.10	3.35	3.69	3.60	3.59	3.53	3.95	3.21	3.17	3.65	3.57
RRII 417	3.81	3.64	3.73	3.77	3.30	3.16	3.53	3.98	5.04	3.87	3.76
RRII 422	4.12	4.16	4.14	4.48	2.59	3.17	3.56	3.90	3.4	3.31	3.68
RRII 429	3.73	4.01	3.83	3.99	3.91	3.32	3.43	3.82	3.75	3.39	3.71
RRII 430	4.00	4.32	4.63	4.31	4.37	3.71	3.42	4.12	3.58	3.48	3.97
RRII 105	3.85	3.82	3.92	3.82	3.49	3.42	3.19	3.74	3.72	4.09	3.69
RRIM 600	3.95	4.06	4.02	4.09	2.95	3.52	3.83	3.62	3.41	3.28	3.68
Mean	3.94	3.91	4.00	4.01	3.46	3.40	3.56	3.77	3.72	3.58	3.72
CD (P = 0.01)	Clone - 0.084; Month - 0.0131; Clone x Month - 0.0347										

in latex. Organic non-rubber constituents may vary both in composition and concentration, depending upon various physiological and physical parameters (Gelling and Porter, 1988; Pakianathan *et al.*, 1992). The clonal, monthly and clone to month interactions were observed to be significant (Table 3).

In addition to rubber, certain mineral constituents such as carbonates and phosphates of potassium, magnesium, calcium, sodium and other trace elements are also present in the latex. Ash content in rubber is a measure of the presence of these mineral matter. High ash content also results from contamination of latex during collection and processing. The ash content of latex from seven clones in different months is presented in Table 4. The annual average ash content was 0.51 per cent which was high compared to that of the traditional region (George *et al.*, 2004). The monthly average ash content was in the range of 0.42 to 0.64 per cent. All the seven clones showed higher values of ash in the month of April.

Nitrogen content in rubber originates from proteinaceous materials present in rubber, either tenaciously-held or

Table 4. **Clonal variation in ash content of latex**

Clone	Ash content (%)										
	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Mean
RRII 414	0.73	0.50	0.55	0.53	0.52	0.43	0.55	0.48	0.41	0.49	0.52
RRII 417	0.66	0.56	0.54	0.50	0.50	0.41	0.51	0.44	0.50	0.50	0.51
RRII 422	0.66	0.55	0.53	0.51	0.52	0.41	0.49	0.50	0.44	0.46	0.51
RRII 429	0.55	0.61	0.56	0.57	0.56	0.38	0.51	0.49	0.44	0.41	0.51
RRII 430	0.61	0.56	0.59	0.53	0.50	0.41	0.44	0.46	0.48	0.46	0.50
RRII 105	0.65	0.55	0.52	0.50	0.51	0.49	0.49	0.51	0.44	0.48	0.51
RRIM 600	0.61	0.56	0.48	0.49	0.50	0.42	0.53	0.44	0.45	0.47	0.50
Mean	0.64	0.56	0.54	0.52	0.52	0.42	0.50	0.47	0.45	0.47	0.51
CD (P = 0.01)	Clone - 0.282; Month - 0.326; Clone x Month - 0.863										

chemically-bonded to rubber (Burfield *et al.*, 1976). It was reported earlier that certain proteinaceous materials had been shown to influence the technological properties of rubber (Othman and Hasma, 1988). Even though the proportion of nitrogen varies in different proteins, there exists an empirical relationship between protein and nitrogen content (protein content = 6.25 nitrogen content) (Bengtson and Stenberg, 1996). The annual average value of nitrogen was 0.46 per cent which was almost the same as that of the traditional region. The monthly average nitrogen values showed a variation from 0.40 to 0.53 per cent (Table 5).

Magnesium increases resistance to harmful environmental conditions like drought, diseases *etc.* However, the presence of excess magnesium was found to be a major cause of destabilisation of natural rubber latex. On the other hand, the addition of excess diammonium hydrogen phosphate (DAHP) to remove magnesium could adversely affect the physical properties of dipped products made from NR latex (Karunanayake and Priyanti, 2006). Clonal variation of magnesium over two years is shown in Table 6. Soil in North East is rich in magnesium in the range of 0.64 to 5.80 mg/100 g of soil. During winter season, due to the production of large volume of latex, the intake of magnesium could be high which might reflect in latex during winter. The annual average magnesium content was 141 ppm and clonal, monthly and clone to month interactions were observed to be significant.

Mooney viscosity is an important processability parameter. It is an indication of molecular weight, degree of branching, entanglement and cross-linking. It also suggests the quantum of mechanical work required on raw rubber to give mixes with consistent rheological properties after mastication, compounding and mixing. A rubber with high Mooney viscosity will require longer pre-mastication or expensive peptisers to obtain a product of workable and consistent viscosity. It was found that all the seven clones produced low viscosity rubber (in the range 53 to 73 units) in winter season (Table 7). The annual mean of seven clones was 73 which was at par with that of the traditional region. RRII 430 showed the lowest annual mean and RRII 417 showed the highest annual mean value.

Table 5. **Clonal variation in nitrogen content of latex**

Clone	Nitrogen content (%)										
	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Mean
RRII 414	0.51	0.55	0.52	0.52	0.53	0.39	0.41	0.42	0.40	0.39	0.46
RRII 417	0.55	0.52	0.52	0.51	0.52	0.43	0.44	0.42	0.44	0.39	0.47
RRII 422	0.57	0.55	0.54	0.52	0.51	0.41	0.40	0.43	0.40	0.41	0.47
RRII 429	0.48	0.53	0.51	0.47	0.49	0.41	0.45	0.44	0.41	0.41	0.46
RRII 430	0.54	0.53	0.52	0.49	0.48	0.41	0.45	0.44	0.38	0.40	0.46
RRII 105	0.52	0.54	0.51	0.48	0.49	0.40	0.44	0.41	0.42	0.37	0.46
RRIM 600	0.51	0.50	0.48	0.46	0.45	0.43	0.44	0.44	0.40	0.40	0.45
Mean	0.53	0.53	0.51	0.49	0.50	0.41	0.43	0.43	0.41	0.40	0.46
CD (P = 0.01)	Clone - 0.0095; Month - 0.0118 ; Clone x Month - 0.0313										

Table 6. **Clonal variation in magnesium content of latex**

Clone	Magnesium (ppm)										
	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Mean
RRII 414	101	103	101	111	116	107	111	119	122	121	111
RRII 417	141	142	137	150	150	161	160	186	188	176	159
RRII 422	105	142	116	125	128	126	130	139	140	132	128
RRII 429	117	139	133	131	133	146	145	160	160	149	141
RRII 430	125	133	131	134	131	144	142	155	159	145	140
RRII 105	115	121	115	124	128	126	129	138	139	135	138
RRIM 600	142	154	147	161	162	174	200	204	206	178	173
Mean	121	133	126	134	135	141	145	157	159	148	141
CD (P = 0.01)	Clone - 1.394; Month - 1.331; Clone x Month - 3.521										

Bulk viscosity of rubber measured by the Wallace plasticity (P_0) is also an important property. The seasonal average plasticity values showed a range from 37 to 46 units (Table 8). The annual average value was 43 which was low compared to that of the traditional region.

The resistance of rubber to molecular breakdown by heat is measured by plasticity retention index (PRI). It is assessed by the percentage change of the original plasticity when the rubber is heated at 140 °C for 30 min. High PRI values indicate good resistance to oxidative degradation. The study of PRI from seven clones indicated that the annual average value was 79 which was lower than that of the traditional region and the annual PRI values ranged from 75 to 83 (Table 9).

Table 7. **Seasonal variation in Mooney viscosity**

Clone	Mooney viscosity {ML (1+ 4) 100°C}			
	Summer	Pre-winter	Winter	Mean
RRII 414	85	83	54	74
RRII 417	90	86	73	83
RRII 422	76	64	58	66
RRII 429	87	81	69	79
RRII 430	66	66	53	62
RRII 105	77	80	65	74
RRIM 600	78	72	67	72
Mean	80	76	62	73
CD (P = 0.01)	Clone - 0.223; Season - 0.00026; Clone x Season - 0.106			

Table 8. **Seasonal variation in initial Wallace plasticity (P_0)**

Clone	Initial Wallace plasticity			
	Summer	Pre-winter	Winter	Mean
RRII 414	47	49	35	44
RRII 417	53	53	42	49
RRII 422	42	37	36	38
RRII 429	50	48	44	47
RRII 430	35	37	31	34
RRII 105	52	47	37	45
RRIM 600	43	44	39	42
Mean	46	45	37	43
CD (P = 0.01)	Clone - 0.044; Season - 0.028; Clone x Season - 0.94			

It was observed that the Mooney viscosity of rubber increases during storage as it undergoes hardening when stored at

Table 9. **Seasonal variation in plasticity retention index over two years**

Clone	Plasticity retention index			
	Summer	Pre-winter	Winter	Mean
RRII 414	80	77	84	80
RRII 417	75	76	85	79
RRII 422	71	78	76	75
RRII 429	74	77	81	77
RRII 430	88	77	84	83
RRII 105	85	76	76	79
RRIM 600	85	78	84	82
Mean	85	77	81	79

CD (P = 0.01) Clone - 0.404 ; Season - 0.121 ; Clone x Season - 0 .058

Table 10. **Seasonal variation in accelerated storage hardening test**

Clone	Accelerated storage hardening test			
	Summer	Pre-winter	Winter	Mean
RRII 414	5	4	8	6
RRII 417	4	5	8	6
RRII 422	7	4	7	6
RRII 429	9	5	6	7
RRII 430	4	4	6	5
RRII 105	7	4	5	3
RRIM 600	2	3	6	3
Mean	5	4	7	5

CD (P = 0.01) Clone - 0.645; Season - 0.009; Clone x Season - 0.013

ambient temperature and humidity over a period of time. This hardening process is accelerated at elevated temperatures and dry conditions. The hardening is due to the cross-linking among the rubber molecules involving the naturally occurring aldehyde groups (Subramaniam, 1975) and certain aldehyde condensing groups in the non-rubber phase including some amino acids (Gregory and Tan, 1975). The hardening effect of rubber is generally assessed by the ASHT in which the rubber is stored at 60 °C over phosphorus pentoxide (P_2O_5) for 24 h and the extent of storage hardening is expressed in terms of resulting increase in Wallace plasticity number, ΔP. The concentration of aldehyde condensing groups in rubber is 10 to 20 times that of aldehyde groups and the extent of hardening of the rubbers would depend only on the aldehyde group concentration (Table 10).

Rubber contains gel which is the insoluble fraction when dissolved in a solvent. Two types of gel *viz.* micro and macrogel exist in natural rubber. Microgel consists of particles of submicron size which are cross-linked latex particles. Macrogel is a secondary bonded network incorporating microgel and most of the proteinaceous materials. Gel content of the rubber from the seven clones is shown in Table 11. The annual average of seven clones was 21.99 per cent which was high compared to that of the traditional region. The lowest annual average was shown by RRIM 600 and the highest by RRII 429.

Table 11. **Seasonal variation in gel content of latex**

Clone	Gel content (%)			
	Summer	Pre-winter	Winter	Mean
RRII 414	25.41	20.45	12.54	19.47
RRII 417	28.09	18.67	20.53	22.43
RRII 422	34.02	12.72	21.64	22.79
RRII 429	34.07	26.23	25.07	28.46
RRII 430	23.72	19.43	15.25	19.47
RRII 105	20.35	24.62	22.80	22.59
RRIM 600	19.98	18.20	18.02	18.73
Mean	26.52	20.05	19.41	21.99

CD (P = 0.01) Clone - 0.455; Season - 0.027 ; Clone x Season - 0.126

Mooney viscosity and P_0 are directly related to gel content. The decrease in Mooney viscosity and P_0 during winter may be due to low gel content (Table 11) found in winter. It is also possible that the very low temperature in winter season may affect the polymerisation of isoprene units which contribute to the low values for Mooney viscosity and P_0.

CONCLUSION

Properties of latex and dry rubber from the North East India which experiences severe winter were studied in seven clones of *Hevea brasiliensis*. The impact of clonal and seasonal variations on these parameters was observed to be significant. In North East season was found to have a strong influence on DRC and TSC. The lowest DRC and TSC in winter and the highest DRC and TSC in summer were shown by RRIM 600. It was also observed that there was a tendency for DRC and TSC to decrease from summer to winter. This effect was observed to be stronger in the North East than in the traditional region. Positive correlation was obtained between DRC and TSC for all the clones. Seasonal effect on magnesium, NRC, ash and nitrogen was also statistically significant. The clone RRII 414 showed the lowest value for magnesium content while RRIM 600, the highest.

Most of the clones under study gave medium to hard rubbers in terms of plasticity and Mooney viscosity. RRII 430 had the lowest P_0 and Mooney viscosity, whereas the highest values were observed for the clone RRII 417. Good correlation was observed between Mooney viscosity and P_0 for all the clones. All the clones under the study produced relatively low viscosity rubber with low P_0 during winter season. The clone RRIM 600 showed the lowest value for gel content while RRII 429 recorded the highest. The lowest PRI value was recorded for the clone RRII 422 and the highest for the clone RRII 430. In the case of accelerated storage hardening, the lowest values were observed for the clones RRII 105 and RRIM 600 and the highest for the clone RRII 429. The study revealed that in the North East, the properties of rubber are specific in winter. In winter, DRC is very low even though the volume of latex is more. The best processing properties in terms of Mooney viscosity (in the range of 53 to 73 units) and low P_0 are obtained in winter season when the temperature is very low. However, this is not observed in the traditional regions where seasonal variations are less. The data generated could provide a comparative assessment of the behaviour of different clones in the North East in different seasons, where the changes are more pronounced than in the traditional areas.

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