RUBBER CULTIVATION IN ALKALINE SOILS OF DOOARS AREA OF WEST BENGAL: A REPORT ON GROWTH OF YOUNG PLANTS

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High soil pH affects sustainability of tea crop adversely and it deteriorates the tea quality. There are large areas under tea plantations where soil pH is not suitable for its growing. Cultivation of rubber would be an alternate approach to use this land profitably. Growth of rubber plants in high pH (7.9) soil was higher than that of normal pH (5.4) during immature period which may be due to extra care taken in the form of application of additional organic manure to the plants of high soil pH. Variation in girth of different clones gave an opportunity to screen better adapted clone(s) under such type of soil. In general, chlorophyll content index and photosynthetic efficiency in high pH grow plants were lower than that of normal soil during juvenile phase. The study demonstrated the scope of expanding rubber in the abandoned tea growing areas of high soil pH under the climatic condition of Dooars areas of West Bengal.

Keywords: Growth, *Hevea*, High pH soil, Immature phase, Photosynthetic efficiency

The soil of Dooars and Terai region of North Bengal is mainly from Glacial deposits of Himalayan range where tea is growing luxuriously and is giving high-quality Made-Tea. In general, tea grows in acidic soil of 4.5 to 5.5 pH and pH beyond 6.0 or above push down the quality of tea (Ghosh-Hajra, 2001). There are large areas lying vacant inside the tea estates where the soil is either sodic/or stony or low-lying lands (Chakraborty and Dutta, 2013).

These soils are developed from the rivers that originate from Bhutan hills. There are mines of dolomite in Bhutan hills which is being blasted by the cement factories. Being a heavy rainfed area, the river water brings dolomite washouts along with pebbles during rainy season. Because of these dolomite deposits, the soil of the tea gardens near to the river belt became alkaline. Hence, tea cultivation is abandoned in such soil (Chakraborty and Dutta, 2013).

However, rubber being a tree crop having wide range of adaptability, this crop can be introduced in these abandoned tea growing areas. The large tea growers are benefitted by cultivating rubber in tea

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gardens generating additional income. The present study was a trial-cum-demonstration of growing rubber in dolomite rich soil evaluating the performance of rubber in such soil. A few promising rubber clones were planted in this high pH soil of Dooars area of Sub-Himalayan West Bengal.

The abandoned tea growing area of Sarugaon tea garden (~1.25 ha) under Ethelbari tea estate in Birpara, Jalpaiguri, West Bengal was selected as the experimental site. Control plot was at Regional Experiment Station, Rubber Research Institute of India (RRII), Nagrakata, Jalpaiguri, West Bengal where the soil pH was 5.4. The soil pH in different depths and N, P and K content were measured following standard methods. Organic carbon was determined by wet digestion method (Jackson, 1973). Bray-I extract was used for extracting the available P (Bray and Kurtz, 1945). Neutral normal ammonium acetate was used for available K extraction. Soil pH was measured in 1:2.5 soil-water suspension (Jackson, 1973). The experiment site was covered with luxurious growth of herbs, ferns and shrubs. Six promising rubber clones *viz*., RRIM 600, RRIM 605, RRII 208, RRII 422, RRII 417 and RRII 429 were planted in this high soil pH (7.9) as well as in normal soil (pH 5.4) as control in blocks of 77 plants (7rows, 11 plants per row) per clone. Polybag plants of 3-4 whorl stage were planted during August 2011 (rainy season). All the cultural operations were carried out as recommended by the Rubber Board.

The girth of the plants at 20 cm height was recorded at different time intervals. The chlorophyll content index (CCI) was assessed using SPAD-502Plus system. CCI was recorded during December, 2012 (winter), September, 2013 (pre-winter) and January, 2014 (winter) from two leaves (top whorl) per plant and ten plants per clone. The efficiency of excitation energy in dark adapted condition and photosynthetic efficiency of PSII reaction centres under light exposed condition during May, 2012

Table 1. **Distribution of of weather parameters during chlorophyll and photoefficiency data recording period**

Months of data recording	T_{max}(^{0}C)	T_{min}(^{0}C)	Sunshine duration (hr)	Total rainfall (mm)	Evaporation (mm)
May 2012 (Post-winter)	33.0±0.30	22.0±0.49	5.0±0.58	251.2	3.30±0.23
October 2012 (Pre-winter)	31.1±0.20	19.7±0.58	7.2±0.42	114.1	2.7±0.14
December 2012 (Winter)	24.5±0.44	10.6±0.57	4.3±0.57	0.00	1.9±0.09
May 2013 (Post-winter)	31.5±0.31	22.9±0.30	3.0±0.47	280.1	3.0±0.26
September 2013 (Pre-winter)	32.9±0.34	24.2±0.14	5.6±0.74	520.1	2.6±0.25
January 2014 (Winter)	23.8±0.58	8.7±0.32	4.7±0.54	0.0	1.6±0.11

(post-winter), October, 2012 (pre-winter) and May, 2013 (post-winter) period was measured in mature leaves by portable Fluorescence Modular System (FMS2, Hansatech Instruments Ltd., Norfolk, UK). During measurement, the leaf was held directly against the fibre optic probe and exposed to a saturation pulse of 3000 $\mu molm^{-2}s^{-1}$. Intact leaves from second whorl from the top were dark-adapted with leaf clips for 30 min to allow relaxation of fluorescence quenching associated with thylakoid membrane energization (Krause *et al.*, 1983). Minimal fluorescence (Fo) and maximal fluorescence (Fm) were obtained by imposing one second saturating flash to reduce all the PSII reaction centres. The maximum potential photochemical efficiency of PSII was expressed as the ratio Fv/Fm = (Fm –Fo)/Fm. Effective PSII quantum yield (ΦPSII) under light condition was calculated (Schreiber *et al.*, 1998) as follows: Φ PSII = (Fm′–Ft/Fm′). Photo-efficiency data was recorded from minimum of two leaves per plant and ten plants per clone. Meteorological data were collected from the meteorological observatory at the Regional Research Station, Nagrakata and tabulated (Table 1). During pre-winter and post-winter period, the mean maximum and minimum temperatures were similar; sunshine duration was low during post-winter than pre-winter. Compared to pre- and post-winter period, mean maximum temperature during winter was lower with mean minimum temperature of below 10 ^{0}C; duration of sunshine was around four hour only with evaporation of below two mm. Total rainfall during pre-and post-winter period was higher than winter period with no rainfall at all. All the data were subjected to simple statistical analysis using MS Excel.

The soil pH at different depths of the experimental site showed that soil in the surface layer was alkaline while that of the sub-surface layer was almost neutral (Table 2). The river deposits of alkaline nature on the surface (top) soil might have caused the increase in pH of the soil in the study area. Organic carbon content in the surface soil (0-30 cm) was medium range and was higher than the sub-surface (30-60 cm) layer. Available P was low in both the surface and sub-surface layers. There was not much difference in the available K content of the soil, though it was slightly higher in the surface layer. The surface soil is rich in

Table 3. **Vacancy of plants after seven months of field planting in high pH and normal soil**

Clone	Vacancy after 7 months of field planting (%)	
	High pH	Normal pH
RIM 600	6.5	0.0
RRII 208	0.0	0.0
RRIM 605	9.1	0.0
RRII 417	10.4	0.0
RRII 422	13.0	10.2
RRII 429	1.3	0.0

Table 2. **Soil nutrient status at two depths in the dolomite deposited high pH area of North Bengal**

Parameter	Soil pH		Organic carbon (%)		Av. P ($mg100g^{-1}$)		Av. K ($mg100g^{-1}$)	
Soil depth (cm)	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60
Range	7.46-8.25	6.24-7.20	0.79-1.28	0.58-0.85	0.42-0.54	0.12-0.32	6.54-7.85	6.42-7.24
Mean	7.93	6.93	1.00	0.70	0.56	0.22	7.22	6.97
Standard deviation	0.24	0.28	0.15	0.10	0.08	0.07	0.36	0.26

dolomite which was brought by the flood water of the nearby river.

The data on vacancy after seven months of field planting showed that casualty is more in high pH soil compared to that of normal soil (Table 3). Maximum casualty was found in RRII 422 in both the soils because of its high susceptibility to cold stress (Meti *et al*., 2003). Vacancy was high in RRII 417 and RRIM 605 also under high pH soil. The survival percentage after two months of field planting was 100 per cent in all the five clones under both the soil types; however, after the following winter some vacancies were observed due to severe cold stress which was filled up accordingly.

Among the clones in high pH soil, the girth of RRII 208 was better than that of RRII 417 which showed lowest girth (Table 4). In control, the girth of RRIM 600, RRII 417, RRII 208 and RRII 429 was better than that of RRII 422 which showed lowest girth. The difference between the mean of girth of plants (irrespective of clones) in high pH soil was not significant though numerically girth in high pH soil was high compared to that of control plot. Significant increase in girth was noticed in plants grown in high soil pH (7.9) compared to that of normal (5.4 pH) soil after second year of planting (Table 4). Girth of RRII 208 and RRII 429 was significantly higher than RRIM 600 with lowest girth in high pH soil; RRII 429, RRII 208 and RRII 417 showed significantly higher girth than RRII 422 girth of which was the lowest. The low girth in RRII 422 under soil of normal pH, compared to that of high pH, was due to the damage of plants during low winter temperature period (Meti *et al*., 2003). Girth increment in high pH soil was also high compared to the control but it was not statistically significant. In general, it was observed that plants in alkaline medium showed low growth (Guo *et al*., 2011; Li, *et al*., 2010a, Yang, *et al*., 2011; Zhang *et al*., 2015). The better girth of rubber plants in alkaline pH would be the result of enriched soil in sub-soil layer of the dolomite deposit area. This result indicated adaptability of the rubber plants in partially suitable alkaline soil under the agroclimatic condition of Dooars area of West Bengal. Variation in

Table 4. **Girth and girth increment of rubber plants during early immature phase under soil of high and normal pH**

Clone	Girth at 4th month of planting (cm)		Girth at 2nd year of planting (cm)		Average girth increment during early immature phase (cm month^{-1})	
	High pH	Normal pH	High pH	Normal pH	High pH	Normal pH
RRIM 600	1.01	1.09	12.82	11.08	0.59	0.50
RRII 208	1.31	0.98	22.45	16.03	1.06	0.75
RRIM 605	0.94	0.46	16.55	10.37	0.84	0.49
RRII 417	0.87	1.02	16.70	14.00	0.79	0.65
RRII 422	1.04	0.29	16.01	5.36	0.77	0.25
RRII 429	1.07	0.89	20.22	17.63	0.96	0.84
Mean	1.05	0.83	17.46	12.41	0.83	0.58
CD ($P \leq 0.05$)	—	—	5.52	7.22	0.26	0.34
SD	0.47	0.60				

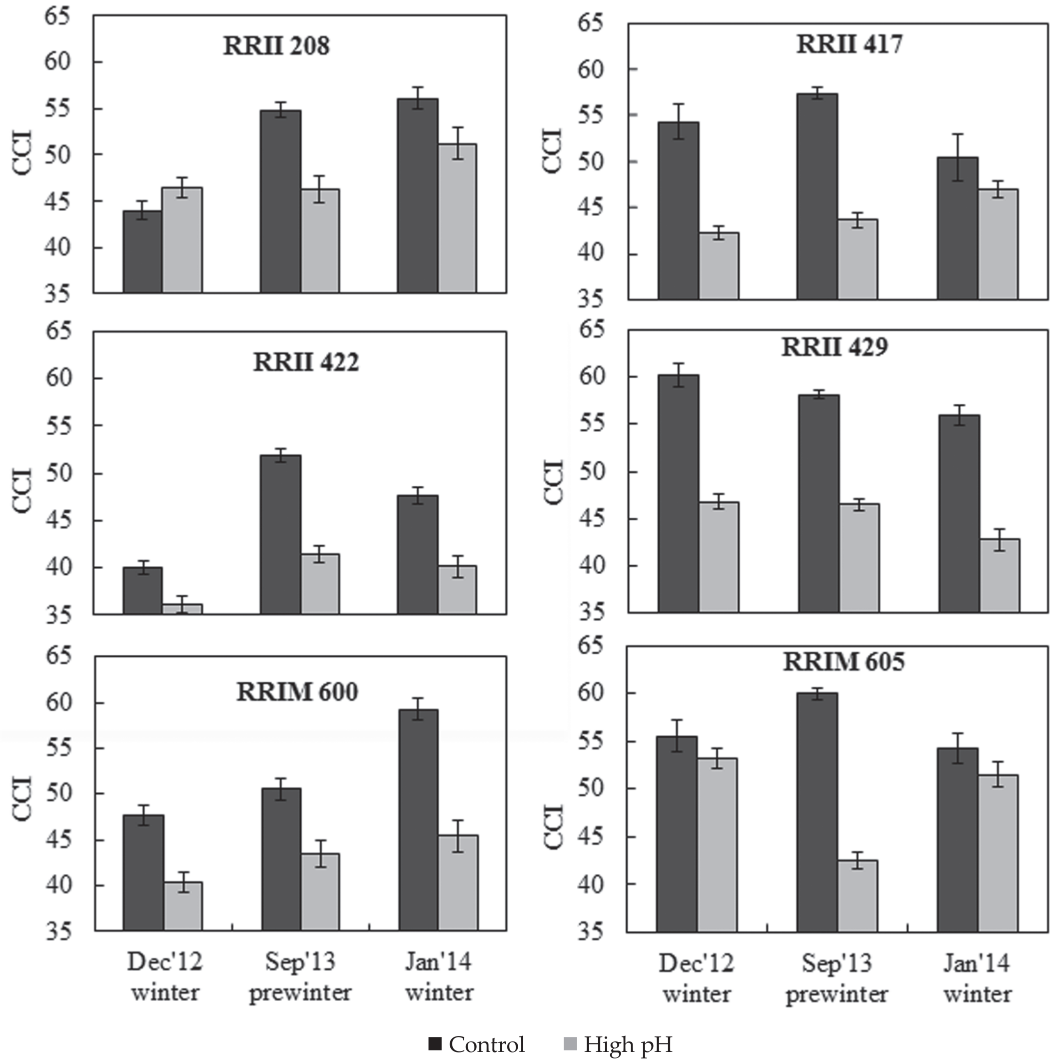

Fig. 1. Pattern of chlorophyll content index (CCI) of *Hevea* grown under the soil of different pH

performance of clones under high alkaline soil pH would help in selecting suitable rubber clones for growing in such soils.

The pattern of chlorophyll content index (CCI) in six clones was different at the two sites. In all the clones, the chlorophyll content index in high alkaline soil pH was lower than that of control soil pH (Fig.1). In RRII 208 and RRII 422 the difference in CCI was narrow but in RRII 417 there was a wide difference during early growth phase subsequently narrowed during late growth phase. In RRII 429 and RRIM 600, CCI was higher in plants grown in control soil pH throughout the growth phase compared to that in high alkaline soil pH. The effect of high soil pH on chlorophyll was distinct in this study. Effect of Ca *in vitro* (the major

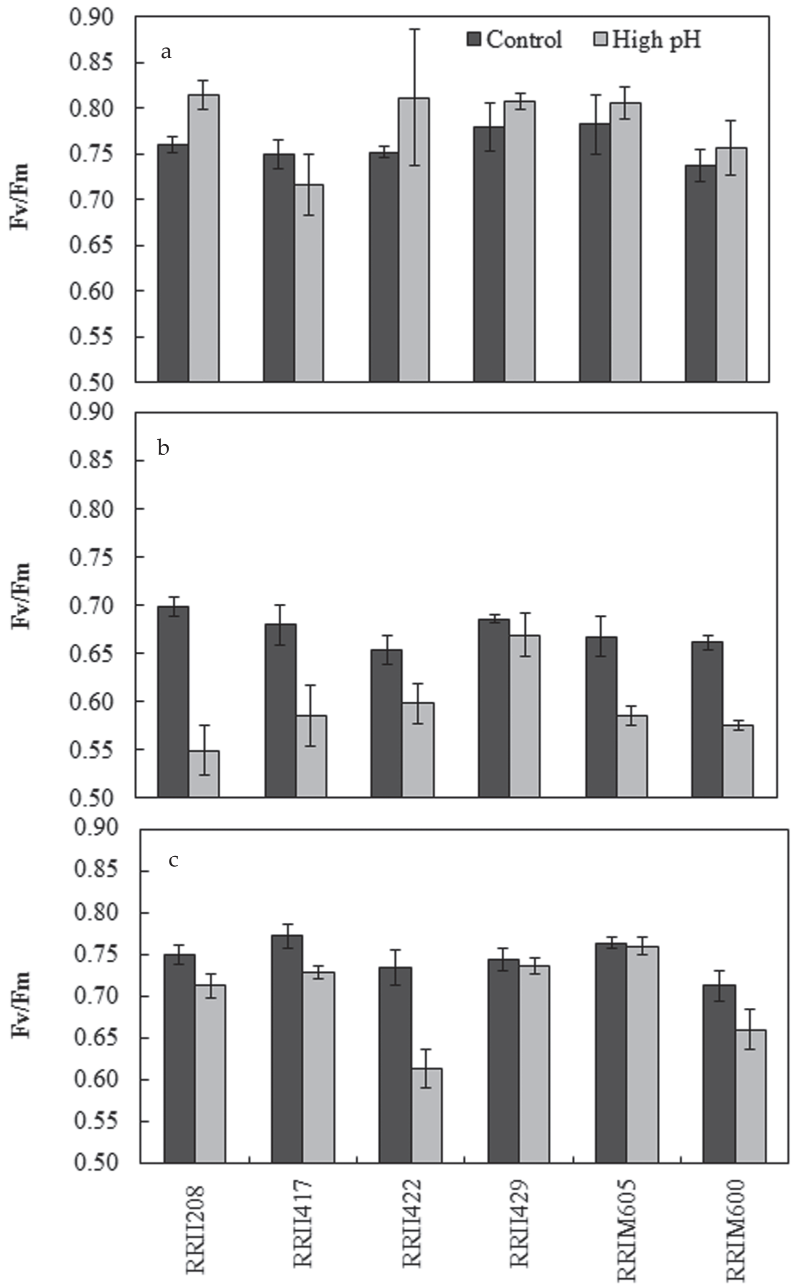

Fig. 2. Difference in dark adaptive efficiency of excitation energy of plants under different soil pH. (a) 9 months after planting during post-winter; (b) 14 months after planting during pre-winter; (c) 21 months after planting during post winter; Bar indicates SE of mean

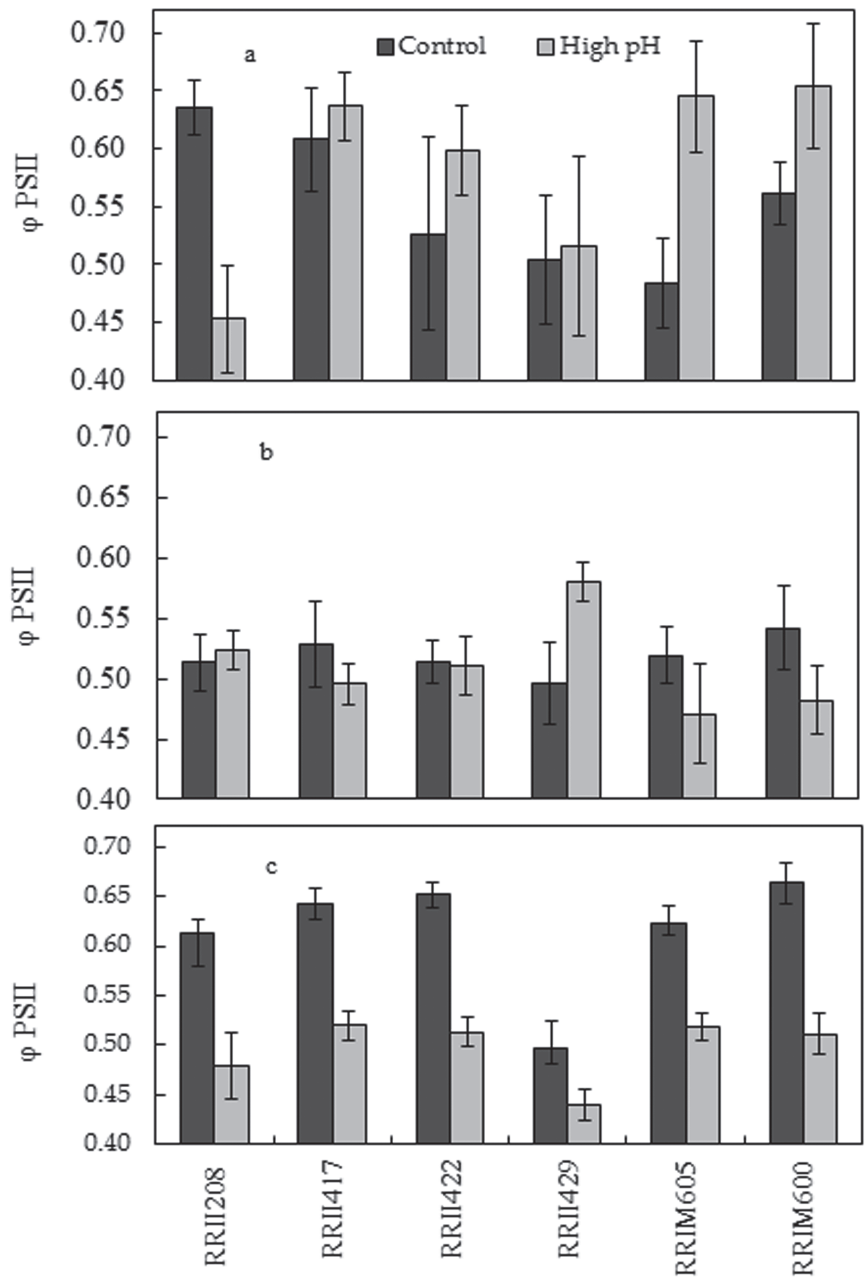

Fig. 3. Pattern of light adapted photosynthetic efficiency by Φ PS II in plants grown under the soil of high and normal pH; (a) 9 months after planting during post winter; (b) 14 months after planting during pre-winter; (c) 21 months after planting during post winter; Bar indicates SE of mean

component of dolomite high pH soil), on leaf chlorophyll was also reported in *Pinus* needle (Zhang *et al*., 2015), alfalfa (Li *et al*., 2010b) and *Medicago* (Yang *et al*., 2011).

After nine months of field planting the dark adapted Fv/Fm of plants in high soil pH was on par with control plants grown in pH 5.4 (Fig. 2). After 14 months of field planting during pre-winter period, when duration of sunshine was high with no precipitation for a long time, Fv/Fm value was higher in control plants than that grown in high soil pH. Except RRII 429, the rest of the clones in control plot showed significantly higher Fv/Fm value than in high pH area during this period. It may be a combined effect of longer sunshine duration along with insufficient rainfall and high soil pH in pre-winter period which affected the photo-efficiency of plants. The photochemical efficiency in plants grown in high alkaline soil pH area affected adversely during post-winter period also. The difference in these two soil types again narrowed down during the following post-winter (except RRII 422). The declining trend of maximum potential quantum yield in plants grown in high alkaline soil pH would be due to the combined effect of low winter temperature and high soil pH.

The photosynthetic efficiency (Φ PS II) was high in high alkaline soil pH in all the clones after nine month of growth (post-winter period) in the field condition except in RRII 208 (Fig.3). Thereafter, the plants in normal pH picked up and showed higher photosynthetic efficiency than that of high soil pH after twenty one months of field planting (subsequent post-winter period). Reduction in photosynthetic rate was reported in alfalfa plant under *in vitro* alkali stress condition (Li *et al*., 2010a) and at the root zone of jack pine (Zhang *et al*., 2015).

The high alkaline soil pH area of the experimental site is rich in dolomite deposit. Dolomite is an anhydrous carbonate mineral composed mainly of calcium carbonate, $Ca(CO_3)_2$ (Chakraborty and Dutta, 2013). High alkaline soil pH showed adverse effect on chlorophyll content, excitation energy and photosynthetic efficiency in plants compared to that of normal soil pH (5.4) during immature period but, the growth of plants was not affected. In the present study, it may be the $Ca(CO_3)_2$ in the form of dolomite which raised the pH to 7.9 in the top soil that showed the adverse effect on growth and photosynthetic efficiency of the plants during the initial growth period.

Considering performance of clones during immature phase in high alkaline soil pH with regards to all the parameters studied it was noted that RRII 208 was better adapted to the high alkaline pH calcium rich soil during immature phase followed by RRIM 605 and RRII 429. Whereas the growth performance of some clones like RRII 429 was better followed by RRIM 605 and RRII 417 when growing under low acidic pH. In both the soil types, performance of RRII 422 was not appreciable because of its high susceptibility to cold temperature.

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