Impact of cyclones and periodic strong winds in *Hevea* plantations and screening of wind resistant clones in Odisha state

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Abstract

A study was conducted to determine the impact of cyclones and periodic wind damage on Hevea *clones planted under different research plantations at Dhenkanal and Bhubaneswar in Odisha state of eastern India. This region usually experiences a wind speed of 70-140 km/hr during cyclones and periodic strong winds of around 27 km/hr during April- May. Thirty clones (RRII 414, RRII 417, RRII 422, RRII 429, RRII 430, RRII 300, RRII 351, RRII 352, RRII 357, RRII 105, RRII 208, RRII 203, RRII 176, RRII 51, RRII 5, RRIM 600, RRIM 701, GT 1, PB 310, PB17, PB 28/59, PCK I, PCK II, SCATC 88-13, SCATC 93-14, Haiken 1, RRIC 100, RRIC 102, IRCA 109, IRCA 111) and polyclonal seedlings were evaluated for wind endurance. Parameters assessed were up rooting, trunk snapping and branch breakage. The study indicates that the most common type of wind damage caused by cyclones is uprooting followed by branch breakage and the least common is trunk snap. However, the periodically occurring strong winds caused maximum branch breakage followed by uprooting and trunk snap. Periodic strong winds usually occur in April- May and results in visible wind damages. Study showed that wind endurance varied among the clones. The overall study clearly suggests cyclones devastated the rubber plantation at Bhubaneswar and considerable loss at Dhenkanal. Periodically occurring strong winds damaged around 40 to 150 trees in different forms in every year. Overall, SCATC 93-14, Haiken 1, PB 310, PR 255, RRIC 102, IRCA 109, RRII 430 and Polyclonal seedlings were broadly categorized as most wind fast clones; followed by moderate tolerant clones as PB 217, PR 261, RRII 105, SCATC 88-13, IRCA 111, RRIC 100, RRII 422, RRII 300 and RRIM 600 . Clones PB 28/59, RRII 51, RRII 208, RRII 176, GT 1, RRII 417, RRII 414, RRII 429, RRII 203 and RRIM 701 found comparatively susceptible to wind damage in the region. Initial vacancies, gaps in plantations, tall trees, heavy canopy, poor anchorage of trees in soil and strong speed winds coupled with rains seem to be the major cause of wind damages. Form of wind damages and remedial measures to mitigate the damages are also discussed*


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Key words: *Hevea* plantation, Clones, Cyclone, Wind damage, Wind resistance, Wind breaks, Odisha, Eastern region

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Introduction

Odisha state encompasses a net area of 1,55,707 sq.km and hugs the voluminous shores of the Bay of Bengal with a coast line that stretches for about 450 km. The state stretches across the latitudinal parallels extending between 17° 49' North and 22° 34' North and the longitude meridian that spans between 81° 27' East and 87° 29' East. The region experiences a tropical climate, characterised by searing hot summers, monsoon rains and mild winters. The voluminous seas and the hilly terrains of the Eastern Ghats play a major role in shaping the weather in Odisha.

Cyclones, periodic strong winds, heat wave, drought and flood are major meteorological disasters in Odisha. The proximity to the Bay of Bengal has ensured that cyclone in the state is a rather frequent in occurrence. Strong wind and gales followed by heavy thundershowers are known to have caused wanton destruction in the coastal state. Odisha, being a maritime state in the east coast of India, is cyclone prone an any storm formed in the Bay of Bengal mostly moves towards east coast of India during storm season (March - May and October - December). During the months of October- December and March- May, the atmosphere pattern is favorable for movement of cyclonic storms towards the east coast of India.

For over a decade, Odisha has been teetering from one extreme weather condition to another - from heat wave to cyclone, from drought to flood. Most of the causalities were from coastal Odisha, a region known for its moderate climate. The Super cyclone (1999) and Phailin cyclone (2013) affected places like Bhubaneswar, Dhenkanal, Nayagarh and adjoining areas which were never traditionally cyclone prone. Thus the disasters not only have become frequent but they are striking new areas. The state has experienced big cyclones tornadoes and heavy depressions causing cyclones.

Natural calamities (cyclones etc.) have seriously affected agriculture and plantation crops, and livelihoods in the state. The losses in rubber plantations caused by cyclones/strong winds in eastern and northeastern region of India in particular are a matter of serious concern. Storms are regular in this region and can be more problematic in exposed areas. Rubber is subject to high risk of wind damage. Wind causes mechanical and physiological damages, resulting in reduced performance and low productivity (Yee

Fig 1. Uprooted trees

Fig 2. Branch breakage

et al., 1969, Vijayakumar *et al.*, 2000). It is well understood that damage due to cyclone/strong wind is prevalent in the region and productive rubber plantations are the victims in majority of cases.

Wind damage is a very serious problem in rubber plantations and an important factor having influence on performance there. Rubber plants of all age groups are affected by strong wind. Frequent gales cause considerable damage to rubber plantations by way of branch breakage, trunk snap and uprooting. *Hevea* is a perennial crop that has certain inherent and induced weaknesses that make it more susceptible to damage by wind. The arboreal nature of the crop itself is the primary cause of wind susceptibility. Shallow root system, and the method of harvesting which causes a perpetual weakness along the centre section of the trees are the other reasons for increased susceptibility. Some clones are reported inherently susceptible to wind damage though few are reported to be windfast (Zongdao and Xuegin, 1983; Rubber Board, 1999).

Wind damage is generally associated with the ground characteristics of the plantation/trees. Above ground features that may predispose trees to damage include stand, age, gap in tree stands, tree height, unbalanced branches, heavy canopy and poor girth increment on tapping.

Fig 3. Trunk snap

Additional weight due to rain water on the leaves together contributes to crown heaviness with high turning movement around the trunk which easily predisposes the trees to snapping and toppling (Vijayakumar *et al.*, 2000). Below ground characteristics like poor root system, type of soil etc. also plays an important role. Further the impact of wind depends on its severity. In rubber plantations, wind speeds determined are in the range of 1 to 4m/s (Oldeman & Frere, 1982).

Loss of mature rubber trees will result in cumulative loss. Growers cannot fill the gaps with new seedlings once the loss occurs Thus growers lose the mature productive rubber tree forever. Being a long term perennial crop that remain productive for around thirty years due attention is required in assessing the possibility of wind damage and ways to minimize the damage. There are occasional reports on the issue of cyclones and their effect on rubber plantations (Jeevaratnam, 1964; Hegden, 1998; Thomas, 2013). However documentation of such data from scientifically laid out experimental rubber plantations with maximum possible clones are found necessary to get an exhaustive view on different kinds of wind damage, wind endurance of clones, reasons of wind damage and possible measures to minimize wind damages in the particular region of study or elsewhere. The present study is an attempt towards this direction.

Materials and methods

A field study to evaluate the impact of cyclone, periodically occurring wind damage and screening of windfast clones was carried out in different experimental rubber plantations of almost the same age at Dhenkanal and in an experimental plantation at Bhubaneswar, in Odisha state. The experimental rubber plantations under wind damage evaluation consisted of thirty *Hevea* clones and polyclonal seedlings.

Experimental rubber plantation at Bhubaneswar was planted in 1996 in Randomized Block Design (RBD) at a spacing of 4.8 x 4.8 m in three replications covering an area of 4.0 ha. The clones are RRII 417, RRII 422, RRII 429, RRII 430, RRII 105, RRII 203, RRII 176, RRII 51, RRIM 600, RRIC 100, and PB 217.

Experimental rubber plantations at Dhenkanal were planted during 1989 – 1991 and in 1999 in Randomized Block Design at an almost common

Fig 4. Devastation of plantation in cyclone Phailin

Table 1. Super Cyclone (1999) and cyclone Phailin (2013) caused damages in an experimental rubber plantation in Bhubaneswar, Odisha.

Clones	Damage due to Super Cyclone (1999)			Damage due to cyclone Phailin (2013)			
	3 years old plantation			17 years old plantation			
	Uprooted trees	Leaned trees	Total affected trees	Uprooted trees	Trunk snap	Branch breakage	Total affected trees
RRII 414	6	5	11	41	1	3	45
RRII 417	11	12	23	42	5	2	49
RRII 422	13	13	26	27	2	4	33
RRII 429	5	25	30	36	7	2	45
RRII 430	9	13	22	29	2	5	36
RRII 105	11	15	26	22	2	6	30
RRII 203	6	18	24	43	1	5	49
RRII 176	18	11	29	34	1	4	39
RRII 51	17	13	30	25	3	4	32
RRIM 600	3	4	7	40	1	3	44
RRIC 100	2	11	13	33	1	4	38
PB 217	11	17	28	30	6	4	40
Total	**112**	**157**	**269**	**402**	**32**	**46**	**480**

spacing of 4.6m x 4.6 m covering a total area of 24.0ha. Twenty one clones namely RRII 105, RRII 208, RRII 701, RRII 300, RRII 351, RRII 352, RRII 357, RRII 51, RRII 5, RRII 28/59, RRIM 600, GT 1, SCATC 88-13, SCATC 93-14, Haiken1, RRIC 102, PB 310, PR 255, PR 261, IRCA 109, IRCA 111 and polyclonal seedlings are planted here. The wind damage in the form of uprooting, trunk snap and branch brakeage of trees for each clone due to Super Cyclone in 1999 and cyclone Phailin in 2013 was assessed in experimental plantations in Bhubaneswar and Dhenkanal. Periodic wind damage for the period from 2008 to 2013 were also further assessed in different experimental rubber plantations in Dhenkanal. The extent of total damage per clone was assessed and their percentage was calculated by using the following formula.

Wind damage percentage

$$\frac{\text{Sum of all damaged trees} \times 100}{\text{Total trees surveyed}}$$

Wind endurance varies considerably with clones and are categorized as most wind fast, medium wind fast and poor wind bearer.

Results and discussion

The wind speed of 3.5 km to 17.6 km/hr reaching as high as 27 km/hr at times were generally noticed in plantation areas in Dhenkanal. On October 29 and 30, 1999 a severe heat wave blew and also a Super Cyclone occurred in the region including Dhenkanal and Bhubaneswar. These places experienced cyclone wind speed of 120-140 km/hr. Cyclone Phailin again after a gap of thirteen years hit the region on October 12 and13, 2013. A speed of 70 -90 km/hr was estimated in Dhenkanal and Bhubaneswar regions.

Table 2. Super Cyclone (1999) and cyclone Phailin (2013) caused damages in different experimental rubber plantations in Dhenkanal, Odisha

Clones	Damage due to Super Cyclone (1999)			Damage due to cyclone Phailin (2013)			
	9 -12 years old plantations			23 - 25 years old plantations			
	Uprooted trees	Trunk snap	Total affected trees	Uprooted trees	Trunk snap	Branch breakage	Total affected trees
RRIM 600	246	129	375	98	6	21	125
RRIM 701	4	3	7	1	0	2	3
RRII 105	24	15	39	24	4	21	49
RRII 208	4	16	20	5	0	10	15
RRII 300	10	11	21	3	0	3	6
RRII 5	8	11	19	3	1	5	9
GT 1	8	21	29	47	12	28	87
SCATC 88-13	0	3	3	0	0	3	3
SCATC 93-14	6	7	13	1	0	1	2
Haiken 1	6	4	10	2	0	0	2
RRIC 102	2	1	3	2	0	0	2
PB 310	8	2	10	1	1	1	3
PR 255	4	8	12	2	0	0	2
PR 261	2	1	3	0	0	4	4
Polyclonal	9	14	23	10	6	9	25
Total	**341**	**246**	**587**	**199**	**30**	**108**	**337**

The study showed that wind damage varied among the clones. The study indicates that the most common form of wind damage caused by cyclone was uprooting (Fig 1) and the next was branch breakage (Fig 2) and the least common was trunk snap (Fig 3). However, the common periodically occurring strong winds caused maximum branch breakage followed by uprooting and trunk snap.

Super Cyclone (1999) and cyclone Phailin (2013) has devastated the rubber experiment plantation at Bhubaneswar (Fig 4). The wind damage caused uprooting of 514 trees, trunk snap in 32 trees and branch breakage in 46 trees (Table 1). Clone RRII 105, RRII 430, RRII 422 and PB 217 were found most windfast. On the other hand RRII 176, RRII 203 and RRII 417 were recorded as most wind susceptible (Table 1, Fig 1).

Similarly, Super Cyclone and cyclone Phailin have also severely affected the rubber plantations in Dhenkanal. However impact was comparatively less in Bhubaneswar. Cyclones occurred in this region and recorded uprooting (540 trees), trunks snap (276 trees) and branch breakage (108 trees) in different experimental rubber plantations (Table 2). Clones SCATC 93-14, Haiken 1, RRIC 102, PB 310, PR 255, PR 261 and polyclonal seedlings were recorded as most wind resistant. However, GT 1 and RRII 208 were found comparatively susceptible (Table 2,3 and Fig 2). An impact of cyclone Phailin occurred in 2013 was also studied in another plantation (around 14 years old) having clones of RRII 300 and IRCA Cyclone damaged

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90 trees in form of uprooting (480), trunk snapped (9160) and branch breakage (26). Clones IRCA 109, RRII 105, RRII 300 and RRII 351 were found most windfast; while PB 28/59 and RRII 51 behaved most susceptible (Table 3, Fig 2).

Rubber plantations in Dhenkanal experience strong periodic wind damages every year. The marked wind damage usually occure during April-May and rarely in the month of October. During April- May, strong winds coupled with rain occurs and cause heavy damages to rubber plantations. Wind damage in different forms affect nearly 40-150 trees every year, making considerable loss in rubber.

During the six year period between 2008 to 2013 periodic strong winds caused damage in forms of uprooting, trunk snap and branch breakage in rubber plantations in Dhenkanal. The rubber plantations, field planted during the period from 1988 to 1991 experienced wind damage during the period from 2008 to 2013. The loss of trees in each year is 50, 48, 70, 149, 31 and 42 respectively. The total damage was in form of uprooted trees (50), trunk snapped (86) and branch breakage (254). In another plantation of 1999 field planting, 83 trees were damaged during the period from 2008 to 2013. The damage occurred was in the form of uprooting (4), trunk snap (25) and branch breakage (54). Details are given in Table 5. Clones having most poor wind endurance are PB 310 (1.72 per cent), Haiken 1(2.38 per cent), SCATC 93-14 (3.63 per cent), PR 261 (4.16 per cent), IRCA 111(6.06 per cent), PR 255 (9.30 per cent), RRII 300 (9.83 per cent), IRCA 109 (10.52 per cent) and polyclonal seedlings (4.16 per cent) were found most resistant; though PB 28/59 (52.38 per cent), RRII 5 (23.52 perc ent), RRII 208 (23.34 per cent) and RRIM 701(18.60 per cent) have shown poor wind endurance(Table 4 & 5; Fig 3).. It may be noted that the two plantations cannot fully be compared as some of the clones in plantations at Bhubaneswar and at Dhenkanal are different. However it is observed that common clones in both sites shows almost same wind endurance behavior. It is also found that in mature plantations under tapping age factor matters least.

It is noticed that performance of common

Table 3. Cyclone Phailin (2013) caused damages in an experimental rubber plantation (Field planted 1999) in Dhenkanal, Odisha

Clones	Damage due to cyclone Phailin (2013)		
	14- years age plantations		
	Uprooted trees	Leaned trees	Total affected trees
RRII 414	6	5	11
RRII 417	11	12	23
RRII 422	13	13	26
RRII 429	5	25	30
RRII 430	9	13	22
RRII 105	11	15	26
RRII 203	6	18	24
RRII 176	18	11	29
RRII 51	17	13	30
RRIM 600	3	4	7
RRIC 100	2	11	13
PB 217	11	17	28
Total	**112**	**157**	**269**

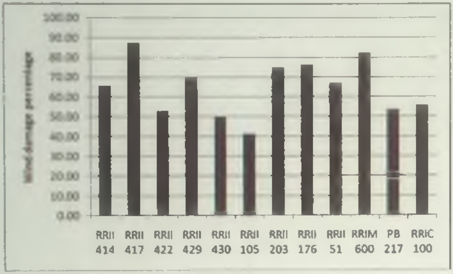

Fig 5. Cyclone Phailin (2013) - Total wind damage percentage among clones in an experimental rubber Plantation (planted in 1996) in Bhubaneswar, Odisha

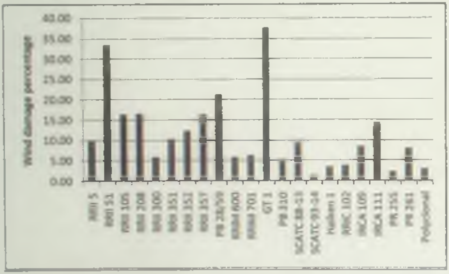

Fig 6. Cyclone Phailin (2013) - Total wind damage percentage among different experimental rubber Plantations (planted during 1988- 1991 and 1999) in Dhenkanal, Odisha

central leader is the speciality of these clones. Further, high rate of wind damage in clones like GT 1, PB 28/59, RRII 203 and RRIM 600 might be due genetic character. These clones are having hemispherical or fan crown with dense canopy consisting of bunch branches and smaller branching angle.

Polyclonal seedlings were endowed with better wind fastness than budgrafted trees owing to their strong tap root that penetrates deep in to the subsoil, anchoring the tree against uprooting.

Conical shape of the trunk of polyclonal seedlings also helps in wind endurance (Jeevaratnam, 1964; Lian, 1984). Budded trees should be regarded as more susceptible to damage in that they are essentially the artefacts of branches and therefore exhibit the morphological features of branches and not those of trees (Grace, 1977).

clones in different plantations exhibit almost same form and extent of wind damage. This confirms the categorization of clones in the region under 'most windfast' and 'susceptible'. The wind endurance varies considerably with clones and seems to be an important inherent character. (Yagaratnam, 2000). Haiken 1, SCATC 88-13, SCATC 93-14, PB 310 and PB 217 are the most wind resistant clones and might be due to inherent characters. Open conical crown with evenly arranged horizontal branches on

On the basis of the study the various clones in different experimental plantations were broadly categorized in to three categories based on wind endurance. Haiken 1, SCATC 93-14, PB 310, RRIC 102, PR 255, IRCA 109, RRII 430 and polyclonal seedlings were categorized under most windfast clones. Medium windfast category includes SCATC 88-13, PB 217, PR 261, RRII 105, IRCA 111, RRIC 100,RRII 300, RRIM 600, and RRII 422; while clones PB 28/59, RRIM 701,

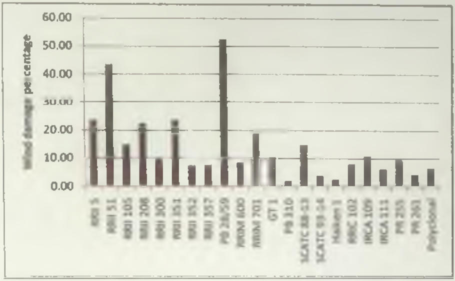

Fig 7. Cumulative periodic wind damge percentage during six years period (2008-2013) in differentexperimental rubber plantations (planted during 1988- 1991 and 1999).

RRII 51, GT 1, RRII 208, RRII 417, RRII 414, RRII 429, RRII 203 and RRII 176 were grouped under poor windfast clones (Fig. 5, 6, & 7)

Wind damage generally occurred in the form of uprooting, trunk snap and branch breakage in rubber plantations in Bhubaneswar and Dhenkanal. Usually tall trees with heavy crowns are most affected by wind. Tall trees with a high canopy will exert a greater leverage and 'squat' trees are made more susceptible to wind damage than short trees.

The size, height and density of the canopy in relation to the size and height of the trunk also play a significant role Trees with heavy main branches and those with branches arising at narrow angles from the main stem are more susceptible to wind. It has been recorded that incidence of uprooting is highest near gaps and was less common in closed plantings.

The important factor contribute to damage was accentuation of the wind force by gaps. The gaps created by the initial vacancies and damages may be responsible for the accentuation of the force of subsequent gusts of wind, leading to further damages, culminating in severelossesofdevastating nature as was experienced in the experimental rubber plantations in Bhubaneswar. The poor anchorage of the tree root in the soil is another major causes of uprooting. The lateritic, shallow soil give only poor anchorage and result in high incidence of uprooting in the region. The incidence of trunk snap in different clones varies, indicating the correctness of the assumption that girth increment is a clone character and have relation with susceptibility to wind damage. The trunk snap is clone specific and have little relationship to terrain. Further, it has been observed that incidence of trunk snap is highest in closed plantings. This shows that trunk snap is also determined by move by the pressure of wind and wood strength. Branch breakage in rubber is clone characteristic and recorded usually higher near gaps in rubber plantations.

Various remedial approaches to wind damage have been suggested (Zongdao and Xuegin, 1983, Kang and Zongdao, 1987, Vijayakumar *et al.*, 2000) and could be significant to minimize the wind damages in the present region of study. Use of wind enduring rubber clones for planting and avoiding of occurrence of initial gaps and vacancies must be taken care off. High planting density may be preferred in wind prone areas because a denser population gives better self protection and high survival rate. Wider avenue system of planting is likely to give rise to paths which the wind can be funneled. Equidistant planting may also be used judiciously, for reasons of chances for wide gap resulting in loss of trees (Jeevaratnatnam, 1964).

The appropriate soil conservation measures may be taken to improve the anchorage of trees in the soil. Use of root trainer plants as planting material could be of significant advantages to minimize the wind damage. Being uncoiled and air pruned, the tap root of the root trainer plants can grew vertically and can provide better anchorage in soil (Soman *et al.*, 2011).

Generally, selective pruning at the early growth stage of heavy lateral branches, reduction of canopy weight, to develop a balanced canopy and adequate fertilizer application may also be effective measures to minimize the wind damage. Beside the above all remedial methods, establishment of wind breaks around the rubber plantation boundary, prior to raising new plantation in wind prone region is found to be most effective to mitigate the adverse affect of wind. Shelter belt of 10 to 20 m width connected to each other to form a windbreak net work can offer better protection.

Trees for wind breaks shall be fast growing, good soil anchorage and wind resistant. Trees as *Eucalyptus* sp. and *Acacia* sp. were most preferred species. The wind protection efficiency of wind breaks is associated with its structure, height, width, orientation and size of sheltered block (Zongdao and Xuegin, 1983).

The early establishment of wind breaks could be of great significance to mitigate the cyclone and strong wind damages in the wind prone eastern region of the country.

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