Short note

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A case study of crown bending disorder in date palm cv. Barhee and the impact of cyclone Biparjoy

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Introduction

Date palm (*Phoenix dactylifera*) is one of the oldest cultivated fruit crops in the world, and in India, it is believed to have been cultivated for more than four and a half centuries, where a significant area under cultivation is under the Kachchh district of Gujarat, which accounts for more than 85 % of the total area and production of the country (Muralidharan *et al.*, 2022). Unlike other countries, harvesting of the date fruits is mostly done in the *khalal* stage while most countries harvest at their *tamar* stage due to the climatic conditions (incidence of early rainfall). Among the various cultivars evaluated, cultivar Barhee was recommended by Date Palm Research Station, Mundra, under AICRP-Arid Zone Fruits for cultivation in Gujarat in 2002 (Sharma *et al.*, 2019), and since then Barhee has become the primary cultivar of the country, with a population of more than three lakh plants in Gujarat itself (data collected through personal communication).

Internationally, Barhee is a popular cultivar that initially originated in Iraq owing to its golden yellow-coloured fruits, round shape, prolific bearing, and non-astringent fruits at the *Khalal* stage. While, it is globally popular, it is uniquely susceptible to a disorder known as crown bending, also referred to as "Barhee disorder" due to its particular occurrence in this cultivar (Muralidharan *et al.*, 2019). This condition manifests as an abnormal bending of the palm's crown, typically towards the east or south-east.

The earlier reports of crown bending disorder of Barhee variety were from California (USA) by Darley *et al.* (1960), Al Basra (Iraq) by Hussain (1974), and at the Kibbutz Yotvata (Israel) by Zaid (1996). Affected palms were observed to bend primarily towards the south and occasionally towards the southwest. However, previous studies in the Kachchh region of India revealed that date palms that exhibited crown bending had a significantly higher number of bunches as well as distribution of bunches in the east when compared with date palms without bending disorder (Muralidharan, 2019). The proportion of bending is dependent on height and has been noted by Muralidharan *et al.* (2019). They noted that the presence of crown bending is observed in plants having a height of more than 5 m, and chances of bending increase with the

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increase in height. However, they also noted that the pattern was noted in the Barhee alone and not on other cultivars. The severity of the bending can be understood by the verge of bending, and we classified them as acute bending (< 90° bending with respect to the crown portion) and severe bending (>90° bending with respect to the crown portion). Similar observations were also done at Kibbutz Kineret in Israel, where this phenomenon was particularly severe, with the bending sometimes reaching angles as extreme as 90°.

In Israel, this bending disorder was also observed in the Dayri variety, and literature indicates that it affects the Jahla and Aguellid varieties as well (Djerbi, 1983). At Yotvata Kibbutz, growers have been addressing the issue by attaching a heavy iron bar to the side opposite the bending fruit bunches. The bunches are then tied to the bar to counterbalance the weight. It appears that within two to three years, this method successfully corrected the bending which suggests bunch handling has been found to be an effective solution (Yost, 1968). However, the factors driving crown bending remain poorly understood, based on earlier reports it suggesting that wind direction, height, and bunch weight distribution are possible contributing factors (Muralidharan, 2019). There is still no permanent solution for this disorder, emphasizing the need for further studies to understand its root causes and management.

Material and Methods

Based on the earlier suggestion by Darley *et al.* (1964) and earlier observations with the moderate crown bending disorder, a trial was initiated to straighten the plant terminal part (crown) in the year 2022 at Date Palm Research Station, Mundra-Kachchh, Gujarat, India. Due to limited availability of the similar bending plants, twelve plants of similar bending were identified and were treated with two treatments, replicated six times with one plant in each replication. The treatments were T_1 = The outer canopy leaves were pruned, terminal leaves were tied with rope and pulled in the opposite direction in the month of April and kept tied with the plant in the opposite direction of the bending (Fig. 1a, 2b), and T_2 = control. The direction of the bending was South-East for all the experimented plants. The comparison was made using a T-test. Their observations with respect to bending were noted after one year.

Results and Discussion

After one year of treatment, there were significant differences in bending between the treated and untreated palms (Table 1). The treated plants have largely recovered from the bending from 28.16° to 7.16° after a year (Fig. 1c), while in the untreated plants the bending were slowly rising (Fig. 1).

Table 1: Crown bending in treated and untreated plants

Treatment	Average angle of bending (Before treatment) (April, 2022)	Average angle of bending (one year after treatment) (April, 2023)	Average angle of bending (After cyclone) (June, 2023)
Treated crown	28.16° [a]	7.16° [b]	44.00° [b]
Untreated crown	26.83° [a]	28.66° [a]	144.16° [a]

Cyclone Biparjoy and its effects on date palm cv. Barhee

Cyclone Biparjoy, categorized as a "very severe cyclonic storm," impacted the Kachchh region on June 15–16, 2023, with wind speeds reaching up to 125 km/h, accompanied by heavy rainfall (Anonymous, 2023). After the cyclone their impact on the crown bending were recorded at the Date Palm Research Station in Mundra, situated close to the coastal area of the Gulf of Kachchh. The cyclone had a pronounced effect on Barhee palms, particularly those exhibiting crown bending disorder. Treated palms, which had initially shown a reduction in bending angle from an average of 28.16° to 7.16° between April 2022 and April 2023, exhibited renewed bending post-cyclone, albeit to a lesser degree (around 44°) (Fig. 1d). In contrast, untreated palms showed severe bending angles of over 90° (Fig. 2a), with some experiencing complete crown detachment or trunk breakage (Fig. 2b). As terminal leaves play a significant role in the palm trees as the new leaves emerge from there, separation of the terminal leaves destroys the meristematic part responsible for the regeneration of new leaves and ultimately leads to mortality (Fig. 2c). Among the various cultivars and germplasms, no other germplasms were showing any such bending symptoms. The presence of crown bending not only impacts the tree's structural integrity but also affects its overall health and productivity. Due to crown bending, it might be possible that there is a rise in the stress in the internal stress withing the trunk which potentially impeding nutrient and water transport, which may weaken the meristematic tissue at the crown, vital for new leaf growth and overall plants regenerative capacity. This may ultimately leads to mortality, especially severe bending leads to crown detachment. Such physiological implications underline the importance of addressing crown bending disorder in Barhee, both for enhancing plant survival and sustaining productivity.

Fig.1 (a) Date palm with crown bending disorder (July 2021)
(b) Pruned date palm with tied terminal leaves (April 2022)
(c) Treated date palm with a straight crown (April 2023)
(d) Bending of the crown after cyclone (June 2023)

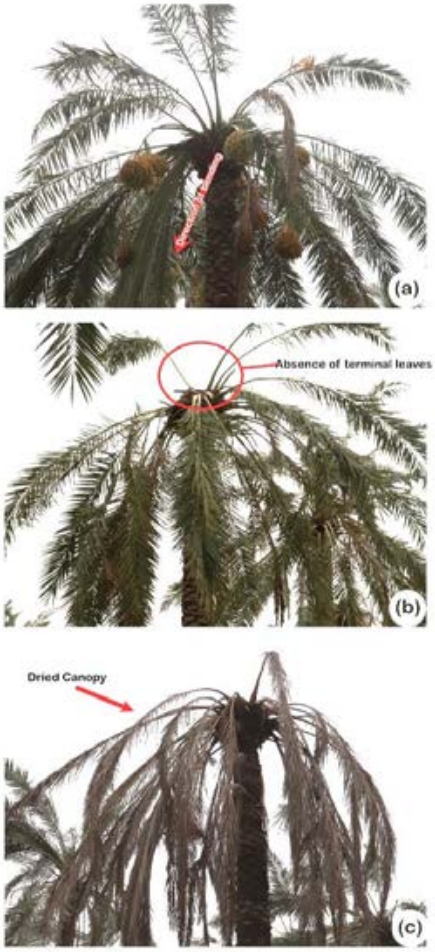

Fig. 2 (a) Untreated date palm with severe bending
(b) Untreated date palm with broken crown (June, 2023)
(c) Untreated date palm after one month of broken crown (July, 2023)

Conclusion and future directions

The impact of the cyclone highlights the vulnerability of the Barhee palms and its susceptibility to high wind conditions. The combined forces of heavy wind and imbalanced bunch weights suggests both environmental and physiological factors contributing to the disorder. This infers to the following conclusions: (i) crown bending is typical for the cultivar Barhee; (ii) it can be influenced by heavy wind; (iii) wind can influence and alter the direction and proportion of bending; (iv) excessive wind may result in breakage of terminal leaves and may result in death of the plant.

This case study illustrates the importance of understanding localized disorders and their interactions with environmental stressors, particularly in regions like Kachchh region of Gujarat where date palm cultivation plays a significant economic role. Exploring agronomic practices, such as enhanced support structures, regulated pruning, and targeted bunch management, may also offer practical solutions for mitigating bending severity. In addition, a more extensive study examining the biomechanical properties of crown bending across different heights and canopy structures could provide valuable data to inform cultivation strategies. Since, Barhee is a popular cultivar in the regions and is under extensive cultivation, developing practical solutions for crown bending is needful to support productivity and sustainability for growers across cyclone-prone areas.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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