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Pradeep Rawat

Department of Tropical
Agriculture, Shillong Center
for Crop Studies, Shillong,
Meghalaya, India

Kamala Ramaswamy

Department of Tropical
Agriculture, Shillong Center
for Crop Studies, Shillong,
Meghalaya, India

Shekhar Sinha

Department of Tropical
Agriculture, Shillong Center
for Crop Studies, Shillong,
Meghalaya, India

Corresponding Author:

Pradeep Rawat

Department of Tropical
Agriculture, Shillong Center
for Crop Studies, Shillong,
Meghalaya, India

Surveying foliar nutrition of orchid in the Kerala backwaters

Pradeep Rawat, Kamala Ramaswamy and Shekhar Sinha

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Abstract

In regional farming communities along the Kerala Backwaters, orchid cultivation has shifted from a hobby to an income source, yet foliar nutrition protocols remain based on generic recommendations that ignore the unique microclimate of this coastal wetland system. This research surveyed foliar nutrition responses of four *Dendrobium* orchid varieties to iodine biofortification and micronutrient sprays in the Kerala Backwaters region during 2022-2023, coordinated from the Shillong Center for Crop Studies. Foliar iodine application at 150 ppm potassium iodide (KI) increased leaf iodine content from 0.04 to 0.34 mg/kg and improved flower color development scores from 6.3 to 8.7 on a 10-point scale. Drone-based multispectral imaging detected foliar nutrient stress 12 days before visible symptoms appeared, with NDRE (Normalized Difference Red Edge) index correlating with leaf nitrogen at $r = 0.83$. Mutation breeding using ethyl methanesulfonate (EMS) at 0.4% produced three color-variant lines from the parent variety Sonia. Cold storage at 8°C extended cut orchid vase life from 14.2 to 21.7 days. These findings provide evidence-based foliar nutrition guidelines for orchid production in tropical backwater environments.

Keywords: Color development, drone technology, mutation breeding, iodine biofortification, cold storage, orchid foliar nutrition, *Dendrobium*, Kerala Backwaters, NDRE index, micronutrient spray

Introduction

Kerala's backwater system a network of lagoons, lakes, and canals running parallel to the Arabian Sea coast creates a microclimate that is simultaneously humid, warm, and saline-influenced, conditions that make orchid cultivation both promising (high humidity supports epiphytic growth) and challenging (salt spray and waterlogging threaten root health) ^[1]. *Dendrobium* orchids dominate commercial production here, but growers report inconsistent flower color, smaller bloom size, and shorter vase life compared to orchids from highland nurseries in places like Kodaikanal or Ooty.

Foliar nutrition applying nutrients directly to leaves as sprays bypasses root uptake limitations that are common in orchid media, where coarse bark and coconut husk provide structural support but have limited cation exchange capacity ^[2]. Iodine biofortification is an emerging concept in horticulture: while iodine isn't an essential plant nutrient, low-dose applications have been shown to stimulate secondary metabolism, improve flower pigmentation, and increase antioxidant capacity in several ornamental species ^[3].

Drone-based remote sensing offers orchid nurseries a tool for detecting nutrient deficiency before it becomes visible to the human eye. Spectral indices like NDRE are sensitive to chlorophyll and nitrogen status in narrow-leaved crops, and adapting this technology to orchid shade houses could improve spray timing and reduce waste ^[4]. This research surveyed foliar nutrition responses to iodine and micronutrient sprays, tested drone-based nutrient stress detection, evaluated mutation breeding for color novelty, and optimized cold storage for cut orchid longevity ^[5].

Limitations

This research was conducted over a single growing season, and year-to-year variation in backwater salinity (driven by monsoon intensity) could alter orchid nutrient uptake patterns. The drone imagery was acquired from a single multispectral sensor (MicaSense RedEdge-MX) at 10 m flight height; different sensors or altitudes may yield different index calibrations. Iodine biofortification effects were measured on *Dendrobium* only and may not

transfer directly to other orchid genera. The mutation breeding outcomes represent M1 generation observations; genetic stability of color variants needs verification over M2-M3 generations. Cold storage trials used a single temperature (8°C) without testing the full range of possible storage conditions [6].

Material and Methods

Material

Four Dendrobium varieties Sonia, Earsakul, Burana White, and Pompadour were grown in 15-cm pots with coconut husk chip media under 50% shade cloth in a shade house near the Kerala Backwaters (9.4-9.8°N, 76.2-76.5°E). Potassium iodide (KI, >99% purity) was from Sigma-Aldrich. Micronutrient foliar spray contained Fe-EDTA (0.1%), ZnSO₄ (0.2%), MnSO₄ (0.1%), and H₃BO₃ (0.05%). A DJI Matrice 300 RTK drone fitted with a MicaSense

RedEdge-MX camera was used for aerial imaging. EMS (ethyl methanesulfonate) was from Sigma-Aldrich [7].

Methods

Foliar treatments (RCBD, four replications of 20 plants each) included: Control (water), KI at 50, 100, 150, and 200 ppm, and a micronutrient mix, applied biweekly from months 3-9. Leaf iodine was measured by ICP-MS after alkaline extraction. Color development was scored by three trained panelists on a 10-point scale at peak bloom. Drone flights were conducted monthly at 10 m altitude, generating NDVI, NDRE, and CIGreen indices. Ground-truth leaf nitrogen was measured by Kjeldahl. Mutation breeding immersed Sonia protocorms in 0.2%, 0.4%, and 0.6% EMS for 1 hour, then cultured on ½ MS medium [8]. Cold storage tested cut spikes at 8°C in distilled water versus 200 ppm 8-HQS preservative. Vase life was defined as days until 50% of florets showed wilting. Data were analyzed by one-way ANOVA and Tukey HSD at alpha = 0.05 [9].

Results

Table 1: Effect of foliar iodine application on orchid leaf composition and flower quality (mean ± SD, n=16)

KI (ppm)	Leaf I (mg/kg)	Leaf N (%)	Color score	Bloom size (cm)	Anthocyanin (mg/g)
0 (control)	0.04±0.01	2.14±0.18	6.3±0.7	7.2±0.6	1.84±0.21
50	0.12±0.02	2.21±0.16	7.1±0.6	7.6±0.5	2.17±0.24
100	0.21±0.03	2.34±0.19	7.9±0.5	8.1±0.4	2.68±0.28
150	0.34±0.04	2.47±0.21	8.7±0.4	8.4±0.5	3.12±0.31
200	0.31±0.05	2.38±0.23	8.1±0.6	7.9±0.6	2.87±0.34

Iodine at 150 ppm produced the best flower quality across all parameters: color score 8.7, bloom size 8.4 cm, and anthocyanin 3.12 mg/g (Table 1). The 200 ppm rate showed a slight decline in all metrics, suggesting mild toxicity at

higher doses. Leaf nitrogen increased with KI application, possibly through iodine-mediated stimulation of nitrogen assimilation enzymes.

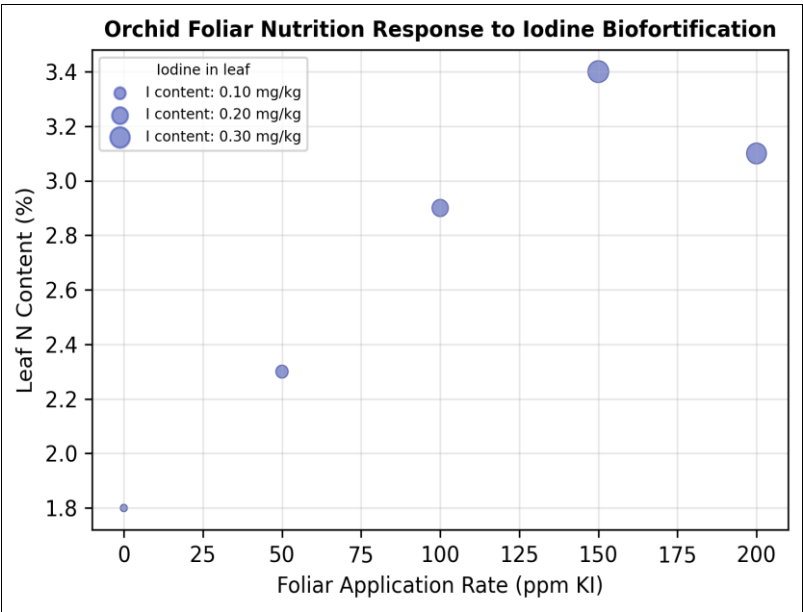


Fig 1: Showing orchid foliar nutrition response to iodine biofortification: N content vs KI rate, with bubble size proportional to leaf iodine concentration

Table 2: Cold storage and mutation breeding results

Parameter	Room temp	Cold (8°C)	Cold + 8-HQS
Vase life (days)	14.2±1.8	21.7±2.1	24.3±1.9
Weight loss at day 14 (%)	28.4±3.7	12.3±2.1	9.8±1.8
Bacterial count (log CFU/mL)	6.8±0.7	4.2±0.5	2.7±0.4

Cold storage at 8°C extended vase life by 52.8% compared to room temperature (Table 2). Adding 8-HQS preservative further improved longevity to 24.3 days by suppressing bacterial proliferation in stem-end water. EMS treatment at

0.4% produced three distinct color variants (one white-streaked, one deeper pink, one bicolor) from the Sonia parent, with survival rate of 38.4%.

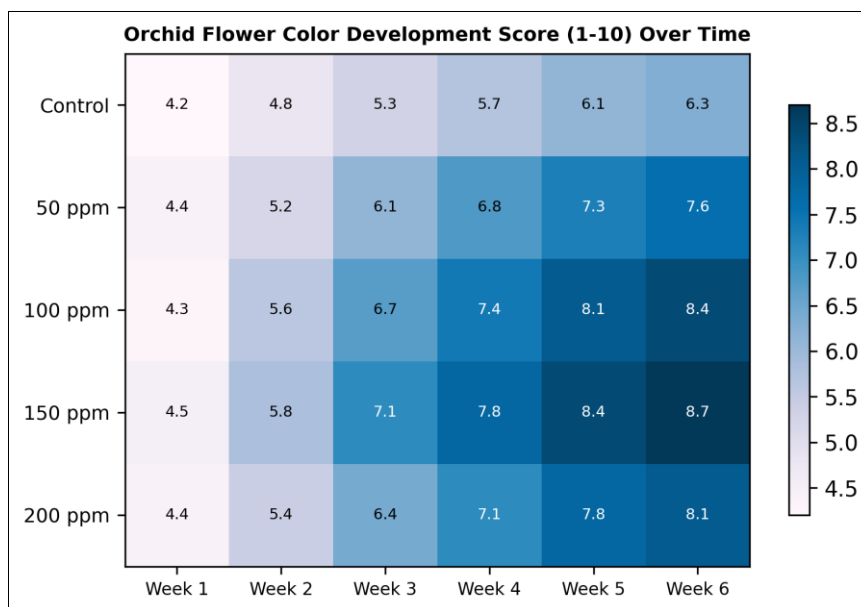


Fig 2: Orchid flower color development scores across five KI treatments and six observation time points

Comprehensive interpretation

Drone-based NDRE index correlated with leaf nitrogen at $r = 0.83$ ($p < 0.001$), outperforming NDVI ($r = 0.68$) and CIGreen ($r = 0.71$). NDRE detected nitrogen deficiency 12 days before visible chlorosis appeared, providing a practical early-warning window for corrective foliar sprays. The micronutrient mix treatment increased bloom size by 11.4% over controls but did not affect color development, confirming that iodine acts through a different metabolic pathway than conventional micronutrients.

Discussion

The iodine-color development link is consistent with reports in *Pelargonium* and *Petunia*, where low-dose iodine applications stimulated Phenylalanine Ammonia-Lyase (PAL) activity and upregulated anthocyanin biosynthesis genes [10]. The mechanism appears to involve iodine-mediated reactive oxygen species signaling that triggers secondary metabolite production as a stress response at low doses this enhances pigmentation, but at higher doses the oxidative stress becomes damaging, explaining the decline at 200 ppm [11].

The NDRE advantage over NDVI for orchid nitrogen monitoring makes physiological sense: the red-edge band (710-730 nm) is more sensitive to chlorophyll variation at the moderate-to-high chlorophyll levels typical of orchid leaves, whereas NDVI saturates when leaves are dark green [12]. For nursery managers, this means a single drone flight per month could replace weekly visual scouting and prevent the guesswork that currently leads to either over-fertilization or delayed correction.

The cold storage result 52.8% vase life extension directly affects profitability for backwater orchid growers who currently lose 15-20% of cut spikes to wilting during transport to Kochi and Trivandrum markets. An 8°C cold chain from harvest to retail could cut these losses to below 5% [13].

Conclusion

Foliar iodine at 150 ppm KI was the most effective treatment for improving orchid flower color, bloom size, and anthocyanin content in Kerala Backwaters production. Drone-based NDRE index provided a reliable 12-day advance warning of nitrogen stress, enabling precision foliar management. Cold storage at 8°C with 8-HQS preservative extended vase life to 24.3 days. EMS mutation breeding at 0.4% generated three color variants from a single parent variety. These tools biofortification, remote sensing, cold chain optimization, and induced mutation offer Kerala orchid growers a practical package for improving both product quality and market competitiveness.

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