Efficacy of kaolin and salicylic acid in reducing heat stress damage and enhancing yield of dragon fruit

Waghmare G.[1,2], Kakade V.D.[1*], Amrut Morade[1], Agale M.G.[2], Chavan S.B.[1], Shitole P.A.[2] Kshirsagar J. K.[2], Shinde G. S.[2], Sarode S.S.[2], Magar S. D.[3], and Patil B.T.[3]

[1]ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra, India 413115

[2] Dr. Sharadchandra Pawar College of Agriculture (MPKV, Rahuri), Baramati, Maharashtra, India 413115

[3]Department of Horticulture, Mahatma Phule Krishi Vidyapyth, Rahuri,Maharashtra, India 413722

**Email: vijaykakade.7@gmail.com*

Receipt: 25.08.2025 Revised: 26.09.2025 Acceptance: 28.09.2025

DOI: https://doi.org/10.53552/ijmfmap.11.2.2025.35-45

ABSTRACT

Dragon fruit holds high economic value due to its rich nutrition and growing export demand throughout the world. However, sunburn caused by high temperatures and intense solar radiations is a major constraint, leading to yellowing, bleaching, rotting and drying of cladodes, poor growth, higher disease susceptibility, and yield loss. To mitigate this, foliar sprays of kaolin (4%, 6%, 8%), salicylic acid (SA, 300 ppm), and their combinations were evaluated, with water spray as control. Among treatments, 8% kaolin was most effective, reducing sunburn incidence and severity in April (65.63% SI, 22.08% SS) and May (57.29% SI, 23.75% SS), and lowering disease incidence (32.42%) and severity (13.96%). It also improved physiological traits including new shoot emergence (14.00), chlorophyll (3.25 mg/g FW), and NDVI, as well as reproductive traits such as buds (92.00), flowers (76.00), and fruits (48.33). The 4% kaolin + SA treatment enhanced fruit set (91.23%). Highest yield (15.77 kg/plant; 15.01 t/ha) was recorded with 8% kaolin, with SA also contributing positively. Kaolin sprays enhanced phenols and flavonoids, while 6% kaolin improved vitamin C (45.68 mg/100 g). Overall, 8% kaolin effectively mitigated heat stress by reducing sunburn and disease, while SA, though less effective against disease, significantly boosted yield alone or with kaolin.

Keywords: Kaolin, salicylic acid, sunburn management, yield.

INTRODUCTION

Dragon fruit (*Selenicereus undatus*) is a perennial climbing cactus of the Cactaceae family. Its earlier genus name *Hylocereus* is derived from the Greek word *hulos* meaning "forest," reflecting its natural habitat and drought tolerance (Le Bellec *et al*., 2006). Dragon fruit is a nutrient-rich super-fruit, consumed fresh and processed into juice, jam, and wine. Its pulp and pectin-rich peel are also useful for food products and natural colorants. The fruit offers health benefits due to antioxidants, vitamins (C and B3), phenolics, flavonoids, fibres, and minerals such as phosphorus and calcium, while being relatively low in sugar (Doke *et al.,* 2024; Patil *et al*., 2024). Its cultivation is profitable in regions with 500–1500 mm rainfall and temperatures of 20–30 °C (Kokani *et al*., 2024; Kakade *et al*., 2025). However, with expansion into hot-arid and humid zones, heat stress has emerged as a major challenge

(Jinger *et al*., 2024; Patil *et al.,* 2024). Heat stress occurs when temperatures exceed the tolerance threshold for extended periods, causing irreversible damage (Sharma *et al*., 2018). It disrupts chlorophyll synthesis, photosynthesis, and photosystem II activity, resulting in poor vigour, reduced flowering, lower yield, and weaker fruit quality. Plants also become more prone to sunburn, fruit drop, pests, and diseases (Patil *et al*., 2024). Being a CAM plant, dragon fruit closes stomata during the day to conserve water, limiting cooling through transpiration and increasing tissue heat load. Succulent stems are particularly vulnerable, showing chlorosis, bleaching, or even rot and then dry under stress (Patil *et al.,* 2024). High light intensity combined with day–night temperature fluctuations aggravates heat stress, often resulting in sunburn (Chang *et al.,* 2016). Yield losses due to sunburn can range from 6% to 30% (Lal and Sahu, 2017). In India, 80–95% of growers reported sunburn, especially in Rajasthan, Gujarat, and Maharashtra, when temperatures exceed 38 °C in March–April (Kakade *et al*., 2025). Farmers are using shade nets, anti-transpirants, and intercropping to reduce damage.

Management strategies include kaolin sprays, protective fruit bagging, and shade nets. Kaolin forms a reflective white film that reduces sunlight exposure, lowering fruit surface temperature by 5–10 °C and protecting against heat, UV, and insects (Lal and Sahu, 2017). It is widely applied in fruit crops, it improves yield and quality. Salicylic acid (SA) is a natural phenolic growth regulator involved in signalling and defence. It regulates growth, photosynthesis, and water relations and enhances resistance by activating defence genes and systemic acquired resistance (Kumar *et al.,* 2023). This study was conducted to evaluate kaolin and salicylic acid sprays at different concentrations for reducing heat stress and sunburn in dragon fruit. Their effects on physiological and biochemical responses were assessed to develop cost-effective and practical management strategies supporting plant growth, yield, and resilience under stress.

MATERIALS AND METHODS

The study was conducted in 2024 at Plot I4, North Block orchard, ICAR-NIASM, Baramati, India (18.167°N, 74.498°E; 570 m). The site lies in the Deccan Plateau (AZ-95, AER-6) with a hot semi-arid climate and ~56 cm annual rainfall, mostly from the southwest monsoon. Mean monthly temperatures range 21.8–22.7 °C, peaking in May (38.9/22.3 °C). During the experiment (Mar–May), maximum temperatures were 36.1–38.9 °C with 7.8–8.7 sunshine hours/day, 20–72% RH, negligible rainfall, and winds of 5.7–8.5 km/h. The shallow soil (0.1–0.3 m) was rocky, alkaline (pH 7.86–7.98), low in organic matter (0.82–0.83%), and contained 199–202, 12–17, and 428–495 kg/ha available N, P, and K, respectively. The trial was conducted on 11-year-old white-fleshed dragon fruit spaced at 3.5 × 3.0 m (952 poles/ha, four plants/pole). Eight foliar treatments were imposed: kaolin (4, 6, 8%), salicylic acid (SA; 300 ppm), kaolin + SA combinations, and a water control. Kaolin (400–800 g) was mixed in 10 L water, and SA was dissolved in ethanol before dilution. Sprays were applied at 25-day intervals, starting in second week of March (19th March) and last spray taken in first week of May (2nd May). So, 3 sprays were taken during March-May.

Plant growth and physiological parameters

New shoots were counted manually after treatment. The moisture content of cladodes (%) was determined by drying them in an oven at 65°C for 3 to 4 days until a stable weight was reached. Chlorophyll content was estimated using N, N-dimethyl formamide as the solvent, based on the method described by Inskeep and Bloom (1985). Absorbance readings were taken at wavelengths of 647 nm and 664 nm using a UV-VIS spectrophotometer (Lab India, Hyderabad, India). The Normalized

Difference Vegetation Index (NDVI) was recorded during the summer season using a Green Seeker handheld crop sensor (Trimble, Ukraine). Light intensity was measured under the canopy centre at a depth of 30 cm using a digital lux meter (HTC LX-102A) between 11:00 a.m. and 1:00 p.m. Membrane stability index (MSI) of cladodes was estimated according to Sairam, (1994) and canopy temperature (CT) was assessed using an IR gun during summer. Sunburn incidence (SI) in the field was assessed by counting chlorotic (yellowing) cladodes, following the method of Chang *et al.* (2016). Sunburn and disease symptoms were predominantly observed during periods of elevated temperatures, which caused visible damage to the cladodes. For consistent evaluation, eight cladodes were selected from each direction of the plant north, south, east and west. Healthy green cladodes turned yellow when affected by sunburn or heat stress. Disease incidence was calculated by counting number cladodes showing disease symptoms (mainly stem canker was observed) and expressed in percentage. Disease severity (DS) and sunburn severity (SS) were visually rated using a grading scale with slight modifications from the method described by Hieu et *al.* (2018). The formula was used to calculate SI, DI and SS, DS are as follows;

$$\text{SI (Sunburn incidence)} = \frac{\text{Total number of cladodes infected1}}{\text{Total number of cladodes}} \times 100$$

$$\text{DI (Disease incidence)} = \frac{\text{Total number of cladodes infected}}{\text{Total number of cladodes}} \times 100$$

$$\text{SS (Sunburn severity)} = \frac{\text{Sum of total score}}{\text{No. of observations} \times \text{maximum score}} \times 100$$

$$\text{DS (Disease severity)} = \frac{\text{Sum of total score}}{\text{No. of observations} \times \text{maximum score}} \times 100$$

Flowering and Fruit yield parameters

The number of flower buds and fruits was manually recorded on each plant during every flush from May to December and reported as cumulative counts per pole. Flower bud drop (%) was determined by comparing the number of dropped buds to the total number of flowers produced on the plant. Fruit set was calculated by counting the number of fruits to the total number of flowers. Fruit yield was estimated by summing fruit weight from all flushes and cumulative yield expressed in kg per plant and tons per hectare.

Physical and biochemical fruit quality parameters

Six fruits were randomly selected from each treatment and weighed using an electronic balance to determine the average weight of the whole fruit, pulp and peel with results expressed in grams. Fruit length and width and also peel thickness measured using vernier calliper and expressed in mm. Fruit firmness was evaluated using a texture analyzer (XT Plus, Stable Micro Systems, UK) by measuring both penetration and cutting force at a speed of 0.5 mm/sec, with the results expressed in grams. Total soluble solids (TSS) were determined using a handheld refractometer following AOAC (2005) guidelines. Titratable acidity was estimated by titrating 1 g of fruit sample with 0.1 N NaOH using phenolphthalein as an indicator and the results were expressed as a percentage of citric acid. The pH of the fruit was measured using a pH meter. A 10 mL sample was taken and distilled water was added. The pH meter was then used to record the reading. The ratio was determined by dividing the TSS by the fruits titratable acidity content. Total phenolic content was measured using the Folin-Ciocalteu method as outlined by Singleton *et al.* (1999). For this, 20 g of pulp was homogenized in 80% methanol and centrifuged at 7500 rpm for 15 minutes at 4°C. From the supernatant, 0.5 ml extract was mixed with 0.2 ml Folin-Ciocalteu reagent, 3.3 ml distilled water and 1 ml of 20% sodium carbonate. After 30 minutes of incubation in darkness, absorbance was read at 765 nm using a UV-VIS spectrophotometer and results were expressed in gallic acid equivalents. Total flavonoid content was analysed following the

method of Zhishen *et al.* (1999). The sample was crushed in 80% methanol centrifuged at 7500 rpm for 15 minutes at 4°C and 0.5 ml of the extract was mixed with 0.4 ml distilled water and 0.3 ml of 5% sodium nitrite. After a 5-minute reaction 0.3 ml of 10% aluminum chloride was added and allowed to react for another 5 minutes. Then 3.4 ml of 4N sodium hydroxide was added and the mixture was incubated at room temperature for 30 minutes. Absorbance was recorded at 415 nm and expressed in mg catechin equivalent. Total sugars were estimated using the method described by Nielsen (2010). Ascorbic acid content was measured by titrating a known amount of sample with 2,6- dichlorophenol indophenol dye using metaphosphoric acid as a stabilizer (Ranganna, 1986). Antioxidant activity through DPPH radical scavenging was evaluated as per Brand-Williams *et al.* (1995). Samples were extracted in 80% methanol centrifuged at 12000 rpm for 8 minutes and 0.5 ml of extract was combined with 3 ml of 0.001 M DPPH solution. The mixture was kept in the dark for 45 minutes at room temperature and absorbance was read at 517 nm. Results were expressed as mg Trolox equivalent per 100 g sample. Ferric Reducing Antioxidant Power (FRAP) was estimated following Benzie and Strain (1999). The FRAP reagent was prepared using 1 mM 2,4,6-TPTZ and 20 mM ferric chloride in 0.25 M sodium acetate buffer. After extraction in 80% methanol and centrifugation, 0.2 ml of supernatant was mixed with 1.8 ml of FRAP reagent and incubated for 40 minutes at room temperature. Absorbance was taken at 593 nm, and results were expressed as mg Trolox equivalent per 100 g of sample.

The experiment was conducted using a randomized block design (RBD) with 8 treatments and 3 replications. Statistical analysis was performed through ANOVA to obtain F-values followed by a least significant difference (LSD) test using R Studio (Versions 4.1.1 and 1.4.1417) for Windows. A significance level of $p < 0.05$ was used.

RESULTS AND DISCUSSION

Plant growth and physiological parameters

Significant variation in new shoot formation was observed among treatments, with the maximum (14.00) in T3 (8% kaolin) and the minimum (4.67) in T8 (control) (Table 2). Cladode moisture content ranged from 81.47% (T2, 6% kaolin) to 86.23% (T1, 4% kaolin), though differences were non-significant, reflecting the CAM physiology and succulent nature of dragon fruit that favour water conservation. Treatments significantly influenced chlorophyll content, with T3 recording the highest chlorophyll a (1.72 mg/100 g), chlorophyll b (1.53 mg/100 g), and total chlorophyll (3.25 mg/100 g), while the lowest values were in T8. The chlorophyll a/b ratio ranged from 1.07 (T6) to 1.48 (T5). Enhanced chlorophyll under kaolin and salicylic acid treatments was attributed to reduced heat stress and prevention of pigment degradation, consistent with earlier reports (Doke *et al*., 2024; Patil *et al*., 2024). NDVI values also varied significantly: in April, the highest (0.54) was in T1 and T3, while the lowest (0.42) occurred in T8; in May, T1 and T6 had the highest (0.58) and T7 the lowest (0.47). Higher NDVI under kaolin treatments indicated improved canopy health and stress tolerance.

Sunburn incidence did not differ significantly in April (Table 3), although the control (80.21%) recorded the highest values and 8% kaolin the lowest (65.63%). By May, differences were significant, with 8% kaolin (57.29%) showing the least incidence, comparable to 4% (61.46%) and 6% (63.54%) kaolin, while the control remained highest (88.54%). Kaolin was more effective than salicylic acid combinations, likely due to its reflective properties, consistent with reports in mandarin, pomegranate, and mango (Ennab *et al*., 2017; Hamdy *et al.,* 2022). Disease incidence was also

significantly reduced by treatments, from 60.42% in the control to 35.42% with 8% kaolin, statistically similar to 6% kaolin (43.75%), 4% kaolin (46.88%), and salicylic acid (47.92%). Similar effects of kaolin against pathogens were reported in apple (Sharma *et al*., 2020). As shown in Table 4, MSI varied significantly among treatments, with the highest in 8% kaolin (59.23%), at par with 6% kaolin + SA (56.58%), and the lowest in the control (22.41%). Canopy temperature also differed, with maximum values being non-significant (51.03 °C in T1 vs. 48.67 °C in T3), while minimum temperatures were significantly lower in 8% kaolin (17.37 °C) compared to the control (25.73 °C).

Flowering and yield parameters

Significant differences were observed in flowering and yield parameters (Table 5). The highest flower bud initiation (92.00%) and flower number (76.00) occurred in 8% kaolin, compared to the lowest in the control (47.33% and 36.00, respectively). Kaolin reduced canopy temperature and sunburn stress, thereby enhancing photosynthesis and bud initiation, consistent with Patil *et al.* (2024) and Khayyat and Samadzadeh (2023). Flower bud drop was lowest with 8% kaolin (17.23%) and highest with 6% kaolin + SA (28.61%), reflecting the stress-mitigating role of kaolin (Al-Saif *et al*., 2022). Fruit number was maximum in 8% kaolin (48.33) and lowest in SA (24.66) and control (32.66), while fruit set was highest in 4% kaolin (91.23%) and control (90.46%) but lowest in 8% kaolin + SA (60.87%). Differences were attributed to kaolin's role in alleviating heat stress and reduced competition in the control (Al-Saif *et al.,* 2022). Fruit yield also varied significantly, with 8% kaolin producing the highest values (15.77 kg/plant; 15.01 t/ha) and the control the lowest (7.12 kg/plant; 6.78 t/ha). The improvement was linked to enhanced photosynthesis and stress mitigation, in agreement with Khayyat and Samadzadeh (2023) and Nazari *et al.* (2021).

Fruit physical and biochemical parameters

Fruit weight differed significantly, with the maximum in 6% kaolin (433.00 g) and the minimum in control (214.87 g) (Table 6). Kaolin reduced heat stress and improved fruit growth, while salicylic acid (SA) further enhanced tolerance, corroborating earlier findings (Ennab *et al.,* 2017; Ogiela, 2020). Fruit length and width were highest in 6% kaolin (108.17 mm, 88.68 mm) and lowest in control (77.37 mm, 66.09 mm). Similarly, fruit volume peaked in 6% kaolin (419.00 cm^3) and was lowest in control (144.67 cm^3), reflecting improved microclimate, photosynthesis, and assimilate supply.

Pulp weight was highest in 4% kaolin (228.07 g) and lowest in control (110.80 g), while peel weight peaked in 6% kaolin (220.60 g). Pulp and peel percentages were non-significant, though peel thickness varied, with the maximum in 6% kaolin + SA (7.50 mm). Fruit firmness also showed no significant variation (Table 6).

Antioxidant activity (DPPH) was highest in 6% kaolin (83.25), with similar effects under 8% kaolin and SA treatments (Table 7). FRAP values were non-significant. Phenols (50.66 mg/ml) and flavonoids (23.18 mg/g) were highest in 6% and 8% kaolin, respectively, while ascorbic acid peaked in 6% kaolin (45.68). These improvements reflect kaolin's role in stress alleviation and antioxidant induction (Hamdy *et al.,* 2022). Sugar content varied significantly, with the maximum in 8% kaolin + SA (10.87%), while TSS was highest in 8% kaolin (11.23 ºBrix) (Table 7). Titratable acidity ranged from 0.32% (8% kaolin) to 0.57% (6% kaolin + SA). The TSS: acidity ratio was highest in 8% kaolin (36.07), enhancing sweetness, whereas the lowest was in 6% kaolin + SA (13.90). Fruit pulp pH ranged from 2.81 (6% kaolin) to 3.27 (8% kaolin + SA), indicating improved fruit quality and shelf life (Table 7).

CONCLUSION

Sunburn damage in dragon fruit cladodes was observed when average monthly temperatures reached ~38 °C with high solar radiation, low relative humidity (20–25%), extended sunshine (8.7 h/day), and moderate winds (10–15 km/h) during March–May. Application of 8% kaolin effectively reduced sunburn and disease incidence while significantly improving reproductive and yield traits such as bud, flower, and fruit numbers, fruit set, and yield per plant and per hectare. Kaolin (6%) enhanced fruit weight, length, and width, while 8% and 4% kaolin treatments improved phenol and flavonoid contents. Antioxidant activity (DPPH and FRAP) was highest under kaolin compared to control. Kaolin is easily washed off by rain, so farmers need to reapply it after rainfall. Therefore, spraying should be timed with sunny weather and avoided on cloudy days. Further, frequent stirring is required during its application as it settle down. Overall, kaolin mitigated heat stress, with 8% kaolin proving most effective; however, as this study was conducted for one-year, further research is required before final recommendations can be made.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Al-Saif, A. M., Mosa, W. F., Saleh, A. A., Ali, M. M., Sas-Paszt, L., Abada, H. S. and Abdel-Sattar, M. 2022. Yield and fruit quality response of pomegranate (*Punica granatum*) to foliar spray of potassium, calcium and kaolin. *Horticulturae*, **8**(10): 946. https://doi.org/10.3390/horticulturae8100946

AOAC., 2005. Official methods of analysis of the association of official analytical chemistsinternational (18th Ed.). USA: Maryland.

Benzie, I. F. F. and Strain, J. J. 1996. Ferric reducing ability of plasma (FRAP) as a measure of antioxidant power the FRAP assay. *Analytical Biochemistry*, **239**(1): 70-76.

Brand-Williams, W., Cuvelier, M.E. and Berset, C., 1995. Use of a free radical method to evaluate antioxidant activity. *LWT Food Science and Technology*, **28:** 25–30. https://doi.org/10.1016/S0023-6438(95)80008-5.

Chang, P.T., Hsieh, C.C. and Jiang, Y.L. 2016. Responses of 'Shih Huo Chuan' pitaya (*Hylocereus polyrhizus* (Weber) Britt. and Rose) to different degrees of shading nets. *Scientia Horticulturae*, **198**(6): 154-162.

Doke, A., Kakade, V. D., Patil, R. A., Morade, A. S., Chavan, S. B., Salunkhe, V. N. and Reddy, K. S. 2024. Enhancing plant growth and yield in dragon fruit (*Hylocereus undatus*) through strategic pruning: A comprehensive approach for sunburn and disease management. *Scientia Horticulturae*, **337**(1): 113562. https://doi.org/10.1016/j.scienta.2024.113562

Ennab, H. A., El-Sayed, S. A. and El-Enin, M. M. S. 2017. Effect of kaolin applications on fruit sunburn, yield and fruit quality of Balady mandarin (*Citrus reticulata, Blanco*). *Menoufia Journal of Plant Production*, **2**(2): 129-138.

Hamdy, A. E., Abdel-Aziz, H. F., El-Khamissi, H., AlJwaizea, N. I., El-Yazied, A. A., Selim, S. and Elkelish, A. 2022. Kaolin improves photosynthetic pigments and antioxidant content and decreases sunburn of mangoes: Field study. *Agronomy*, **12** (7): 1535. https://doi.org/10.3390/agronomy12071535

Hieu, N.T., Thu, N.N.A., Linh, D.T., Thanh, N.T.K., Van Hoa, N., and Rangaswamy, M. 2018. Effect of various degree of canopy pruning on

plant growth, yield, and control of canker disease of dragon fruit crop. In: *Proceedings of the International Conference on Tropical Fruit Pests and Diseases, Kota Kina balu, Sabah, Malaysia*, 25–27 September.

Inskeep, W. P. and Bloom, P. R. 1985. Extinction coefficients of chlorophyll a and b in N, N-dimethyl formamide and 80% acetone. *Plant Physiology*, **77**(2): 483-485.

Jinger, D., Kakade, V., Bhatnagar, P. R., Nandha Kumar, N., Dinesh, D., Singh, G. and Madhu, M. 2024. Dragon fruit: A Remunerative Fruit under Rainfed Conditions for Ravine Lands of Central Gujarat. *Technical bulletin*. ICAR–Indian Institute of Soil and Water Conservation, Dehradun, pp. 18. ISBN- 978-93-94687-87-5.

Kakade, V. D., Morade, A. S., Salunkhe, V. N., Boraiah, K. M., Jinger, D., Singh, G., Chavan, S. B., Kumar, R., Pradhan, A., Jadhav, S., Magar, S., Patil, A., Doke, A., Jadhav, P., Nangare, D. D., and Sammi Reddy, K. 2025. Dragon fruit cultivation in new areas: challenges, management strategies, and insights from India. *Discover Agriculture*, **3**, 168. https://doi.org/10.1007/s44279-025-00243-2

Khayyat, M. and Samadzadeh, A. 2023. Application of kaolin on different chemical and physical properties of pomegranate. *Journal of Plant Nutrition*, **46**(7): 1391-1399.

Kokani, N., Kakade, V.D.**,** Amrut Morade, Tayade, S.A., Safakal, O.U., Chavan, S.B., Holkar, S.R., Agale, M.G., Shitole, P.A. and Shinde, G.S. 2024. Responses of dragon fruit (Selenicereus undatus) to NaCl-Induced salinity stress. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, **10**(2): 103-112.

Kumar, A., Prakash, S., Pandey, V., Prakash, O., Meena, N. K., Kumar, R. and Shukla, K. K. 2023. Biosynthesis, mechanism and potential application of hormones for mitigating stress, conserving bioactive constituents in fruits. *International Journal Plant Soil Science*, **35**(19): 1467-1480.

Lal, N. and Sahu, N. 2017. Management strategies of sun burn in fruit Crop. *International Journal of Current Microbiology and Applied Sciences*, **6**(6): 1126 -1138 .

Le Bellec, F., Vaillant, F. and Imbert, E. 2006. Pitahaya (*Hylocereus spp*.) a new fruit crop, a market with a future. *Fruits*, **61**(4): 237-250.

Nazari, F., Eshghi, S. and Tafazoli, E. 2021. Role of salicylic acid in improving growth, yield and stress tolerance in strawberry under high temperature conditions. *Scienntia Horticulture*, **12**(4): 284-287.

Nielsen, S.S., 2010. Phenol-Sulfuric Acid Method for Total Carbohydrates. In: Nielsen, S. S. (Ed.), Food Analysis Laboratory Manual. Food Science Texts Series. Springer, Boston, MA. https://doi.org/10.1007/978-1-4419-1463-7_6.

Ogiela, H. M. A. 2020. Effect of kaolin foliar on fruit sunburn yield and fruit quality of persimmon trees. *Menoufia Journal of Plant Production*, **5**(4): 181-194.

Patil, A., Kakade, V. D., Kamalvandi, B. M., Morade, A. S., Chavan, S. B., Salunkhe, V. N. and Reddy, K. S. 2024. Mitigating heat stress in dragon fruit in semi-arid climates: the strategic role of shade nets in enhancing fruit yield and quality. *Environment, Development and Sustainability*, 1-37. https://doi.org/10.1007/s10668-024-05619-w

Ranganna, S. 1986. Mannual of Analysis of Fruits and Vegetables. Tata Mc. Hill. Pb.Co. Ltd.

Sairam, R. K. 1994. Effect of moisture stress on physiological activities of two constratsing wheat genotypes. *Indian Journal of Experimental Biology*, **32**(2): 593-594.

Sharma, B., Singh, V., Sheoran, R.K.,

Thakral, N.K. and Naruka, A. 2018. Heat stress in plant. *Annals of biology*, **6**(34):70-78.

Singleton, V.L., Orthofer, R. and Lamuela-Raventos, R.M. 1999. Analysis of total phenols and other oxida tion substrates and antioxidants by means of Folin–Ciocalteu reagent. *Methods in Enzymology*, **299:** 152–178. https://doi.org/10.1016/S0076-6879(99)99017-1.

Zhishen, J., Mengcheng, T. and Jianming, W. 1999. The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals, *Food Chemistry*, **64**(4): 555-559.

Table 1: Monthly Meteorological data collected during experimental period (Jan 2024 to Dec 2024)

Month	Temperature (°C)			Relative Humidity (%)			Sunshine (hr/day)	Rainfall (mm)	Wind speed (km/hr)
	Max	Min	mean	Max	Min	Mean			
Jan	29.9	13.8	21.8	85	38	62	7.4	0.2	4.5
Feb	33.4	15.0	24.2	76	25	50	8.8	0.4	4.0
Mar	36.1	17.5	26.8	63	20	41	7.8	0.2	5.7
Apr	38.6	21.9	30.2	59	23	41	8.6	2.1	5.8
May	38.9	22.3	30.2	72	31	52	8.7	2.6	8.5
Jun	32.7	22.0	27.4	88	58	73	4.9	25.0	8.4
Jul	29.6	21.7	25.6	92	71	82	1.6	9.5	9.5
Aug	30.4	21.1	25.8	92	65	78	3.7	14.8	7.5
Sep	30.7	20.4	25.6	91	60	76	5.4	8.7	8.5
Oct	32.0	20.1	26.1	93	52	72	7.1	8.3	5.4
Nov	30.1	14.9	22.5	84	37	60	6.9	0.0	3.5
Dec	29.8	15.6	22.7	87	42	65	5.3	0.0	3.9

Table 2: Effect of kaolin and salicylic acid (SA) on plant growth and physiological parameters in dragon fruit

Treatment	Treatment details	New shoots (nos.)	Cladode moisture (%)	Chlorophyll a (mg/g of FW)	Chlorophyll b (mg/g of FW)	Total Chlorophyll (mg/g of FW)	Chlorophyll a/b (mg/g of FW)	Normalized Difference Vegetation Index (NDVI) APR 24	Normalized Difference Vegetation Index (NDVI) MAY 24
T1	4 % Kaolin	10.33^{b}	86.23^{a}	1.47^{abc}	0.95^{bc}	2.41^{ab}	1.38^{ab}	0.54^{a}	0.58^{a}
T2	6 % Kaolin	6.67^{c}	81.47^{b}	1.41^{abc}	1.23^{ab}	2.64^{ab}	1.17^{bc}	0.47^{ab}	0.56^{ab}
T3	8 % Kaolin	14.00^{a}	82.55^{ab}	1.72^{a}	1.53^{a}	3.25^{a}	1.12^{c}	0.54^{a}	0.54^{ab}
T4	4 % Kaolin + SA 300 ppm	5.33^{c}	84.43^{ab}	1.25^{bc}	1.12^{bc}	2.36^{b}	1.12^{c}	0.48^{ab}	0.49^{ab}
T5	6 % Kaolin + SA 300 ppm	4.67^{c}	85.91^{ab}	1.60^{ab}	1.08^{bc}	2.68^{ab}	1.48^{a}	0.47^{ab}	0.53^{ab}
T6	8 % Kaolin +SA 300 ppm	6.33^{c}	82.77^{ab}	1.20^{bc}	1.13^{bc}	2.34^{b}	1.07^{c}	0.49^{ab}	0.58^{ab}
T7	SA 300 ppm	6.33^{c}	83.75^{ab}	1.51^{abc}	1.19^{b}	2.70^{ab}	1.27^{abc}	0.44^{b}	0.47^{b}
T8	Control	4.67^{c}	84.09^{ab}	1.12^{c}	0.80^{c}	1.92^{b}	1.40^{a}	0.42^{b}	0.48^{ab}
LSD $_{(p<0.05)}$		3.10	4.71	0.41	0.34	0.87	0.22	0.08	0.11
SEm (±)		1.02	1.55	0.13	0.11	0.28	0.07	0.03	0.04

Values with the same letter were not significantly different within column in LSD test ($p< 0.05$).

Table 3: Effect of Kaolin and Salicylic acid (SA) on sunburn, disease incidence and severity index in dragon fruit

Treatment	Treatment details	Sunburn incidence (%) APR	Sunburn incidence (%) MAY	Sunburn severity (%) APR	Sunburn severity (%) MAY	Disease incidence (%)	Disease severity (%)
T1	4 % Kaolin	72.92^{a}	61.46^{cd}	27.71^{abc}	27.92^{bc}	46.88^{abc}	18.75^{ab}
T2	6 % Kaolin	69.79^{a}	63.54^{bcd}	20.83^{c}	22.71^{c}	43.75^{bc}	14.17^{b}
T3	8 % Kaolin	65.63^{a}	57.29^{d}	22.08^{bc}	23.75^{c}	35.42^{c}	13.96^{b}
T4	4 % Kaolin + SA 300 ppm	79.17^{a}	77.08^{ab}	24.79^{bc}	32.08^{abc}	51.04^{ab}	24.38^{a}
T5	6 % Kaolin + SA 300 ppm	76.04^{a}	78.13^{ab}	29.17^{abc}	31.25^{abc}	55.21^{ab}	23.33^{a}
T6	8 % Kaolin +SA 300 ppm	75.00^{a}	73.96^{abc}	28.96^{abc}	31.04^{abc}	51.04^{ab}	24.17^{a}
T7	SA 300 ppm	78.13^{a}	72.92^{bc}	30.21^{ab}	34.79^{ab}	47.92^{abc}	24.58^{a}
T8	Control	80.21^{a}	88.54^{a}	34.59^{a}	40.00^{a}	60.42^{a}	24.38^{a}
LSD $_{(p<0.05)}$		16.97	15.02	8.67	9.65	13.84	6.23
SEm (±)		5.60	4.95	2.86	3.18	4.56	2.06

Values with the same letter were not significantly different within column in LSD test ($p< 0.05$)

Table 4: Effect of Kaolin and Salicylic acid (SA) on Membrane stability index and Canopy temperature

Treatment	Treatment details	Membrane stability index (%)	CT maximum (°C)	CT minimum (°C)	CT average (°C)
T1	4 % Kaolin	38.66^{bc}	51.03^{a}	23.53^{abc}	41.77^{a}
T2	6 % Kaolin	39.07^{bc}	48.90^{a}	17.47^{bc}	40.57^{a}
T3	8 % Kaolin	59.23^{a}	48.67^{a}	17.37^{c}	40.83^{a}
T4	4 % Kaolin + SA 300 ppm	36.81^{c}	49.53^{a}	19.77^{abc}	41.30^{a}
T5	6 % Kaolin + SA 300 ppm	56.58^{a}	49.93^{a}	23.83^{abc}	42.57^{a}
T6	8 % Kaolin +SA 300 ppm	43.98^{b}	50.67^{a}	26.77^{a}	43.53^{a}
T7	SA 300 ppm	30.24^{d}	49.40^{a}	24.63^{ab}	42.80^{a}
T8	Control	22.41^{e}	50.37^{a}	25.73^{a}	41.50^{a}
LSD $_{(p<0.05)}$		5.68	3.44	7.26	3.31
SEm (±)		1.87	1.14	2.39	1.10

Values with the same letter were not significantly different within column in LSD test ($p< 0.05$).

Table 5: Effect of Kaolin and Salicylic acid (SA) on Flowering and Fruit yield parameters in dragon fruit.

Treatment	Treatment details	Buds (nos.)	Flowers (nos.)	Fruit (nos.)	Bud drop (%)	Fruit set (%)	Plant yield (kg/plant)	Yield (tons/ha)
T1	4 % Kaolin	50.66^{de}	38.66^{cd}	35.33^{b}	23.69^{bcd}	91.23^{a}	13.54^{ab}	12.89^{ab}
T2	6 % Kaolin	60.00^{c}	47.33^{c}	33.33^{b}	20.79^{d}	70.34^{cd}	14.45^{ab}	13.75^{ab}
T3	8 % Kaolin	92.00^{a}	76.00^{a}	48.33^{a}	17.23^{e}	63.72^{d}	15.77^{a}	15.01^{a}
T4	4 % Kaolin + SA 300 ppm	59.33^{c}	46.00^{c}	36.00^{b}	22.65^{cd}	78.93^{bc}	9.92^{bcd}	9.44^{bcd}
T5	6 % Kaolin + SA 300 ppm	54.00^{cde}	38.66^{cd}	34.66^{b}	28.61^{a}	89.98^{ab}	11.18^{bcd}	10.64^{bcd}
T6	8 % Kaolin +SA 300 ppm	74.66^{b}	57.33^{b}	34.66^{b}	23.09^{bcd}	60.63^{d}	13.42^{abc}	12.77^{abc}
T7	SA 300 ppm	55.33^{cd}	40.66^{cd}	24.66^{c}	26.06^{ab}	60.87^{d}	8.89^{cd}	8.47^{cd}
T8	Control	47.33^{e}	36.00^{d}	32.66^{bc}	24.16^{bc}	90.46^{a}	7.12^{d}	6.78^{d}
LSD $_{(p<0.05)}$		7.87	9.23	8.54	3.34	11.14	4.58	4.36
SEm (±)		2.59	3.04	2.81	1.10	3.67	1.51	1.43

Values with the same letter were not significantly different within column in LSD test ($p< 0.05$).

Table 6: Effect of Kaolin and Salicylic acid (SA) on physical Fruit quality parameter in dragon fruit

Treatment	Treatment details	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Fruit volume (m^3)	Pulp weight (g)	Peel weight (g)	Pulp (%)	Peel (%)	Peel thickness (mm)	Fruit firmness (g)	
											Penetration force	Cutting force
T1	4 % Kaolin	379.60^{abc}	102.22^{ab}	81.65^{abc}	325.33^{b}	228.07^{a}	151.53^{bc}	59.83^{ab}	40.17^{bc}	4.03^{c}	477.60^{a}	6944.03^{a}
T2	6 % Kaolin	433.00^{a}	108.17^{a}	88.68^{a}	419.00^{a}	212.40^{ab}	220.60^{a}	49.04^{c}	50.96^{a}	7.10^{ab}	495.97^{a}	6557.23^{a}
T3	8 % Kaolin	324.67^{bc}	89.00^{bcd}	77.21^{abc}	278.00^{bc}	178.80^{b}	145.87^{bcd}	53.33^{abc}	46.67^{abc}	5.93^{ab}	320.47^{b}	5440.20^{a}
T4	4 % Kaolin + SA 300 ppm	358.80^{abc}	92.65^{abcd}	77.16^{abc}	313.33^{bc}	226.00^{a}	132.80^{cd}	62.49^{a}	37.51^{c}	3.98^{c}	452.77^{ab}	6154.97^{a}
T5	6 % Kaolin + SA 300 ppm	281.47^{cd}	80.42^{cd}	69.02^{bc}	243.33^{c}	133.47^{c}	148.00^{bcd}	47.30^{c}	52.70^{a}	7.50^{a}	376.53^{ab}	6157.87^{a}
T6	8 % Kaolin +SA 300 ppm	391.13^{ab}	95.65^{abc}	83.65^{ab}	325.00^{b}	210.73^{ab}	180.40^{ab}	53.94^{abc}	46.06^{abc}	5.67^{bc}	454.80^{ab}	4976.73^{a}
T7	SA 300 ppm	318.38^{bc}	85.66^{cd}	76.93^{abc}	250.89^{bc}	184.96^{b}	133.41^{cd}	57.26^{abc}	42.74^{abc}	5.61^{bc}	426.21^{ab}	5910.98^{a}
T8	Control	214.87^{d}	77.37^{d}	66.09^{c}	144.67^{d}	110.80^{c}	104.07^{d}	51.48^{bc}	48.52^{ab}	5.40^{bc}	499.33^{a}	5859.97^{a}
LSD $_{(p<0.05)}$		98.78	15.71	15.82	76.70	36.30	45.63	10.30	10.30	1.74	150.54	2086.55
SEm (±)		32.56	5.17	5.22	25.29	11.96	15.05	3.40	3.40	0.57	49.63	687.90

Values with the same letter were not significantly different within column in LSD test ($p< 0.05$).

Table 7: Effect of Kaolin and Salicylic acid (SA) on Biochemical Fruit quality parameter in dragon fruit

Treatment	Treatment details	DPPH (mg TE/100 g)	FRAP (mg TE/100 g)	Phenol (mg/100 g GAE)	Flavonoids (mg/100 g CE)	Ascorbic acid (mg/100g)	TSS (°B)	Acidity (%)	Total Sugars (%)	TSS: Acid ratio	pH
T1	4 % Kaolin	74.72^{b}	17.38^{ab}	44.77^{ab}	21.39^{abc}	13.82^{e}	9.93^{abc}	0.37^{cd}	5.93^{c}	29.20^{abc}	3.19^{a}
T2	6 % Kaolin	83.25^{a}	20.13^{a}	50.66^{a}	21.94^{ab}	45.68^{a}	6.83^{d}	0.48^{abc}	8.38^{b}	14.33^{d}	2.81^{b}
T3	8 % Kaolin	81.10^{a}	16.59^{ab}	48.47^{a}	23.18^{a}	19.96^{cd}	11.23^{a}	0.32^{d}	7.57^{bc}	36.07^{a}	2.85^{b}
T4	4 % Kaolin + SA 300 ppm	81.67^{a}	16.80^{ab}	42.66^{abc}	19.69^{abc}	38.03^{b}	10.70^{ab}	0.40^{bcd}	5.79^{c}	31.83^{ab}	3.21^{a}
T5	6 % Kaolin + SA 300 ppm	73.79^{b}	14.40^{b}	34.42^{cd}	19.17^{abc}	36.80^{b}	7.47^{cd}	0.57^{a}	7.49^{bc}	13.90^{d}	3.04^{ab}
T6	8 % Kaolin +SA 300 ppm	79.25^{ab}	17.66^{ab}	33.16^{d}	19.84^{abc}	25.75^{c}	9.27^{abcd}	0.50^{ab}	10.87^{a}	22.18^{bcd}	3.27^{a}
T7	SA 300 ppm	81.67^{a}	18.38^{ab}	38.75^{bcd}	18.57^{bc}	24.36^{cd}	8.46^{abcd}	0.45^{bc}	7.49^{bc}	19.53^{cd}	3.11^{ab}
T8	Control	74.76^{b}	16.05^{ab}	32.02^{d}	17.60^{c}	19.10^{de}	8.00^{bcd}	0.45^{abc}	5.48^{c}	18.29^{cd}	3.17^{a}
LSD $_{(p<0.05)}$		6.07	4.89	8.69	4.14	5.87	2.85	0.11	2.35	11.69	0.30
SEm (±)		2.00	1.61	2.87	1.36	1.93	0.94	0.04	0.78	3.86	0.10

Values with the same letter were not significantly different within column in LSD test ($p< 0.0$)