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Effect of chemical substances on preventing sunburn injury of mandarin

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Abstract
Mandarin (*Citrus reticulata* Blanco) is a promising fruit crop gaining popularity for its human nutrition and economic importance in the world. The qualitative losses during pre- harvest stage hinder the quality production. Recently sunburn is major problem caused due to 'October heat', high temperature and direct solar radiation, which leads to significant economic losses in mandarin yield. So, a field experiment was conducted during 2017 and 2018 seasons at AICRP on Fruits (Citrus) Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. An experiment was conducted to assess the effect of foliar spray of chemical substances 3% and 5% of Kaolin and $MgCO_3$ with combination of urea 1% and GA_3 15 ppm with respective treatments twice in month of September and October on sunburn percentage and fruit quality of mandarin. The obtained results showed that, GA_3 15 ppm+ urea 1% and kaolin 5% foliar applications were effective to control fruit sunburn as well as reducing severity percentage of sunburned fruit as compared to untreated trees. Moreover, Kaolin foliar application at two times was decreased leaf and fruit surface temperature especially at the concentration of 3% and 5%. Therefore, it could be recommended that, spraying kaolin at 3% and 5% two times in month of September and October, because it had a positive effect on preventing fruit sunburn damage and improvement marketable yield of mandarin trees.

Keywords: *Citrus reticulata*, kaolin, $MgCo_3$, urea, GA_3, yield

Introduction
Nagpur mandarin (*Citrus reticulata* Blanco) is an important commercial orange cultivar mainly grown in Vidharbha region of Maharashtra and adjoining states like Madhya Pradesh as well Rajasthan. Nagpur mandarin is also popularly known as Santra. It is only cultivar of mandarin grown in Vidharbha for last 200 years in a round of the 1.85 lakh hectares and considered as one of the best mandarins of the world, because of its attractive colour, pleasant flavor, good taste and wonderful blend of acid sugar. Cultivation of Nagpur mandarin is mostly concentrated in Amravati, Nagpur, Wardha, Yevatmal, Akola and Buldhana districts of Vidharbha region. Production of good quality fruits is an area emphasized now a days neither undersized blemished inferior quality fruits also received very good prices in market. But sunburn is a major problem on early maturing mandarins and yearly leads to large financial losses to growers. But damage due to sunburn (discoloration or burning of fruits surfaces exposed to direct sun) may account for economical losses of the total harvest in mandarin production areas especially in Vidharbha region of Maharashtra.

In October months, fruits of mandarin exposed to direct heat caused by high temperature, together with solar radiation which causes sunburn in fruits. Sunburn (solar injury) causes important economic losses in a large number of fruit species such as apple, mango, grapevine, pomegranate and olive, as well as income loss to farmers (Schrader *et al*., 2003) [51]. In addition, with the continued depletion of the stratospheric ozone layer, the levels of UV-B radiation (280 to 320 nm) reaching the earth's surface are increasing, together with global warming, indicate a probability of increasing incidence of sunburn in the future (Kerr and McElroy, 1993). Fruits are more prone to sunburn compared with the leaves, mainly because they are not capable with efficient mechanisms of using and/or dissipating solar radiation (Blanke and Lenz, 1989). Therefore, the inadequacy of resistance mechanisms and the high susceptibility of fruit to sunburn would suggest the need for external intervention to

suppress sunburn in fruit, and growers looking for the ways to escape from sunburn. Among the numerous cultural practices developed to control sunburn in various crops using kaolin, particle film applications by spraying canopies with a suspension of different types of clay along with kaolin and $MgCO_3$ leaving a film on the leaves and fruits, which reflect sunlight this led to lower the temperature of leaf surface and fruits thereby reducing sunburn and improving fruit quality (Glenn and Puterka, 2005; Glenn, 2009 and Weerakkody *et al.,* 2010) [25, 26]. Kaolin (a clay) is a natural mineral which main constituent is kaolinite (Al2Si2O5 (OH) 4). Kaolin clay treatments have been successfully applied in different fruit species to minimized fruit sunburn and improve yield and fruit quality (Kerns and Wright, 2000; Colavita *et al.,* 2011 and Alvarez *et al.,* 2015) [14, 3].

So, the aim of this study is to plan a research work to study the effect of chemical substances in different combinations and concentration on preventing sunburn injury of mandarin fruits.

Materials and Methods

The present study was carried out at AICRP on Fruits (Citrus), Dr. PDKV, Akola during year 2017-18 and 2018-19 on Mrig bahar fruits of Nagpur mandarin. The experiment is laid out in Randomized Block Design with ten treatments and three replications. The growth promoting substances and chemicals such as gibbrellic acid, urea, kaolin, magnesium carbonate and their treatment combinations were applied in different concentration and time for preventing sunburn injury of mandarin. Statistical analysis of the observations recorded in the experiment was undertaken by adopting standard statistical methods as per Panse and Sukhatme). The experiment included 10 treatments as follow:

T_1 (GA_3 15 ppm + Urea 1%)
T_2 Kaolin @ 3%
T_3 Kaolin @ 5%
T_4 Magnesium carbonate @ 3%
T_5 Magnesium carbonate @ 5%
T_6 (GA_3 15 ppm + Urea 1%) and Kaolin @ 3%
T_7 (GA_3 15 ppm + Urea 1%) and Kaolin @ 5%
T_8 (GA_3 15 ppm + Urea 1%) and Magnesium carbonate @ 3%
T_9 (GA_3 15 ppm + Urea 1%) and Magnesium carbonate @ 5%
T_{10} Control

Results and Discussion

Effect of chemical substances on sunburned fruit percentage

It's clear from table (1) that total percentage of sunburned fruits was the highest with untreated trees (control) in both studied seasons. On the other hand, all the spraying material had a positive effect in reducing the total sunburned fruit percentage over the control. In this respect, the total sunburned percentage was reduced by increasing the concentration.

However, the highest concentration both kaolin 5% followed by magnesium carbonate 5% with combinations of GA_3 15 ppm+ urea 1% respectively recorded the lower sunburned fruits percentage in both seasons. From data in table (1) the lowest percentage of total sunburned fruits per tree (3.17%) was observed in treatment T_7 (GA_3 15 ppm+ urea 1% and kaolin 5%) which was at par with treatment T_9 (3.30%), while the highest percentage of total sunburned fruits per tree (8.49%) was recorded in treatment T_{10} (Control). The minimum the percentage of total sunburned fruits per tree resulting in treatment T_7 (GA_3 15 ppm + Urea 1%+ Kaolin 5%) because of initially applied chemicals that is GA_3 15 ppm+ urea 1% had improved canopy, enhances plant growth and great effect on vegetative growth of leaves also due to protection from high temperature and reflection of solar radiation which lead to reduced heat stress on fruit surface area and enhances fruit water content and reduced rate of transpiration. Similar results found by Ennab *et al.* (2017) [16] in Balady mandarin, Abd- Allah *et al.* (2013) [1] in mango, Parashar *et al.* (2012) in pomegranate, Mohsen and Asharaf Ali (2019) in grapes.

On the other hand, the percentage of total sunburned fruits was reduced when the trees sprayed by all material. In this concern, the sunburned drop fruit percentage was gradually decreased by increasing the spraying concentration from 3% to 5%. The differences were significant among treatments in both seasons. The lowest percentage of sunburned drop fruits per tree (0.31%) was observed in treatment T_7 (GA_3 15 ppm+ urea 1%+ kaolin 5%) which was at par with treatment T_9 (0.46%) while the highest percentage of sunburned drop fruits per tree (3.13%) was recorded in treatment T_{10} (control). Whereas, the minimum percentage of retain sunburned fruits (2.63%) per tree was recorded in treatment T_3 (Kaolin 5%) followed by treatment T_5 (2.86%), T_7 (2.87%) and T_9 (2.89%) while highest percentage of retain sunburned fruits per tree was recorded in treatment T_{10} (5.77%). The percentage of sunburned fruit drop and percentage of retained sunburned fruits per tree decreased with increase in concentration of antitranspirants, owing to the fact that GA_3 sprays reduced fruit drop percentage also increased fruits retention and protection from high temperature and reflection of solar radiation which led to reduced heat stress on fruit surface enhances fruit water content and reduced transpiration rate.

In case of other fruit drop percentage recorded The minimum percentage of fruit drop other than sunburned fruits (8.35%) was recorded in treatment T_7 (GA_3 15 ppm+ urea 1% + kaolin 5%) which was at par with treatments T_9 (9.71%) and T_1 (11.95%) while maximum percentage of fruit drop other than sunburned fruits per tree was recorded in treatment T_{10} (28.96%). As per the study, the percentage of fruit drop other than sunburned fruits per tree decreased with increased concentration of antitranspirants rate resulting in treatment T_7 (GA_3 15 ppm + Urea 1% + Kaolin 5%) might be due to the GA_3 minimizes fruit drop and increased in fruit retention and kaolin appears to be an important and helpful tool to reduced insect attack and pest diseases of fruit damage also could be a valid alternative to intensive application of insecticide. Similar results found by Mohsen and Asharaf (2019) in grapes, Kumar *et al.* (1975) [29] in sweet lime and Ennab *et al.* (2017) [65] in balady mandarin.

Table 1: Effect of chemical substances on percentage of total sunburned fruits, sunburned drop fruits, retain sunburned fruits and fruit drop other than sunburned fruits (per tree)

Treatment	Percentage of total sunburn fruits/tree			Percentage of sunburned drop fruits / tree			Percentage of retain sunburned fruits / tree			Percentage of fruit drop other than sunburned fruits / tree		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1	7.01 (2.64)	5.99 (2.44)	6.50 (2.54)	1.80 (1.34)	1.16 (1.07)	1.48 (1.21)	5.47 (2.34)	4.94 (2.22)	5.20 (2.28)	10.19 (3.18)	13.70 (3.68)	11.95 (3.43)

T_2	3.93 (1.97)	4.34 (2.07)	4.13 (2.02)	1.35 (1.16)	0.96 (0.98)	1.16 (1.07)	2.62 (1.61)	3.49 (1.85)	3.06 (1.73)	20.14 (4.46)	27.23 (5.19)	23.69 (4.83)
T_3	3.38 (1.83)	3.58 (1.88)	3.48 (1.86)	1.45 (1.20)	0.47 (0.67)	0.96 (0.94)	2.03 (1.42)	3.23 (1.78)	2.63 (1.60)	16.63 (4.06)	22.31 (4.70)	19.47 (4.38)
T_4	4.23 (2.05)	4.56 (2.13)	4.40 (2.09)	1.26 (1.09)	0.84 (0.92)	1.05 (1.01)	2.97 (1.72)	3.76 (1.93)	3.36 (1.82)	16.73 (4.07)	22.66 (4.74)	19.69 (4.41)
T_5	3.55 (1.87)	3.89 (1.96)	3.72 (1.92)	1.29 (1.13)	0.69 (0.82)	0.99 (0.97)	2.45 (1.56)	3.27 (1.79)	2.86 (1.67)	18.04 (4.23)	24.34 (4.91)	21.19 (4.57)
T_6	3.74 (1.92)	3.98 (1.98)	3.86 (1.96)	0.82 (0.89)	0.47 (0.67)	0.64 (0.78)	2.99 (1.73)	3.52 (1.87)	3.26 (1.80)	10.84 (3.28)	14.82 (3.83)	12.83 (3.55)
T_7	2.88 (1.69)	3.47 (1.85)	3.17 (1.77)	0.38 (0.60)	0.24 (0.49)	0.31 (0.54)	2.50 (1.57)	3.24 (1.79)	2.87 (1.68)	7.16 (2.66)	9.55 (3.07)	8.35 (2.87)
T_8	3.77 (1.93)	4.34 (2.07)	4.05 (2.01)	0.73 (0.84)	0.52 (0.72)	0.62 (0.78)	3.03 (1.74)	3.85 (1.96)	3.44 (1.85)	11.23 (3.33)	15.28 (3.89)	13.25 (3.61)
T_9	3.13 (1.76)	3.47 (1.85)	3.30 (1.81)	0.59 (0.76)	0.34 (0.58)	0.46 (0.67)	2.58 (1.60)	3.19 (1.78)	2.89 (1.69)	8.38 (2.88)	11.05 (3.30)	9.71 (3.09)
T_{10}	7.99 (2.81)	8.99 (2.98)	8.49 (2.89)	3.90 (1.97)	2.36 (1.53)	3.13 (1.75)	4.43 (2.10)	7.10 (2.66)	5.77 (2.38)	24.70 (4.94)	33.23 (5.73)	28.96 (5.33)
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig	Sig	Sig
SE (m)	0.06	0.07	0.41	0.07	0.04	0.05	0.06	0.09	0.07	0.14	0.16	0.15
CD 5%	0.20	0.21	1.16	0.20	0.12	0.15	0.18	0.27	0.21	0.43	0.48	0.43

From table no 2 the maximum reduction percentage of sunburned fruits (62.61%) was noted in treatment T_7 (GA_3 15 ppm+ urea 1%+ kaolin 5%) followed by T_9 (61.07%) whereas, minimum reduction percentage was observed in T_{10} (Control). Whereas, minimum intensity of sunburned fruits percentage 11.54% was obtained in treatment T_7- GA_3 15 ppm + Urea 1% + Kaolin 5% which was significantly superior among the treatments while maximum intensity of sunburned fruits percentage (37.45%) was recorded in treatment T_{10}- Control. On basis of mean data, ratio of harvested fruits and sunburned fruits was influenced by foliar application of chemical substances. The maximum ratio of harvested fruits and sunburned fruits (29.55) was recorded in treatment T_7 (GA_3 15 ppm+ urea 1%+ kaolin 5%) followed by T_9 (27.90) while minimum ratio of harvested fruits and sunburned fruits was recorded in treatment T_{10} (8.00).

Table 2: Effect of chemical substances on reduction percentage, intensity of sunburned fruits percentage and ratio of harvested fruits and sunburned fruits

Treatment	Reduction percentage of sunburned fruit/ tree			Intensity of sunburned fruits (%)			Ratio of harvested fruit: sunburned fruit		
	2017-18	2018-19	Mean	2017-18	2018-19	Pooled	2017-18	2018-19	Mean
T_1	11.83	33.09	22.46	17.19 (4.24)	19.67 (4.52)	18.43 (4.39)	12.38	14.10	13.24
T_2	50.71	51.47	51.09	24.12 (4.99)	31.60 (5.68)	27.86 (5.34)	20.46	16.68	18.57
T_3	57.45	59.93	58.69	19.97 (4.56)	25.89 (5.16)	22.93 (4.87)	24.83	21.78	23.31
T_4	45.78	48.22	47.00	21.01 (4.68)	27.23 (5.30)	24.12 (4.99)	19.30	16.71	18.00
T_5	53.91	55.27	54.59	21.57 (4.72)	28.24 (5.38)	24.90 (5.07)	23.13	19.49	21.31
T_6	51.92	54.58	53.25	14.63 (3.94)	18.81 (4.43)	16.72 (4.20)	23.73	21.30	22.52
T_7	63.79	61.42	62.61	10.01 (3.30)	13.06 (3.73)	11.54 (3.52)	32.62	26.48	29.55
T_8	52.22	51.09	51.66	15.05 (3.99)	19.63 (4.52)	17.34 (4.27)	23.38	19.22	21.30
T_9	60.80	61.34	61.07	11.47 (3.51)	14.54 (3.92)	13.00 (3.72)	29.83	25.96	27.90
T_{10}	0.00	0.00	0.00	32.69 (5.77)	42.21 (6.53)	37.45 (6.17)	9.02	6.98	8.00
F test	-	-	-	Sig	Sig	Sig	-	-	-
SE (m)	-	-	-	0.15	0.18	0.17	-	-	-
CD 5%	-	-	-	0.48	0.54	0.51	-	-	-

In Table no 3 data revealed that significantly influenced by chemical substances and fruit yield. In respect of number of harvested fruits, treatment T_7 (804.58) recorded maximum number of harvested fruits per tree and statistically at par with T_9 (750.50) while minimum number of harvested fruits was observed in untreated trees in T_{10}(Control) whereas the maximum fruit yield per tree was associated with the treatment T_7 (129.57 kg tree^{-1}) followed by T_9 (118.70 kg tree^{-1}) and T_6 (113.25 kg tree^{-1}) while the minimum fruit yield per tree was recorded in treatment T_{10} (76.60kg tree^{-1}), in table 3 showed that the average weight of marketable fruits was non significantly influenced by chemical substances. In the both year of study increases in number of harvested fruits (marketable fruits) per tree and fruit yield kg per tree as resulting of kaolin treatments may be due to its protective effect from high temperature and reflection of solar radiation, especially UV wavelength, which leads to reduce heat stress on fruit surface, enhances fruit water content by decreasing transpiration from fruit surface and ultimately increased in fruit number and yield resulting to successfully protected fruits from insect – pest.

Table 3: Effect of chemical substances on number of harvested fruits, fruit yield and average weight of fruits

Treatment	Number of harvested fruits per tree (Marketable fruits)			Fruit yield (kg per tree)			Average weight of fruit (g)		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean	2017-18	2018-19	Mean
T_1	751.67	690.83	721.25	107.43	98.01	102.72	139.10	142.30	140.70
T_2	621.33	578.83	600.08	89.85	86.15	88.00	143.75	149.03	146.39
T_3	696.50	728.50	712.50	105.04	111.53	108.28	149.71	153.67	151.69

T_4	626.67	619.83	623.25	87.45	90.63	89.04	142.79	146.14	144.46
T_5	662.00	664.67	663.33	94.68	97.63	96.15	144.40	150.12	147.26
T_6	720.67	753.33	737.00	105.30	121.20	113.25	147.16	160.97	154.07
T_7	878.17	731.00	804.58	139.69	119.44	129.57	158.88	163.99	161.44
T_8	712.67	716.33	714.50	102.11	112.39	107.25	144.61	156.60	150.61
T_9	811.00	690.00	750.50	121.86	115.54	118.70	153.28	167.84	160.56
T_{10}	598.00	517.00	557.50	80.49	72.71	76.60	134.70	140.65	137.67
F test	Sig	Sig	Sig	Sig	Sig	Sig	NS	NS	NS
SE (m)	41.34	41.07	40.45	6.72	6.84	6.63	5.78	6.95	6.24
CD 5%	122.84	122.03	116.24	19.97	20.32	19.07	-	-	-

Conclusion

On the basis of the above experimental findings, we concluded that foliar application of GA_3 15 ppm+ urea 1% and kaolin 5% was found more reduction percentage of sunburn fruit followed by GA_3 15 ppm+ urea 1% and magnesium carbonate at 5% two times in month of September and October had a effective in decreasing of sunburn injury there by improved marketable yield of mandarin fruits.

References

1. Abd-Allah ASE, El-Razek EA, Saleh MMS. Effect of sun- Block materials on preventing sunburn injury of keitt Mango fruits. Journal of Applied Sciences Research 2013;9(1):567-571.
2. Adegoke S, Adegoroye R, Joliffe PA. Initiation and control of sunscald injury of tomato. Journal of the American Society for Horticultural Science 1983;108:23-28.
3. Alvarez HL, Bella CM, Colavita GM, Oricchio P, Strachnoy J. Comparative effect of kaolin and calcium carbonate on apple fruit surface temperature and leaf net CO_2 assimilation: Journal of Applied Horticulture 2015;17(3):179-180.
4. Alvarez HL, Di Bella CM, Colavita GM, Oricchio P, Strachnoy J. Comparative effects of kaolin and calcium carbonate on apple fruit surface temperature and leaf net $C0_2$ assimilation. Journal of Applied Horticulture 2015;17(3):176-180.
5. Aly Mahmound, Nagwa AEM, Awad RM. Reflective particle films affected on, sunburn, yield, mineral composition and fruit maturity of 'Anna' apple (*Malus domistica*) trees. Research journal of agriculture and biological sciences 2010;6(1):84-92.
6. Anderson JM, Osmond CB. Shade sun responses: Compromise between acclimation and photoinhibition, p. 1-38. In: DJ. Kyle CB. Osmond and CJ. Arntzen (eds.). Photoinhibition. Elsevier, Amsterdam, Neth 1987.
7. Andrews PK, Johnson JR. Physiology of sunburn development in apples. Good Fruit Grower 1996;47:33-36.
8. Andrews PK, Johnson JR. Anatomical changes and antioxidant levels in the peel of sunscald damaged apple fruit. Plant Physiol 1997;114(3):103.
9. Andris HL, Crisoto CH. Reflective material enhance 'Fuji' apple colour. California Agr 1996;50:27-30.
10. Anonymous. http://www.nhb.gov.in. Indian Horticulture Database 2015, 302.
11. Barber HN, Sharpe PJH. Genetics and physiology of sunscald of fruits. Agr. Meterol 1971;8:175-191.
12. Bergh O, Franken J, Van Zyl EJ, Kloppers F, Dempers A. Sunburn on apples. Preliminary results of an investigation conducted during the 1978/79 season. The Deciduous Fruit Grower. January 1980, 8-22.
13. Brown G. Minimising sunburn damage of fruit. Australian Fruit grower (magazine), February 2009;3(1):14-18, Apple and Pear Aust. Ltd.
14. Colavita GM, Blackhall V, Valdez S. Effect of kaolin particle films on the temperature and solar injury of pear fruits. Acta horticulturae 2011;909:609-615.
15. Conradie W. Mango fruit quality. Strip analysis. Unpublished workshop. May 23, 2000.
16. Ennab HA, El-Sayed SA, Abo El-Enin MM. Effect of kaolin applications on fruit sunburn, yield and fruit quality of Balady mandarin (*Citrus reticulata*, Blanco). Menoufia Journal of plant production 2017;2:129-138.
17. Farazmand H. Effect of kaolin clay on pomegranate fruits sunburn. Applied entomology and phytopathology 2013;80(95):173-183.
18. Felicetti DA, Schrader LE. Photooxidative sunburn of apples: Characterization of a third type of apple sunburn. Intl. J Hort. Sci 2008;8:160-172.
19. Gill BS, Jalota SK. Evaporation from soil in relation to residue rate, mixing depth, soil texture and evaporativity. Soil. Technol 1996;8:293-301.
20. Gindaba J, Wand SJE. Do fruit sunburn control measures affect leaf photosynthetic rate and stomatal conductance in Royal Gala apple? Environmental and Experimental Botany 2007;59:160-165.
21. Gindaba J, Wand JE. Comparative effects of evaporative cooling, kaolin particle film and shade net on sunburn and fruit quality in apples. Hortscience 2005;40(3):592-596.
22. Glenn DM. The mechanisms of plant stress mitigation by kaolin- based particle films and applications in horticultural and agricultural crops. HortScience. Vol 2012;47(6):710-711.
23. Glenn DM, Erez A, Puterka GJ, Gundrum P. Particle films affects carbon assimilation and yield on Empire apple. Journal American Society of Horticulture science 2003;128(3):356-362.
24. Glenn DM, Puterka GJ, Drake SR, Unruh TR, Knight AL, Baherle P *et al*. Particle film Application influence apple leaf physiology, fruit yield, and fruit quality. Journal American Society of Horticulture Science 2001;126(2):175-181.
25. Glenn DM, Drake S, Abbott JA, Puterka GJ, Gundrum P. Season and cultivar influence the fruit quality response of apple cultivars to particle film treatments. Horticulture Technology 2005;15(2):249-253.
26. Glenn DM. Particle film mechanisms of action that reduce the effect of environmental stress in Empire apple. Journal of American Society Horticulture Science 2009;134(3):314-321.
27. Glenn DM, Prado E, Erez A, McFerson J, Puterka GJ. A reflective, processed- kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple. Journal of American Society Horticulture Science 2002;127(2):188-193.

28. Harben PW. The industrial mineral handbook II: A guide to markets, specifications, and prices. Arby industrial mineral division metal bulletin. PLC, London 1995.
29. Harris JR. Nutritional evaluation of food processing. 2nd ed. AVI, Westport. CT 1975, 33-57.
30. Jifon J, Syvertsen JP. Kapolin particle film applications can increase photosynthesis and water use efficiency of Ruby Red Grapefruit leaves. Journal of American Society Horticulture Science 2003;128(1):107-112.
31. Ketchie DO, Ballard AL. Environments which cause heat injury to Valencia oranges. J Amer. Soc. Hort. Sci 1968;93:166-172.
32. Khalil SE, Hussein MM, Jaime A, Teixeira da Silva. Roles of Antitranspirants in improving growth and water relations of *Jatropha cuucas* L. grown under water stress conditions. Plant stress© 2012 Global Science books 2012.
33. Lal N, Sahu N. Management Strategies of Sun Burn in Fruit Crops-A Review. International Journal of Current Microbiology and Applied Sciences 2017;6(6):1126-1138.
34. Le Grange M, Wand SJE, Theron KI. Effect of kaolin application on sunburn of apple and pear. J.S.A. Society Horticulture Sciences. July. Nelspruit. RSA 2000.
35. Le Grange M, Wand SJE, Theron KI. Effect of kaolin applications on apple fruit quality and gas exchange on apple leaves. Acta Horticulturae 2004;636:545-550.
36. Le Grange M. Effect of kaolin applications on solar injury and colour development in apples. MSc thesis, University of Stellenbosch 2001, 29-42.
37. Litz RE. The Mango: Botany, Production and Uses. CAB International, Wallington, UK 1997.
38. Ma F, Cheng L. The sun exposed peel of apple fruit has higher xanthophylls cycle dependant thermal dissipation and antioxidants of the ascorbate-glutamate pathway than the shaded peel. Plant Sci 2003;165:819-827.
39. Melgarejo P, Martinez JJ, Hernandez F, Martinez-Font R, Barrows P, Erez A. Kaolin treatment to reduce pomegranate sunburn. Scientia Horticulturae 2004;100:349-353.
40. Nijjar GS. Nutrition of fruit trees. Kalyani, New Delhi 985, 10-20.
41. Nirmaljit Kaur, Josan JS, Monga PK, Arora PK. Chemical regulation of over bearing in Kinnow mandarin. Indian Journal of Horticulture 2005;62(4):396-397.
42. Palitha W, Jobling J, Infante MMV, Rogers G. The effect of maturity, sunburn and the application of sunscreens on the internal and external qualities of pomegranate fruit grown in Australia. Scientia Horticulturae 2009;12:003.
43. Parashar A, Ansari A. A therapy to protect pomegranate (*Punica granatum*) from sunburn. Pharmacie Globale © (IJCP) 2015;03(5):1-3.
44. Rabinowitch H. Superoxide dismutase activity in ripening cucumber and pepper fruit. Physiologia Plantarum 1981;52:380-384.
45. Rabinowitch H, Kedar N, Budowski P. Induction of sunscald damage in tomatoes under natural and controlled conditions. Scientia Horticulturae 1974;2:265-272.
46. Racsko J, Szabo Z, Nyeki J. Importance of the supraoptimal radiance supply and sunburn effects on apple fruit quality. Acta Biol 2005;49:111-114.
47. Racskó J. Sunburn assessment: A critical appraisal of methods and techniques for characterizing the damage to apple fruit. Intl. J Hort. Sci 2010;16:7-14.
48. Rokaya PR, Baral DR, Gautum DM, Shrestha AK, Paudyal KP. Effect of pre- harvest application of gibberellic acid on fruit quality and shelf life of mandarin (*Citrus reticulata* Blanco). American Journal of Plant Sciences 2016;7:1033-1039.
49. Saleem BA, Malik AU, Pervez MA, Khan AS, Khan MN. Spring application of growth regulators affects fruit quality of Blood Red sweet orange. Pakistan J Bot 2008;40(3):1013-1023.
50. Schrader LE, Kahn C, Elfving DC. Sunburn browning decreases At- harvest internal fruit quality of apples (Malus domestica Borkh). Intl. Fruit Sci 2009;9:425-437.
51. Schrader LE, Zhang J, Sun J. Environmental stress that cause sunburn of apple. Acta Horticulturae 2003;618:397-405.
52. Schrader LE, Zhang J, Duplaga WK. Two types of sunburn in apple caused by high fruit surface (peel) temperature 2001. http://wwwplanthealth progress.org/Current/research/sunburn/article.htm2001/10/15.
53. Schupp JR, Fallahi E, Chun I. Effect of particle film on fruit sunburn, maturity and quality of Fuji and Honeycrisp apples. Horticulture Technology 2002;12(1):87-90.
54. Singh G, Nath V, Pandery SD, Ray PK, Singh HS. The Litchi (Food and Agriculture Organization of the United Nations) 2012, 181.
55. Smart RE, Sinclair TR. Solar heating of grape berries and other spherical fruit. Agri. Meteorol 1976;17:241-259.
56. Suman M, Sangma PD, Meghawal DR, Sahu OP. Effect of plant growth regulators on fruit crops. Journal of pharmacology and Phytochemistry 2017;6(2):331-337.
57. Van den Ende B. Sunburn management. The Compact Fruit Tree 1999;32:13-14.
58. Verreynne S, Merwe SVD. Sunburn reduction on Miho Wase Satsuma mandarin. SA Fruit Journal 2011, 52-55.
59. Warner G. Particle film doesn't affect photosynthesis of the tree. Good Fruit Grower July 2001, 16.
60. Wiinsche JN, Greer DH, Palmer JW, Lang A, McGhie T. Sunburn- The cost of a high light environment. Acta Horticulturae 2001;557:349-356.
61. Wiinsche JN, Bowen J, Ferguson I, Woolf A, McGhie T. Sunburn on apples- causes and control mechanism. Acta Horticulturae 2004;636:631-636.
62. Wiinsche JN, Greer DH, Lombardini L. Surround particle film applications- effects on whole canopy physiology of apple. Acta Horticulturae 2004;636:565-571.
63. Wilton J. Sunburn and what to do about it. The Orchardist. December 1999, 14-16.
64. Woolf AB, Ferguson IB. Post harvest responses to high fruit temperatures in the field. Postharvest Biol. Technology 2000;21:7-20.
65. Zaghloul AE, Ennab HA, El-Shemy MA. Influence of kaolin sprays on fruit quality and storability of Balady mandarin. Alexandria science exchange journal 2017;38(4):661-670.