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Study of chemical substances on preventing sunburn injury of mandarin

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Abstract
An experiment was conducted with Nagpur mandarin (*Citrus reticulata* Blanco) during 2017-18 and 2018-19 at AICRP on Fruits (Citrus) Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The qualitative losses during pre- harvest stage hinder the quality production. Recently sunburn is major problem caused due to high temperature and direct solar radiation, which leads to significant economic losses in mandarin yield. An experiment was conducted to assess the study of chemical substances (3% and 5% of Kaolin and $MgCO_3$) with respective treatments twice in month of September and October on sunburn percentage. The obtained results showed that, GA_3 15 ppm+ urea 1% and kaolin 5% and 3% respectively foliar applications were effective to control fruit sunburn as well as percentage of South – West, South – East, North – East and North – West direction per tree sunburned fruit as compared to untreated trees. This result was clear detected that effect of kaolin 5% with combination of GA_3 15 ppm+ urea 1% followed by magnesium carbonate 5% with (GA_3 15 ppm+ urea 1%) under this experiment conditions.

Keywords: Chemical, substances, preventing, sunburn, mandarin

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 since last 200 years in around 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, Yavatmal, Akola and Buldhana districts of Vidharbha region.

Fruit producers strive to adopt production practices that produce high yields of good quality fruit that sells for the highest attainable prices. Good quality fruit sold for fresh market consumption is often judged on appearance. Due to high summer temperatures and high irradiation, high quality mandarin production in the Vidarbha is hindered by sunburn. About 10-15% of fruits in this province are downgraded solely due to sunburn. Losses caused due to sunburn to the farmers in are greater Vidarbha zone. Sunburn is common in fruits which are exposed to high solar radiation, air temperature, low relative humidity and high elevations. The combination of high irradiance and high temperatures causes the formation of highly reactive and hazardous active oxygen species (AOS) in plant tissue. The free radicals cause a loss of membrane integrity that leads to electrolyte leakage that affects the cell lipids and proteins, ultimately killing the cell. Severe sunburn alters the cuticle even more and damages both the epidermal and sub epidermal tissues. Sunburned fruit is discoloured and exhibits varying degrees of cell death (Mishra *et al*. 2016) causing commercial losses of fruits. It also alters the photosynthetic systems and ruptures oil glands, leading to subsequent water loss and reductions in growth and yield (Tsai *et al*., 2 Management of sunburn in fruit crops grower must firstly follow best management practices to minimize sunburn on fruit before considering investment in expensive sunburn protection products and infrastructure such as spray on sun protection, shade netting or evaporative cooling. Grower should identify which fruit blocks are more susceptible to sunburn, what control strategies can be employed in each block and which blocks have the best chance of achieving good returns on the additional investment (Brown, 2009) [13]. Besides the primary external damage caused by pre harvest exposure to elevated solar radiation, sunburn can severely decrease fruit finish and quality, and thus market value (Bergh *et al*., 1980; Brown, 2009) [12, 13].

Materials and Methods

This experiment 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) [43] 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) in sweet lime and Ennab *et al.* (2017) [16] 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

Effect of chemical substances on sunburned fruit percentage of South – West, South – East, North – East and North – West direction per tree

Data presented in Table 2 it is revealed that, percentage of sunburned fruits in South – West, South – East, North – East and North – West direction was significantly influenced by chemical substances during both the years of experimentation. On the basis of pooled analysis result, the percentage of sunburned fruits in South - West direction was significantly lowest percentage of sunburned fruits South - West direction (1.61) was observed in treatment T_7 (GA_3 15 ppm+ urea 1% and kaolin 5%) which was at par with treatment T_9 (1.62), T_3 (1.63), T_5 (1.83), T_6 (1.91) and T_8 (1.93) while the highest percentage of sunburned fruits in South - West direction (4.20) was noted in treatment T_{10} (Control).

In case of percentage of sunburned fruits in South - East direction per tree was significantly lowest percentage of sunburned fruits in South - East direction (0.67) was observed in treatment T_3 (Kaolin 5%) which was at par with treatment T_9 (0.81), T_4 (0.90) and T_7 (0.92) while the highest percentage of sunburned fruits in South - East direction (2.42) was recorded in treatment T_{10} (Control).

However, the lowest percentage of sunburned fruits in North - East direction (0.20) was observed in treatment T_3 (Kaolin 5%) which was at par with treatment T_4 (0.24), T_5 (0.24), T_8 (0.26), T_9 (0.29) and T_7 (0.34) while the highest percentage of sunburned fruits in North - East direction (0.74) was recorded in treatment T_{10} (Control).

And the minimum percentage of sunburned fruits in North - West direction (0.44) was observed in treatment T_6 (GA_3 15 ppm+ urea 1% and kaolin 3%) which was at par with treatment T_7 (0.46), T_5 (0.55) and T_9 (0.61) while the maximum percentage of sunburned fruits in North - West direction (1.14) was recorded in treatment T_{10} (Control).

Table 2: Effect of chemical substances on percentage of sunburned fruits south – west, south – east, north – east and north – west of direction per tree

Treatment	Percentage of sunburned fruits South – West direction per tree			Percentage of sunburned fruits South – East direction per tree			Percentage of sunburned fruits North – East direction per tree			Percentage of sunburned fruits North – West direction per tree		
	2017-18	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**
T_1	3.55 (1.82)	2.94 (1.71)	3.25 (1.79)	1.90 (1.36)	1.68 (1.29)	1.79 (1.32)	0.52 (0.72)	0.41 (0.64)	0.47 (0.68)	1.04 (1.02)	0.95 (0.97)	0.99 (0.99)
T_2	1.97 (1.37)	1.98 (1.40)	1.97 (1.40)	1.03 (1.00)	1.20 (1.09)	1.12 (1.05)	0.30 (0.54)	0.48 (0.69)	0.39 (0.61)	0.63 (0.79)	0.69 (0.81)	0.66 (0.80)
T_3	1.60 (1.29)	1.66 (1.28)	1.63 (1.27)	0.56 (0.75)	0.77 (0.87)	0.67 (0.81)	0.18 (0.42)	0.22 (046)	0.20 (0.44)	0.95 (0.97)	0.93 (0.96)	0.94 (0.96)
T_4	2.07 (1.57)	2.26 (1.50)	2.17 (1.47)	0.90 (0.95)	0.90 (0.94)	0.90 (0.94)	0.26 (0.50)	0.21 (0.37)	0.24 (0.44)	1.00 (1.00)	1.20 (1.09)	1.10 (1.04)
T_5	1.70 (1.52)	1.95 (1.39)	1.83 (1.34)	0.96 (0.97)	1.06 (1.02)	1.01 (1.00)	0.14 (0.37)	0.33 (0.57)	0.24 (0.47)	0.55 (0.73)	0.54 (0.74)	0.55 (0.73)
T_6	1.86 (1.52)	1.96 (1.39)	1.91 (1.38)	1.04 (1.01)	1.20 (1.09)	1.12 (1.05)	0.39 (0.62)	0.38 (0.62)	0.38 (0.62)	0.45 (0.67)	0.43 (0.65)	0.44 (0.66)
T_7	1.46 (1.18)	1.77 (1.32)	1.61 (1.26)	0.85 (0.92)	1.00 (0.99)	0.92 (0.95)	0.40 (0.63)	0.27 (0.51)	0.34 (0.57)	0.49 (0.70)	0.43 (0.65)	0.46 (0.67)
T_8	1.86 (1.39)	2.01 (1.41)	1.93 (1.39)	1.03 (1.01)	1.17 (1.07)	1.10 (1.04)	0.19 (0.44)	0.32 (0.56)	0.26 (0.50)	0.70 (0.83)	0.84 (0.92)	0.77 (0.87)
T_9	1.62 (1.16)	1.62 (1.26)	1.62 (1.26)	0.67 (0.81)	0.94 (0.96)	0.81 (0.88)	0.34 (0.58)	0.23 (0.47)	0.29 (0.53)	0.53 (0.73)	0.68 (0.83)	0.61 (0.78)
T_{10}	4.01 (1.91)	4.39 (2.09)	4.20 (2.04)	2.35 (1.52)	2.50 (1.57)	2.42 (1.54)	0.59 (0.76)	0.89 (0.94)	0.74 (0.85)	1.04 (1.01)	1.24 (1.11)	1.14 (1.06)
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m)	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.06	0.05	0.04	0.05	0.04
CD 5%	0.19	0.18	0.18	0.18	0.17	0.16	0.12	0.18	0.15	0.12	0.15	0.12

With reference of pooled result, the percentage of sunburned fruits South – West, South – East, North – East and North – West direction per tree in table 2 showed that, As per the study tree outer canopy exposed to the direct sunlight on South- Western side and South- Eastern direction and assumes maximum sunlight hours between period 12:00 pm to 16:00 pm on these direction of the tree. Thus reflected in increased number and percentage of sunburned fruits in

South- West and South- East direction of respective treatments. However spraying of kaolin and $MgCO_3$ caused reduction in number and percentage of sunburned fruits in South - West direction and minimum sunburned fruit percentage (1.61%) reported in treatment GA_3 15 ppm + urea 1% and kaolin 5%, In case of South - East and North - East direction having minimum percentage of sunburned fruits in treatment of kaolin 5%, whereas in North - West direction the minimum number and percentage of sunburned fruits recorded in treatment GA_3 15 ppm + urea 1% and kaolin 5%. All the direction of sunburned fruits reduced due to the kaolin treatment it's helped in the protection against high temperature and reflection of solar radiation which lead to reduced cell and tissue death usually occurs in fruit surface area. The similar findings observed by Bergh *et al.* (1980) [12] in apple, Andrews and Johnson (1997) [8] in apple, Conaradie (2000) [15] in mango, Wiinsche *et al.* (2004a) [61] in apple.

Conclusion

According to experiment results, it could be concluded that, foliar application of kaolin at 5% with combination of GA_3 15 ppm + urea 1% treatment during September and October could be used as an effective for reducing of sunburn and with respective direction of tree that is South – West, South – East, North – East and North – West of Nagpur mandarin grown under the Vidharbha conditions.

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