



ISSN (E): 2277- 7695  
 ISSN (P): 2349-8242  
 NAAS Rating: 5.23  
 TPI 2022; SP-11(2): 205-208  
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[www.thepharmajournal.com](http://www.thepharmajournal.com)

Received: 16-12-2021  
 Accepted: 18-01-2022

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## Sunscald incidence and its management in *mrig bahar* of Nagpur mandarin in central India conditions

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**Abstract**

Sunscald is one of the important disorder in *mrig bahar* of Nagpur mandarin grown in central India and cause the severe yield loss to mandarin growers by reducing the fruit quality characteristics like juice per cent, TSS and acidity. From the present study it was concluded that application of 6%, 8% and 10% of kaolin and calcium sulphate control the incidence of sunscald in *mrig bahar* and improved the quality characteristics of Nagpur mandarin fruits. Kaolin was the more effective particle film in controlling sunscald incidence compared to calcium sulphate.

**Keywords:** Sun scald, Nagpur mandarin, *mrig bahar*, kaolin and calcium sulphate

**Introduction**

Nagpur mandarin (*Citrus reticulata* Blanco) is the finest cultivar of mandarin grown commercially in central India. In central India, mainly two types of Nagpur mandarin crops are taken viz. spring blossom (*Ambia*) and monsoon blossom (*Mrig*) with harvesting in October-December and February-April respectively. Sunscald is one of the major fruit disorder in Nagpur mandarin in central India and severe in *ambia bahar* during September-October months due to temperature more than 33 °C and dry spells of low rain fall compared to sun scald occurrence during April-May months due to high temperature and low relative humidity on developing fruits. In *mrig bahar* this disorder occurs on developing fruits during September-October months due to above said reason. Sun exposed fruit surface is yellow/brown in colour with ruptured oil glands and remaining part unexposed to sun remaining green in colour. The fruit peel of sun scalded fruit becomes hard with increased firmness. Fruit segments become dried and granulated with less juice content, reduced TSS and titratable acidity. Thus, sunscald incidence in Nagpur mandarin grown in central India causes significant economic loss to growers by reducing the marketable yield and quality characteristics. Foliar application of particle films such as kaolin and calcium types i.e. calcium carbonate (CaCO<sub>3</sub>) or calcium based fertilisers will give good sun protection quality to fruit crops through light reflection and by reducing the leaf and fruit temperature.

**Materials and Methods**

To study the effect of particle films viz. kaolin and calcium sulphate on quality characteristics and to reduce sunscald of Nagpur mandarin in central India conditions, orchard was earmarked at Hetikundi village of Wardha district, Maharashtra for *mrig bahar* during 2020. The orchard was 10 years old, spaced at 6 m x 6 m and grafted on Rangpur lime rootstock. The details of treatments applied to control sunscald incidence and to improve yield and quality are given in the table below (Table 1). The treatments were replicated thrice and experiment was laid out in randomized block design.

The disordered and normal fruits were collected at maturity in the month of February 2020 and subjected to physico-chemical analysis. The yield and yield attributing characteristics, per cent of sunscald incidence, physical and biochemical characteristics of fruits were recorded at harvest.

**Table 1:** Schedule of application of different concentrations of kaolin and calcium sulphate to control sunscald and to improve quality characteristics of Nagpur mandarin fruits in *Mrig bahar*

Treatments	Time of application in <i>Mrig bahar</i>
Kaolin (Aluminium Sylicate) 2, 4, 6, 8 and 10%	September and October
Calcium sulphate (CaSO <sub>4</sub> ) 2, 4, 6, 8 and 10%	
Control	

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**Per cent of sunscald incidence**

The number of sun scalded fruits per plant were counted and

divided by total number of fruits per plant and expressed in per cent by multiplying with 100.

$$\text{Per cent of sunscald} = \frac{\text{Number of sun scalded fruits per plant}}{\text{Total number of fruits per plant}} \times 100$$

**Results and Discussion****Effect of kaolin and calcium sulphate on yield characteristics**

The different concentrations of kaolin and calcium sulphate are applied to control the loss due to sunscald of fruits and to improve yield and quality characteristics of *Mrig* crop of

Nagpur mandarin at Hetikundi village. The significant results are noted for the applied treatments in improving yield and yield attributes, and in controlling the sunscald disorder. The data related to yield and yield attributes, number of sun scalded fruits and per cent of disorder was presented in Table 2.

**Table 2:** Effect of kaolin and calcium sulphate on yield and yield attributes in *Mrig bahar* of Nagpur mandarin at Hetikundi village

Treatment	No. of fruits harvested per plant	Yield (Kg/ plant)	Yield (t/ha)	No. of fruits sun scalded	Per cent of sunscald
Kaolin 2%	413	56.65	15.69	26	6.38
Kaolin 4%	415	58.33	16.16	19	4.57
Kaolin 6%	494	76.12	21.08	16	3.35
Kaolin 8%	425	63.66	17.63	14	3.49
Kaolin 10%	438	66.47	18.41	13	3.01
Calsium sulphate 2%	371	50.57	14.01	32	8.94
Calsium sulphate 4%	384	53.74	14.88	30	8.18
Calsium sulphate 6%	386	54.79	15.17	28	7.38
Calsium sulphate 8%	449	67.13	18.59	23	5.17
Calsium sulphate 10%	413	61.58	17.05	22	5.59
Control	332	43.44	12.03	52	15.81
CD at 5%	53.67	7.07	1.96	4.99	2.07
SE(m)	18.06	2.38	0.66	1.68	0.69

Among all the treatments kaolin 6% recorded the maximum number of fruits harvested per plant (494), yield per plant (76.12 kg/plant) and total estimated yield per hectare (21.08 t/ha) followed by Kaolin 10% (438 number of fruits harvested per plant, 66.47 kg/plant and 18.41 t/ha respectively) over the control (332 number of fruits, 43.44 kg/plant and 12.03 t/ha respectively). With respect to different concentrations of calcium sulphate, 8% noted the maximum number of fruits harvested per plant (449), yield per plant (67.13 kg/plant) and total estimated yield per hectare (18.59 t/ha) followed by calcium sulphate 10% (413 number of fruits harvested per plant, 61.58 kg/plant and 17.05 t/ha respectively) over the control. Application of kaolin 3-6% increase the yield of citrus crop by reducing the damages caused by sunburn injury [5, 12, 19, 20]. Calcium based reflectants increased the fruit yield by reducing fruit temperature, leaf temperature and stomatal conductance [14].

**Number of sun scalded fruits per plant and per cent of disorder**

The minimum number of sun scalded fruits (13) and minimum per centage of sunscald (3.01) recorded in the treatment Kaolin 10% followed by Kaolin 8% (14, 3.49%

respectively) over the treatment control (52 and 15.81% respectively). Among the different concentrations of calcium sulphate, 10% noted the minimum number of sun scalded fruits (22) followed by 8% (23) and minimum per centage of sunscald (5.17) recorded in the treatment calcium sulphate 8% followed by 10% (5.59%) over the treatment control (Table 3). Foliar spray of kaolin 3 or 4% during summer reduced the fruit sunburn damage of 'Balady' mandarin trees by reducing leaf and fruit surface temperature due to an increased reflectance of direct solar radiation, UV and visible range of wavelengths [6]. The sunburn percentage decreased due to reduced heat stress and lowering fruit surface temperature. Similarly, application of kaolin 4% has increased the yield, reduced fruit disorders (sunburn, splitting and bruising) and improved fruit quality [19]. The calcium carbonate spray was the most rapid method, but was less effective in controlling sunscald, and resulted in the lowest photosynthetic rate [17]. Similar results are noted by Glenn *et al.* (2001), Glenn *et al.* (2002), Schupp *et al.* (2002), Wunsche *et al.* (2004), Curry *et al.* (2004), Gindaba and Wand, (2005), Aly *et al.* (2010) and Sarooghinia *et al.* (2019) in apple; Melgarejo *et al.* (2004) and Morsy *et al.* (2008) in pomegranate by applying kaolin.

**Table 3:** Physico-chemical characteristics of sun scalded Nagpur mandarin fruits in *Mrig bahar* at Hetikundi village

Treatment	Fruit weight (g)	Fruit dimensions			Fruit volume (cm <sup>3</sup> )	No. of segments	Rind thickness (mm)	Core diameter (m)	No. of seeds	Juice (%)	TSS (%)	Acidity (%)	TSS/ Acid ratio	Vitamin C (mg/ 100 ml)
		Length (mm)	Breadth (mm)	Length/ breadth ratio										
Kaolin 2%	143.33	64.45	67.05	0.96	140.66	10.33	2.47	17.54	11.66	36.45	7.00	0.70	9.99	37.37
Kaolin 4%	137.00	59.28	66.88	0.89	134.33	10.33	2.62	17.52	9.66	36.28	7.06	0.70	10.08	38.11
Kaolin 6%	146.66	60.81	70.95	0.89	144.00	10.66	2.75	17.47	8.66	38.39	7.03	0.72	9.71	38.11
Kaolin 8%	144.33	60.01	71.53	0.85	141.66	10.33	2.76	16.61	10.00	38.59	7.36	0.78	9.34	38.48
Kaolin 10%	144.66	63.10	70.56	0.83	142.00	11.00	2.63	18.67	9.66	38.49	7.30	0.78	9.25	38.85
Calcium sulphate 2%	139.66	65.67	70.40	0.86	137.00	10.00	2.62	16.76	10.33	36.32	7.10	0.61	11.50	37.74
Calcium sulphate 4%	149.33	62.47	65.79	0.93	146.66	10.33	2.53	18.37	8.66	37.05	7.16	0.66	10.85	37.37
Calcium sulphate 6%	146.33	58.85	67.64	0.92	143.66	10.66	2.56	18.84	7.66	37.57	7.26	0.64	11.43	38.48
Calcium sulphate 8%	141.66	64.31	70.04	0.95	139.00	10.33	2.58	17.58	8.33	37.68	7.23	0.68	10.62	38.85
Calcium sulphate 10%	144.66	59.86	66.79	0.89	142.00	10.33	2.54	16.89	9.66	37.56	7.13	0.64	11.23	38.48
Control	143.66	58.47	66.81	0.89	141.00	10.33	2.80	19.06	9.00	34.33	6.80	0.59	11.40	34.78
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.08	1.43	1.86
SE(m)	2.54	2.19	1.84	0.03	2.54	0.30	0.13	0.81	0.83	1.43	0.12	0.02	0.48	0.62

### Effect of kaolin on physico-chemical characteristics of fruits at harvest

The physico-chemical characteristics of fruits at harvest were presented in Table 4. The maximum fruit weight (154.00 g) recorded in the treatment kaolin 6% followed by kaolin 10% (151.66 g) and minimum fruit weight (130.66 g) noted in control. Among fruit dimensions, maximum fruit length (60.90 mm) and fruit breadth (68.81 mm) recorded in kaolin 6% over the control (49.80 mm and 58.54 mm respectively). The length to breadth ratio (0.85-0.89) shows all the fruits are almost uniform in shape. The treatment kaolin 6% recorded the maximum fruit volume (152.00 cm<sup>3</sup>) followed by kaolin 10% (148.33 cm<sup>3</sup>) over the control (128.33 cm<sup>3</sup>). No treatments effect was observed on the characteristics viz. number of segments, rind thickness, core diameter, number of seeds and TSS/Acid ratio. Maximum juice per cent noted in

kaolin 6% (44.83%) followed by kaolin 10% (44.15%) and minimum in the control (37.03%). Application of kaolin 6% recorded the maximum TSS (10.30%) and vitamin C (44.77 mg/100 ml) followed by kaolin 8% and 10% for TSS (10.16% in both), and kaolin 8% for vitamin C (44.40 mg /100 ml of juice), and minimum TSS (8.20%) and vitamin C (37.74 mg/100 ml) recorded in the control. Maximum acidity noted in treatment kaolin 6% (0.83%) followed by 10% (0.76%) over the control (0.57%). The similar results of improved fruit quality in terms of fruit size, diameter, weight, peel thickness and vitamin C at the concentrations of 3 and 4% of kaolin sprayed during summer on preventing fruit sunburn damage of Balady mandarin trees [6]. Similarly, foliar application of 4% kaolin noted the improved fruit quality of Balady mandarin (fruit firmness, acidity level, soluble solids content (SSC%) and vitamin C) [19].

**Table 4:** Effect of kaolin and calcium sulphate on physico-chemical characteristics of Nagpur mandarin fruits in *Mrig bahar* at Hetikundi village

Treatment	Fruit weight (g)	Fruit dimensions			Fruit volume (cm <sup>3</sup> )	No. of segments	Rind thickness (mm)	Core diameter (mm)	No. of seeds	Juice (%)	TSS (%)	Acidity (%)	TSS/ Acid ratio	Vitamin C (mg/ 100 ml)
		Length (mm)	Breadth (mm)	Length/ breadth ratio										
Kaolin 2%	137.00	54.59	62.94	0.86	134.66	10	2.44	17.68	12	40.37	10.00	0.70	14.28	41.44
Kaolin 4%	140.33	55.69	65.05	0.85	137.66	10	2.53	17.82	9	40.81	10.06	0.72	13.91	42.18
Kaolin 6%	154.00	60.90	68.81	0.88	152.00	10	2.47	18.74	11	44.83	10.30	0.83	12.38	44.77
Kaolin 8%	149.66	60.41	68.44	0.88	147.33	10	2.65	18.19	10	44.14	10.16	0.74	13.62	44.40
Kaolin 10%	151.66	60.25	68.55	0.87	148.33	10	2.63	17.45	9	44.15	10.16	0.76	13.30	44.03
Calcium sulphate 2%	135.66	54.17	63.41	0.85	134.00	10	2.38	17.18	12	40.75	9.43	0.72	13.18	41.81
Calcium sulphate 4%	139.66	55.79	63.59	0.87	135.66	10	2.59	17.98	11	41.29	10.10	0.74	13.61	42.55
Calcium sulphate 6%	141.66	57.96	64.84	0.89	139.66	10	2.47	17.81	11	41.41	10.13	0.76	13.26	42.92
Calcium sulphate 8%	149.33	58.96	67.65	0.87	147.66	10	2.51	17.89	9	41.94	10.20	0.83	12.44	44.40
Calcium sulphate 10%	149.66	58.35	67.57	0.86	147.66	10	2.51	17.52	8	41.66	10.16	0.81	12.74	44.03
Control	130.66	49.80	58.54	0.85	128.33	10	2.64	17.71	12	37.03	8.20	0.57	14.23	37.74
CD at 5%	7.54	1.35	0.72	0.02	7.48	NS	NS	NS	NS	2.97	0.30	0.13	NS	2.45
SE(m)	2.54	0.45	0.24	0.007	2.51	0.29	0.12	0.44	0.94	1.00	0.10	0.04	0.78	0.82

### Effect of calcium sulphate on physico-chemical characteristics of fruits at harvest

Among the different concentrations of calcium sulphate, maximum fruit weight (149 g) recorded in the treatment calcium sulphate 8% and 10%. Maximum fruit length (58.96 mm) and fruit breadth (67.65 mm) noted in calcium sulphate 8% followed by 10% (58.35 mm and 67.57 mm respectively) compared to control. Both calcium sulphate 8% and 10% recorded the maximum fruit volume (147 cm<sup>3</sup>) followed by 6% (139 cm<sup>3</sup>) compared to control. Maximum juice per cent

(41.94%), TSS (10.20%) and vitamin C (44.40 mg/100 ml of juice) noted in calcium sulphate 8% followed by calcium sulphate 10% (41.66%, 10.16% and 44.03 mg/100 ml of juice respectively) compared to control. Maximum acidity recorded in calcium sulphate 8% (0.83%) followed by calcium sulphate 10% (0.81%) compared to control.

The spray of 4.0% calcium carbonate improved the yield and fruit quality (decreased total acidity and improved the berry weight, cluster weight, yield, total soluble solids and total sugars) of Crimson seedless grapevines by reducing the

effects of sunburn<sup>[1]</sup>. The similar results are noted by Alvarez *et al.* (2015) in apple and Hegazi *et al.* (2014) in pomegranate.

### Conclusion

Sunscald is one of the important disorder in *mrig bahar* of Nagpur mandarin grown in central India due to temperature more than 33 °C and dry spells of low rain fall during September-October months. It will cause the huge yield and economic loss to mandarin growers by reducing the critical fruit quality characteristics viz. juice per cent, TSS and acidity. From the present study it was concluded that application of 6%, 8% and 10% of kaolin and calcium sulphate control the incidence of sunscald and improved the quality characteristics of Nagpur mandarin fruits. Kaolin was the more effective particle film in controlling sunscald incidence compared to calcium sulphate.

### Acknowledgements

The authors would like to acknowledge the Director, ICAR-Central Citrus Research Institute, Nagpur (Maharashtra State) for his valuable support and facilitation.

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