



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(8): 677-682
www.agriculturaljournals.com
Received: 24-06-2026
Accepted: 27-07-2026

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Economic analysis of fruit drop in sweet orange in Nagpur district

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DOI: <https://www.doi.org/10.33545/2664844X.2026.v8.i8h.1828>

Abstract

Sweet orange (*Citrus sinensis*) is one of the important commercial citrus fruit crops cultivated in India, with Nagpur district of Maharashtra being a major production area. Despite its economic importance, the crop suffers substantial yield and income losses due to fruit drop, which occurs as a result of various biotic, abiotic and management-related factors. The study aimed to identify the major biotic and abiotic factors of fruit drop, analyse the economic losses at the level of adoption of Standard Operating Practices and constraints for non-adoption of Standard Operating Practices (SOPs) released by Dr. PDKV, Akola. The study was conducted in four major sweet orange-growing tehsils of Nagpur district, i.e., Katol, Kalmeshwar, Saoner and Narkhed. A total of 120 sweet orange growers were selected for the study using primary data, comprising 60 adopters and 60 non-adopters of recommended SOPs. The dropping of fruits was calculated from the collected data, and the analysed data were presented in tabular form with the help of averages, percentages, etc. The study revealed that the adopters experienced lower production losses (7.08 quintals per hectare) and economic losses (Rs. 15,806.14 per hectare) compared to non-adopters, who faced higher production losses (17.39 quintals per hectare) and economic losses (Rs. 41,717.83 per hectare). Adoption led to a 59.34 per cent decrease in fruit drop and a 62.12 per cent decrease in economic losses, with a 19.96 per cent increase in productivity over non-adopters. The key constraints to adoption of fruit drop practices included lack of awareness about the practices (91.66 per cent), limited access to advisory services (85.00 per cent), and high cost of implementation (73.33 per cent). Growers expressed the need for regular technical guidance, compensation for losses, and processing avenues for dropped fruits. The findings indicated that minimization of fruit drop and enhancement of profitability in sweet orange cultivation require focused extension efforts, financial support mechanisms, and better dissemination of recommended practices.

Keywords: Sweet orange, fruit drop, economic losses, production losses, adopters, non-adopters

Introduction

Sweet orange (*Citrus sinensis*) is an economically important fruit crop cultivated widely in tropical and subtropical regions. India is among the major producers of sweet orange, with Maharashtra being one of the important producing states. The Vidarbha region, particularly Nagpur district, is a major sweet orange-growing area where the crop contributes significantly to farmers' income and livelihoods (FAOSTAT, 2024; NHB, 2023). In India, total area under sweet orange in 2024-25 was 239 thousand ha with production 4013 thousand MT and the productivity of sweet orange in India was 16.78 MT/ha. (2nd Advance Estimates, Ministry of Agriculture and Farmers Welfare, Govt. of India, 2024-25) In the year 2024-25 area under sweet orange cultivation in Maharashtra state was 79.39 thousand ha with production 965.18 thousand MT and the productivity was 12.15 MT/ha. (2nd Advance Estimates, Ministry of Agriculture and Farmers Welfare, Govt. of India, 2024-25) Fruit drop is one of the major constraints in sweet orange production. Although some fruit drop is a natural physiological process, excessive fruit shedding at different stages can cause substantial yield and economic losses. It is influenced by several biotic and abiotic factors, including moisture stress, high temperature, nutrient imbalance, insect pests and diseases (Bishnoi *et al.*, 2023) [7]. Therefore, effective management of fruit drop is important for improving yield, fruit quality and profitability of sweet orange cultivation. Several Standard Operating Practices (SOPs) have been recommended by Dr. PDKV, Akola for managing

fruit drop; however, the extent of their adoption and their effect on production and economic losses at the farm level need to be investigated with the following objectives.

1. To identify the major biotic and abiotic factors of fruit drop.
2. To analyse the economic losses at level of adoption of Standard Operating Practices (SOP).
3. Practices (SOP).
4. To identify the constraints for non-adoption of Standard Operating Practices (SOP) released by Dr. PDKV, Akola.

Material and Methods

Nagpur district has favourable climatic conditions for growing sweet orange; therefore, the district was purposively selected for the study due to its concentration of sweet orange production. Out of fourteen tehsils of Nagpur district, four tehsils, namely Narkhed, Katol, Saoner and Kalmeshwar, were selected for the study on the basis of the potential area under sweet orange cultivation. From each selected tehsil, three villages were selected for the present study; hence, a total of twelve villages were selected.

Estimation of economic and production losses due to fruit drop

Following tools were used (Ashraf *et al.*, 2012)

1. Percent loss of income was estimated by following formula:
2.
$$\frac{(\text{total income per hectare} - \text{Loss of income per hectare})}{\text{Total income per hectare}} \times 100$$
3. Production loss per ha =
$$\frac{\text{Total fruit drop (in Qtl)}}{\text{Total are (in hectare)}}$$
4. Economic losses = Production losses $\times$ Mean price
5. Fruit drop per cent =
$$\left(\frac{\text{Total quantity of fruit per ha} - \text{Total quantity of fruit drop per ha}}{\text{Total quantity of fruit drop per ha}} \right) \times 100$$

Results and Discussion

Table 1: Identification of major biotic and abiotic factors of fruit drop in sweet orange

Abiotic factors	Biotic factors	Management factors
1. High rainfall and high humidity 2. High temperature/ Sudden change in temperature 3. Windstorm 4. Water stress and Drought condition 5. Cold and fog	A. Entomological factors 1. Fruit Fly 2. Fruit sucking moth 3. Citrus Psylla 4. Citrus mite 5. Black fly B. Pathological Factors 1. Brown rot 2. Stem end rot 3. Fruit rot 4. Gummosis 5. Bacterial Infection	1. Nutrient deficiency 2. Type of irrigation 3. Time of application of Pesticides and Fungicides 4. Time of application of FYM and NPK 5. Over-ripening of fruits

It is revealed from Table 1 that the factors responsible for fruit drop in sweet orange were broadly categorized into abiotic, biotic and management factors. The major abiotic factors identified were high rainfall and high humidity, high temperature/sudden changes in temperature, windstorms, water stress and drought conditions, and cold and fog. The biotic factors were further categorized into entomological and pathological factors. The major entomological factors

For the present study, based on the level of adoption of Standard Operating Practices recommended by Dr. PDKV, Akola, for reducing fruit drop, 60 growers who had adopted the recommended Standard Operating Practices and 60 growers who had not adopted the recommended Standard Operating Practices were selected. From each selected village, ten sweet orange growers were selected; therefore, a total of 120 growers were selected for the present study from Nagpur district. To accomplish the objectives, primary data were collected from the selected sweet orange growers using a specially designed schedule through personal interview method. Information regarding fruit drop due to abiotic and biotic factors, as well as the adoption of Standard Operating Practices (SOPs) used to reduce fruit drop, was collected. The data pertaining to the Ambia bahar of sweet orange for the year 2024-25 were collected.

The collected data, was analysed and presented in tabular form with the help of averages, percentages, etc. For identification of constraints, frequency distribution, percentages and a simple ranking method were used.

included fruit fly, fruit-sucking moth, citrus psylla, citrus mite and black fly, while the pathological factors included brown rot, stem-end rot, fruit rot, gummosis and bacterial infection. The management factors identified were nutrient deficiency, type of irrigation, time of application of FYM and NPK, time of application of pesticides and fungicides, and over-ripening of fruits. Similar findings have been reported Bishnoi *et al.* (2023) [7], and Datir *et al.* (2023) [9].

Table 2: Category-wise distribution of factors responsible for fruit drop faced by sweet orange growers

Category	Factors	No. of growers	Per cent to total N=120
Abiotic factors	1. High rainfall and high humidity	120	100.00
	2. High temperature/Sudden change in temperature	120	100.00
	3. Windstorm	45	37.50
	4. Water stress and Drought condition	69	57.50
	1. Cold and Fog	42	35.00
Biotic factors	A. Entomological Factors		
	1. Fruit fly	61	50.83
	2. Fruit sucking moth	53	44.17
	3. Citrus psylla	65	54.17
	4. Citrus mite	35	29.17
	5 Black fly	47	39.17
	B. Pathological Factors		
	1. Brown rot	57	47.50
	2. Stem end rot	46	38.33
	3. Fruit rot	55	45.83
	4. Gummosis	76	63.33
	5. Bacterial infection	38	31.67
Management Factors	1. Nutrient deficiency	66	55.00
	2. Type of irrigation	53	44.17
	3. Time of application of pesticides and pesticides	57	47.50
	4. Time of application of FYM and NPK	48	40.00
	5. Over-ripening of fruits	41	34.17

It is observed from Table 2 that abiotic factors were the most widely reported causes of fruit drop, with 100.00 per cent of the growers identifying high rainfall and high humidity and high temperature/sudden changes in temperature as major contributing factors. Other notable abiotic factors included water stress and drought conditions 57.50 per cent, windstorms 37.50 per cent, and cold and fog 35.00 per cent. Among the biotic factors, citrus psylla 54.17 per cent and fruit fly 50.83 per cent were the major insect

pests, while gummosis 63.33 per cent and brown rot 47.50 per cent were the major diseases reported by the growers. The major management-related factors included nutrient deficiency 55.00 per cent, followed by the time of application of pesticides and fungicides 47.50 per cent and type of irrigation 44.17 per cent. The results highlight the need for improved pest and disease management, along with timely and balanced cultural practices to minimize fruit drop in sweet orange.

Table 3: Production and economic losses due to fruit drop of sweet orange adopters

Sr. No.	Particulars	Production losses Qtl/ha	Percentage	Economic losses Rs/ha
A.	Abiotic losses			
1	Heavy rainfall and high humidity	0.98	13.84	2062.70
2	High temperature/Sudden Change in temperature	0.79	11.17	1689.66
3	Windstorm	0.21	2.91	470.64
4	Water stress and drought condition	0.44	6.17	1010.72
5	Cold and fog	0.31	4.34	668.25
	Sub-total	2.72	38.41	5901.97
B.	Biotic losses			
I	Entomological causes			
1	Fruit fly	0.30	4.27	682.07
2	Fruit sucking moth	0.29	4.15	663.80
3	Citrus psylla	0.44	6.22	930.41
4	Citrus mite	0.19	2.69	423.02
5	Black fly	0.19	2.71	431.59
	Subtotal	1.42	20.03	3130.90
II	Pathological causes			
1	Stem end rot	0.24	3.35	552.33
2	Fruit rot	0.21	2.94	468.68
3	Brown rot	0.31	4.36	681.84
4	Gummosis	0.42	5.98	953.54
5	Bacterial infection	0.22	3.05	488.48
	Sub- total	1.39	19.69	3144.86
	Total biotic losses	2.81	39.72	6275.76

C	Management factors			
1	Nutrient deficiency	0.32	4.50	830.29
2	Type of irrigation (Ineffective water management)	0.40	5.70	941.71
3	Time of application of pesticides and fungicides	0.26	3.61	574.58
4	Time of application of FYM and NPK	0.24	3.39	531.18
5	Over-ripening of fruits	0.33	4.67	750.65
	Sub-total	1.55	21.87	3628.41
	Grand total of production losses (quintals)	7.08	100.00	15806.14
	Actual yield per hectare (quintals)	111.70		
	Expected yield per hectare (quintals)	118.78		
	Fruit drop percentage		5.96	

It is revealed from Table 3 that the results provide a comprehensive overview of the production and economic losses in sweet orange cultivation due to fruit drop among adopters, categorized into abiotic, biotic and management-related factors. The total fruit drop per hectare was observed to be 7.08 quintals per hectare, accounting for 5.96 per cent of the expected yield (118.78 quintals per hectare), resulting in an actual yield of 111.70 quintals per hectare. This fruit drop resulted in a substantial economic loss of Rs. 15,806.14 per hectare. Among the three major categories, biotic factors contributed the most to fruit drop, accounting for 39.72 per cent of the total loss, corresponding to 2.81 quintals per hectare and an economic loss of Rs. 6,275.76 per hectare. The major biotic causes were further classified into entomological and pathological factors. Among the entomological factors, citrus psylla, fruit fly and fruit-sucking moth were the major contributing pests, while

among the pathological causes, gummosis, brown rot and stem-end rot were the major contributing diseases.

Abiotic factors were the second major contributor, accounting for 38.41 per cent of the total loss, corresponding to 2.72 quintals per hectare and an economic loss of Rs. 5,901.97 per hectare. The major abiotic causes were heavy rainfall and high humidity 13.84 per cent, high temperature/sudden change in temperature 11.17 per cent and water stress and drought conditions 6.17 per cent. These factors are primarily climatic and often beyond the control of growers, yet they have a significant impact on fruit retention. Management-related factors contributed 21.87 per cent of the total loss, accounting for 1.55 quintals per hectare and Rs. 3,628.41 per hectare in economic losses. Ineffective water management, nutrient deficiency, improper timing of pesticide and fungicide application, and failure to harvest fruits at the appropriate maturity stage were the major factors under this category.

Table 4: Production and economic losses due to fruit drop of sweet orange non- adopters

Sr. No.	Particulars	Production losses Qtl/ha	Percent	Economic losses Rs/ha
A.	Abiotic losses			
1	Heavy rainfall and high humidity	2.36	13.49	5628.23
2	High temperature/Sudden change in temperature	1.75	10.01	4179.69
3	Windstorm	0.44	2.52	1060.26
4	Water stress and drought condition	1.62	9.26	3869.96
5	Cold and fog	0.43	2.46	1033.76
	Sub-total	6.60	37.74	15771.90
B	Biotic losses			
I	Entomological causes			
1	Fruit fly	0.76	4.35	1811.28
2	Fruit sucking moth	0.81	4.63	1926.14
3	Citrus psylla	1.20	6.86	2871.55
4	Citrus mite	0.54	3.09	1298.82
5	Black fly	0.37	2.12	892.39
	Sub-total	3.68	21.04	8800.18
II	Pathological causes			
1	Stem end rot	0.44	2.52	1051.43
2	Fruit rot	0.54	3.09	1298.82
3	Brown rot	0.75	4.29	1891.42
4	Gummosis	0.84	4.80	2077.01
5	Bacterial infection	0.53	3.03	1263.48
	Sub-total	3.10	17.72	7582.16
	Total	6.78	38.82	16382.34
C	Management Factors			
1	Nutrient deficiency	0.75	4.29	1784.78
2	Type of irrigation (Ineffective water management)	1.02	5.83	2429.77
3	Time of application of pesticides/fungicides	0.71	4.06	1699.96
4	Time of application of FYM and NPK	0.78	4.46	1864.30
5	Over-ripening of fruits	0.75	4.29	1784.78
	Sub-total	4.01	22.87	9563.59
	Grand total of production losses (quintals)	17.39	100.00	41717.83
	Actual yield per hectare (quintals)	89.40		
	Expected yield per hectare (quintals)	106.79		
	Fruit drop percentage		16.28	

It is revealed from Table 4 that the extent of fruit drop losses in sweet orange cultivation among non-adopters resulted in a significant production loss of 17.39 quintals per hectare, accounting for 16.28 per cent of the expected yield (106.79 quintals per hectare). The actual yield realized was only 89.40 quintals per hectare, with a total economic loss of Rs. 41,717.83 per hectare. These losses were classified into abiotic, biotic and management-related factors. Among the three major categories, biotic factors contributed the highest loss, accounting for 38.82 per cent of the total fruit drop, equivalent to 6.78 quintals per hectare, with an economic loss of Rs. 16,382.34 per hectare. Within this category, entomological causes such as citrus psylla, fruit fly and fruit-sucking moth were the major contributing pests, collectively accounting for 21.04 per cent of the losses. Pathological causes such as gummosis, brown rot and fruit rot were also significant, contributing 17.72 per cent of the fruit drop and an economic loss of Rs. 7,582.16 per hectare.

Table 5: Comparison of production and economic losses between adopters and non-adopters

Sr. No.	Category of growers	Actual Production (Qtl/ha)	Total Production losses (Rs/ha)	Total economic losses (Rs/ha)	Production losses percentage
1	Adopters	111.70	7.08	15806.14	5.96
2	Non-adopters	89.40	17.39	41717.83	16.28
3	Percentage decrease in losses of adopters over non-adopters due to high adoption of recommended practices to reduce fruit drop		59.34	62.12	63.39
4	Percentage decrease in productivity of non-adopters over adopters	19.96			

It is revealed from Table 5 that adopters experienced lower production and economic losses due to fruit drop as compared to non-adopters. The actual production was higher among adopters (111.70 qtl/ha) than non-adopters (89.40 qtl/ha), while total production losses were lower among adopters 7.08 quintals per hectare compared to non-adopters 17.39 quintals per hectare. Similarly, the total economic loss was substantially lower among adopters Rs. 15,806.14 per hectare than non-adopters Rs. 41,717.83 per hectare. The adoption of recommended practices resulted in a 59.34 per cent reduction in total production losses and a 62.12 per cent

reduction in economic losses. Further, production losses as a percentage of expected production were reduced by 63.39 per cent among adopters compared to non-adopters. The actual production of non-adopters was 19.96 per cent lower than that of adopters, indicating the beneficial role of recommended Standard Operating Practices in reducing fruit drop losses and improving production. The results obtained in the present study were similar to the findings of Yadav *et al.* (2025) ^[13], who conducted a comparative study on fruit drop losses and adoption barriers in mandarin.

Table 6: Constraints for non-adoption of Standard Operating Practices

Sr. No.	Constraints	Frequency (N=60)	Percentage	Rank
1	Growers are not fully aware of all the SOP and its benefits	55	91.66	I
2	Non availability of regular advisory services	51	85.00	II
3	The cost of adopting new SOP may be prohibitively expensive for sweet orange growers	44	73.33	III
4	Problem in identification of disease and pest	29	48.33	V
5	Climate and environmental challenges	40	66.66	IV

It is observed from Table 6 that the lack of awareness regarding Standard Operating Practices (SOPs) and their benefits was the major constraint reported by 91.66 per cent of the growers (55 growers), securing Rank I. This was followed by non-availability of regular advisory services, reported by 85.00 per cent of the growers (51 growers), which ranked second. The high cost involved in adopting new SOPs was reported by 73.33 per cent of the growers (44 growers) and ranked third. Climate and environmental challenges were reported by 66.66 per cent of the growers (40 growers), securing Rank IV. The problem in identification of diseases and pests was reported by 48.33 per cent of the growers (29 growers) and ranked fifth. These findings highlight the need for improved extension services,

awareness programs, and financial support to enhanced practices adoption. Similar constraints found by Rathod and Rathod (2016) ^[11] and Meena *et al.* (2017) ^[10].

Conclusion

Based on results obtained from the study, following conclusions are drawn.

The major abiotic factors responsible for fruit drop in sweet orange were high rainfall and humidity, high temperature and sudden changes in temperature, windstorms, water stress and drought conditions, and cold and fog. The biotic factors were categorized into entomological and pathological factors, while management-related factors included nutrient deficiency, type of irrigation, timing of

application of pesticides and fungicides, timing of application of FYM and NPK, and over-ripening of fruits. The findings revealed that adopters experienced lower production and economic losses due to fruit drop than non-adopters. Adopters recorded a production loss of 7.08 quintals per hectare and an economic loss of Rs15,806.14 per hectare, whereas non-adopters experienced higher losses of 17.39 quintals per hectare and Rs 41,717.83 per hectare, respectively. Among adopters, biotic factors contributed the highest share of production losses, followed by abiotic and management-related factors, while abiotic factors were the major contributors among non-adopters.

Adoption of recommended Standard Operating Practices to control fruit drop reduce production losses by 59.34 per cent and economic losses by 62.12 per cent, while increasing productivity 19.96 per cent in sweet orange cultivation. These improvements highlight the critical role of recommended practices in minimizing fruit drop and enhancing growers yield and income.

The major constraints limiting the adoption of recommended practices among sweet orange growers were lack of full awareness 91.66 per cent, unavailability of regular advisory services 85.00 per cent, and high adoption costs 73.33 per cent, followed by climatic challenges 66.66 per cent and problems in the identification of diseases and pests 48.33 per cent.

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