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Post-Harvest Management of Storage Rot of Ginger in Sirmour Areas of Himachal Pradesh, India

Sushma Sharma[1*], Sumitra Phurailatpam[1], Sapna Thakur[4], Durga Prasad [2] and Neelam Thakur[3]

[1]Department of Plant pathology, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, 173230

[2]Department of plant pathology, RHRYS and KVK Sharbo, Kinnaur, Himachal Pradesh

[3]Department of Zoology, Eternal University, Akal college of Basic sciences, Baru Sahib, Sirmour, H.P.

[4]Department of Biotechnology, Eternal University, Akal college of Agriculture, Baru Sahib, Sirmour, H.P.

*Corresponding author E-mail: sushsharma1987@gmail.com

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ABSTRACT

Ginger (Zingiber officinale (Rosc.) is a perennial root crop that is cultivated in almost all the tropical and subtropical regions of the world. The ginger crop suffers massive yield loss due to storage rot caused by Fusarium oxysporum. Per cent mean weight loss of ginger in different market samples due to fungal infection from January to May-2015 recorded and the results indicated that ginger obtained from Nahan market recorded a (27.93%) significantly higher weight loss followed by Shimla market (21.10%) than samples obtained from other markets. Studies on disease incidence, weight loss and chilling injury at different storage temperatures was recorded and results indicated that minimum incidence (20.49 %) was recorded when rhizomes were stored at 15^{0}C temperature and the maximum disease incidence (37.03%) was observed when the rhizomes were stored at 4^{0}C temperature. In post harvest heat treatment, the results indicate that rhizomes dip treatment at temperature 50^{0}C results in minimum disease severity (20.32%) in comparison to control where the maximum disease severity (41.60%) was observed.

Key words: *Ginger, Post harvest, Rot, Storage*

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an important cash crop of Himachal Pradesh fetching remunerative returns to the growers. It is commonly used as a vegetable or spice depending on the age of rhizomes. It is believed to be a native of South East Asia[10]. In India, ginger is grown in an area of 149.1 thousand hectare with a production of 702.0 thousand metric tonnes contributing about 50% of the world production with productivity of 4.7 metric tonnes per hectare. In Himachal Pradesh, ginger is an important cash crop of mid and low hill areas covering an area of 3,495 hectare with annual production of 50,034 metric tonnes[2].

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It is intensively cultivated in districts of Sirmour, Solan, Bilaspur, Shimla, Mandi, Hamirpur, Una and Kangra. Sirmour district alone contributes highest productivity and is having 3/4th of the area and production of the state. It is one of the most important cash crops for farmers. However, during the last few years, the crop severely damaged by different diseases in field, store and market. During storage, the rhizomes soft due to fungal infection (50%) within 3 to 4 weeks. Keeping to the huge losses caused by the disease, the present study was conducted to manage the disease by use of physical methods.

MATERIAS AND METHODS

MYCOFLORA STUDIES

Ginger rhizomes were randomly sampled from 10 local markets. Sampling was done in January to May, 2014 and kept in jars under aseptic conditions. The covers of the jars were perforated to allow free ventilation. Ginger samples were weighed using a digital balance to know the initial weight. Each sample was kept in a jar, labeled and placed on an open shelf in a laboratory (10-20°C and 60 – 90% R. H.). The experiment was laid out in a simple complete randomized block design with 4 replicates. The experiment was monitored for 90 days for emergence of fungi. The data were recorded on per cent loss in weight, disease incidence, spectrum of fungi and sprouting of rhizomes. The sprouting status was recorded by visual observation as – (none, 0%), + (slight, < 30%), ++ (moderate, 30-70%) and +++ (severe, 70-100%).

Loss in rhizome weight (%) was calculated by the following formula.

$$\text{Loss in rhizome weight (\%)} = \frac{\text{Rhizome weight before storage} - \text{Rhizome weight after storage}}{\text{Rhizome weight before storage}} \times 100$$

Spectrum of fungal species were assessed by isolation of fungi on potato dextrose agar (PDA) medium. Samples were surface sterilized with 70 per cent alcohol and was blotted dry on sterilized filter papers. The infected parts were sliced into small segments (5mm) and placed on PDA in 9 cm petri dishes. The plates were incubated at 27±1^{0}C for 3 days. Isolation of fungi were made from the rhizomes cuts on PDA and was done until pure cultures of the fungi were obtained and maintained for future use.

STUDY ON WEIGHT LOSS, CHILLING INJURY AND SPROUTING

Nine Kg of ginger rhizomes in three replicates of 3 Kg each were stored at three different temperatures viz., (15±1 ◦C), (10±1 ◦C) and (4±1 ◦C). The samples were analyzed for weight loss, chilling injury and sprouting at different time intervals viz., 0, 30, 60, 90 and 120 days of storage. Weight loss of ginger was measured at different time intervals using an electronic balance. The surface sprouting status were recorded by visual observation as – (none 0%), + (slight < 30%), ++ (moderate 30-70%) and +++ (severe 70-100%).The rhizomes stored were observed for susceptibility to chilling injury characterized by its presence (+) or absence (-). Loss in rhizome weight (%) was calculated by the formula described earlier.

PHYSICAL METHODS

EFFECT OF POST-HARVEST HEAT TREATMENT

Freshly harvested ginger were sorted for uniform size. The rhizomes then cleaned with wet cotton pads and divided into two lots. One set of rhizomes were left uninoculated, whereas the other inoculated with test fungi separately. Both inoculated and uninoculated rhizomes then further be divided into subgroups and hot water treated at 47^{0}C, 50^{0}C and 52^{0}C before storage and left for 120 days for observations on decay (%), rot (%) and microflora associated. Rhizomes kept in perforated polyethylene bags were removed at different intervals. Disease severity was measured at the end of shelf life. Untreated rhizomes were kept throughout the experiment serving as control. Each treatment was

replicated five times in a randomized block design.

RESULTS

Per cent mean weight loss of ginger in different market samples due to fungal infection from January to May-2015

The results indicated (Table 1) that ginger obtained from Nahan market recorded a (27.93%) significantly higher weight loss followed by Shimla market (21.10%) than samples obtained from other markets.

Table 1: Per cent mean weight loss of ginger in different market samples due to fungal infection from January to May-2015

Market	Sample 1	Sample 2	Sample3	Sample 4	Total	Mean
Shimla	19.59	13.74	33.85	17.23	84.41	21.10
Kandaghat	20.25	16.89	16.74	12.25	66.13	16.53
Shoghi	17.88	19.43	18.93	18.56	74.08	18.70
Solan	14.87	5.62	15.63	16.79	52.91	13.23
Oachghat	19.91	20.59	20.92	19.89	81.31	20.33
Chandigarh	14.95	12.30	8.20	19.73	55.18	13.80
Kalka	11.03	17.04	15.26	13.56	56.89	14.22
Rajgarh	13.06	17.31	18.12	14.16	62.65	15.66
Nahan	8.80	22.42	64.08	16.41	111.71	27.93
Renuka	21.70	19.55	13.23	20.64	75.81	18.80
$CD_{(0.05)}$						2.21

The least weight loss was recorded in ginger obtained from Solan (13.23%) and Chandigarh (13.80%) markets and the mean weight loss in these markets was statistically non significant among each other. The samples collected from Rajgarh and Kandaghat markets resulted (15.66%) and (16.53%) weight loss and these treatments were also statistically non-significant among each other.Results (Table 2) shows that four fungal species i.e. *Aspergilus niger*, *Pythium ultimum*, *Fusarium oxysporum*, *Verticillium chlamydosporium*, *Rhizopus oryzae* and *Penicillium digitatum* were consistently isolated from the ginger samples. *P.ultimum* showed water soaked lesions on infected ginger samples. The rhizomes were completely disintegrated in *P.ultimum* and covered with white cottony mycelium while *F. oxysporum* recorded pinkish fungal growth of the rhizomes. *A. niger* formed a black mycelium and the diseased parts did not exude water freely. *Rhizopus oryzae* produced grayish mycelium with minute fruiting structure. In case of *V. chlamydosporium* mycelium was grey to red coloured while in case of *P. digitatum* the fungal growth was green coloured. *F. oxysporium* had the highest occurrence followed by *P. ultimum*, *A. niger*, *V. chlamydosporium*, *P. digitatum* and *R. oryzae* in a descending order. The fungi were all of economic importance since they caused varying degrees of rot to the ginger samples.

Table 2: Spectrum of fungi isolated from ginger sampled from January to May, 2015

Market	*Aspergillus niger*	*Pythium ultimum*	*Fusarium oxysporum*	*Verticillium chlamydosporium*	*Rhizopus oryzae*	*Penicillium Digitatum*
Shimla	+	+	+	_	+	-
Kandaghat	+	+	+	+	+	+
Shoghi	-	-	+	+	-	-
Solan	-	+	+	+	+	+
Oachghat	+	_	+	+	-	-
Chandigarh	-	+	+	-	+	+
Kalka	-	+	+	-	-	-
Rajgarh	+	+	-	+	-	+
Nahan	+	_	+	-	-	+
Renuka	+	+	+	-	-	-

The data (Table 3) revealed that the minimum incidence of rot (9.41%) was observed in samples drawn from shoghi market followed by (14.68%) from Kalka market and the data were statistically significant from each other. Maximum incidence of rot observed in samples taken from Nahan market (31.50%). It is evident from the perusal on status of sprouting that no surface sprouting was observed in samples taken from Shimla, Kandaghat and Shoghi markets. Slight surface sprouting of rhizomes was however, noticed in rest of the samples. Isolation of species of microflora across markets revealed that some of these fungi were actually carried from same source to the different markets for sales. According to Adebanjo and Shopeju[1] mycoflora could be carried into the store from field as well as the air. The presence of *Aspergillus* and *Fusarium* species on the ginger samples pose a serious threat to ginger consumers. Associated with these fungal species is the production of aflatoxins and fumonins which are known to be carcinogenic to humans[5]. It is also likely that storage system of ginger with components such as time of harvest, type of storage, hygiene and insect infestation interact and influence fungal infection. Similarly, it has been reported that fungal species occurred more abundantly in more humid months than in the drier period[4]. In Nigeria, Fandohan *et al*[6]., have shown that insects, mainly Lepidoptera and Coleoptera play an important role in *Fusarium* infection and revealed a strong relationship between insect damage and *Fusarium* infection in storage rot of ginger. Zakka *et al*[13]., observed that mean weight loss (g) was significantly higher in samples obtained from the fruit garden market and was lowest in ginger sampled from Abuloma market of Nigeria.

Table 3: Disease incidence and sprouting status of rhizomes sampled from different markets

Market	Disease incidence (%)	Sprouting
Shimla	18.50 (25.48)	-
Kandaghat	19.68 (26.53)	-
Shoghi	9.41 (17.86)	-
Solan	24.11 (29.41)	+
Oachghat	16.62 (24.06)	+
Chandigarh	17.06 (24.81)	+
Kalka	14.68 (22.53)	+
Rajgarh	15.78 (22.59)	+
Nahan	31.50 (34.14)	+
Renuka	24.83 (29.89)	+
C.D $_{(0.05)}$	0.29	

Studies on disease incidence, weight loss and chilling injury at different storage temperatures

Ginger rhizomes were stored at three different temperatures i.e. (15±1 ◦C), (10±1 ◦C), (4±1 ◦C) and the observations were recorded at intervals of 30, 60, 90 and 120 days. The data (Table 4) indicated that minimum incidence (20.49 %) was recorded when rhizomes were stored at 15^0C temperature and the maximum disease incidence (37.03%) was observed when the rhizomes were stored at 4^0C temperature.

Table 4: Studies on disease incidence at different storage temperatures

Temperature (^{0}C)	Incidence (%) of storage rot at different intervals (days)				
	2014-15				
	30	**60**	**90**	**120**	**Mean**
4^{0}C	26.40 (30.91)	32.37 (34.67)	37.23 (37.60)	51.47 (45.00)	37.03 (37.38)
10^{0}C	15.30 (23.02)	22.40 (28.24)	29.44 (32.86)	37.23 (37.60)	26.12 (30.51)
15^{0}C	15.20 (22.94)	19.20 (25.98)	21.37 (27.53)	26.33 (30.87)	20.49 (26.87)
Mean	10.97 (25.63)	24.66 (29.63)	29.35 (32.66)	38.32 (38.09)	28.10 (31.84)

CD $_{(0.05)}$

Days = 0.59
Temperature = 0.46
Days ×Temperature = 0.35

The results (Table 4) indicated that ginger stored at 10^{0}C recorded (30.74%) significantly higher weight loss followed by ginger stored at 15^{0}C (24. 32%).Thus both the treatments were statistically significant among each other. It is evident from the perusal of data that chilling injury was only observed in rhizomes stored at 4^{0}C and the surface sprouting was moderate in rhizomes stored at 10^{0}C and 15^{0}C temperature and no surface sprouting of rhizomes were however, noticed in rhizomes stored at 4^{0}C. Helmi *et al*[7]., reported that a refrigerated storage at 10-15^{0}C and 45-55 per cent relative humidity for a period of four weeks did not affect quality but storage at room temperature had adverse effects.

Table 5: Studies on weight loss, sprouting and chilling injury at different storage temperatures

Temperature (^{0}C)	Weight loss of ginger at different intervals (days)						
	2014-15						
	30	**60**	**90**	**120**	**Mean**	**Chilling injury**	**Sprouting**
4^{0}C	8.30 (16.73)	12.30 (20.52)	19.23 (26.01)	22.40 (28.25)	16.74 (23.09)	+	-
10^{0}C	14.30 (22.21)	22.40 (28.24)	33.37 (35.28)	52.27 (46.30)	30.74 (33.22)	-	++
15^{0}C	13.90 (21.71)	17.37 (24.62)	25.30 (30.19)	41.40 (40.05)	24.32 (29.13)	-	++
Mean	12.17 (20.22)	17.36 (24.46)	25.97 (30.49)	38.69 (38.20)	23.82 (29.03)		

CD $_{(0.05)}$

Days = 1.03
Temperature = 0.80
Days ×Temperature = 0.62

Lana *et al*[9]., found that rhizomes stored at room temperature (17-25 °C), 40-80 per cent relative humidity were infected lesser than the rhizomes stored at lower temperature of 13 ±1 °C and 80 per cent relative humidity.

Effect of post-harvest heat treatment

Analysed data (Table 6) reveal that hot water treatment resulted in fair to good control of infection. The results indicate that rhizomes dip treatment at temperature 50^{0}C results in minimum disease severity (20.32%) in comparison to control where the maximum disease severity (41.60%) was observed. The data indicates that all the treatments were statistically significant among each other. It is evident from the perusal on status of decay and rotting it was observed that minimum decay (17.40%) and rot (20.60%) was observed in hot water treatment at 50^{0}C in comparison to control where maximum decay (31.37%) and rot (43.37%) was observed.

Table 6: Studies of post harvest heat treatment on disease severity, decay and rot at different storage temperatures

Temperature (^{0}C)	Disease severity (%) of storage rot at different intervals (days)						
	2014-15						
	30	60	90	120	Mean	Decay (%)	Rot (%)
47^{0}C	13.33 (21.40)	19.37 (26.10)	25.30 (30.20)	35.37 (36.49)	23.55 (28.75)	25.53 (30.35)	29.37 (32.81)
50^{0}C	12.40 (20.60)	17.40 (24.65)	21.50 (27.62)	27.63 (31.71)	20.32 (26.28)	17.40 (24.65)	20.60 (26.99)
52^{0}C	16.47 (23.93)	19.47 (26.18)	27.53 (31.65)	39.37 (38.86)	27.47 (30.44)	27.37 (31.54)	31.40 (34.08)
Control	29.53 (32.92)	35.37 (36.49)	43.60 (41.32)	53.47 (46.99)	41.60 (40.16)	31.37 (34.06)	43.37 (41.39)
Mean	17.95 (24.71)	22.90 (28.35)	29.48 (32.70)	38.96 (38.51)	28.45 (32.04)	25.42 (30.15)	31.18 (33.77)

$CD_{(0.05)}$

Temperature = 0.25
Days = 0.28
Days×Temperature = 0.19

Hot water dip treatment supplemented with fungicides is reported to check many post-harvest diseases of fruits[12]. Indra *et al*[8]., observed that hot water treatment at 50^{0}C for 15 min enhanced pseudostem number, root weight and rhizome yield and the lowest gall number of root knot nematode infecting ginger. Salami and Popoola[11] used hot water treatment at different temperatures to reduce post-harvest fungal diseases of root tubers. The efficacy of blanching in hot water at 60^{0}C was significantly higher than that blanching in hot water at other temperature. The control method adopted in this study showed that the problems of potatoes rot diseases in storage can be eradicated by thermal treatments without reducing the quality of Irish tuber. Hot water treatment at 55^{0}C reduced storage rot in melon caused by *Fusarium* sp[3]. Reduction of rot was partly as a result of host resistance induced from post harvest heat shock and increased activity of peroxidase.

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