Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2019, Special Issue, Page 56-61

Impact Assessment of Hailstorm on *Khasi mandarin* and other Horticultural Crops in Umiam, Meghalaya

H. Rymbai* . N.A. Deshmukh . V.K. Verma . H.D. Talang . M.B. Devi. A.K. Jha

Division of Horticulture, ICAR Research Complex for NEH Region, Umiam, Meghalaya

ARTICLE INFO

Article history:
Received 13 May 2018
Revision Received 27 July 2018
Accepted 5 October 2018

Key words:
Hailstorm, horticulture, damage, losses

ABSTRACT

Hailstorm is frequently occurs in Meghalaya and caused crops damage and losses including houses. In Umiam areas, it was observed on 03rd, 16th and 17th April, 2018 which affected horticultural crops particularly *Khasi mandarin* at varying degrees. The incident has reduced the commercial and appealing value of the crops. So far meagre information is available on impact of hail damage on horticultural crops. Therefore, the main objective of this study was conducted to monitor the impact of hail storm on *Khasi mandarin* and other horticultural crops. Result showed significant damaged in all the crops at varying degree; however, the severity of damage was higher at flowering, fruit setting, fruiting stage, and nursery stage. In *Khasi mandarin*, the damage for leaves was recorded (8.33%), flowers (46.66%) and fruits (42.76%), while flower drop (62.66%) and fruit drop (53.67%) was observed. In peach, hailstorm causing 61.3% damage to matured fruit, 22.5% fruit drop and 32.0% leaf damaged. In all the ornamental flower crops, the damage is measured in term of damaged stalk and broken shoot tip. In gerbera, damage occurrence was recorded 86.66% in leaves and flowers, 92.33%. In gladiolus, the damage was recorded 13.66% in leaves and 96.66% in flowers. In dolichos bean, flower drops (pole type, 53.54-61.48%; bush type, 55.86-57.69%) and fruit drop (pole type, 17.53-23.68%; bush type, 59.09-66.67%). In tomato, flower drop (31.25- 89.41%) and fruit drop (14.29-31.43%) was recorded. The flower and fruit drops in vegetables may lead to 35-58% yield loss in dolichos bean and 30-45% in tomato due to hailstorm. The tender seedlings of *Khasi mandarin* at two leaf stage were highly damaged (93.33%) leading to its drying and dying. Result show that it is the need of the hour to develop pre-event measures post hail storm strategies to minimize crop losses.

1. Introduction

Hailstorm is not uncommon in India and its incidence has been reported yearly in some parts of the country. It was reported that hailstorm ravaged standing crops of Marathwada and Vidarbha during February, 2018 has damaged crops to the tune of Rs 313 crore (Anon., 2018). Similarly, hailstorm is frequently occurring in Meghalaya with various intensity, direction and time. This year it was reported across the state during the month of March and April which caused misery for several households due to crop loss and damage to houses. In Umiam areas, hailstorm was reported on 03rd, 16th and 17th April, 2018 which damaged horticultural crops particularly *Khasi mandarin*. The incident of hail damaged and crop losses have been poorly documented since farmers are stakeholders and are not ready yet to acquire scientific information related to incident of hail stones. Horticulture is a highly commercial adventure and value of horticultural products are mostly determined by its degree of excellence including nutritional and attractiveness features such as appearance, shape and colour. Any visual defects may have an adverse effect on market value of the crops.

*Corresponding author: rymbaihort@gmail.com

Therefore, horticultural crops are vulnerable to erratic and extreme weather events. According to IPCC (2007) the incidence and intensity of such weather is expected to increase with climate change. Hailstorm damage is one amongst the extreme weather events which severely affect the crops within a short span of time (Nicolaides *et al.,* 2009). When evaluating hail damage, it is important to determine the stage of growth, the extent of damage to the stem, leaves, flowers and the fruit. So far meagre information is available on impact of hail damage on horticultural crops in the areas. Therefore, the main objective of this study was to monitor the impact of hail storm on *Khasi mandarin* and other horticultural crops.

2. Materials and Methods

The incident of hailstorm on 03rd, 16th and 17th April, 2018 in Umiam areas hit many crops in Horticultural farm, Division of Horticulture, ICAR Research Complex for NEH Region, Umiam and caused significant damage and losses to several crops including fruit crops, flowers and vegetable crops at field and at nursery stage. The level of injury varies with crops and stage of incident of hailstorm within the same location. Therefore, the data collection was carried out in the Horticultural farm of the institute during the pre- and post - hailstorm incident. The standing crops, *viz*. *Khasi mandarin*, peach, guava, *sohphie*, gerbera, lilium, amaryllis, gladioulus, tomatoes, brinjal and nursery were selected for study.

The percentage of leaf/ flowers/ fruits damage was taken by the following formula;

Percentage of damage (%)	=	Number of damaged parts / Total number of parts	x	100

Flower/ Fruit drop (%) was taken as follow;

Percentage of drop (%)	=	Number of parts dropped / Total number of parts	x	100

The data were collected using randomized block design with five replications, each replication containing 20 plants. The data on different parameters were analyzed using analysis of variance (ANOVA) by employing Statistical Package for Agricultural Workers (STAT OP Sheoran). Valid conclusions were drawn only on significant differences between the genotype mean at 0.05 level of probability.

3. Result and Discussion

Result showed significant damaged in all the crops at varying degree; however, the severity of damage was higher at flowering, fruit setting, fruiting stage, and nursery stage.

3.1 Severity of damage in fruit crops

In fruit crops, damage was seen as wounds on scaffold branches, shoots and other vegetative parts. This may aggravate the secondary infection of disease, rotting and insects' infestation. Leaves were tattered, split and broken especially in peach and guava. Fruits were pitted and dropped, while young fruit may carry the deformity till maturity. This may have direct consequences on yield, quality and health of the plants (Table 1). In *Khasi mandarin*, hailstorm occurred at flowering and fruit-setting stage (Figure 1 a & b). The damage for leaves (8.33%), flowers (46.66%) and fruits (42.76%), while flower drop (62.66%) and fruit drop (53.67%) was recorded. In peach, the damage took place at fruit maturity phase causing 61.3% damage to matured fruit, 22.5% fruit drop and 32.0% leaf damaged (Figure 1 e & f). In guava, it was observed that damage was very high in leaves (about 70%). While, in *Sohphie*, the stage of hailstorm occurrence was at fruiting stage (maturing) and damage was observed in leaves (0.38%) and fruits (30.47%), while fruit drop was about 46.63%). The damage of fruit during setting and development stages retarded the growth and development of the fruits. This is because in the post hail damage, the plants divert its resources towards repairing and coping itself. This is has been demonstrated through transcriptional reprogramming and altered protein profiles upon detection of pathogen or herbivore to promote defense at the expense of growth (Borges *et al.,* 2013). Production and secretion of proteins with specific defensive properties, such as PR proteins, place a significant demand on the protein folding and secretory systems, which have also been shown to be required for defense (Pajerowska-Mukhtar *et al.,* 2012). Furthermore, this may hindered the fruits to attain its normal size, juice and reduce it appealing nature. It has also been reported a high occurrence of insect and diseases on *Pinus radiate* (Zwolinski and Wingfield, 1995); Japanese pear 'KOUSUI' trees which led to fewer shoots with inferior fruit quality and less bud intensity as compared to undamaged trees (Kosaku *et al.,* 2000); and fruit trees of Rosaceae family had greater losses due to twig canker fungi and bacterial fireblight entry into the wounds (Jones and Aldwinkle, 1990).

Table 1. Affect of hail storm in fruit crops

Crops	Damaged (%)			Flower drop (%)	Fruit drops (%)
	Leaves	Flowers	Fruits		
Khasi mandarin	8.33	36.66	42.76	62.66	53.67
Sohphie	0.48	na	46.63	na	30.47
Peach	32.00	na	61.30	na	22.5
Guava	70.00	na	na	na	na
C.D. (*p=0.05*)	5.27	-	-	-	-

na, data not available for recording as *sohphie* and peach fruits were in mature stage while guava was in vegetative phase.

Figure 1. Fruit crops affected by hail stones (a) Flower drop in *Khasi mandarin* (b) damage of fruit set in *Khasi mandarin* (c) Seedlings of *Khasi mandarin* in pre-hailstones (d) Seedlings of *Khasi mandarin* in post hailstones (e & f) damage of peach fruits.

3.2 Severity of damage in flower crops

In all the flower crops, damaged stalk and broken shoot tip was observed. The leaves became tattered, shredded, pock marked or ripped by hail. Flowers were split, broken and dropped. The damage severely affected the vigorous growth and decimates the yield and quality of flowers (Figure 2). Six month old gerbera at full bloom was affected by hail under open cultivation (Figure 2a). Damage occurrence was 86.66% in leaves and flowers (92.33%). In gladiolus the damage was at full bloom period and recorded 13.66% damage in leaves and 96.66% in flowers (Figure 2b). In Lilium, it was at vegetative stage and about 75.73% damage to leaves was recorded (Figure 2c). It was recorded about 46.33% damage to leaves and 99.37% to flowers in amaryllis (Figure 2d). Hail damage in flowers has detrimental effect on quality and attractiveness of flower which caused permanent damage and losses in flowers.

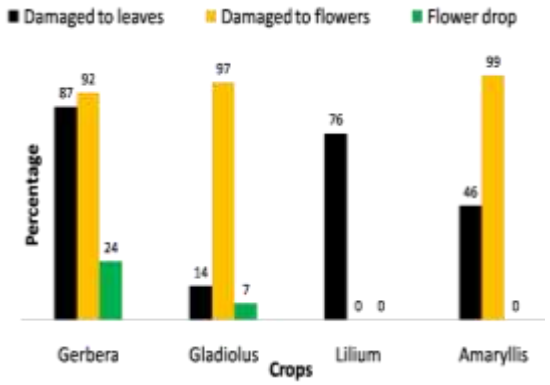

Figure 3. Affect of hail storm in flower crops

3.3 Severity of damage in vegetable crops

In vegetable crops, observations were recorded in two crops, tomato and dolichos bean and both the crops were at reproductive stage during the incidence of hail stones. In vegetables, defoliation, tearing and shredding was observed in leaves. In addition, stem breakage, stem bruising and dropping of flowers and fruit was observed (Table 3). In dolichos bean, leaf damaged showed 8.79 – 9.56% in pole type and 27.27 – 38.10% in bush type. Similarly, flower drops (pole type, 53.54 – 61.48%; bush type, 55.86 – 57.69%) and fruit drop (pole type, 17.53 – 23.68%; bush type, 59.09 – 66.67%). In tomato, leaf damaged ranged 22.21 – 24.47%, flower drop (31.25 – 89.41%) and fruit drop (14.29 – 31.43%, Figure 3a). The flower and fruit drops in vegetables may lead to 35 – 58% yield loss in dolichos bean and 30 – 45% in tomato during hailstorm. The data presented in table 3 showed that the bush types in dolichos bean were more prone to damage in term of flower and fruit drops as compared to pole type. Likewise in tomato flower drop was more severe in determinate type (Sel – 2, 89.41%) while fruit fruit drop is more in cherry tomato (31.43%). The recovery of damage crops depending on various factors, type or varieties of vegetables, stage of growth, immediate micro-climate and incidence of secondary infections. Leaf damaged reduced leaf area and plants will replacement through generation of fresh leaves which may take weeks. This in turn delayed in fruiting and maturity. When the crops are at advanced stage, reduction in leaf area decrease fruit storage organ quality such as reduced sugar, thus severely affected the yield, quality and storage life of products (Ernest, 2013).

Figure 2. Flower field affected by hail stones (a) Gerbera (b) Gladiolus (c) Lilium (d) Amaryllis

Table 3. Affect of hail storm in vegetable crops

Genotype	**Growth habit**	**Leaf Damaged (%)**	**Flower drop (%)**	**Fruit drop (%)**
A. *Dolichos bean*				
Local	Pole type	8.75	53.54	23.68
Swarn Utkrisht	Pole type	9.56	61.48	17.53
Sel-1	Bush Type	38.1	57.69	66.67
Konkan bhushan	Bush Type	27.27	55.86	59.09
B. *Tomato*				
Cherry Tomato	Indeterminate	22.21	31.25	31.43
Megha Tomato-3	Indeterminate	22.62	68.30	20.25
Selection-2	Determinate	24.47	89.41	14.29
C.D. (*p=0.05*)	-	0.32	6.62	3.81

Figure 3. Vegetable crops affected by hail stones (a) Nursery (Brinjal) (b) Cherry tomato

3.4 Severity of damage in nursery

The tender seedlings of *Khasi mandarin* at two leaf stage were highly damaged (Figure 1 c & d). The tip of seedlings was broken, defoliated and damaged (93.33%) leading to drying and dying. Although, appropriate post hail measure was taken to accelerate recovery of seedlings, yet about 87.33% mortality was recorded. The affected plants at tendered seedling (sprouting and emerging) were completely killed. Similarly, tender seedling of tomato and brinjal were recorded about 80-90% damaged by hail stone (Figure 3b). The damage incurred in the early stage of growth may kill the cells leading to subsurface injury which is not easily detected. In nursery plants, when cambium is injury free, it may cover up with time. It was also observed that minor injury seedling slowly recovered with less noticeable damage, although it may show sign of secondary infection (Schubert, 1991). It is also reported that such affected seedlings may have weakened tissue if the wound closure is very slow (Fare, 2010).

However, in case of *Khasi mandarin* the seedling were completely broken resulting in total mortality. Authors also observed that the occurrence of cutworm in nursery bed was aggravated in the post hail occurrence which was also found by Schubert (1991) to increase the post hail secondary infestations.

Conclusion

Hail is a perilous weather element which may cause widespread damage and losses to the horticultural production system and human activities. The impact caused by hail storm was experienced in all the crops, however, severity was maximum at flowering, fruit setting and two leaf stage of seedlings. Furthermore, it is estimated that annual hailstorm damage to unprotected farming could increase from 25% to 50% by 2050 (Bal and Minhas, 2017). Although, pre- event measures are important but constraints were due to highly unpredictable and localized nature of the storm. Thus it is the need of the hour to develop post hail storm strategies to minimize crop losses.

References

Anonymous (2018). Maharashtra: Last month's hailstorm damaged crops worth Rs 300 crore. The Times of India dated Mar 3, 2018. https://times of india .indiatimes.com/city/mumbai/maharashtra-last months-hailstorm-damaged-crops-worth-rs-300-crore/articleshow/63141654.cms. (*Accessed on 25th June 2018*)

Bal, S. K. and P. S Minhas. (2017) Atmospheric stressors: challenges and coping strategies. In Abiotic Stress Management for Resilient Agriculture (eds. Minhas *et al.,*), Springer, pp. 9–50 (doi: 10.1007/978-981-10-5744-1_2.)

Borges, L.L., Santana, F.A., Castro, I.S.L., Arruda, K.M.A., Ramos, H.J.D., Moreira, M.A., and De Arros, E.G. (2013). Differentially expressed proteins during an incompatible interaction between common bean and the fungus *Pseudocercospora griseola*. *Molecular Breeding* 32: 933-942

Ernest, E. (2013). Storm damaged vegetables – wind and hail. https://extension.udel.edu/weeklycropupdate/ ?p=5813 (Accessed on 26th June 2018)

Fare, D.C. and M.A. Halcomb (2010). Hail damage recovery on ornamental trees. (*in*): Field Production, John Lea-Cox (ed.). SNA Research Conference 55: 144–148.

IPCC. (2007). *Climate Change*, *Climate Change Impacts, Adaptation and Vulnerability*, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, Summary for Policy Makers, Cambridge University Press, UK, 2007, p. 23.

Jones, A.L., and H.S. Aldwinkle (eds). (1990). Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, MN. p. 85-86.

Kosaku, U., Kimihiko, J., Hiroyuk, C. and M. Tadayuk, (2000). Influence of hail damage on Japanese pear trees, 'KOUSUI' in blooming in terms of growth of tree, fruit quality and flower-bud formation. *Bulletin of the Fukuoka Agricultural Research Center* 19: 72-75.

Nicolaides, K.A., Photiou, G., Savvidou, K., Orphanou, A., Michaelides, S.C., Karakostas, T.S., Charalambous, D. and C. Kannaouros (2009). The impact of hail storms on the agricultural economy of Cyprus and their characteristics. *Adv. Geosci*.17: 99–103.

Pajerowska-Mukhtar, K.M., Wang, W., Tada, Y., Oka, N., Tucker, C.L., Fonseca, J.P. and X. Dong (2012). The HSF-like transcription factor TBF1 is a major molecular switch for plant growth-to-defense transition *Current Biology* 22: 103-112

Schubert, T. Hail damage to plants. (1991). Hail damage to plants. Fla. Dept. Agric. & Consumer Serv. Division of Plant Industry. Plant Pathology Circular No. 347. www.doacs.state.fl.us/pi/enpp/pathology/pathcirc/pp347.pdf (Accessed 25th June 2018)

Zwolinski, J. B., W. J. Swart and M. J. Wingfield. (1995). Association of *Sphaeropsis sapinea* with insect infestation following hail damage of *Pinus radiate*. *Forest Ecology and Management.* 72: 293-298.