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Impact of Abiotic Factors on Population Dynamics of Leaf Rollers on Apple Nursery in Temperate North Kashmir

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ABSTRACT: Apple, *Malus domestica* known as queen of fruits is the major contributor of economy to Jammu and Kashmir. Various factors (*viz*., diseases, insect pests, disorders, weeds etc) are responsible for limiting the production: Among these insect pests are posing major threat to the apple industry. Leaf rollers are posing a threat to the newly developed high density orchard ecosystem being a low fighter these pests reaches easily the dwarf plantation compared to that of traditional orchard systems. This pest has been infesting apical shoots, hence curtailing the apical dominance and resulting in busy side shoots in nursery plants. To ascertain/frame the appropriate management strategy an attempt was made to monitor the insect population of this pest in two consecutive years. Two species of leaf roller (*Choristoneura roseceana* and *Rhopobota navena*) were observed during the investigations carried out in 2016 and 2017 years. Population dynamics studies revealed that leaf roller adults appeared from 14th standard week till 43rd standard week with its peak in 27th standard week during 2016. However, during the year 2017 the leaf roller adults also appeared from 14th standard week with its peak in the 28th standard week and continued up to 39th standard week. Their correlation studies made it clear that maximum temperature, minimum temperature had significant and positive impact on the population build-up, however, larvae of leaf roller during 2016 showed significant and negative correlation with relative humidity, while sunshine showed positive and significant correlation. Moreover, other weather parameters like sunshine, rainfall, relative humidity morning and evening both had non-significant correlation with leaf roller population. The data obtained from the experimental finding shall help in devising the best management integrated pest management strategy especially emphasis might be given to organic approaches.

Keywords: Leaf roller, apple nursery and abiotic parameters.

INTRODUCTION

Apple (*Malus domestica* Borkh) is the commonly domesticated fruit tree in all temperate regions of the world. It belongs to the sub family Pomoideae and the family Rosacea and is grown in temperate and subtropical regions of the world. The apple is believed to have been originated in the Caucasus mountains of South western Asia - Kazakhstan and China (Janick, 2005). Apple, known as the 'King of temperate fruits' grown in most wide range of temperate areas of the world. It has been cultivated in Southeast Asia and Europe from times immemorial and has been spread by man in all temperate belts of the world. The major apple producing countries are U.S.A., Germany, France, Japan, Russia, Argentina, Turkey, Italy, Spain and China (Westwood, 1978). History of fruit growing in Jammu and Kashmir dates back to even 2000 BC, when apples are reported to have been cultivated. Lawrence has called Kashmir a fruit country in his famous book "The Valley of Kashmir", however horticulture started in an organised form around 1865 when Ermus, Head gardener of Public Works

Department in France, after preliminary survey introduced some fruit plants at Chashma-shahi, Srinagar in 1875. It is estimated that annual world production of apple is more than 56 million tonnes and in India production of apple is more than 1.7 million tonnes. The major apple producing countries are USA (8.27%), Argentina (2.14%), China (23.82%), Turkey (4.19%), France (3.42%), Germany (2.50%), Italy (2.55%), Poland (3.74%), and Russia Fed (3.75%). India with world production share of 2.36 per cent possesses 11th rank. The major apple producing states include Jammu and Kashmir (80%), Himachal Pradesh (12.5%), Uttarakhand (6.0%), Arunachal Pradesh (1.4%). The area of apple in Jammu and Kashmir is (1.65 lakh ha) with annual production of 18.82 lakh tonnes with productivity of 11.40 tonnes. District Baramulla ranks first both in area and production (Anonymous, 2020). Apple grown in Kashmir holds the national and international pride for its delicacy, but fruit yield, fruit quality and even growth of the apple plants are directly influenced by a number of factors *viz*., insect pests, diseases, disorders etc. Among these factors, number of insect pests and diseases usually at all the stages of growth causing huge economic loss to growers as growers invest so much on pesticide applications. The most important pests attacking apple are, European red mite (*Panonychus ulmi* Koch), two spotted spider mite (*Tetranychus urticae* Koch), San Jose scale (*Quadraspidiotus perniciosus* Comstock), woolly apple aphid (*Eriosoma lanigerum* Hausman), hairy caterpiller (*Lymantria obfuscata* Walker), apple stem borer (*Aeolesthes sarta* Solsky), leaf roller (*Archips pomivora* Meyrick) Blossom thrips (Anonymous, 1987). Among these pests, San Jose scale and European red mite are key pests and cause huge economic losses. Besides these few non insect pests *viz.* rodents and bear are also posing threat in most of the apple growing areas.

Lepidoptera comprises of about 2 lakh species of which 85 per cent are moths and remaining are butterflies. Among moths, the Tortricidae is one of the largest families of so called micro-lepidoptera. Though, worldwide in distribution, the family is more strongly represented in temperate and tropical upland regions than lowland tropics and probably reaches its greatest diversity in the moss forests of tropical latitudes. In addition to this, the rose tortrix, *Archips rosana* is a moth of the family Tortricidae (Lepidoptera). This species plays an important role in plant protection due to a large number of harmful species and frequent occurrence on different cultivations. In recent years the observations conducted in orchards have shown that the population and the economic importance of these phytophagous species is increasing, which often makes the use of chemical control necessary. The nature of damage has been studied by Fletcher (1920) who reported that larvae bored into apple fruits and caused rotting. Later, Janjua and Samuel (1941) reported that 1arvae fed on foliage by webbing the leaves together with silken threads. The larva severed the petiole and spun the leaf to the surface of the adjacent fruits. It lived inside the shelter and fed on soft tissues between the veins of leaf and the skin of the fruit. Tortricids are one of the major groups of Lepidopterous pests of apple throughout the world. *A. rosanus* is a primary or sometimes secondary pest on apple orchards depending on the year and the location (Mayer and Beirne 1974; Aliniazee *et al.,* 1997). Similar, studies reveal that the filbert leaf-roller (*A. rosanus* L.) is a pest of all fruit tree species as well as of other deciduous trees and shrubs. The oblique-banded leaf roller, *Choristoneura rosaceana* (Harris) (Lepidoptera: Tortricidae), feeds on a wide range of plant species including rose (*Rosa* spp.), dewberry (*Rubus flagellaris* L.), raspberry (*Rubus idaeus* L.), blueberry (*Vaccinium corymbosum* L.), apple (*Malus domestica* Borkh.), peach (*Prunus persica* Botsch), pear (*Pyrus communis* L.), cherry (*Prunus avium* L.), European hazel (*Corylus avellana* L.), pistachio (*Pistacia vera* L.), and forest trees (Chapman and Lienk, 1971). In apple orchards, outbreaks have become more severe during the last 10-15 years in the United States and Canada, as *C. rosaceana* can damage apple trees seriously by attacking floral parts, fruit and leaves (Reissig, 1978). Another leaf roller, *A. micaceana* was prevalent all over India which was reported under its different synonyms. Bhardwaj and Bhardwaj (1983) reported that larvae fed on foliage, spur and on the skin of fruit and the larval period was completed in 45-52 days. Leaf rollers are common pests of pome fruits throughout the world. In the northwest United States, damage from leaf rollers has been exacerbated by increased resistance to some pesticides and reduced mortality of leaf rollers in orchards switching from pesticide-based control of codling moth (*Cydia pomonella* L. Lepidoptera: Tortricidae) to the use of mating disruption (Gut and Brunner, 1998). In recent years OBLR has become an increasingly important pest as OP's are replaced by more selective insecticides. Studies have shown that OBLR larvae develop at different rates when feeding on different food sources. Thus, the number of degree-days (heat units) required to complete larval development on different hosts may not be the same.

Long-term light-trap data is highly useful in studying the seasonal dynamics of pests. When compared with other sampling methods, light-trap sampling was found to be more efficient for lepidopteran population dynamics (Raimondo *et al.,* 2004). However, many factors affect catches of insects in light traps Trap design, the light source and its energy, and the attraction efficiency under certain conditions all contribute to sampling errors. The effects of weather conditions and moonlight on light-trap catches are well documented. For example, trap efficiency for Lepidoptera is positively correlated with temperature and the thickness of cloud cover, and negatively

correlated with wind speed, precipitation and the fullness of the moon on the trap night. They are also pests to forests and park trees Tortricidae, commonly known as leaf rollers or leaf twisters, are the largest family of micro lepidoptera with more than 10000 species (Brown, 2005). The family includes some of the most economically important pests of agriculture, forest trees, and ornamental plants. The common name, leaf rollers, originates from the larval behaviour of spinning and/or rolling leaves of the host plant upon which they feed and develop (Timm, 2005). The native North American pest, oblique banded leaf roller, *C. rosaceana* (Harris) (Lepidoptera: Tortricidae), is widely distributed and has a broad range of over 50 hosts, but members of the Rosaceae family are preferred. This polyphagous larva is the injurious stage of *C. rosaceana*, as it feeds on flower buds, leaves, and developing fruit. *C. rosaceana* is a foliage and fruit feeding pest in apple, causing significant damage, especially by the summer generation. In cherry, the foliage and fruit injury caused by *C. rosaceana* is less serious compared with apple. However, *C. rosaceana* is a more critical pest in cherry in the late season. In recent years an integrated control system has been started to be used to keep pest populations below a critical value by using all possible control methods and techniques taking into consideration the population dynamics of pest species and their interactions with the environment. In such a control system, identification and monitoring of pests are key points to obtain successful results. In particular, life histories of pests as well as their hosts and natural enemies should be well-known (Lotfalizadeh *et al.*, 2009; Lotfalizadeh, 2010; Polat and Tozlu 2010). From the above facts the experiment was designed to study the apple leaf rollers in temperate conditions of north Kashmir

MATERIALS AND METHODS

The present investigation, "Studies on insect pest complex and management of leaf roller in apple nursery" was carried out at Faculty of Agriculture Wadura, Sopore situated at extreme North Kashmir during the years 2016 and 2017.

To study population dynamics of apple leaf roller

Adult activity. It is established fact that visible light attracts a wide range of insects and in the management part this has led to the development of various forms of light traps. It offers an efficient means of obtaining information regarding distribution, seasonal flight periods and peak of abundance of various insect species, thereby helping in the suppression of pest through suitable plant protection measures at appropriate time. To achieve this objective, a multi directional light trap was operated from 18.00 to 6.00 hours daily. The collections were recorded weekly throughout the experiment. Number of adults on the basis of weekly catches, were correlated with the abiotic factors (temperature, relative humidity and rainfall).

Larval activity. Leaf roller being low fighter insect infests nursery plantations and high density plantations. Larval activity was determined by counting the total number of larvae at weekly interval from 10 selected plants replicated thrice. To assess the larval populations at experimental sites each apical portion was keenly observed for presence of larvae. Larvae registered in the experiment were correlated with the abiotic factors (temperature, relative humidity, sunshine and rainfall).

Meteorological data. Data on temperature (Maximum and Minimum in ^{o}C), sunshine (hr.) relative humidity (%) and rainfall (mm) were collected from Automatic Weather Station, Wadura. Multiple correlations were worked out to determine the cumulative and individual effects of weather factors (temperature, sunshine, rainfall and relative humidity) on population buildup of the insect pests.

RESULT AND DISCUSSION

Population dynamics of apple leaf roller

Adult activity. The data presented in (Tables-1 & 2) revealed occurrence of leaf rollers in the nursery. Leaf roller adults appeared from14th standard week (0.66 adult/trap/week) and continued up to 43rd standard week with same number (3.0adult/trap/week) during 2016. The population increased gradually, reached its peak from 27th standard week (9.66 adult/trap/week) then the population showed declined trend. However, during the year 2017 the leaf roller adults also appeared from 14th standard week (0.33 adult/trap/week) and reached its peak in the 28th (8.0 adult/trap/week) standard week and continued for 39th standard week. Although, our work is in close conformity with the studies on the population dynamics of *Rnaevana* from Kashmir in 2010 to 2012 which, revealed that flight period commenced from 22nd standard week till 39th standard week. Results further showed there were three mean peak flight periods *viz*. 25th standard week (26 moths/Trap/night) for first generation, 33rd standard week (35.66 moths/Trap/night) for second generation and 38th standard week (30.66 moths/Trap/night) for third generation which were corresponding to the period when mean maximum temperature ranged from 26-31^{o}C, minimum temperature from 11-18^{o}C, morning relative humidity from 77-87%, evening relative humidity 48-57 per cent, sunshine from 7.02-9.6 hours and rainfall from 0.47-1.19 mm which seems to be favourable for its emergence (Mushtaq and Zakir 2017).

Table 1: Population dynamics of apple leaf roller with important weather parameters during the year 2016.

Month	Standard week	Leaf roller		Temperature (^{0}C)		Rainfall/ week/(mm)	Relative humidity (%)		Sunshine (hrs)
		No. of Adults/trap/ week	Larvae/ 10 plants	Max.	Min.		Morning	Evening	
January	1st	0.00	0.00	7.64	-0.57	3.14	92.71	79.14	1.42
	2nd	0.00	0.00	10.14	-3.97	0.00	92.72	62.14	3.94
	3rd	0.00	0.00	12.00	-5.02	0.00	94.00	42.14	6.20
	4th	0.00	0.00	9.40	-0.04	1.57	91.42	70.85	1.71
February	5th	0.00	0.00	13.31	-1.78	0.00	90.14	42.14	6.45
	6th	0.00	0.00	9.00	-0.66	3.40	91.42	60.00	2.18
	7th	0.00	0.00	13.21	-0.58	4.37	88.28	52.71	5.80
	8th	0.00	0.00	19.00	-1.11	0.00	87.00	28.00	8.60
March	9th	0.00	0.00	19.70	4.07	0.21	73.42	47.21	8.05
	10th	0.00	0.00	15.00	2.90	5.30	86.14	61.28	3.78
	11th	0.00	0.00	10.00	2.20	16.42	92.14	75.71	1.52
	12th	0.00	0.00	14.08	2.75	6.23	85.00	66.33	3.65
April	13th	0.00	1.00	18.21	5.60	1.80	80.71	60.14	2.42
	14th	0.66	0.66	15.14	6.50	5.90	91.43	82.42	1.44
	15th	0.33	0.66	19.57	6.75	2.17	89.42	66.85	2.50
	16th	1.00	2.00	23.91	6.12	6.87	88.85	73.00	2.50
	17th	2.33	3.66	23.08	4.51	0.00	77.57	47.57	3.74
May	18th	2.00	4.33	24.71	4.20	0.00	79.50	48.83	2.50
	19th	0.66	3.66	30.21	9.90	2.70	82.70	57.28	5.54
	20th	3.00	4.66	26.50	10.28	0.57	74.57	42.57	9.05
	21st	4.00	5.66	26.50	11.14	3.22	79.28	53.00	7.71
June	22nd	2.33	6.33	29.16	11.88	0.35	72.16	43.30	10.1
	23rd	3.66	5.00	29.28	12.77	0.48	75.14	42.71	8.52
	24th	3.00	6.33	29.92	14.20	0.10	75.14	45.85	8.47
	25th	3.33	4.66	31.42	15.07	0.00	69.00	51.14	10.08
	26th	5.00	3.66	32.35	17.27	0.00	75.00	48.71	8.50
July	27th	9.66	5.00	31.21	15.45	1.65	76.85	43.85	9.42
	28th	7.00	3.66	30.00	18.15	0.00	78.28	52.42	4.58
	29th	7.66	2.66	30.78	15.50	4.40	81.85	44.71	8.30
	30th	7.00	2.33	28.28	16.95	0.05	88.00	60.28	5.70
August	31st	6.33	3.00	10.81	-4.63	1.91	94.12	53.25	0.25
	32nd	3.66	1.33	27.92	17.20	4.42	86.57	55.14	5.50
	33rd	8.33	2.66	27.67	13.71	0.00	83.57	42.49	8.90
	34th	6.33	2.66	26.50	14.78	0.94	85.28	66.00	3.50
September	35th	5.00	2.00	25.00	13.27	0.00	86.42	60.00	5.30
	36th	4.00	0.33	29.91	12.83	0.00	80.83	54.66	6.55
	37th	4.33	0.0	28.28	10.57	0.00	85.14	44.57	7.41
	38th	5.00	0.0	28.71	9.92	0.91	89.14	42.71	7.40
	39th	6.33	0.0	29.92	9.65	0.00	90.28	36.71	8.38
October	40th	6.66	0.0	26.21	7.21	0.00	83.85	38.00	6.64
	41st	3.00	0.0	25.57	3.52	0.00	77.14	31.42	7.60
	42nd	2.33	0.0	24.21	3.10	0.00	80.28	39.14	7.32
	43rd	3.00	0.0	22.57	0.07	0.00	83.42	43.28	7.07
November	44th	0.0	0.0	21.40	-0.72	0.00	87.00	45.00	4.52
	45th	0.0	0.0	17.28	-2.50	0.00	94.00	38.00	0.00
	46th	0.0	0.0	14.78	-4.10	0.00	93.57	44.14	0.07
	47th	0.0	0.0	13.37	1.28	0.00	85.57	52.78	0.00
December	48th	0.0	0.0	14.00	-1.25	0.00	93.85	55.71	0.00
	49th	0.0	0.0	16.64	-3.44	0.57	33.14	62.57	0.75
	50th	0.0	0.0	11.47	-3.35	0.00	33.57	53.42	2.63
	51st	0.0	0.0	3.24	-5.72	0.00	34.66	59.16	0.10
	52nd	0.0	0.0	1.76	-5.08	0.00	35.28	51.87	0.12
Mean		12.63	9.66						
Standard Error		1.33	1.10						

Table 2: Population dynamics of apple leaf roller with important weather parameters during 2017.

Month	Standard week	Leaf roller		Temperature (^{0}C)		Rainfall/ week/(mm)	Relative humidity (%)		Sunshine (hrs)
		No. of Adults/trap/week	Larvae/ 10 plants	Max.	Min.		Morning	Evening	
January	1st	0.0	0.0	4.71	1.44	10.94	94.14	82.00	0.00
	2nd	0.0	0.0	3.52	4.38	0.00	92.71	71.71	1.75
	3rd	0.0	0.0	3.55	3.02	7.05	92.57	74.71	0.00
	4th	0.0	0.0	2.92	1.28	16.37	93.85	86.00	0.00
February	5th	0.0	0.0	6.07	0.35	3.22	91.14	77.71	0.47
	6th	0.0	0.0	10.5	1.61	2.85	86.14	56.28	5.35
	7th	0.0	0.0	10.85	0.71	5.00	90.85	66.85	1.12
	8th	0.0	0.0	12.35	0.85	2.08	83.71	59.57	4.72
March	9th	0.0	0.0	12.78	1.50	2.08	80.85	56.57	3.87
	10th	0.0	0.0	8.42	0.47	16.88	87.42	67.57	1.05
	11th	0.0	0.0	15.14	1.20	0.14	73.71	40.71	5.61
	12th	0.0	0.0	17.42	4.55	1.85	78.00	47.28	4.38
April	13th	0.0	0.0	20.92	8.14	0.82	77.85	46.42	4.64
	14th	0.33	0.0	13.35	4.21	25.00	82.85	67.85	3.50
	15th	0.66	1.33	23.35	5.02	0.00	73.00	34.57	10.40
	16th	1.00	0.66	24.07	10.00	12.48	85.57	52.42	20.42
	17th	1.33	0.33	19.42	6.98	7.82	85.28	78.28	5.41
May	18th	1.66	1.00	22.28	8.07	2.11	82.57	54.00	6.65
	19th	2.66	2.00	26.14	9.58	0.00	75.14	53.14	6.61
	20th	6.00	6.00	23.78	10.50	6.57	85.42	61.42	5.12
	21st	3.66	7.00	27.71	11.71	1.17	80.42	46.85	7.91
June	22nd	4.33	3.33	29.28	11.1	0.14	67.57	40.85	9.32
	23rd	4.66	4.33	25.14	12.20	9.92	79.57	54.00	6.25
	24th	5.00	4.66	28.50	12.38	1.42	75.00	47.71	9.05
	25th	5.33	4.33	25.92	14.94	5.37	86.42	65.57	6.07
	26th	7.00	5.66	27.07	15.28	0.54	85.85	60.14	5.41
July	27th	7.66	6.00	30.71	16.2	0.31	76.00	46.42	8.94
	28th	8.00	4.00	29.64	18.27	3.71	81.85	53.71	5.52
	29th	7.66	3.33	29.00	17.42	2.82	84.14	56.00	6.07
	30th	7.66	4.33	31.21	18.78	2.22	78.71	51.42	6.04
August	31st	7.66	4.66	31.07	19.08	4.78	83.14	55.28	6.84
	32nd	7.66	4.66	32.14	17.30	1.85	76.71	49.14	7.82
	33rd	7.33	4.66	28.64	14.15	1.85	83.42	57.57	8.47
	34th	6.33	0.0	29.28	14.10	0.94	82.42	49.00	7.22
September	35th	5.33	0.0	27.85	14.64	0.88	85.71	53.28	5.11
	36th	3.66	0.0	28.71	12.17	3.85	82.42	40.28	7.98
	37th	1.33	0.0	27.28	11.00	0.91	85.28	45.00	7.51
	38th	1.00	0.0	29.92	9.71	0.00	82.14	34.42	8.64
	39th	0.33	0.0	29.42	8.42	0.00	84.71	33.00	8.51
October	40th	0.0	0.0	28.50	6.34	0.00	84.57	33.00	7.98
	41st	0.0	0.0	26.28	4.42	0.00	73.42	41.28	7.08
	42nd	0.0	0.0	25.00	2.60	0.00	70.85	44.14	7.00
	43rd	0.0	0.0	22.92	1.20	0.00	75.00	52.14	7.27
November	44th	0.0	0.0	22.50	1.00	0.00	85.00	53.00	5.88
	45th	0.0	0.0	27.35	5.48	0.00	83.28	35.28	7.82
	46th	0.0	0.0	11.64	0.34	2.22	87.42	67.71	1.60
	47th	0.0	0.0	12.50	-2.82	0.00	87.28	58.85	2.15
December	48th	0.0	0.0	13.92	-2.74	0.00	83.42	58.14	2.24
	49th	0.0	0.0	13.71	-4.21	0.00	87.14	51.85	3.90
	50th	0.0	0.0	6.42	-1.21	6.17	91.00	79.85	2.05
	51st	0.0	0.0	7.78	-1.21	0.95	87.71	80.57	1.08
	52nd	0.0	0.0	10.78	-3.77	0.00	90.28	66.14	3.17
Mean		13.30	11.42						
Standard Error		1.62	1.32						

* Each value is mean of 10 observations; ** Each value is mean of 7 observations

Table 3: Population dynamics of leaf roller with important weather parameters during the year 2016-17 pooled data.

Month	Standard week	Leaf roller		Temperature (°C)		Rainfall/ week/(mm)	Relative humidity (%)		Sunshine (hrs)
		No. of Adults/trap/week	Larvae/ 10 plants	Max.	Min.		Morning	Evening	
January	1st	0.00	0.00	6.17	0.43	7.04	93.42	80.57	0.71
	2nd	0.00	0.00	6.83	0.20	0.00	92.71	66.92	2.84
	3rd	0.00	0.00	7.77	-1.00	3.52	93.28	58.42	3.10
	4th	0.00	0.00	6.16	0.62	8.97	92.63	78.42	0.85
February	5th	0.00	0.00	9.69	-0.71	1.61	90.64	59.92	3.46
	6th	0.00	0.00	9.75	0.47	3.12	88.78	58.14	3.76
	7th	0.00	0.00	12.03	0.06	4.68	89.56	59.78	3.46
	8th	0.00	0.00	15.67	-0.13	1.04	85.35	43.78	6.66
March	9th	0.00	0.00	16.24	2.78	1.14	77.13	51.89	5.96
	10th	0.00	0.00	11.71	1.68	11.09	86.78	64.42	2.41
	11th	0.00	0.00	12.57	1.70	8.28	82.92	58.21	3.56
	12th	0.00	0.00	15.75	3.65	4.04	81.5	56.80	4.01
April	13th	0.00	0.50	19.56	6.87	1.31	79.28	53.28	3.53
	14th	0.49	0.33	14.24	5.35	15.45	87.14	75.13	2.47
	15th	0.49	0.99	21.46	5.88	1.08	81.21	50.71	6.45
	16th	1.00	1.33	23.99	8.06	9.67	87.21	62.71	11.46
	17th	1.83	1.99	21.25	5.74	3.91	81.42	62.92	4.57
May	18th	1.83	2.66	23.49	6.13	1.05	81.03	51.41	4.57
	19th	1.66	2.83	28.17	9.74	1.35	78.92	55.21	6.07
	20th	4.50	5.33	25.14	10.39	3.57	79.99	51.99	7.08
	21st	3.83	6.33	27.10	11.42	2.19	79.85	49.92	7.81
June	22nd	3.33	4.83	29.22	11.49	0.24	69.86	42.07	9.71
	23rd	4.16	4.66	27.21	12.48	5.20	77.35	48.35	7.38
	24th	4.00	5.49	29.21	13.29	0.76	75.07	46.78	8.76
	25th	4.33	4.49	28.67	15.00	2.68	77.71	58.35	8.07
	26th	6.00	4.66	29.71	16.27	0.27	80.42	54.42	6.95
July	27th	8.66	5.50	30.96	15.82	0.98	76.42	45.13	9.18
	28th	7.50	3.83	29.82	18.21	1.85	80.06	53.06	5.05
	29th	7.66	2.99	29.89	16.46	3.61	82.99	50.35	7.18
	30th	7.33	3.33	29.74	17.86	1.13	83.35	55.85	5.87
August	31st	6.99	3.83	20.94	7.22	3.34	88.63	54.26	3.54
	32nd	5.66	2.99	30.03	17.25	3.13	81.64	52.14	6.66
	33rd	7.83	3.66	28.15	13.93	0.92	83.49	50.03	8.68
	34th	6.33	1.33	27.89	14.44	0.94	83.85	57.50	5.36
September	35th	5.16	1.00	26.42	13.95	0.44	86.06	56.64	5.20
	36th	3.83	0.16	29.31	12.50	1.92	81.62	47.47	7.26
	37th	2.83	0.00	27.78	10.78	0.45	85.21	44.78	7.46
	38th	3.00	0.00	29.31	9.81	0.45	85.64	38.56	8.02
	39th	3.33	0.00	29.67	9.03	0.00	87.49	34.85	8.44
October	40th	3.33	0.00	27.35	6.77	0.00	84.21	35.50	7.31
	41st	1.50	0.00	25.92	3.97	0.00	75.28	36.35	7.34
	42nd	1.16	0.00	24.60	2.85	0.00	75.56	41.64	7.16
	43rd	1.50	0.00	22.74	0.63	0.00	79.21	47.71	7.17
November	44th	0.00	0.00	21.95	0.14	0.00	86.00	49.00	5.20
	45th	0.00	0.00	22.31	1.49	0.00	88.64	36.64	3.91
	46th	0.00	0.00	13.21	-1.88	1.11	90.49	55.92	0.83
	47th	0.00	0.00	12.93	-0.77	0.00	86.42	55.81	1.07
December	48th	0.00	0.00	13.96	-1.99	0.00	88.63	56.92	1.12
	49th	0.00	0.00	15.17	-3.82	0.28	60.14	57.21	2.32
	50th	0.00	0.00	8.94	-2.28	0.00	62.28	66.63	2.34
	51st	0.00	0.00	5.51	-3.46	0.00	34.66	69.86	0.59
	52nd	0.00	0.00	6.27	-4.42	0.00	35.28	59.00	1.64
Mean			12.96	21.08					
Standard Error			1.47	1.21					

*Each value is mean of 10 observations; **Each value is mean of 7 observations

Table 4: Correlation of leaf roller population with important weather parameters and during 2016 and 2017.

Factors		Year 2016				Year 2017				Pooled data			
		Larvae		Adult		Larvae		Adult		Larvae		Adult	
		Correlation	Regression equation	Correlation	Regression equation	Correlation	Regression equation	Correlation	Regression equation	Correlation	Regression equation	Correlation	Regression equation
Temperature (°C)	Max.	0.415* (0.041)	Y=0.54 X-4.15	0.623** (0.000)	Y=0.92 X - 11.63	0.604 ** (0.008)	Y=0.64 4X-5.52	0.601** (0.001)	Y=1.21 X-19.20	0.509* (0.020)	Y=0.59 X-4.83	0.162*** (0.005)	Y=1.06 X-15.41
	Min.	0.527** (0.008)	Y=0.24 X +7.01	0.696** (0.000)	Y=0.96 X +2.57	0.582** (0.011)	Y=0.69 X +2.72	0.910** (0.000)	Y=1.69 X-7.79	0.554** (0.009)	Y=0.46 X +4.86	0.803*** (0.000)	Y=1.32 X-2.61
Relative humidity (%)	Morning	-0.527** (0.008)	Y=- 0.55X +54.70	-0.055 (0.775)	Y=- 0.05X +17.18	0.005 (0.985)	Y=- 0.01X +12.85	-0.046 (0.824)	Y=- 0.14X +25.01	0.266 (0.496)	Y=0.28 X +33.77	0.0505 (0.799)	Y=0.09 X +21.09
	Evening	-0.396* (0.055)	Y=- 0.30X +26.20	-0.291 (0.119)	Y=- 0.18X +22.04	-0.127 (0.615)	Y=0.01 X +10.63	0.197 (0.334)	Y=0.16 X +4.53	0.2615 (0.110)	Y=0.15 5X +18.41	0.244 (0.226)	Y=0.17 X +13.8
Sunshine (hrs)		0.604** (0.002)	Y=1.11 X +3.27	0.476** (0.008)	Y=1.27 X +4.76	0.362 (0.140)	Y=- 0.71X +16.80	-0.282 (0.162)	Y=- 0.48X +16.91	0.483 (0.071)	Y=0.91 X +10.03	0.379 (0.085)	Y=0.39 X +10.83
Rainfall (mm)		-0.343 (0.101)	Y=- 0.70X +10.94	-0.175 (0.354)	Y=- 0.69X +13.45	-0.278 (0.264)	Y=0.37 X +13.15	-0.275 (0.174)	Y=- 0.43X +14.93	0.310 (0.182)	Y=0.70 X +12.04`	0.225 (0.264)	Y=0.13 X +14.19

adult/trap/week).

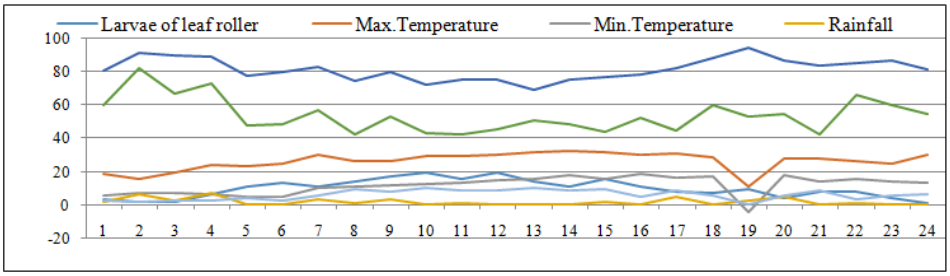

Fig. 1. Correlation of larvae of leaf roller with important abiotic factors during 2016.

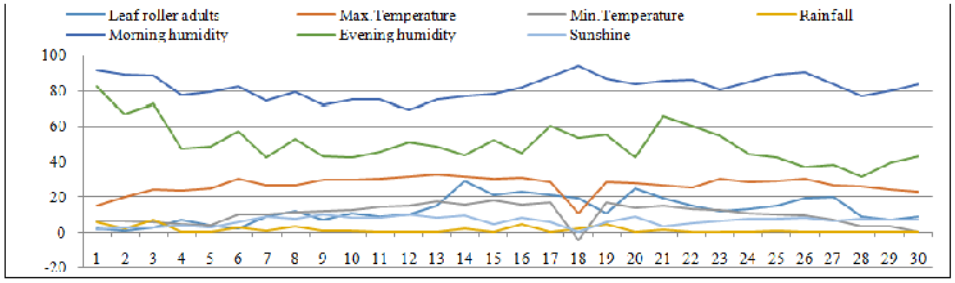

Fig. 2. Correlation of leaf roller adults with important abiotic factors during 2016.

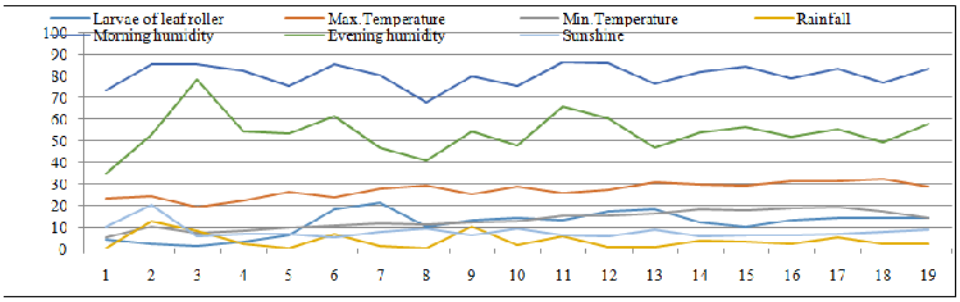

Fig. 3. Correlation of larvae of leaf roller with important abiotic factors during 2017.

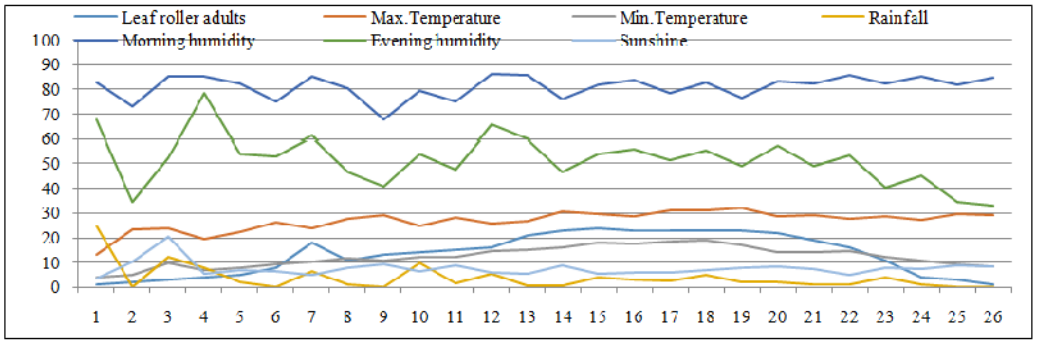

Fig. 4. Correlation of leafroller adults with important abiotic factors during 2017.

Larval activity. The data presented in Table 1 the larvae of leaf roller commenced its activity from 13th standard week (1.00 larvae/plant) and reached its peak from 22nd and 24th standard week (6.33 larvae/plant) during the year 2016. However, during the year 2017 leaf roller showed its activity from 15th standard week (1.33 larvae/plant) and continued for 33rd standard week (4.66 larvae/plant) and reached its peak on 21st standard week (4.66 larvae/plant).

Correlation studies of leaf roller populations with abiotic parameters. The correlation study (Table 4) of adult and larval population with weather factors during 2016-2017 made it clear that maximum temperature, minimum temperature had significant and positive impact on the population build-up, however, larvae of leaf roller during 2016 showed significant and negative correlation with relative humidity while as sunshine showed positive and significant correlation Moreover other weather parameters like sunshine, rainfall, relative humidity morning and evening both had no significant correlation with leaf roller population. Similar, findings has been reported by Mushtaq and Zakir (2017) they found positive correlation between the infestation of leaf roller and minimum temperature. Similarly, correlation studies were worked out between infestation of leaf roller and maximum humidity, minimum humidity and rainfall recorded during different months for a period of three years (Rahmathulla, 2012).

CONCLUSSION

It was evident from the investigations that there is close relation between the insect population buildup and weather parameters as complete activity of both leaf rollers was arrested with onset of cold and in November month and again appeared in the month of April. There were fluctuations in the pest populations observed throughout the growing season and give exact time and stage of the pest when to target. Apple nurseries registered a huge population of leaf folders during both years and it is worth to mention that this pest needs keen attention in the nursery and high density planting system.

FUTURE SCOPE

The pest has become threat in the apple industry from flowering to harvesting season therefore keen attention as to be taken for the management strategies of this pest. Further investigations on this aspect need to be carried out to meet the demands of farming community in temperate conditions of Kashmir. Hence, to devise integrated pest management module much more studies are to be carried out in apple growing areas to combat this pest.

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Conflict of Interest: None.

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