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Impact of weather parameters on insect pest infestation in cauliflower (*Brassica oleracea* var *botrytis* L.) seed crop in mid hill regions of Himachal Pradesh

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Abstract
Cauliflower is one of the commercial vegetable crop of district Solan. The activity of different insect pest infestation on seed crop was studied at three locations viz., Nauni, Saproon and Kandaghat in Solan district of Himachal Pradesh during 2014-15 and 2015-16. During the growth period different insect pest were cabbage aphid (*Brevicoryne brassicae*), cabbage caterpillar (*Pieris brassicae*) and painted bug (*Bagrada hilaris)* at all the locations under study. The relationship between weather parameters and pest population was worked out by correlation analysis. The pest populations were influenced by weather parameters, mainly maximum, minimum temperature and humidity (forenoon and afternoon). The highest number of insect pests were recorded at Nauni, followed by Kandaghat and lowest were recorded at Saproon. Among different insect pest aphids were most frequent in occurrence and had a significant negative correlation with maximum temperature at Nauni and Kandaghat (r=-0.864, r=-0.722), respectively. In Saproon and Nauni, cabbage aphid population also had significant positive correlation with forenoon humidity (r = 0.821) and r = 0.696). Cabbage caterpillars though had negative correlation with maximum temperature at Saproon but it was non-significant while it was significant at Nauni and Kandaghat (r = -0.742 and r = -0.713). Similarly pest population showed positive correlation with forenoon humidity with significant effect at Saproon (r=0.919). Painted bug population exhibited negative effect with forenoon and afternoon humidity at Nauni and Saproon whereas, which was significant while it showed non-significant effect at Kandaghat on population build up.

Keywords: Location, seed crop, pests and weather parameters

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.), a member of family *Brassicaceae* occupies the pride place among cole crops due to its delicious taste, flavour and a good source of protein, minerals, carbohydrates and vitamins. It is grown for its fleshy immature inflorescence which is known as curd. Cauliflower occupies the pride position among cole crops due to its delicious taste, flavour and nutritive value [18]. India is the second largest producer of cauliflower in the world contributing 33% to the global production. It is cultivated in an area of 3.48 lakh hectares with a production of 65.69 lakh Mt and productivity of 18.9 Mt/ha. The major cauliflower producing states in India are Bihar, Uttar Pradesh, Orissa, West Bengal, Assam, Haryana and Maharashtra [14]. It is an important crop which contains kind of vitamins, especially vitamin C and grow in cool temperate climate and is sensitive to high temperature [6]. The cauliflower varieties are very responsive to temperature and photo period. Time of sowing and transplanting are also important factors influencing vegetable production [5]. Climate change is one of the most important environmental challenges in the history of mankind [4] which is greatly affecting the pattern of crops grown in various agro-climatic zones throughout the world. The vegetables are very sensitive to climate extremes [3].

Himachal Pradesh is well known for commercial seed production of temperate vegetable crops. In the state, the cauliflower is grown in an area of 1370 ha with annual production of 24980 Mt of which snowball group is major contribution in terms of seed crop. Himachal Pradesh is well known for commercial seed production of temperate vegetable crops. The mid hill region is suitable for the seed production of cole crops. The Solan area especially Saproon valley has been known for quality seed production of cauliflower due to its unique environmental conditions. The temperature and humidity greatly impact the quality and

quantity of seed produced. This vegetable crop was attacked in every season by number of fungal disease, bacteria, virus, insects and pests caused high damage to the production. Insects and pests generally attacked because of their liking and to complete their life cycle. They damage and used every parts of the plant and ultimate causes high economic loss to the farmers. Pest is an organism that effect vegetable crop.

Several factors attributed to low production, amongst these quality seed and insect pest infestation are important factors. Climate change exhibited a significant impact on incidence of various pests on cauliflower. Solan district is ideal region for cauliflower seed production and a decline in cauliflower seed production was observed. However, in recent years a decline in cauliflower seed production has been observed in the region and one of the factor is Insect pest infestation. Keeping in view the above facts, the present investigation entitled, "Impact of weather parameters on insect pest infestation in cauliflower (*Brassica oleracea* var *botrytis* L.) seed crop in mid hill regions of Himachal Pradesh" was carried out to know the impact of weather parameters on insect pest infestation on cauliflower seed production in mid hills of Himachal Pradesh.

2. Materials and Methods

The present investigation on "Impact of weather parameters on insect pest infestation in cauliflower (*Brassica oleracea* var *botrytis* L.) seed crop in mid hill regions of Himachal Pradesh" was carried out in the field of Department of Environmental science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP), Farmers field Saproon and Regional horticulture station Kandaghat during 2014-15 and 2015-16. The details of material used and methodologies employed have been described as under**.**

Cropping seasons

The research was conducted from October to June in 2014- 15 and 2015-16.

Locations

The field studies were carried out at three locations, *viz.*, Nauni located at 31.27^0 N latitude and 76.91^0 E longitude with an altitude of 1300 m.a.s.l, Saproon at 30.91^0 N latitude and 77.09^0 E longitude with an altitude of above 1502 m.a.s.l and Kandaghat at 30.51^0 N latitude and 77.12^0 E longitude with altitude of 1425 m.a.s.l.

Crop

Cauliflower (*Brassica oleracea* var. *botrytis* L.)

Variety

Pusa snowball K-1 variety which was considered to be suitable for low temperature conditions, was selected for the experiment.

Weather

The Experimental sites fall under sub-temperate and sub humid mid hills agro climatic zones of Himachal Pradesh, where, the summers receive more rainfall than winter. (Fig.1and 2) The annual average temperature of the study sites during 2014-15 was 27.8°C at Nauni, 24.1°C at Saproon and 25.3°C at Kandaghat. During 2015-16 the annual average temperature was 29.1°C at Nauni, 25.3°C at Saproon and 27.2°C at Kandaghat. The average maximum relative humidity recorded during 2014-15 was 71.0, 85.0 and 80.0 per cent at Nauni, Saproon and Kandaghat, respectively, whereas, average minimum relative humidity was 44.6, 50.0 and 52.0 per cent at Nauni, Saproon and Kandaghat, respectively. During 2015-16 average maximum relative humidity was 65.3, 75.3 and 72.1 at Nauni, Saproon and Kandaghat, respectively and minimum was 40.3, 53.2 and 40.6 per cent at Nauni, Saproon and Kandaghat. The monthly average maximum and minimum temperature during the 2014-15 and 2015-16 cropping seasons have been presented graphically in Figures 1 and 2.

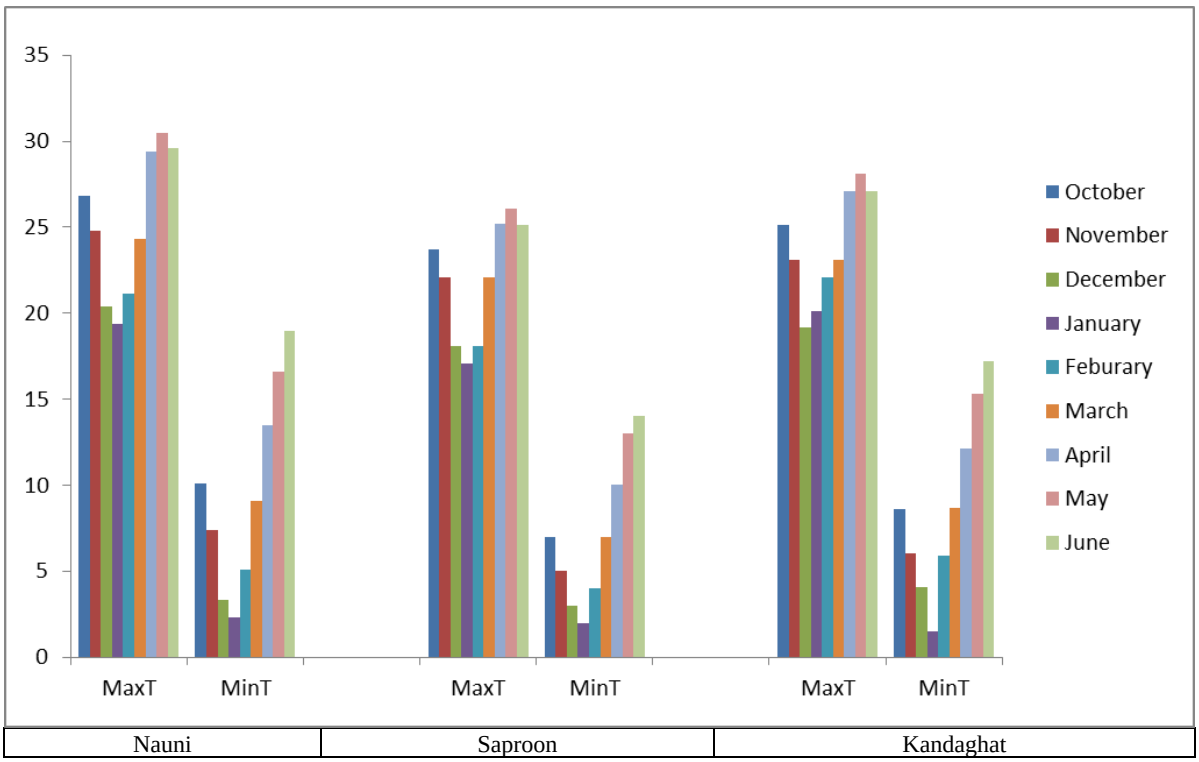

Fig 1: Mean monthly maximum and minimum temperature of three satudy locations during 2014-15

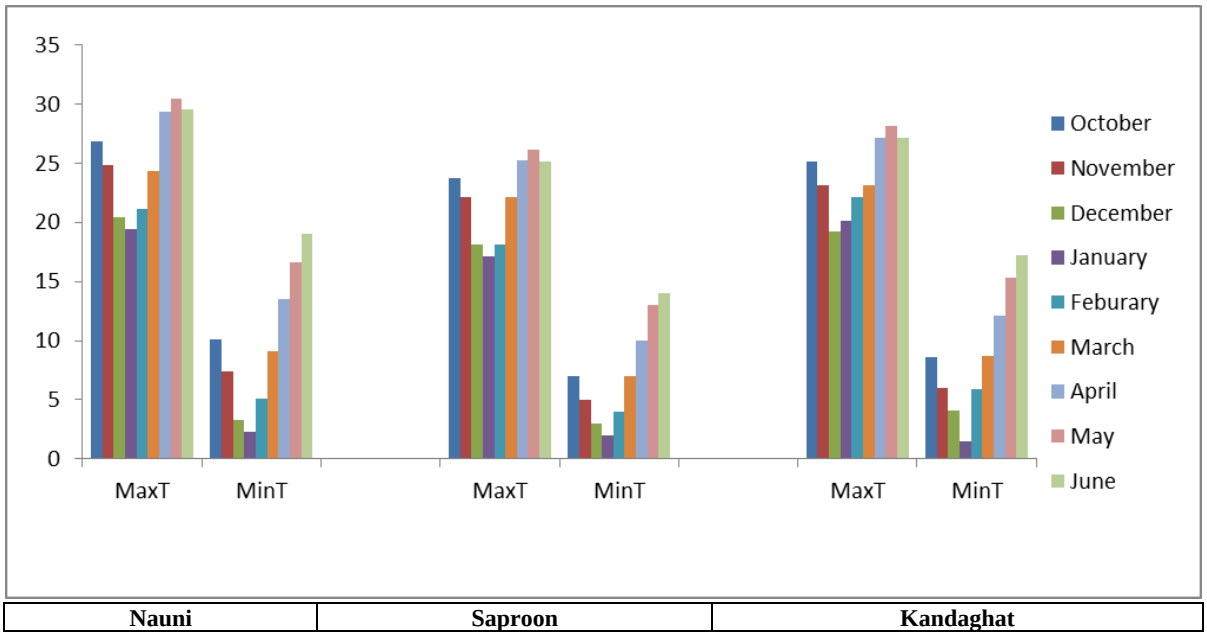

Fig 2: Mean monthly maximum and minimum temperature of three study locations during 2015-16

Monitoring of pests

The incidence of various of pests and diseases at three locations on the cauliflower crop was recorded at weekly intervals.

Aphid (*Brevicoryne brassicae*)

The estimation of aphid population was based on the numerical count method as described by Lal OP [10]. The whole plant was examined and the total number of aphids per plant was counted visually. For recording the aphid population of the early plant stage, leaves were grasped at the petiole by thumb and four fingers and twisted until the entire underside of the leaves clearly visible. In the advance plant stage, these observations were recorded on outer leaves only.

Painted bug (*Bagrada hilaris*)

The total number of adults was counted weekly on five randomly selected plants at three locations.

Cabbage caterpillars (*Pieris brassicae*)

The total number of caterpillars were counted weekly on five randomly selected plants at three locations. The climatic condition of these areas is favorable to the pest so this area is good for the reproduction for Cabbage aphid and other pests. The recorded observations are shown in Table 1.

Statistical Analysis

The data obtained were graphed using MS-Excel-2007 along with weather parameters and correlation coefficients were calculated by using OP-STAT Software.

3. Results and Discussion

Monitoring of pests

Different insect pests observed on cauliflower during 2014-15 and 2015-16 were cabbage aphid (*Brevicoryne brassicae*), cabbage caterpillar (*Pieris brassicae*) and painted bug (*Bagrada hilaris)* at all the locations under study. The pests population were influenced by weather parameters, mainly maximum temperature, minimum temperature and humidity (forenoon and afternoon). The impact of weather parameters on above mentioned insect pests at three locations has been described as below observed of various insect pests in crops.

Cabbage aphid

Data presented in Table 1 revealed that, at Nauni location infestation of cabbage aphid (*Brevicoryne brassicae*) on cauliflower started in third week of November (47th standard week) which increased gradually and population was at the peak (45.5 aphids/plant) in third week (50th standard week) of December 2014. The population declined as the crop progressed towards maturity. After that pest population declined gradually and disappeared in first week of February (3rd standard week).

Table 1: Aphid infestation at different growth stages in Cauliflower in different locations

Aphid/per plant	Initiation		Peak Population		Decline to zero	
Location 2014-15	**Standard week**	**Pest Population**	**Standard week**	**Pest Population**	**Standard week**	**Pest Population**
Nauni	47	10.2	50	45.5	3	6.2-0
Saproon	49	4.2	2	29.3	4	4.0-0
Kandaghat	48	6.9	1	40.1	3	6.1-0
2015-16						
Nauni	46	9.4	51	48.2	2	5.8-0
Saproon	48	4.9	1	30.3	3	3.2-0
Kandaghat	46	7.3	51	45.2	2	4.6-0

During 2015-16, pest appeared at Nauni in 2nd week of November (46th standard week) which increased in number and population reached at maximum in second week of December (51st standard week) with 48.2 aphids/plant.

At Saproon Table 1, the pest population appeared in the first week of December (49th standard week), gradually increased in number and reached to its maximum (29.3 aphids/plant) in the second week of January (4th standard week).

During 2015-16 at this location, first appearance of aphid was noticed in 2nd week of November (46th standard week). Aphid population increased continuously and reached to its peak in 3rd week of December (51st standard week) and slowly declined to zero in the last week of January 2016.

Similarly at Kandaghat aphid infestation was first observed in last week of November (48th standard week) during 2014-15 and increased continuously and reached to its peak in the last week of December (45.2 aphids/plant). Then population declined gradually with zero population in the second week of February (6th standard week).

Table 2: Correlation coefficient (r) of cabbage aphid (*Brevicoryne Brassica*) with weather parameters on cauliflower seed crop at different location

Pest Location	Cabbage aphid (*Brevicoryne brassicae*)							
	2014-15				2015-16			
	Max T	Min T	Forenoon humidity	Afternoon humidity	Max T	Min T	Forenoon humidity	Afternoon humidity
Nauni	-0.864**	0.197	0.696*	-0.301	-0.851**	0.211	0.231	0.291
Saproon	-0.126	0.076	0.821**	-0.312	-0.743*	0.009	0.176	0.215
Kandaghat	-0.722*	0.003	0.200	-0.021	-0.243	0.120	0.775*	0.311

The data presented in Table 2, showed that during 2014-15, aphid population had significant and negative correlation with maximum temperature at Nauni (r=-0.864) and Kandaghat (r=-0.722), respectively. In Saproon and Nauni, cabbage aphid population at Saproon and Nauni also had significant positive correlation with forenoon humidity (r = 0.821) and r = 0.696, respectively).

Cabbage caterpillar

Data presented in Table 3 showed that at Nauni infestation of cabbage caterpillar was first recorded in the third week of October (43rd standard week), gradually increased (5.2 caterpillars/plant) in the last week of November (48th standard week), then pest population declined gradually and disappeared in the third week of December (51st standard week).

During 2015-16, at Nauni location pest infestation in the last week of November (48th standard week) and increased continuously and reached to its peak (4.9 caterpillars/plant) in the (50th standard week). After that pest population gradually declined with zero population in last week of January, 2016.

Table 3: Cabbage caterpillar infestation at different growth stages in Cauliflower in different locations

Cabbage caterpillar Location 2014-15	Initiation		Peak Population		Decline to zero	
	Standard week	Pest Population	Standard week	Pest Population	Standard week	Pest Population
Nauni	43	1.8	48	5.2	50	2.8-0
Saproon	44	1.2	47	3.2	49	2.1-0
Kandaghat	43	1.4	46	4.1	50	2.4-0
2015-16						
Nauni	44	1.6	47	7.9	51	3.8-0
Saproon	45	1.0	48	4.8	50	2.2-0
Kandaghat	44	1.5	48	6.9	51	3.6-0

At Saproon, pest appeared in last week of October (44th standard week) during 2014-15 and increased continuously and reached to its peak (3.2 caterpillars/plant) in 3rd week of November (47th standard week).After that, pest population gradually declined to zero Table 3

During 2015-16, first appearance of cabbage caterpillar at Saproon was also noticed in the last week of October (44th standard week), increased gradually and reached at maximum level (4.80 caterpillars/plant) in last week of November (48th standard week). Then pest population declined gradually and disappeared in 2nd week of December (50th standard week).

At Kandaghat Table 3 caterpillar infestation occurred in (44th standard week) during 2014-15 and increased up to a certain level and become maximum (6.9 caterpillar/plant) in the forth third week of November (48th standard week) respectively.

During 2015-16, pest infestation started in (44th standard week) and increased continuously and became maximum in the last week of November i.e. 48th standard week. The caterpillar population declined with zero population in the third week of December.

Table 4: Correlation coefficient (r) of cabbage caterpillar (*Pieris brassicae*) with weather parameters on cauliflower seed crop at different locations

Pest Location	Cabbage caterpillar (*Pieris brassicae*)							
	2014-15				2015-16			
	Max Temperature	Min Temperature	Forenoon humidity	Afternoon humidity	Max Temperature	Min Temperature	Forenoon humidity	Afternoon humidity
Nauni	-0.742*	0.185	0.201	-0.124	-0845**	0.219	0.921**	-0.213
Saproon	-0.124	0.123	0.919**	-0.012	-0.723*	0.021	0.926**	-0.123
Kandaghat	-0.713*	0.021	0.125	-0.138	-0.214	0.775*	0.130	-0.851**

Correlation analysis Table 4 showed that maximum temperature had a significant negative effect on the pest population during both the years. During 2014-15 the correlation was significant at in Nauni (r=-0.742) and Kandaghat. Similarly pest population showed positive correlation with forenoon humidity with significant effect at Saproon (r=0.919).

During 2015-16, cabbage caterpillar population had a significant negative correlation with maximum temperature at Nauni (r=-0.845) and Saproon (r = -0.723), respectively. The forenoon humidity exhibited a significant positive correlation with caterpillar populations at Nauni (r=0.921) and Saproon r = 0.926).

Painted bug

Data presented in Table 5 showed that at Nauni location, during 2014-15 painted bug appeared on cauliflower in the third week of April (15th standard week) and remained high up to an 18th standard week. Table 5 peak population (15.6 bugs/plant) was recorded in the second week of May (18th standard week) and then pest population declined gradually and disappeared in (20th standard week).

During 2015-16 pest appeared in the second week of April (14th standard week) which increased gradually and the population was at the peak (16.2 bugs/plant) in the first week of May (17th standard week). The population declined gradually with zero population in the first week of June. The population declined gradually with zero population in the first week of June.

At Saproon, during 2014-15 bug infestation started in the last week of April (16th standard week) and increased up to a maximum level (9.8 bugs/plant) in the third week of May (19th standard week).

Table 5: Painted bug infestation at different growth stages in Cauliflower in different locations

Painted bug Location 2014-15	Initiation		Peak Population		Decline to zero	
	Standard week	Pest Population	Standard week	Pest Population	Standard week	Pest Population
Nauni	15	7.5	18	15.6	20	3.2-0
Saproon	16	3.2	19	9.8	21	2.0-0
Kandaghat	14	5.9	17	12.1	20	4.1-0
2015-16						
Nauni	14	6.2	17	16.2	20	4.8-0
Saproon	15	4.6	18	12.3	20	2.2-0
Kandaghat	14	5.2	18	14.2	20	4.7-0

During 2015-16, bug population at Saproon was first noticed in the third week of April (15th standard week), which increased gradually and the population was at the peak (12.3 bugs/plant) in the second week of May (18th standard week). The average temperature and humidity during the week ranged from 8.5-25.8 ^{0}C and 32.2-65.3 per cent, respectively. The population declined gradually with zero population.

At Kandaghat Table 5 first appearance of painted bug was noticed in the second week of April (14th standard week) and reached up to a maximum level (16.2 bugs/plant) during 17th standard week. The average temperature and humidity during week ranged from 13.9-29.4 ^{0}C and 44.7-55.2 per cent, respectively. Pest population gradually started declining and become zero in (20th standard week).

During 2015-16, painted bug appeared in the (14th standard week). The pest population increased continuously and reached to its peak in the 18th standard week (14.2 bugs/plant); during the week average temperature and humidity ranged from 8.4-26.8 and 32.6-55.3 per cent. After that bug population started declining.

Table 6: Correlation coefficient (r) of painted bug with weather parameters on cauliflower seed crop at different locations

Pest Location	Painted bug (*Bagarda hilaris*)							
	2014-15				2015-16			
	Max Temperature	Min Temperature	Forenoon humidity	Afternoon humidity	Max Temperature	Min Temperature	Forenoon humidity	Afternoon humidity
Nauni	**0.900****	0.134	**-0714***	0.138	**0.721***	0.241	-0.965**	0.254
Saproon	0.280	0.201	**-0.860****	0.012	**0.956****	0.012	-0.861*	0.321
Kandaghat	0.120	0.222	-0.212	0.032	**0.789***	0.023	0.432	0.865**

Correlation studies (Table 6) revealed a significant and positive correlation of bug population with maximum temperature at Nauni during both the years (r=0.900; 0.721). Whereas at Saproon and Kandaghat the correlation with maximum temperature was non-significant. Forenoon humidity showed significant correlation with pest population at Nauni (r = -0.965) and Saproon (r = -0.861) during both the years.

Discussion

Abrol DP [1] has reported that temperature played an important role in the population build up of aphids. The low temperature and humidity favored the aphid attack. The attack of aphids was higher in the months of December and January when the mean temperature was low (9.6-13.1 °C) with high relative humidity (70.1-76.6%).

Khurana *et al* [7] Observed that low temperature, high relative humidity and cloudy weather favorable for the multiplication of aphid. [2] reported that Negative correlation between cabbage aphid population and temperature while there was a positive correlation with relative humidity. The ambient maximum (26.5 to 27.5 ºC) and minimum (8.9 to 12.7 ºC) temperature and high humidity (76.2 to 80.4 %) in January favored aphid activity, whereas, 68.2 per cent or lower humidity ceased the aphid multiplication [9].

Forenoon humidity had showed a positive and maximum temperature showed negative effect on the caterpillar pest population. They also reported that the population of pest was also correlated positively with afternoon humidity [15].

Nayak *et al* [12] reported that the maximum temperature above 20 ºC favored the population build up of pest. The positive correlation of painted bug population with maximum temperature in cruciferous has also been reported by [17] Forenoon humidity showed significant negative impact on

pest population. These results are supported by the findings of [8] who observed that pest slowly declined in number and disappeared with the increase in relative humidity.

4. Conclusion

Through the field studies at three locations *viz.*, Nauni, Saproon and Kandaghat, it was observed that these locations were facing maximum infestation of insect pests on the cauliflower seed crop. It was found that Cauliflower crop was attacked by three main pest; ***Brevicoryne brassicae, Pieris brassicae and Bagarda hilaris***. Estimation of the impact of weather parameters on pest build up was carried out at different Standard weeks with difference in pest infestation. Cabbage aphid, Cabbage caterpillar and Painted bug were important insect pests in cauliflower seed crop in all the locations. This study confirmed that weather parameters play an important role in maximum build up of insect pests. The low temperature and high humidity favored the pest attack in these locations. It was concluded that pest attack was maximum, at Nauni due to favourable weather parameters followed by Kandaghat and lowest at Saproon location.

A. B. C. D.

Different insect pest identified during research studies. *A and B: Brevicoryne brassicae C: Pieris brassicae and D: Bagarda hilaris*

5. Acknowledgement

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