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SEASONAL INCIDENCE, VARIETAL PREFERENCE AND MANAGEMENT OF GARDEN SNAIL, *HELIX ASPERSA* IN CAPSICUM

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ABSTRACT

Experiments were devised to study snail infestation and relative efficacy of Molluscicides in capsicum under protected cultivation. Eight hybrids/varieties of capsicum (Bharath, Mallika, Manhattan, California Wonder, Tanvi, Orobelle, Bomby and Natasha) were raised in summer and rainy season with crop geometry of 45x45 cm planting density with two branching system for six months in RBD design with three replications. Three molluscicides (Fenvalerate, Metalaldehyde and Sodium Chloride) with three concentrations were tried to know the invasion and control of snail under locally design polyhouse. Infestation of snail was high in rainy season with prolonged rainy season supplemented with high temperature and relative humidity. Snail invaded crop non-selectively and highest infestation was recorded in Mallika11.7% which was non-significantly different from other varieties. The snail has adversely affected the crop with economic losses of 12.5% in controlled plants. Highest malformed or unmarketable fruits were recorded in Mallika hybrid owing to light colour leaf, lesser pericarp thickness and oblong in shape with four lobed fruits. Chemical baiting Metaldehyde was found effective at 3% concentration was at par with Fenvalerate at 5% concentration to kill snail within 96 hours with 100% mortality. The application of sodium chloride was found ineffective against snail.

***Key words*: Bait, Capsicum, Garden snail, Metaldehyde, Molluscicides, Mortality and Pest control.**

Introduction

The snails are the most troublesome pests in many orchards, pastures and open fields. In terms of number of species, the phylum Mollusca, to which land snails belong, is the largest phylum after Arthropoda (Sen *et al*., 2012). The snail (*Helix aspersa*) is the most common invasive seasonal and nocturnal pest causing serious problems in rainy season in cultivated and non-cultivated areas in high hill regions. Snails and slugs are very harmful pests for crops, vegetables, fruit, ornamental plants, and ecosystem. These creatures are known for destructive nature on cultivated plants. Populations of the molluscs can be controlled by using different tools and technique such as physical control, chemical control, biological control, bait formulations and by help of different plant derived molluscicides (Kumar, 2020). Crops are damaged by gastropods due to feeding and contamination of harvested plants with their bodies, eggs, slime or faeces, leading to deterioration in the quality of the harvest and financial loss. They do not usually feed in winter but hibernate in clusters in relatively dry and sheltered places. They emerge in the spring and causes serious economic injury and damage in plant species, including vegetables, forage crops, fruit trees, shrubs, flowers, green cover and newly sown lawn grasses. Moreover, the pest plays an important role in transmitting and spreading diseases to cultivated plants (Alvarez, 2009).Snail (*Helix aspersa*) represents a significant problem to cultivated plants and other species due to its feeding habits. This herbivory habit ofpest is considered as important threat to many species (Routray and Dey, 2016).

Snails move by gliding along on a muscular foot and constantly secrete mucus, which facilitates their movement. Snails are most active at night and on cloudy or foggy days. On sunny days pest seek hiding places out of the heat and bright light (Barker *et al*., 1991).Snails are mostly active only in rainy season in high altitude places. Control of snails on different crops is heavily dependent on the use of pesticides that limit the effect of these pests below the damaging level. Hence, the synthetic molluscicides or pesticides are the most effective available at present for the control of terrestrial snails (Heiba *et al*., 2002; Genena, *et al*., 2008). Traditionally, ineffective management practices in high hills against pests, sometimes uses rock salt (organic, unprocessed form) in their practices.

Capsicum (*Capsicum annuum* L.), Sweet pepper or Bell pepper is important cash crop of hilly farmers and grown as off season cropduring summer and rainy seasons. Growing of capsicum in high hills in low temperature regime during summer and rainy season is well established. Indian snails (*Helix aspersa*) are posing serious problem and affecting growth and development of the capsicum during the rainy days. The present studies were aimed to study the losses caused by mollusc inside indigenous polyhouse by Indian snail, Halix *aspesra* and to suggest mollusc pest management and, in particular, control with molluscicides in high altitude area of Uttarakhand. An attempt to improve current molluscicide bait technologies and research needs with specific reference to control of *H. aspersa* in high altitude ecosystems were identified.

Material and Methods

Studies were conducted during 2019-2020 at College of Horticulture-Bharsar (GB Pant University of Agriculture and Technology-Pantnagar) under polyhouse conditions during the summer and rainy season (May-November). Eight genotypes of capsicum (Bharath, Mallika, Manhattan, California Wonder, Tanvi, Orobelle, Bomby and Natasha) were selected. Eight weeks old seedlings of hybrids were transplanted in mid-May in 45x45cm planting distance in two row system in both years. The crop was raised in double row system with two branching system to study pest infestation in addition to the performance of hybrids. The experiment was laid out in Randomized Block Design (RBD) with three replications. Data on horticultural traits such as percent plant infestation, percent leaf damage, percent fruit damage, total fruit yield (kg/m$^{2)}$, pericarp thickness (cm) and number of lobes per fruit were recorded during crop season (May to November).

Three chemicals *viz.* Fenvalerate, Metalaldehyde and Sodium Chloride (control) were used as bait at soil level @ 1%, 3% and 5% in the month of August at 12-13 weeks old crop (Highest incidence of pest occurred).The baits were prepared as small pallets in wheat flour as per doses and kept in evening inside the polyhouse. About 20 small pallets were kept per square meter area for effective management of snails. Baits were prepared by maxing of requisite quantity of chemical, water and wheat flour manually as applied freshly. Bait was applied in evening to manage the pest or to determine the mortality of snails. The data on various parameters were recorded in treated and control plants. Baits were also applied close to walls and fences, or in other moist and protected locations, or scatter it along areas that snails inside the polyhouse. Data on various parameters of weather conditions was recorded twice the day and depicted in the graphical form (Fig. 1) to make assess of the study. Data was calculated on infestation of snail as:

$$\text{Percent infestation} = \frac{\text{Total number of infested leaf/fruit}}{\text{Total number of leaves/fruits}} \times 100$$

Data was subjected to analysis of variance with SPSS. Analysis of Variance (ANOVA) was carried out and the Standard Error (SE) and least significant differences (LSD) were determined as per procedure of Gomez and Gomez (1984).

Result and Discussion

The incidence of snail was recorded in the rainy season commencing from 27th Calendar week to 38th calendar week during the investigation. The polyhouse was constructed in flat area near forest land, wherein inoculums of snail appears both from soil and hatching of eggs and crawling inside the polyhouse. High incidence of snail is a serious menace in the cultivation in *Tarai* region of Uttarakhand (Karnataka *et al.*, 1998). The presented results in the context are discussed here under as follows:

Yield loss

The data in the Table 1 exhibited a significant difference in the infestation of Indian snail in capsicum.

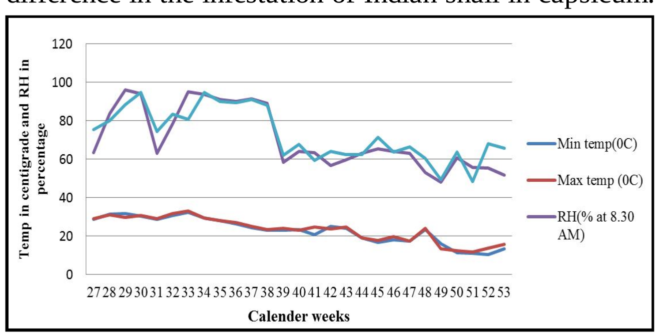

Fig. 1: Weather data inside polyhouse during the period of growth in capsicum.

Table 1: Infestation of Indian snail in capsicum under polyhouse conditions at Bharsar.

Sr No.	Variety/Hybrid	Plant Infestation (%)	Fruit damage (%)	Leaf damage (%)	Yield Parameters			Pericarp thickness
					Total Fruit yield Kg/m$^{2)}$	Marketable Yield (Kg/m$^{2)}$	Losses (Kg/m^2)	
1	Bharath	51.70	8.30	26.70	6.44	5.59	0.53	0.43
2	Mallika	46.30	11.70	20.30	6.33	5.57	0.74	0.45
3	Manhattan	32.23	8.09	22.73	6.06	5.35	0.49	0.40
4	California Wonder	43.33	4.80	28.93	5.62	5.28	0.27	0.43
5	Tanvi	34.40	2.30	23.40	5.40	4.10	0.12	0.42
6	Orobelle	24.50	4.60	27.50	4.30	3.40	0.20	0.46
7	Bomby	46.05	8.70	36.40	3.72	3.16	0.32	0.52
8	Natasha	34.50	5.60	27.44	3.35	3.25	0.15	0.45
	Mean	39.18	6.76	24.68	5.15	4.46	0.35	0.44
	CD0.05	2.78	2.68	1.98	0.89	1.12	2.20	0.32

Highest infestation of fruits and leaves was recorded at 12-13 weeks after transplantation of crops within the polyhouse. Among various weather parameters, relative humidity more than 80% conditions suitable for the invasion of snail. Low temperature and less humidity reduced snail population and infestation in the experiment. The infestation of snail was purely seasonal, and was serious in rainy season with rain showers and continued till end of season. Since the pest is nocturnal in habit, mostly crop was damaged in the night through movement inside the polyhouse. The pest in general moved up to the height of 45-50 cm in plant height. The highest leaf infestation on plant was recorded in Bharath (51.7%), but fruit damage was low (8.3%). The percent fruit infestation was recorded highest in hybrid Mallika with (11.7%) and the variety was selectively more prone to snail invasion in fruits. The economic losses and total yield per square meter in all tested varieties are given in the Fig. 2. The highest losses were recorded in the variety Manhattan (0.74 kg/m^2), owing to thin pericarp thickness and blocky shape of fruits. Ideal conditions for snails cause the greatest damage are damp, mild (15 to 25°C) and calm periods. The seedling stage is the most vulnerable and pest damage can often lead to major losses (Davis *et al.*, 2012).

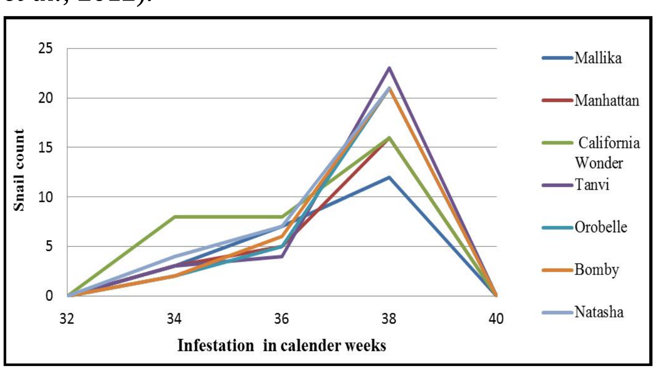

Fig. 2: Progressive increase in the population of snails inside polyhouse.

The highest leaf damage percentage was recorded in cultivar Bomby (36.4%) which was significantly highest than other cultivars. The leaves of colour hybrid Bomby was found comparatively softer and tender. In the present investigation, no such relationship of infestation in total plant, leaf incidence and invasion in fruits was recorded. It seems that snails attacked non-selectively the capsicum crop. The entrance or movement of pest or spreadwas location and area specific and depending upon the population, inoculums level and growth stage of the crop. Highest marketable yield was recorded in Bharath hybrid (6.44 kg/m^2) followed by Mallika (6.33 Kg/m^2) in the present set of studies. Highest losses were recorded in Mallikaas fruits were having less thick pericarp/rind and having more lobs than the other cultivar made the cultivars more prone to fruit attack.

Bait Formulation and mode of application

In present studies, wheat flour was used as baiting material, which mixes well and pallets were smooth. Wheat bran is at best only slightly attractive to *H. asperses* and thus control of this species was effective with most current molluscicidal bait formulations. Palatability of baits declines with increasing concentration of the active ingredient (Wright & Williams 1980; Wedgwood & Bailey, 2002). A single baiting at a rate of 20 baits in square meter at three concentration level resulted in varied level of control as depicted in the Table 2. Under the relatively uniform conditions of agricultural fields, the level of control with a single baiting operation is rarely above 70%, and typically 10-60% (Barker *et al.*, 1991). Minimum of 20 baits per square meters gave excellent results, however, in other studies smaller pallets placed relatively short distances of 5 mm was suitable.

Pest Management Studies

Snails were managed by hand collection and destroyed manually in Himalayan region. Hand collection

Table 2: Percentage Mortality of Indian snails due to different concentration in capsicum.

Mollus-cicides	Concent-ration (%)	P.M. (hrs.) 24	48	96	Mean
Fenva-lerate	1	25.5	35.5	43.0	34.56
	3	35.0	50.0	56.0	47.00
	5	90.0	92.5	100.0	94.17
	Mean	50.06	59.33	66.33	
Metalal-dehyde	1	38.0	55.0	75.0	56.00
	3	52.5	75.5	100	76.00
	5	60.0	100	100	86.67
	Mean	50.17	76.83	91.67	
Sodium Chloride	1	5.0	7.5	7.5	6.67
	3	22.5	27.5	37.7	29.17
	5	47.5	52.5	62.5	54.16
	Mean	25.00	29.17	36.66	
		41.74	55.11	64.88	
	SE(d)=0.891 SE(d) (C×L×I)= 1.545				
CD (p=0.05)	C×L=1.788 C×L×I=3.101				

C= Per cent concentration; **L**= level and **I**= Interval
P.M.: Percent Mortality

with subsequent destruction of snails is the oldest method of control of pest molluscs (Godan, 1983) and has been used effectively in conjunction with chemical methods for management of snails in agricultural areas (Deniu *et al.*, 2002). Since the snails are seasonal pest, appearance and aestivation of pest depend upon the rainfall; resulted in high humidity, therefore strategies for management is not a regular feature in the regions. Early monsoon sometimes brings problem in management of pest. The pest count and progressive count is given in the Fig. 2, over a calendar weeks in the experiment. Highest number of snail count was recorded in the 38-39 weeks, when RH was maximum afterward snail count was minimum owing to natural death. Manual removal as a control method has two primary constraints: the high labour costs, and the physical disturbance of the habitat. Both constraints are highest where the species being controlled is small and individuals are therefore difficult to detect in infested habitat. Nonetheless, garden snails may be efficiently controlled in high proportion located and removed from some habitats during the summer aestivation period, when the snails occur above the ground.

The perusal of data in the Table 2 and Fig. 4 depicted differential role of chemical in the management of snails. Mortality of pest was enhanced with increasing doses of chemicals as well as with lapse of time interval progressively. Highest mortality was recorded in metalaldehyde with 3% baiting at 48 hours interval and same results were recorded in 5% baiting in Fenvalerate eat 96 hour interval. Use of sodium chloride at different concentrations was not found effective in comparison to others chemicals. Highest mortality was recorded in sodium chloride was 62.5% in high concentration (5%) of sodium salt, which is otherwise not recommended due to harmful effect inside polyhouse. These findings are in conformity with findings of Pinku Paul *et al.,* (2016) who reported that metaldehyde 2.5% pellets@ 5kg/ha was most effective against against giant African snail, *Achatina fulica* Ferussac and registered 90.0% mortality at 15 days after treatment in capsicum followed by crystal salt @25kg/ha and documented 86.67% mortality. The results of studies conducted by Pieterse *et al.*, (2020) in South Africa, reported that application of 40g/kg concentration of metaldehyde caused significant mortality of brown garden scale as compared with 15 g/kg treatments.

Highest infestation of fruits and leaves was recorded at 12-13 weeks after transplantation of crops within the polyhouse. Among various weather parameters, high temperature and relative humidity more than 80% favoured the infestation of snail as evidenced in the Fig. 1. The loss of humidity around the polyhouse or environment has direct effect on the population of snails.

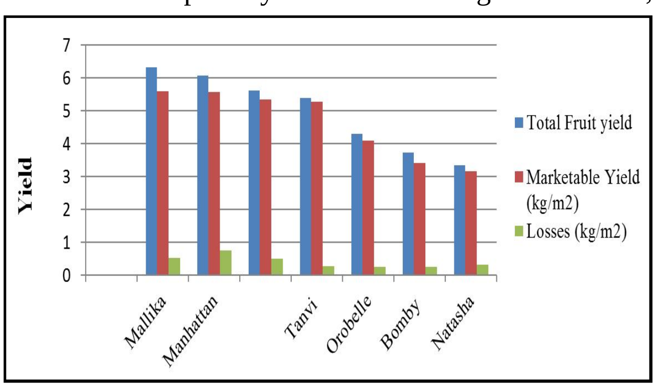

Fig. 3: Marketable yield and lossess incurred due to snails in capsicum.

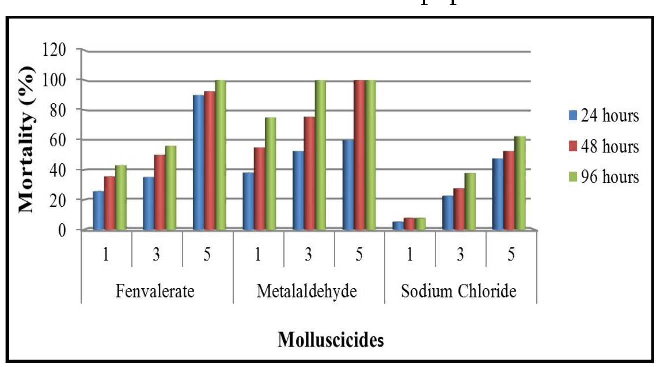

Fig. 4: Percentage Mortality of Indian snails due to different concentration of Molluscicides in capsicum.

Contrary to other findings, metaldehyde was most effective when low humidity and high temperature conditions follow ingestion of bait (Godan 1983), reflecting the primary role of excess mucus production and desiccation as the mode of action of this molluscicide. However, it is now recognised that many early studies underestimated the level of control affected by metaldehyde bait treatments because those individuals moving away from the baits before death were not included in mortality estimate.

Metaldehyde affect primarily the mucous cells and causes major disruption of the water balance physiology of the molluscs, resulting in their desiccation (Triebskorn & Ebert 1989). Metaldehyde has a secondary neurotoxic effect, contributing to loss of motor activity (Coloso *et al.*, 1998). The mode of action of metaldehyde includes both ingestion and dermal contact (Godan 1983). The greatest mortality was obtained using the highest rate of metaldehyde in the 4% formulation known as Deadline. The reduced control obtained at lower dosages of deadline is deceiving because it does not reflect the material's ability to kill *H. aspersa.* This application method and rate can be quite effective if concentrated in areas where snails and slugs are known to be a problem. In this way control can be achieved, keeping the dosage/area (and therefore the cost) at a low level. Parrella and Schultz (1984) reported that none of the 8 treatments tested provided 100% control. The reduced control obtained at lower dosages of Deadline is deceiving because it does not reflect the material's ability to kill *H. aspersa.* The highest dosage used, 67 kg a.i./ha (60 lba.i./acre), represents about one tablespoon per square dosages require proportionately less material. Past research has shown that the data for brown garden snail should not be extrapolated to other snail or slug species, as different species react differently to the toxicants (Singh and Aggarwal, 1982). Likewise, a small number of each plant should be tested prior to general use of a new pesticide to avoid unpredicted losses from phytotoxicity. The snails intoxicated with lethal concentrations of chemicals during the first hour, the snails still moved actively. After five to six hours, they secreted lucent mucus. The snails became inactive and immobile. After 12 hours, some snails died. Snails those have not given any response or muscular contraction when being touched with a pin inside the shell was considered dead.

Conclusion

It is desirable that bait formulation offers greatest effectiveness against *H. aspersa* and ease of application at the sites. The high mortality or use of Metaledehyde @ 3% baiting with wheat flour at 96 hours interval or high doses of 5% baiting at 48 hours interval gave excellent results. A series of molluscicide bait applications over a single season could be used to provide initial reduction in *H. aspera* numbers, and repeated in subsequent seasons to reduce *H. aspersa* to below the ecological threshold or until eradication achieved. Thus, additional research is needed to evaluate the molluscicides effect of the tested pesticides against the economically terrestrial snails under field conditions.

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Conflict of Interest: There is no conflict of interest.

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