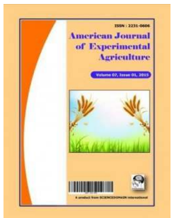

American Journal of Experimental Agriculture
13(1): 1-10, 2016, Article no.AJEA.25620
ISSN: 2231-0606

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Population Dynamics of *Pieris brassicae* (Pieridae: Lepidoptera) on Different Cauliflower (*Brassica oleracea* L. var. *botrytis* L.) Genotypes

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AS and IAK designed the study. Author AS performed the experiments, collect the data and did statistical analysis and wrote the first draft of the manuscript. Both authors IAK and AURS read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2016/25620
Editor(s):
(1) Slawomir Borek, Department of Plant Physiology, Adam Mickiewicz University, Poland.
(2) Mintesinot Jiru, Department of Natural Sciences, Coppin State University, Baltimore, USA.
Reviewers:
(1) Klára Kosová, Crop Research Institute, Prague, Czech Republic.
(2) Bożena Denisow, University of Life Sciences in Lublin, Poland.
(3) Anonymous, Duzce University, Turkey.
Complete Peer review History: http://sciencedomain.org/review-history/15125

Original Research Article

Received 12th March 2016
Accepted 1st June 2016
Published 23rd June 2016

ABSTRACT

Aim: The aim of our study was to evaluate commercially available cauliflower genotypes against *Pieris brassicae* (Pieridae: Lepidoptera) infestation. This would be helpful in evolving resistant varieties of cauliflower (*Brassica oleracea* L. var. *botrytis* L.) against *P. brassicae*.
Study Design: The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.
Place and Duration of Study: was conducted at the Agricultural Research Institute Tarnab, Peshawar during 2012-2014.
Methodology: To study on Population dynamics of *Pieris brassicae* (Pieridae: Lepidoptera) ten cauliflower genotypes, i.e. White corona, Snow mystique, Snow grace, Local, Clima, 5340, Sydney, Snow crown, White magic and AX-2034 was used. The treatments were regularly inspected for appearance of pest and data was recorded weekly from appearance of larvae till harvest of crop. In each treatment, five healthy plants of uniform size were randomly selected for data recording. Total

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number of larvae on upper and lower leaf surfaces was calculated as larvae plant^{-1}. The weight of cauliflower fruits (curd) for each genotype was recorded separately after each picking and total yield was calculated by adding the yield from all picking for each treatment.

Results: The results of field experiments revealed that maximum larval poulation of *Pieris brassicae* per plant were recorded on White magic (361.83 larvae plant^{-1}) and lower on White corona (15.83 larvae plant^{-1}). And no larvae were recorded on Sydney and AX-2034. Population trend of *P. brassicae* larvae on cauliflower genotypes during 2012-13 greatly fluctuates between 22nd Nov to 14 Feb. During 2013-14, it gives 3 maximum peaks between 11 Oct to 21 Feb. Mean yield of cauliflower for the year 2012-14 was significantly higher in White Magic (46550 kg ha^{-1}) and lower in White Corona (9913 kg ha^{-1}).

Conclusion: It is concluded that all heighted genotypes have more larval population then short height genotypes. White magic was proved itself as a tolerant genotype having more *Pieris brassicae* larval population per plant but give maximum yield too.

Keywords: Cauliflower; commercial genotypes; cabbage butterfly; Peshawar.

1. INTRODUCTION

Cauliflower, *Brassica oleracea,* is one of the important vegetable in the family Brassicaceae. Its white curd is used for eating purpose while its stalk and leaves are used as fodder. It contains several phytochemicals that may be beneficial to human health. It includes sulforaphane, a compound released when cauliflower is chopped or chewed, which may protect against cancer. Glucosinolates, carotenoids, indole-3-carbinol, are chemicals that enhance DNA repair, and acts as an estrogen antagonist slowing the growth of cancer cells [1]. Cauliflower is an economical crop, which can be produced under smallholder conditions [2]. Pakistan is included in top ten cauliflower producing countries in the world. [3]. Cauliflower is cultivated more intensively in Peshawar valley and attacked by different insect pests at different growing stages, which reduces its yield. The major insect pests include aphids, cabbage butterfly, cutworm and diamondback moth. Among which cabbage butterfly (*Pieris brassicae* L.) causes severe damage to cruciferous vegetables [4]. In Khyber Pakhthoonkhwa, *Pieris brassicae* is present throughout the year its single larva can consume 74–80 cm^2 leaf area and cause economic losses to cruciferous crops [5].

In order to get maximum yield and avoid excessive use of insecticides different resistant cultivars are sown. Variety selection and crop management practices are the main factors that contribute to growing profitable cauliflower [6].

The aim of our study was to evaluate commercially available cauliflower genotypes against *P. brassicae* infestation. This would be helpful in evolving resistant varieties of cauliflower against *P. brassicae*.

2. MATERIALS AND METHODS

The research studies on Population dynamics of *P. brassicae* on different cauliflower genotypes was conducted at the Agricultural Research Institute Tarnab, Peshawar during 2012-2014. The research trial consisted of field experiment.

2.1 Screening of Cauliflower Genotype

Ten commercially available genotypes of cauliflower, i.e. White corona, Snow mystique, Snow grace, Local, Clima, 5340, Sydney, Snow crown, White magic and AX-2034 were transplanted in the last week of September, 2012 on ridges in separate plots each measuring 4 m x 2 m. Plant to plant and row to row distance was kept at 45 cm and 75 cm, respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 30 experimental units and, in each experimental unit, there were 30 plants. Standard agronomic practices were applied to all the treatments throughout the crop growing season but no preventive measures were applied. The treatments were regularly inspected for appearance of pest and data was recorded weekly from appearance of larvae till harvest of crop. In each treatment, five healthy plants of uniform size were randomly selected for data recording. Total number of larvae on upper and lower leaf surfaces was calculated as larvae plant^{-1}. The weight of cauliflower fruits (curd) for each genotype was recorded separately after each picking and total yield was calculated by adding the yield from all picking for each treatment. The formula used for yield (kg ha^{-1}) calculation was:

Yield (kg ha^{-1}) =

$$\frac{\text{row length x row to row distance x No. of rows}}{0{,}000\ m^2}$$

2.2 Statistical Analysis

The data was analyzed by using Statistix 8.1 statistical package. The means were separated by Least Significant Difference (LSD) at 0.05 level of probability. The relationship of larval population and yield of cauliflower was carried out by simple correlation.

3. RESULTS

The larval population $plant^{-1}$ recorded on different cauliflower genotypes during 2012-13 and 2013-14 is given in Table 1. In 2012-13, significantly highest larval population $plant^{-1}$ was recorded on White magic (288 larvae $plant^{-1}$) while lowest on Snow mystique (58 larvae $plant^{-1}$). No larva was recorded on White corona, Clima, 5340, Sydney and AX-2034. In 2013-14, significantly more larvae $plant^{-1}$ were recorded on White magic (436 larvae $plant^{-1}$) and the lowest on White corona (32 larvae $plant^{-1}$). The average of two years results revealed that significantly higher no of 361.83 *P. brassicae* larvae $plant^{-1}$ were recorded on White magic and lower on White corona (15.83 larvae $plant^{-1}$). The interaction between year and genotype was significant at $P \le .01$.

It is clear from the Fig. 1 that during 2012-13, *P. brassicae* larvae first appeared on 22nd Nov on White Corona and Snow Grace. There were two peaks of larval population on each of the two genotypes. On White Corona, larval population peaked on 22nd Nov and 24th Jan. On Snow Greece first peak of larval was observed on 22nd Nov and second on 17th Jan. On Snow Mystique, larvae appeared on 27th Dec and disappeared on 31st Jan. On White Magic larvae appeared on 3rd Jan and peaked on 24th Jan. On Snow crown larvae appeared on 10th Jan and disappeared on 14th Feb 2014.

Response of *P. brassicae* larva to different cauliflower genotypes during 2013-14 showed that larvae appeared on 11th Oct and disappeared on 21st Feb (Fig. 2). On Clima, larvae appeared on 11th Oct and peaked on 15th Nov. On Local genotype, larvae appeared on 18th Oct, increased to its maximum no. on 1st Nov. On Snow Mystique, larvae appeared on 18th Oct, and peaked twice on 3rd Jan and 24th Jan. On genotype 5340 larvae appeared on 25th Oct, remained more or less similar and disappeared on 27th Dec. On Snow Greece larvae appeared on 20th Dec, increased afterwards with two peaks on 27th Dec and 17th Jan. On White Magic larvae appeared on 27th Dec, and peaked twice on 3rd Jan and 24th Jan.

Table 1. Mean *Pieris brassicae* larval population $plant^{-1}$ on 10 cauliflower genotypes during 2012-14

Genotype	Mean larval population $plant^{-1}$		
	2012-13	**2013-14**	**Mean (2012-14)**
White corona	0.0 f	32 e	15.833 g
Snow mystique	58 e	342 b	200.17 c
Snow grace	165 c	171 d	168.00 d
Local	252 b	176 d	214.00 b
Clima	0.0 f	223 c	111.50 e
5340	0.0 f	37 e	18.500 g
Sydney	0.0 f	0.0 f	0.0000 h
Snow crown	115 d	0.0 f	57.500 f
White magic	288 a	436 a	361.83 a
AX-2034	0.0 f	0.0 f	0.0000 h
LSD $_{(0.05)}$	4.1352	5.4835	3.3149
Years			
2012-13			87.80 b
2013-14			141.67 a
Significance level			**
Interaction			Significance level
Year x Genotype			**

Means in columns with similar letters are non significantly different at α =0.05 (LSD test)
***Significant at P ≤ .01*

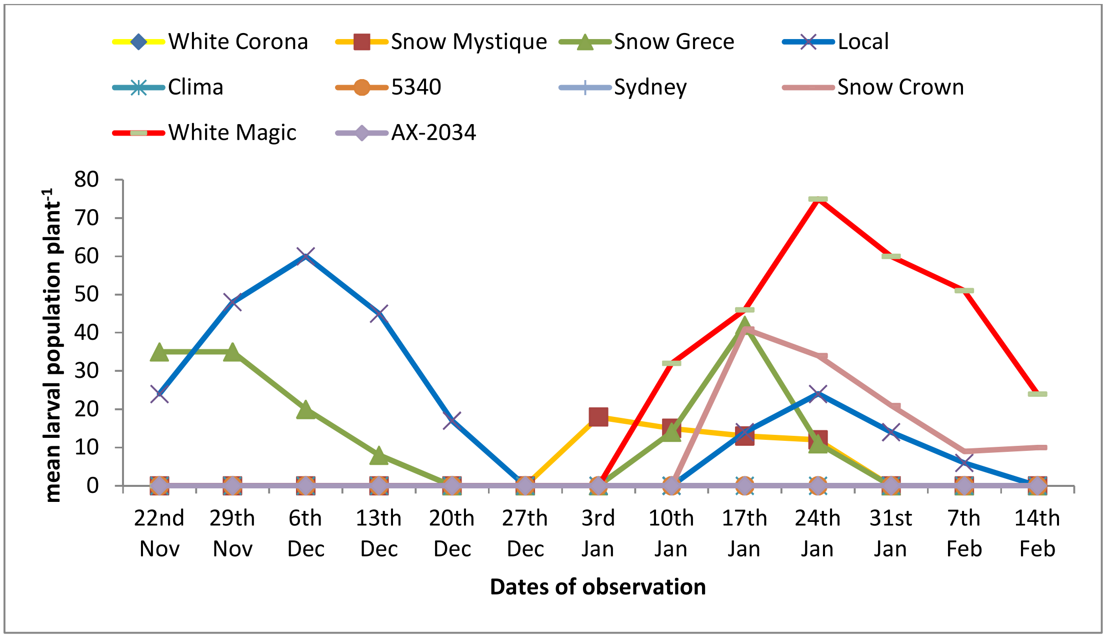

Fig. 1. Response of *Pieris brassicae* larval population on various cauliflower genotypes during 2012-13

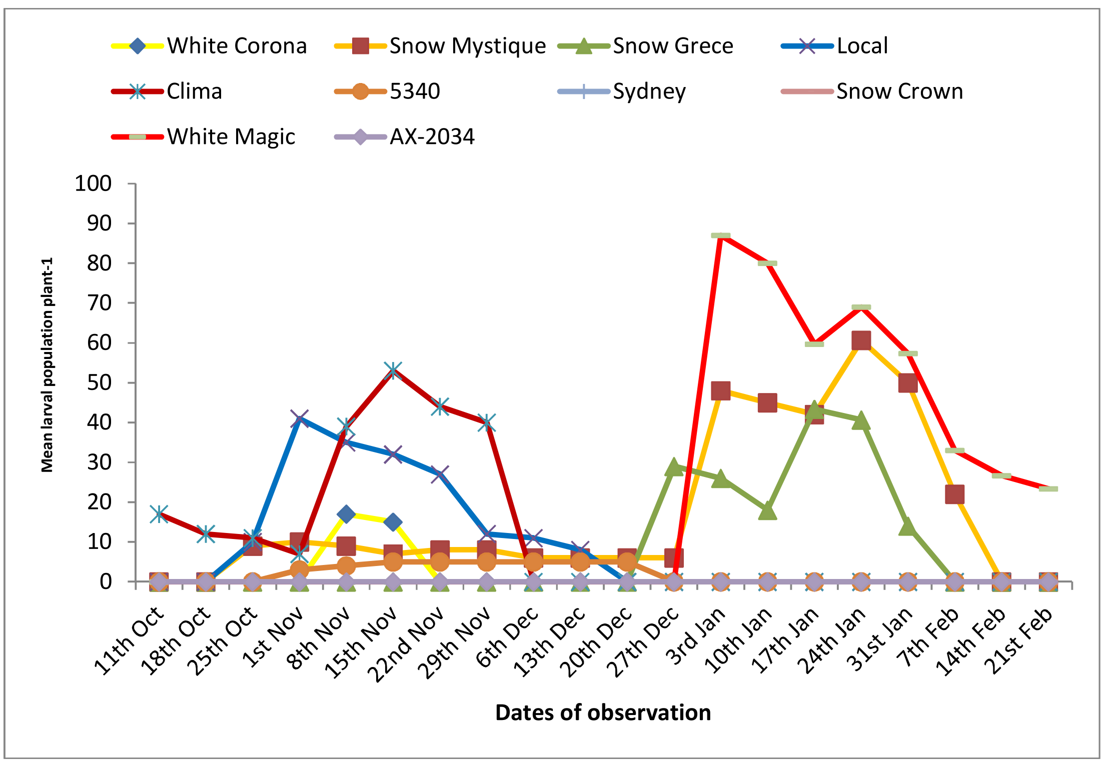

Fig. 2. Response of *Pieris brassicae* larval population on various cauliflower genotypes during 2013-14

3.1 Population trend of *P. brassicae* Larvae on Cauliflower Genotypes during 2012-13

P. brassicae larval population greatly fluctuated in 2012-13 (Fig. 3). First larvae were observed on 22nd Nov, 2012. Its population increased and then decreased in the coming weeks, till its disappearance on 27th Dec. Larvae appeared again after 27th Dec, increased to its peak during 17th Jan to 24th Jan, and declined afterwards till end of data recording (14th Feb, 2013).

3.2 Population Trend of *P. brassicae* Larvae on Cauliflower during 2013-14

In 2013-14 *P. brassicae* larvae appeared on 11th Oct (Fig. 4). Its population increased exponentially in the next few weeks to its first peak on 15th Nov, after which it declined abruptly to its minimum on 20th Dec. Larval population started increasing again from 20th Dec, till its second and 3rd peaks on 3rd Jan and 31st Jan, 2014, respectively. Its population declined afterwards till end of data recording (21st Feb, 2014).

3.3 Screening Cauliflower Genotypes on the Basis of Yield (kg ha^{-1})

Yield of cauliflower recorded during 2012-13 showed that mean yield (kg ha^{-1}) was significantly higher of 37617 kg ha^{-1} for White Magic and lower of 8950 kg ha^{-1} for White Corona (Table 2). In the year 2013-14 too yield of cauliflower was a significantly higher of 55483.33 kg ha^{-1} for White Magic and lower of 10875 kg ha^{-1} for White Corona. Mean yield of cauliflower for the year 2012-14 was significantly higher of 46550 kg ha^{-1} for White Magic and lower of 9913 kg ha^{-1} for White Corona. The interaction of Year x Genotype was significant at $p \leq 0.01$ and significant at $P \leq .05$.

Table 3 shows correlation between yield with overall larval number per genotype. Results of table reveal that genotype White Corona, Snow Mystique, Clima, 5340, Snow Crown has non significant correlation with larval population of *P. brassicae.* Snow Grace and White Magic have positive and significant correlation with infestation by *P. brassicae* at $P \leq .05$ and $P \leq .01$ respectively. But local genotype has negative and highly significant correlation. While no linear correlation of the production of Sydney and AX-2034 was found.

4. DISCUSSION

4.1 Screening on the Basis of *P. brassicae* Larval Population Plant^{-1}

P. brassicae larval population plant^{-1} recorded on ten cauliflower genotypes varied significantly during 2012-13 and 2013-14, where it was significantly higher (361.83 larvae plant^{-1}) on White magic and lower (15.83 larvae plant^{-1}) on White corona. No larvae were recorded on Sydney and AX-2034. The interaction between year and genotype was significant at $P \leq .01$.

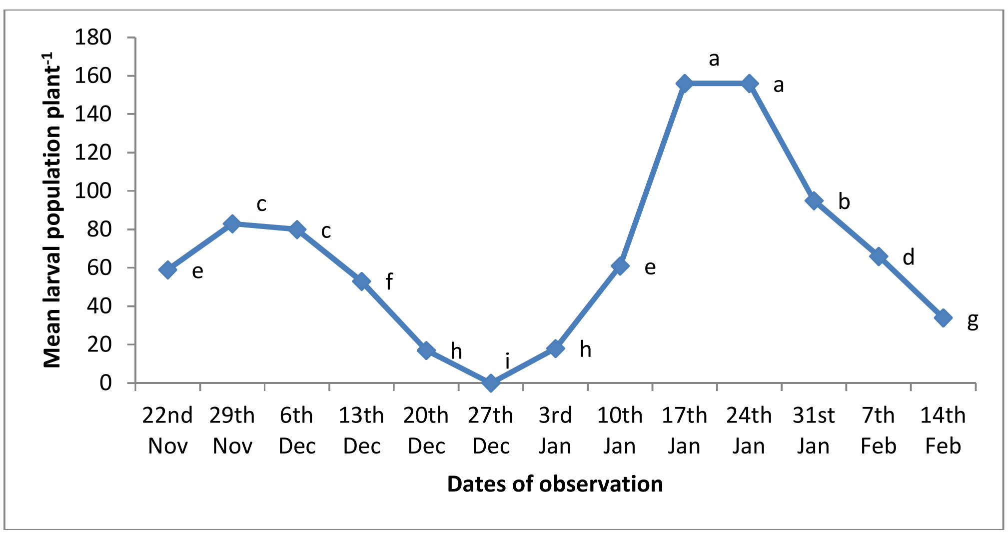

Fig. 3. Larval population trend of *Pieris brassicae* on cauliflower crop during 2012-13

Table 2. Mean yield (kg ha^{-1}) of 10 cauliflower genotypes during 2012-14

Genotype	Cauliflower yield (kg ha^{-1})		
	2012-13	**2013-14**	**Mean yield (2012-14)**
White corona	8950 g	10875 f	9913 e
Snow mystique	30750 b	29300 b	30025 b
Snow grace	13150 f	31350 b	22250 c
Local	9350 g	13550 ef	11450 e
Clima	15200 ef	16580 de	15890 d
5340	16133 de	16525 de	16329 d
Sydney	18800 cd	21850 c	20325 c
Snow crown	19150 c	21800 c	20475 c
White magic	37617 a	55483.33 a	46550 a
AX-2034	13650 ef	18500 d	16075 d
LSD $_{(0.05)}$	2964.6	3279.7	2134.3
Years			
2012-13			23581a
2013-14			18275b
Significance level			*
Interaction			Significance level
Year x Genotype			**

Means in columns with similar letters are non-significantly different at α = 0.05 (LSD test).
***Significant at P ≤ .01*
**Significant at P ≤ .05*

Table 3. Correlation between cauliflower yield with overall larval number per genotype

	Larval population									
	White corona	**Snow mystique**	**Snow grace**	**local**	**Clima**	**5340**	**Sydney**	**Snow crown**	**White magic**	**AX-2034**
Yield	0.6787 ns	-0.3516 ns	0.8129 *	-0.9285 **	0.5132 ns	0.2772 ns	---	-0.5746 ns	0.9864 **	---

*** Significant at P ≤ .01*
** Significant at P ≤ .05*
ns Non significant

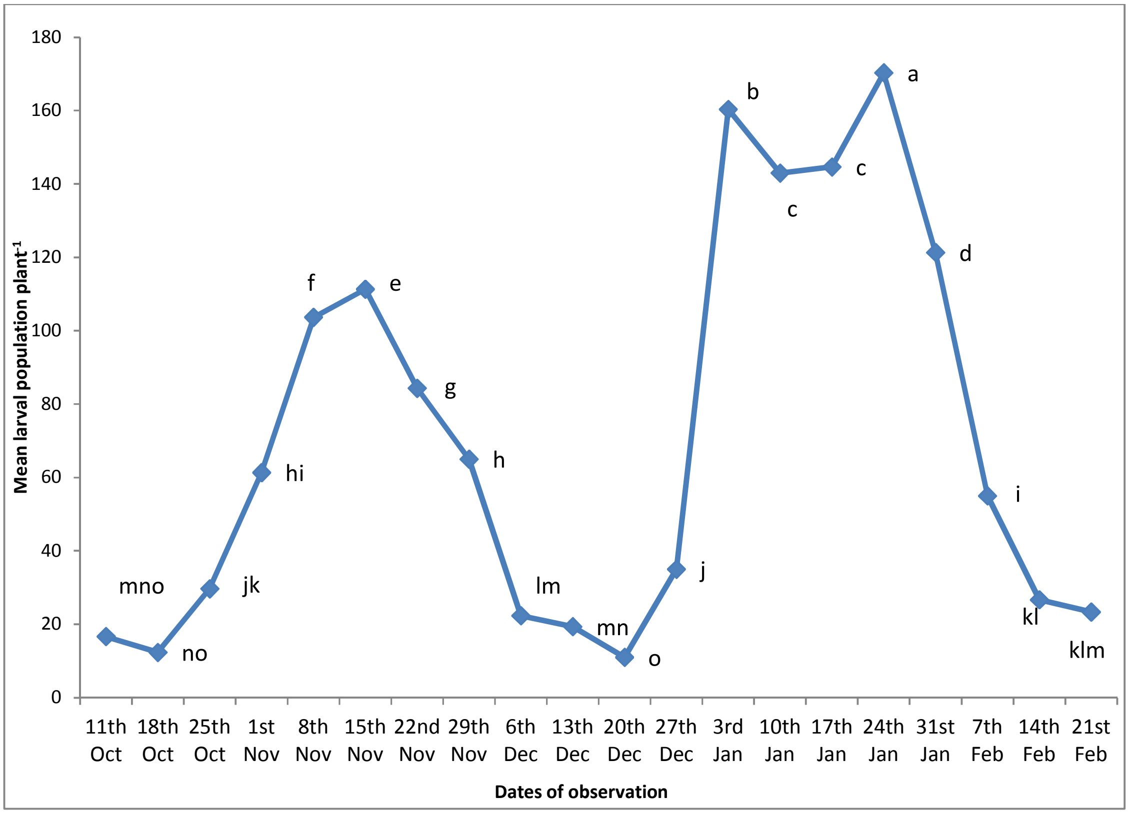

Fig. 4. Larval population trend of *Pieris brassicae* on cauliflower crop during 2013-14

The present results are comparable to that of some earlier researchers. [5] reported that cauliflower cultivar Snowball has maximum 247.34 larvae plant^{-1} and minimum 0.67 larvae plant^{-1} on Meigettsal. The variation in larval population may be due to physical plant characters, especially the plant height and leaf length and chemical plant factors especially protein content. It was observed during study that White magic has maximum plant height and maximum leaf length while White corona, Sydney and AX-2034 have minimum plant height and minimum leaf length. Also, protein content was more in White magic then White corona, Sydney and AX-2034. Variation in larval population may be due to different ecological conditions, physical and biochemical factors of plant and biotic and abiotic factors [7,8]. [9] reported that *P. brassicae* oviposition is a cue that correlate with the survival of larva. The oviposition site helps the young larvae in seeking out appropriate hosts because for the slow moving larvae it is difficult to reach its host plant and the young larvae usually show high mortality if forced to leave their original host. [10] found that *P. brassicae* laid eggs in batches on host plant in spring. After hatching larvae feed on host plant gregariously. At older stage they disperse on whole plant and in last instar they start searching for pupation site.

According to [11] *P. brassicae* preferred feeding on young leaves that were characterized by higher glucosinolate and nitrogen concentrations in comparison. Reduced levels of defense compounds as well as carbon and nitrogen in old leaves have previously been described for several Brassicales, including *B. oleracea* [12,13]. Higher levels of defense compounds in younger, more valuable leaves [14], are expected according to the optimal defense hypothesis, which states that plant defenses are adjusted to the risk of damage, the cost of a module and its value to a plant [15,16]. However, specialist herbivores, such as *P. brassicae*, often rely on these compounds as host recognition cues and may be attracted to high levels.

Gutbrodt et al. [11] stated that specialist herbivores, such as *P. brassicae*, often rely on higher glucosinolate and nitrogen concentrations of compounds as host recognition cues and may be attracted to high levels of specific defense compounds in young leaves, resulting in an inverse effect to the optimal defense hypothesis [17,18]. Furthermore, *P. brassicae* as a specialist herbivore is known to tolerate high concentrations of glucosinolates due to successful detoxification mechanisms [19] and may even gain a nutritional benefit when feeding on diets of higher glucosinolate concentrations [20]. [21] screened nineteen genotypes and one cross in 1982, 50 genotypes and four crosses in 1983, and 41 genotypes and 23 crosses in 1984 under field conditions against *P. brassicae* in Kulu Valley, India. The varieties were categorized into different grades of resistance depending upon the larval population per plant. None of the genotypes was immune to the pest. 'Red Pickling' and 'Red Rock Mammoth' were highly resistant in 1983 and 1984 but moderately resistant in 1982. 'Red Drum Head' was highly resistant in 1984 but moderately resistant in 1982 and 1983. 'EC 90730' and 'ARU Glory' were moderately resistant in 1984.

4.2 Population Trend of *P. brassicae*

In our study *P. brassicae* larvae appeared on 22nd Nov and 11th Oct and after attaining different population peaks it declined and disappeared on 14th Feb and 21st Feb during 2012-13 and 2013-14, respectively. [5] reported that infestation of *P. brassicae* in Tarnab, Peshawar started at the last week of Oct. It increased gradually and attained its peak during 1st week of Nov. and then decreased gradually till the end of Dec. Maximum larval population 86.67 larvae plant^{-1} was observed in 1st week of Nov and minimum 0.67 larvae plant^{-1} was observed in 1st week of Dec. The fluctuation in larval population during our study might be due to high mobility of larvae in older stage and overlapping generations of *P. brassicae*. [23] reported that full grown larvae usually leave the host plant and crawl 10 m or more on ground and 5 m above the ground on the wall or tree in search for pupation site. [24] reported that high temperatures (above 26℃) along with low air humidity (upto 60%) are adverse conditions for *P. brassicae* development while its distribution is restricted at low temperatures (-20℃ and lower).

4.3 Screening Cauliflower Genotypes on the Basis of Yield (kg ha^{-1})

Cauliflower yield during 2012-13 and 2013-14 was significantly higher for White Magic and lower for White Corona. Combined mean yield of cauliflower for the year 2012-14 was significantly higher of 46550 kg ha^{-1} for White Magic and lower of 9913 kg ha^{-1} for White Corona. The interaction of Year x Genotype was significant at $P \le .01$ as well as significant at $P \le .05$.

The ten cauliflower genotypes yielded differently in our results. Although this variation may be due to genetic yield traits, plant height and leaf length as in White magic, but it might be due to variable infestation of *P. brassicae* on it. Our results showed that White magic proved to be a tolerant genotype as it had maximum larval population plant^{-1} and maximum yield. These findings are comparable to those of [22] who reported that the leaf damage of two cauliflower varieties, Snowball and Snowdrift due to *P. brassicae* larvae were highly significant but the final yield (head weights) were not significant. While Local genotype was found susceptible genotype as it had 2nd maximum larval population plant^{-1} but minimum yield. Genotypes Sydney and AX-2034 with no larva plant^{-1} and White corona with lowest larval population plant^{-1} yielded lowest yield. The reason for low yield might be due to genetic yield traits, lowest plant height and leaf length. As plant height and leaf length is positively correlated with cauliflower yield.

4.4 Correlation between Larvae Plant^{-1} and Yield

Our results reveal that genotype White Corona, Snow Mystique, Clima, 5340, Snow Crown has non significant correlation with larval population of *P. brassicae.* Which is in compliance with [22] where, the predictive equations for the head weights (mg), as affected by the number of insects, were y=674.5-1.92x; r=-0.71 and y=939.54-5.66x; r=0.97 for Snowball and Snowdrift, respectively. The leaf damage due to varieties was highly significant but the final yield (head weights) was not.

5. CONCLUSION

It is concluded that all heighted genotypes have more larval population then short height genotypes. White magic was proved itself as a tolerant genotype having more *Pieris brassicae* larval population per plant but give maximum yield too.

ACKNOWLEDGEMENT

This study is a part of PhD Dissertation Research and was sponsored by Higher Education Commission, Islamabad which is greatly acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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