(35.56–107.86%) for fruit yield per plant revealed that there is great scope for improving pumpkin yield through heterosis breeding.

1. Jha, A., Pandey, S., Rai, M., Yadav, D. S. and Singh, T. B., Heterosis in relation to combining ability for flowering behaviors and yield parameters in pumpkin. *Vegetable Sci.*, 2009, **36**, 332–335.
2. Pandey, S., Jha, A., Kumar, S. and Rai, M.. Genetics and heterosis of quality and yield of pumpkin. *Indian J. Hortic.*, 2010, **67**(3), 333–338.
3. Jahan, T. A., Islam, A., Rasul, M. G., Mian, M. A. K. and Haque, M. M., Heterosis of qualitative and quantitative characters in sweet gourd (*Cucurbita moschata* Duch.ex Poir) *Afr. J. Food Agric., Nutr. Dev.*, 2012, **12**(3), 47–51.
4. Xin-zheng, L. I., Zhen-wei, L. I. U., Li, S. U. N. Xiao-hua, D. U. and Jun-guo, Z. H. O. U., The combining ability analysis and the heterosis performance of Pumpkin. *Acta Agric. Bor-Sin.*, 2013, **28**(1), 61–68.
5. Nisha, S. K. and Veeraragavathatham, D., Heterosis and combining ability for fruit yield and its component traits in pumpkin (*Cucurbita moschata* Duch. ex Poir.). *Adv. Appl. Res.*, 2014, **6**(2), 158–162.
6. Tamilselvi, N. A., Jansirani, P. and Pugalendhi, L., Estimation of heterosis and combining ability for earliness and yield characters in pumpkin (*Cucurbita moschata* Duch. Ex. Poir). *Afr. J. Agric. Res.*, 2015, **10**(16), 1904–1912.
7. Ranganna, S., *Manuals of Analysis of Fruits and Vegetable Products*, Tata McGraw Hill, New Delhi, 1979.
8. Ranganna, S. C.. *Handbook of Analysis and Quality Control of Fruit and Vegetable Products*, Tata Mc Graw Hill, Calcutta, 1991, pp. 279–309.
9. Ranganna, S. C., *Handbook of Analysis and Quality Control of Fruit and Vegetable Products*, Tata McGraw Hill, Calcutta, 1997, pp. 269–299.
10. Hayes, H. K., Immer, F. and Smith, D. C., *Methods of Plant Breeding*, McGraw-Hill Book Co, New York, 1955, pp. 52–66.
11. Singh, R. K.. Studies on heterosis, combining ability and gene action in bottle gourd (*Lagenaria siceraria* (Molina) Standl.) M Sc thesis, Submitted to N.D. Univ. of Agric. & Tech. Kumarganj, Faizabad, 2008.
12. Maurya, P. K., Heterosis and combining ability analysis in bottle gourd [*Lagenaria siceraria* (Molina) Standl.] M Sc thesis, submitted to N.D. Univ. of Agric. & Tech. Kumarganj, Faizabad, 2010.

Received 4 May 2018; revised accepted 6 July 2018

doi: 10.18520/cs/v115/i8/1550-1556

Estimates of losses caused in paddy due to rice hispa, *Dicladispa armigera* (Oliver) (Coleoptera: Chrysomelidae)

Urvi Sharma[1,]* and Ajai Srivastava[2]

[1]Department of Entomology, Chaudhary Sarwan Kumar Himachal Pradesh Krish Vishvavidyalaya (CSKHPKV), Palampur 176 062, India
[2]Rice and Wheat Research Centre, CSKHPKV, Malan 176 047, India

Studies were undertaken for two consecutive years (*kharif* 2015 and 2016) at the CSK Himachal Pradesh Krishi Vishvidyalaya, Rice and Wheat Research Centre, Malan (Himachal Pradesh, India) under field conditions using paddy variety 'Kasturi Basmati'. Losses in paddy due to rice hispa, *Dicladispa armigera* (Oliver) were quantified in terms of release density (number of adults per tiller) and phenological stages of crop. Results revealed that both these aspects significantly influenced leaf damage as well as yield of paddy. Early stage release (20 DAT, days after transplanting) contributed to maximum leaf damage (69.9 PLDI (per cent leaf damage index)) and at the same time exerted a significant negative influence on various yield components, viz. number of tillers, panicles, grains and grain weight (g) for which the respective regression coefficients were 5.82, 5.73, 441.4 and 8.06, respectively (per 4 rice hills).

Keywords: Grain number, grain weight, hispa release density, leaf damage, panicles, tillers, yield components.

MANY insect-pests of paddy continue to be the key biotic constraint in achieving its potential production. With the changing insect-pest scenario, many minor pests are now emerging as pests of major importance. Rice hispa, *Dicladispa armigera* (Oliver) (Coleoptera: Chrysomelidae) is one among them. It was earlier a pest of sporadic occurrence, but has now been reported to cause severe losses, especially in Bangladesh, India and Nepal[1,2]. In India, losses in rice (28–100%) due to this pest were recorded by various studies in different rice growing states[2–4]. Though the losses were quantified in different studies, limited studies provide the exact estimates. Hence this study was undertaken to quantify yield losses caused due to rice hispa based on release density and phenological stage of paddy crop.

Yield losses were assessed in terms of the relationship of hispa density and phenological stage of paddy (cv. Kasturi Basmati) at the experimental farm of CSKHPKV Rice and Wheat Research Centre, Malan (Himachal Pradesh) for two *kharif* seasons (2015 and 2016). The experiment was carried out by dividing the experimental field into three major plots (or ranges, measuring

*For correspondence. (e-mail: urvi.urvi.sharma.sharma@gmail.com)

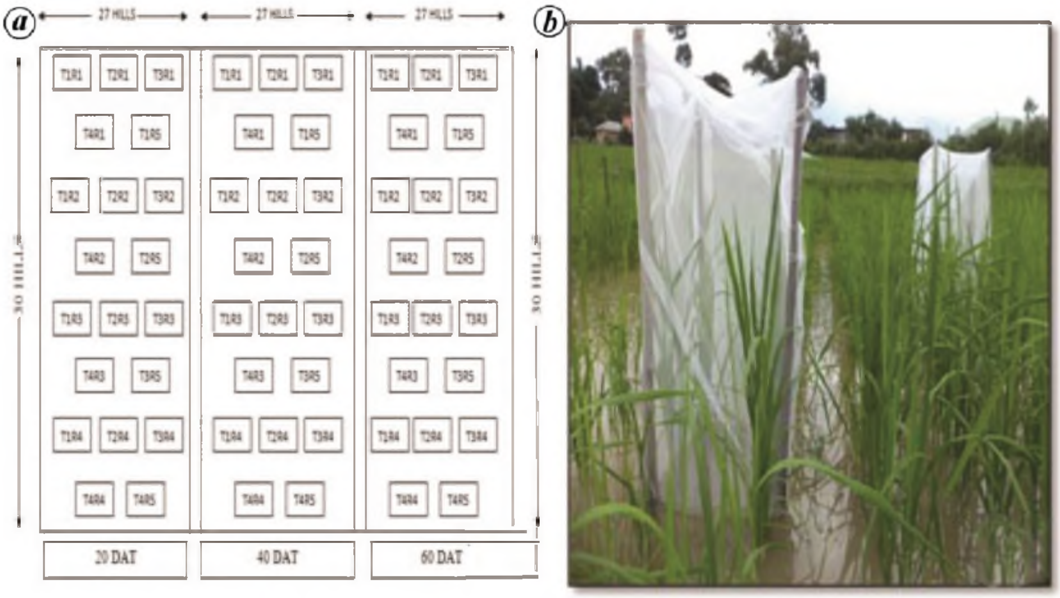

Figure 1 *a*, *b*. Layout of yield loss estimation trials.

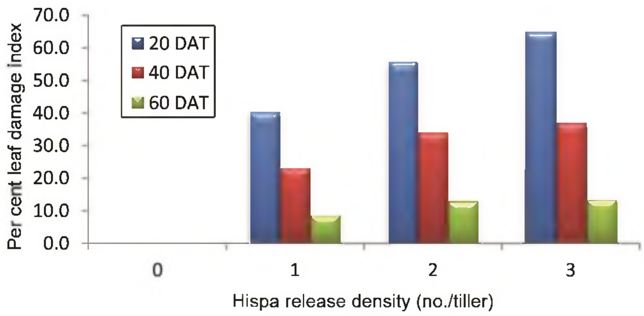

Figure 2. Relationship between per cent leaf damage index and hispa density at different release stages of paddy.

24.8 sq. m each, with 30 lines and 27 hills, spaced at 20 × 15 cm). These major plots (or ranges) were further marked as sub-plots, according to the required treatments and replications (Figure 1 *a*). Each major plot (range) consisted of four different treatments (release densities of 0, 1, 2 and 3 hispa adults per tiller) and every treatment consisted of four rice hills covered by nylon mesh, supported by four bamboo sticks at corners (Figure 1 *b*). Five replications (each consisting of 4 rice hills per caged structure) of every treatment were maintained as per randomized block design (RBD). Hispa releases were made at three phenological stages of paddy, viz. 20, 40 and 60 days after transplanting (DAT) in the respective ranges. Uniform aged adults multiplied in the net house were used for this purpose.

After 10–15 days of confinement, when the desired level of leaf infestation (damage) was achieved, the beetles as well as nylon mesh were removed. In order to control the undesirable insect-pests and diseases in the experimental plot, chloropyriphos @ 2.5 ml/l and fungicide (Blitox 50 @ 3g/l) were applied. However, the time of insecticide application was dependent on the time of hispa infestation. Insecticide was applied either at least 20 days before or after hispa infestation schedule. The observations were recorded to assess the leaf damage and reduction in yield components as given below.

After the removal of hispa beetles and cages, the severity of damage was estimated based on scoring (0 to 4). Then the number of leaves with degree of damages corresponding to the score was counted. The score represented the following degree of damages: (1) 25% of infested or damaged leaf area (2) 26–50% of infested or damaged leaf area; (3) 51–75% of infested or damaged leaf area; (4) 76–100% of infested or damaged leaf area.

Further, to facilitate comparison between leaf damage at different crop growth stages, damage index was calculated following the formula outlined in ref. 5 with slight modifications

Leaf damage index (LDI)

$$= s_1 I_1 + s_2 I_2 + s_3 I_3 + s_4 I_4 + s_5 I_5,$$

where $s_1 = 0$, $s_2 = 1$, $s_3 = 2$, $s_4 = 3$, $s_5 = 4$ (scores for damage rates) and I_1, I_2, I_3, I_4 and I_5 were the number of leaves under that damage category (or score). Also, the per cent leaf damage index (PLDI) was calculated by the formula

$$\text{PLDI} = (\text{LDI}/NK) \times 100,$$

where N is the total number of leaves under different score classes and K is the highest grade of damage score.

Table 1. Paddy leaf damage as influenced by hispa density and phenological stage of release (pooled values for *kharif* 2015 and 2016)

Release density (no./tiller)	20 DAT 0*	20 DAT 1	20 DAT 2	20 DAT 3	20 DAT 4	20 DAT Mean	40 DAT 0*	40 DAT 1	40 DAT 2	40 DAT 3	40 DAT 4	40 DAT Mean	60 DAT 0*	60 DAT 1	60 DAT 2	60 DAT 3	60 DAT 4	60 DAT Mean
0	77.9	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	149.0	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	190.1	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
1	37.4	1.3 (1.47)	4.2 (2.14)	12.3 (3.49)	17.6 (4.17)	8.9 (2.82)	90.6	17.0 (4.09)	23.7 (4.54)	18.7 (4.30)	5.5 (2.33)	16.2 (3.82)	140.2	24.5 (4.88)	11.9 (3.33)	3.3 (1.96)	0.6 (1.21)	8.9 (2.82)
2	29.5	1.4 (1.47)	3.7 (2.00)	10.6 (3.11)	33.7 (5.77)	12.4 (3.09)	65.2	24.5 (4.76)	33.1 (5.75)	21.7 (4.64)	15.0 (3.71)	23.6 (4.72)	108.2	58.1 (7.68)	14.5 (3.84)	1.5 (1.46)	0.2 (1.07)	12.4 (3.09)
3	18.3	2.4 (1.64)	4.6 (2.11)	19.3 (4.31)	33.0 (5.71)	14.8 (3.45)	54.0	27.4 (5.11)	51.5 (7.21)	26.0 (5.00)	10.0 (2.95)	28.7 (5.07)	97.5	72.3 (8.54)	10.4 (3.28)	0.8 (1.28)	0.0 (1.00)	14.8 (3.45)
Mean		1.3 (1.40)	3.1 (1.81)	10.6 (2.98)	21.1 (4.17)			17.2 (3.74)	27.1 (4.62)	16.6 (3.73)	7.6 (2.50)			38.7 (5.52)	9.2 (2.87)	1.4 (1.42)	0.2 (1.07)	
For comparison																		
CD (0.05)																		
A (damage scores, 1–4)				(0.41)						(0.55)						(0..30)		
B (hispa release density)				(0.41)						(0.55)						(0.30)		
A × *B*				(0.82)						(1.10)						(0.59)		

Number of leaves under different damage scores at different infestation stages (Damaged leaves).

Figures in parentheses are square root transformed values; *Score 0 represents mean number of uninfested/undamaged leaves and its corresponding values were not included in factorial analysis; score 1, 2, 3 and 4 represented 1–25%, 26–50%, 51–75% and 76–100% infested/damaged leaf area respectively; DAT, Days after transplanting (i.e. stage of release).

Table 2. Effect of hispa release density at different phenological stages of release on various yield components of paddy (pooled values of *kharif* 2015 and 2016)

Release density (no./tiller)	Under different release stages (per 4 rice hills)															
	Tillers (number)				Panicles (number)				Grain number				Grain weight (g)			
	20 DAT	40 DAT	60 DAT	Mean	20 DAT	40 DAT	60 DAT	Mean	20 DAT	40 DAT	60 DAT	Mean	20 DAT	40 DAT	60 DAT	Mean
0	36.9 (6.15)	38.1 (6.24)	36.7 (6.13)	37.2 (6.17)	36.5 (6.11)	37.4 (6.19)	36.1 (6.08)	36.7 (6.13)	2604.8 (50.93)	2548.1 (50.38)	2566.2 (50.60)	2573.0 (50.63)	46.7 (6.89)	47.2 (6.92)	47.8 (6.97)	47.2 (6.93)
1	23.3 (4.92)	36.6 (6.13)	36.8 (6.13)	30.7 (5.59)	23.1 (4.90)	35.9 (6.07)	36.5 (6.11)	31.8 (5.69)	2137.4 (46.12)	2450.4 (49.48)	2469.3 (49.55)	2352.4 (48.38)	37.7 (6.20)	45.1 (6.79)	46.6 (6.86)	43.1 (6.62)
2	20.6 (4.64)	31.4 (5.68)	36.9 (6.15)	29.4 (5.47)	20.1 (4.59)	30.7 (5.62)	36.9 (6.15)	29.2 (5.45)	1663.5 (40.75)	1965.7 (44.25)	2385.8 (48.81)	2005.0 (44.60)	27.7 (5.34)	32.6 (5.77)	44.2 (6.71)	34.8 (5.94)
3	18.4 (4.40)	33.0 (5.82)	37.8 (6.21)	29.7 (5.48)	18.4 (4.40)	32.2 (5.75)	37.1 (6.16)	29.2 (5.44)	1291.4 (35.89)	1847.7 (42.88)	2487.5 (49.76)	1875.5 (42.84)	23.2 (4.91)	28.4 (5.41)	45.4 (6.79)	32.3 (5.70)
Mean	24.8 (5.03)	34.8 (5.97)	37.1 (6.16)		24.5 (5.00)	34.1 (5.91)	36.7 (6.12)		1924.3 (43.42)	2203.0 (46.75)	2477.2 (49.68)		33.8 (5.83)	38.3 (6.22)	46.0 (6.83)	
For comparison																
CD (0.05)																
A (DAT)		0.16)				(0.15)				(1.36)				(0.22)		
B (hispa release density)		(0.18)				(0.18)				(1.57)				(0.25)		
A × *B*		(0.31)				(0.31)				(2.73)				(0.44)		

Figures in parentheses are square root transformed values; DAT, days after transplanting (stage of infestation).

Table 3. Regression equations[a] showing relationship among various yield components and hispa density at different release stages of paddy

Infestation stage	Tillers (no./4hills)	Panicles (no./4hills)	Grain number (no./4hills)	Grain weight (no./4hills)
20 DAT	$r = -0.904^*$; $y = -5.82x + 33.53$ $R^2 = 0.817$	$r = -0.900^*$; $y = -5.73x + 33.12$ $R^2 = 0.810$	$r = -0.998^*$; $y = -441.4x + 2586$ $R^2 = 0.997$	$r = -0.989^*$; $y = -8.06x + 45.91$ $R^2 = 0.977$
40 DAT	$r = -0.852$; $y = -2.05x + 37.85$ $R^2 = 0.810$	$r = -0.859$; $y = -2.08x + 37.17$ $R^2 = 0.738$	$r = -0.959^*$; $y = -258.5x + 2590$ $R^2 = 0.921$	$r = -0.962^*$; $y = -6.87x + 48.64$ $R^2 = 0.924$
60 DAT	$r = 0.866$; $y = 0.34x + 36.54$ $R^2 = 0.750$	$r = 0.989^*$; $y = 0.34x + 36.14$ $R^2 = 0.979$	$r = -0.557$; $y = -31.96x + 2525$ $R^2 = 0.310$	$r = -0.802$; $y = -0.98x + 47.44$ $R^2 = 0.643$

[a]Derived from values of Table 2; x, hispa release density (no./tiller); y, respective yield component; r, correlation coefficient; R^2, coefficient of determination; *Significant at 5%.

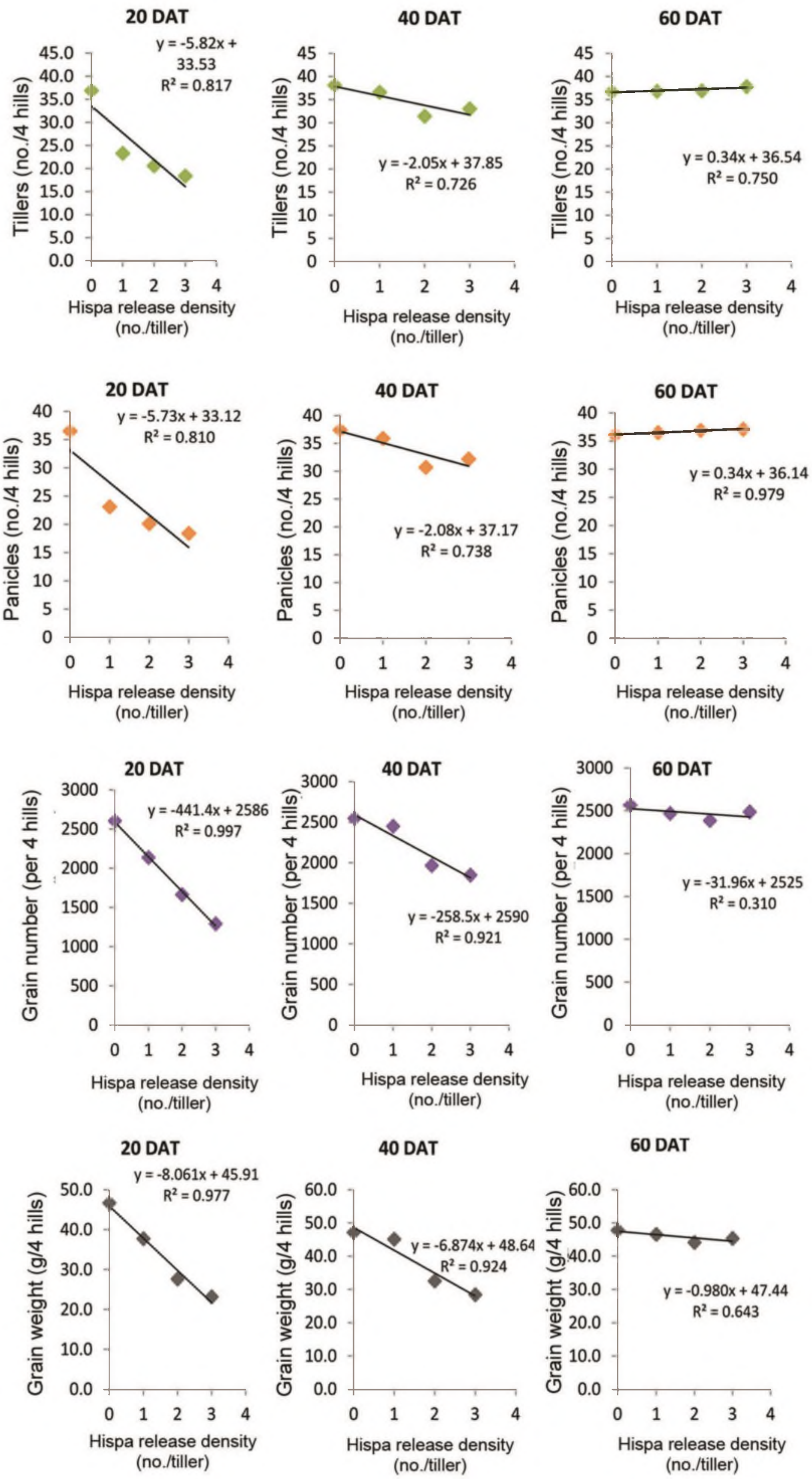

Figure 3. Linear regression analysis of yield components of paddy and hispa density at different release stages.

At crop maturity, total tillers and panicles per four hills were recorded and each hill in the treatment was threshed separately and grain yield per four hills (in terms of number and weight) was worked out.

The data collected on different parameters were analysed with the help of factorial randomized block design using the software CPCS-1 (ref. 6) and the mean values were further subjected to simple linear regression analysis according to the formula described by the workers to determine the relationship between hispa density and yield components[7].

When hispa release was made at 20 DAT, the number of damaged leaves at different release densities (1–3) varied from 1.3 to 2.4, 3.7 to 4.6, 10.6 to 19.3 and 17.6 to 33.0 against the damage score 1, 2, 3 and 4 respectively. Rice hills kept free from hispa release remained devoid of any damage. The mean number of damaged leaves varied significantly under different damage scores with the highest of 21.1 damaged leaves observed under score 4 followed by 10.6 under score 3. Almost a similar trend was observed when release was made at 40 DAT; however when released at 60 DAT, the maximum damage leaves were under score 1 (38.7) as shown in Table 1.

The overall damage to paddy leaves (per 4 rice hills) at different release stages was worked out in terms of LDI and PLDI calculated from values in Table 1. The LDI (number per 4 hills) varied from 117.0 to 201.5, 142.5 to 248.4 and 60.6 to 95.5 when release was made at 20, 40 and 60 DAT respectively. There was a proportional increase in LDI with increase in release level. Similarly, PLDI (%) varied from 8.4 to 40.2, 12.7 to 55.6 and 13.2 to 64.9 at 1, 2 and 3-HRD (hispa release density) respectively. With delay in release, the respective values for PLDI decreased. The maximum of 64.9 PLDI was observed at the early stage of release (20 DAT) when 3 hispa per tiller were released and the minimum PLDI (8.4) against 1 HRD, when release was made at 60 DAT (Figure 2).

Limited studies with regard to leaf damage assessment are available in the literature. However, other studies reported that different densities of rice hispa caused 9–89% leaf damage at 20 DAT, 5–69% at 40 DAT and 3–36% at 60 DAT, suggesting that with advancing age there was increased resistance in plants which corroborates our findings[8].

Different densities of hispa release, stages of release and their interactions were significant during the two years. The pooled analysis for the two years indicated that the mean number of tillers decreased significantly with increase in hispa density. Minimum tillers (29.4) were produced against the release density of 2 hispa per tiller which was statistically at par with 3 HRD that produced 29.7 tillers. A maximum of 37.2 tillers were recorded when no hispa was released. With respect to the stage of release, early stage release (20 DAT) recorded lowest mean number of tillers (24.8). Almost a similar trend was obtained for panicles and grain yield as depicted in Table 2. However, no significant differences (with respect to any of the yield component) were observed among infestation levels (0–3) at delayed infestation (60 DAT).

An inverse and significant relationship ($P < 0.05$) was observed between the hispa release density and various yield components when release was made at an early stage of 20 DAT. With the increase in density of 1 hispa per tiller, the respective rice hills produced 5.82, 5.73, 441.4 and 8.06 g lesser number of tillers, panicles, grain number and grain weight respectively. However, when the release was delayed till 40 DAT, there was a significant negative relationship only with two yield components, viz. grain number and grain weight, having respective regression coefficients of 258.5 and 6.87. At 60 DAT, when the release was executed, the relationship with regard to tillers and panicles was positive. With respect to grain number and weight, it was negative, being insignificant ($P < 0.05$), implying that at delayed release stage (60 DAT) there was no more significant damage inflicted due to rice hispa (Table 3 and Figure 3).

The present studies with regard to yield losses inflicted by rice hispa, are more or less, in line with previous findings. The experiments carried out by some studies revealed that when 64 adult hispa per m^2 were exposed at booting, tillering, flowering and milk stage, it resulted in potential yield losses of 4.5, 3.1, 2.2 and 2.1 kg per ha which are partly in conformity with current findings[9]. However, in the present study, no yield losses at delayed release stage (60 DAT) were recorded.

The effect of hispa infestation on tillering, panicle formation and grain yield was observed at active tillering stage (20–35 DAT), where hispa infestation resulted in reduced number of panicles[5]. Also, the grain yield varied with the release stage but not with the densities of hispa. However, in our studies, release made at 20 and 40 DAT showed more or less significant variation in yield with the release densities as well. The rice yield varied significantly with hispa infestation level (9 and 29 g grain yield at 20 and 60% infestation respectively)[10] which supports the present findings.

Thus, the present study which is an attempt to quantify losses caused in paddy due to rice hispa explains that early stage infestation is more critical compared to later advanced stages. However, further studies with comparative estimates in unlimited and limited exposures need to be explored.

1. Polaszek, A. P., Rabbi, M. F., Islam, Z. and Buckley, Y. M., *Trichogramma zahiri* (Hymenoptera: Trichogrammatidae) an egg parasitoid of the rice hispa *Dicladispa armigera* (Coleoptera: Chrysomelidae) in Bangladesh. *Bull. Entomol. Res.*, 2002, **92**, 529–537.
2. Hazarika, L. K., Deka, M. and Bhuyan, M., Oviposition behavior of the rice hispa *Dicladispa armigera* (Coleoptera: Chrysomelidae). *Int. J. Trop. Insect Sci.*, 2005, **25**, 1–6.

3. Nath, R. and Dutta, B., Economic injury level of rice hispa, *Dicladispa armigera* (Olivier). *J. Agric. Sci. Soc. North-East India*, 1997, **10**, 273–274.
4. Deka, M. and Hazarika, L. K., Mating behavior of *Dicladispa armigera* (Coleoptera: Chrysomelidae). *Ann. Entomol. Soc. Am.*, 1996, **89**, 137–141.
5. Haque, S. S., Relationship between rice hispa, *Dicladispa armigera* (Oliver), damage and grain yield. M Sc thesis, Department of Entomology, Banglabandhu Shaikh Mujibur Rahman Agricultural University, Bangladesh, 2000, p. 56.
6. Singh, S., Singh, T., Bansal, M. L. and Kumar R., *Statistical Methods for Research Workers*, Kalyani Publishers, New Delhi, 1991.
7. Gomez, K. A. and Gomez, A. A., *Statistical Procedures for Agricultural Research*, John Wiley, New York, 1984, 2nd edn, p. 680.
8. Haque, S. S. and Islam, Z., Effects of rice hispa damage on grain yield. *Int. Rice Res. Notes*, 2001, **26**(2), 44–45.
9. Gyawali, B. K., Yield loss of rice due to rice hispa, *Dicladispa armigera* (Olivier). In Ecological Agriculture and Sustainable Development: Volume 1. Proceedings of an International Conference on Ecological Agriculture: Towards Sustainable Development, Chandigarh, India, 15–17 November 1997–1998, 1998, pp. 475–481.
10. Nath, R. K. and Dutta, B. C., Yield loss assessment and economic injury level of rice hispa, *Dicladispa armigera* (Oliv.) (Coleoptera: Chrysomelidae). *Res. Crops*, 2002, **3**(1), 154–158.

ACKNOWLEDGEMENTS. We thank DST-INSPIRE, New Delhi and mentors and staff of CSKHPKV, Palampur, HP for facilitating various endeavours and providing logistic support for carrying out this research.

Received 6 March 2018; revised accepted 17 July 2018

doi: 10.18520/cs/v115/i8/1556-1562

Effect of light interception and penetration at different levels of fruit tree canopy on quality of peach

Yamini Sharma*, Harminder Singh and Sompal Singh

Punjab Agricultural University, Ferozepur Road, Ludhiana 141 004, India

Peach trees were trained to four systems, viz. Y-shaped, Hedge row, Espailer and V trellis. Irrespective of the training system in upper canopy total PAR increased from January to July and then a decrease was recorded. However, in lower canopy an inverse trend was recorded. The total radiation intercepted during the year was maximum (59.99%) in Espailer system followed by V trellis (57.76%). Minimum radiation interception (49.05%) was recorded in trees trained to Hedge row. Upper canopy part of the tree received more PAR which influenced fruit quality in terms of size, weight, acidity, total sugars, firmness.

Keywords: Canopy management, quality improvement, Peach, PAR, training systems.

THE light environment in which a fruit develops will affect its size, shape and quality. Improvement of light penetration within tree canopies has been a constant objective of fruit tree architecture manipulation through the setting up of training systems. Quality peaches require more light exposure than many fruit crops to grow and mature. The achievement of an adequate yield and good quality of fruit and the setting of flower buds depend on light conditions, which can be improved through the formation of an adequate tree canopy[1,2]. Overall effects of shade on fruit quality are very clear, but the processes responsible for these effects are not. Shade reduces photosynthetically active radiation (PAR) and, therefore, reduces local photosynthetic activity, canopy temperature[3] and changes wavelength distribution of transmitted light. Recently, different training systems, i.e. Y-shaped, Espailer, Hedge row, and V-shaped were proposed to improve fruit size and colour as well as return-bloom as compared to conventional central leader trained trees with equivalent.

The experiment was conducted at the Fruit Research Farm of the Department of Fruit Science, Punjab Agricultural University, Ludhiana during 2014 and 2015. The trees were trained on to four different training systems, i.e. Y-shaped, Hedge row, Espailer and V trellis (Figure 1).

There were a total four treatments each with four replications and each replication consisted of 2 trees in a randomized block design.

PAR was taken at fortnightly intervals on clear days at three times (10 a.m., 1 p.m. and 4 p.m.) by recording the sensor output from a quantam sensor using a digital multi-voltmeter (Figure 2). Incoming solar radiation measurements (watt/m^2) were recorded one feet above the canopy and at the centre of upper and lower parts of the canopy by the quantam sensor facing upward. The quantam sensor was inverted one feet above the canopy to record the amount of reflected short wave radiation {albedo (A)} (ref. 4).

Radiation intercepted in the upper part =

$$\frac{I-(I_1+A)}{I}\times 100 = x\%,$$

radiation intercepted in the lower part =

$$\frac{I-(I_2+A)}{I}\times 100 \; - x\% = y\%,$$

total interception by the tree canopy = $x\% + y\%$,

*For correspondence. (e-mail: yaminisharma@pau.edu)