later[1]. Syn rifting of the Indian Plate from Seychelles and the Deccan Trap eruption were contemporaneous to the time when the Indian Plate passed over the La Reunion hotspot[2]. The consequence of the Indian Plate rifting resulted in the horst and graben structure and a number of intrusions along the west coast passive margin, which is evident from several studies. Thus, we infer that large intraplate stresses associated with the upper crustal mafic intrusions along with the prevailing in-plane compression of the Indian Plate might have induced near to critical stressed regions for the pre-existing west-dipping or vertical normal faults in the region, which might have caused the genesis of earthquake sequence in the Palghar region. Geophysical studies like gravity, magnetics and magnetotellurics are in progress to understand the seismotectonics of this region.


1. Reeves, C. V. and de Wit, M., Making ends meet in Gondwana: retracing the transforms of the Indian Ocean and reconnecting continental shear zones. *Terra Nova*, 2002, **12**(6), 272–280.
2. Courtillot, V. E., Besse, J., Vandamme, D., Montigny, R., Jaeger, J. and Cappetta, H., Deccan flood basalts at the Cretaceous/Tertiary boundary? *Earth Planet. Sci. Lett*., 1986, **80**, 361–374.
3. Deshpande, G. G. and Pitale, U. L., *Geology of Maharashtra*, Geological Society of India, 2014, pp. 1–265.
4. Kissling, E., Geotomography with local earthquake data. *Rev. Geophys*., 1988, **26**, 659–698.
5. Chatelain, J. L., Roecker, S. W., Hatzfeld, D. and Molnar, P., Microearthquake seismicity and fault plane solutions in the Hindu Kush region and their tectonic implications. *J. Geophys. Res*., 1980, **85**, 1365–1387.
6. Gomberg, J. S., Shedlock, K. M. and Roecker, S. W., The effect of *S*-wave arrival times on the accuracy of hypocenter estimation. *Bull. Seismol. Soc. Am*., 1990, **80**, 1605–1628.
7. Dasgupta, S. *et al*., *Seismotectonic Atlas of India and its Environs*, Geological Survey of India, 2000.
8. Ottemoller, L., Voss, P. and Havskov, J., Seisan Earthquake Analysis Software, Version 11, 2018.
9. Kaila, K. L., Murthy, P. R. K., Rao, V. K. and Kharetchko, G. E., Crustal structure from deep seismic sounding along the Koyna II (Kelsi–Loni) profile in the Deccan Trap area, India. *Tectonophys*, 1981, **73**, 365–384.
10. Kaila, K. L., Reddy, P. R., Dixit, M. M. and Lazarenko, M. A., Deep crustal structure at Koyna, Maharashtra, indicated by deep seismic sounding. *J. Geol. Soc. India*, 1981, **22**, 1–16.
11. Kissling, E., Velest User's Guide. Internal report, Institute of Geophysics, ETH Zürich, Switzerland, 1995, p. 26.
12. Wiemer, S., A software package to analyze seismicity: ZMAP. *Seismol. Res. Lett*., 2001, **72**(3), 373–382.


ACKNOWLEDGEMENTS. We thank the Director, CSIR–NGRI, Hyderabad, for encouragement and permission to publish this work. We acknowledge the help rendered by district authorities in obtaining permissions and logistic support during seismic station network installation.

Received 3 April 2019; revised accepted 10 February 2020

doi: 10.18520/cs/v118/i10/1592-1598

# Inheritance of fruiting habit traits in chilli (*Capsicum annuum* L.)

**C. Anilkumar*, A. Mohan Rao, S. Ramesh, B. Bhavani and Pranesh**

Department of Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru 560 065, India

**Fruiting habit, viz. fruits node$^{-1}$ and fruit orientation are economically important traits in chilli. Fruiting habit could be solitary erect, solitary pendant, clustered erect or clustered pendant. Farmers' preference for fruiting habit traits varies from region to region. An understanding of the inheritance of fruiting habit traits helps accelerate breeding chilli cultivars with farmer-preferred combination of such traits. Eight diverse genotypes contrasting for fruiting habit traits were crossed to develop ten $F_1$ hybrids of six combinations. The $F_2$ and backcross generations of all the six distinct types of crosses were evaluated and pattern of segregation for fruiting habit traits was recorded. Results indicated bi-allelic, monogenic inheritance of fruits node$^{-1}$ (solitary versus clustered) and fruit orientation (pendant versus erect) with solitary being dominant over clustered and pendant being dominant over erect orientation respectively. Genes controlling fruits node$^{-1}$ and orientation of fruits segregated independently. Implications of these results are discussed in relation to strategic and applied chilli breeding.**

**Keywords:** Chilli, fruiting habit traits, goodness-of-fit, inheritance.

HOT pepper (*Capsicum annuum* L.; $2n = 2x = 24$), popularly known as chilli in India, is an important economic crop worldwide[1], and is ranked second among Solanaceous vegetable crops after tomato[2]. The species *Capsicum* originated in Mexico with centre of diversity in South America[3]. Presence of pepper-specific secondary metabolites – capsaicinoids – which confer pungency to fruits and possess various medicinal properties has made chillian important culinary item[4]. The fruits contain an appreciable quantity of nutrients, including ascorbic acid, $\beta$-carotene and other carotenoid pigments such as lycopene and zeaxanthin possessing anticancer properties[5]. India is the foremost producer and exporter of chilli, contributing to one-fourth of the world market share. Even though chillies are grown in all parts of the country, Andhra Pradesh, Karnataka, Odisha, Maharashtra, Rajasthan and Tamil Nadu are the major chilli-growing states in India, accounting for 80% of area and 84% of total production.

Fruit orientation and number of fruits node$^{-1}$ are fruiting habit traits which are economically important. Fruit

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

**Table 1.** Fruiting habit traits of genotypes used in the present study

| Genotype | Genetic material | Source | Fruiting habit |
|---|---|---|---|
| CMS 6B | Advanced breeding line | AVRDC, World Vegetable Centre, Taiwan | Solitary and pendant fruits |
| CMS 8B | Advanced breeding line | AVRDC, World Vegetable Centre, Taiwan | Solitary and pendant fruits |
| CMS 10B | Advanced breeding line | AVRDC, World Vegetable Centre, Taiwan | Solitary and pendant fruits |
| Gowribidanur | Released variety | Local collection, Karnataka | Solitary and pendant fruits |
| Pant C-1 | Released variety | G.B. Pant University of Agriculture and Technology (Uttarakhand) | Solitary and erect fruits |
| Japani Long | Released variety | Indian Agricultural Research Institute, New Delhi | Clustered and erect fruits |
| Pusa Sadabahar | Released variety | Indian Agricultural Research Institute, New Delhi | Clustered and erect fruits |
| Phule Jyothi | Released variety | Mahatma Phule Krishi Vidyapeeth, Rahuri | Clustered and pendant fruits |

**Table 2.** Types of crosses to study inheritance of fruiting habit traits

| Genetic background of crosses | Contrasting for | Type of cross |
|---|---|---|
| Japani Long (JL) × Pant C-1 (PC1) | Fruits node$^{-1}$ | Clustered erect (CE) × Solitary erect (SE) |
| Phule Jyothi (PJ) × Gowribidanur (GB) | | Clustered pendant (CP) × Solitary pendant (SP) |
| Pusa Sadabahar (PS) × Pant C-1 (PC1) | | CE × SE |
| PC1 × CMS 10B | Fruit orientation | SE × SP |
| PC1 × CMS 6B | | SE × SP |
| PS × PJ | | CE × CP |
| JL × PJ | | CE × CP |
| PJ × PC1 | Fruit node$^{-1}$ and fruit orientation | CP × SE |
| JL × CMS 10B | | CE × SP |
| JL × CMS 8B | | CE × SP |

**Figure 1.** Different fruiting habit types in chilli.

orientation is either pendent (fruit tips are geotropic) or erect (fruit tips are phototropic)[6]. Fruits node$^{-1}$ is either one (solitary) or more than one (clustered). Most chilli cultivars grown in southern India bear solitary pendant fruits. Harvesting solitary pendant fruits is resource-demanding and accounts for up to 20% of cost of the cultivation[7]. The literature indicates that genotypes with clustered fruiting habit produce synchronous fruiting with uniform maturity, and hence reduce the cost of harvesting[8]. A thorough knowledge on the inheritance of fruiting habit traits helps accelerate breeding chilli cultivars with a desired combination of such traits. Studies on the inheritance of fruiting habit traits in chilli are scanty and where attempted, they are based on limited genetic background. Therefore, the objective of the present study was to unravel the genetic control of fruiting habit traits in chilli in diverse genetic backgrounds.

Eight diverse genotypes (CMS 6B, CMS 8B, CMS 10B, Phule Jyothi (PJ), Pusa Sadabahar (PS), Japani Long (JL), Gowribidanur (GB) and Pant C-1 (PC1)) with four distinct fruiting habit traits – solitary erect (SE), solitary pendant (SP), clustered erect (CE) and clustered pendant (CP) (Table 1 and Figure 1) were chosen for the study.

Eight genotypes were used to generate ten crosses of six types (CE × SE, CP × SP, CE × CP, CE × SP, CP × SE and SE × SP) (Table 2) in the polyhouse during the 2015 rainy season. The plants of six types of crosses were grown and selfed to develop $F_2$, and back-crossed to their respective parents to develop $B_1$ and $B_2$ populations respectively, during the 2016 summer season at the experimental plots of the Department of Genetics and Plant Breeding (GPB), University of Agricultural Sciences (UAS), Bengaluru, India. The eight parental genotypes

**Table 3.** Segregation pattern of fruits node$^{-1}$ in chilli based on 2016 and 2017 rainy-season data

| | | Observed segregation pattern | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total no. of plants | | Solitary fruiting | | Clustered fruiting | | | $\chi^2$ | |
| Cross | Generation | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | Expected ratio | 2016 | 2017 |
| JL × PC1 (clustered × solitary) | $P_1$ | 10 | 10 | – | – | 10 | 10 | – | – | – |
| | $P_2$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_1$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_2$ | 90 | 78 | 65 | 61 | 25 | 17 | 3 : 01 | $0.37^{NS}$ | $0.43^{NS}$ |
| | $B_1$ | 54 | 21 | 29 | 12 | 25 | 9 | 1 : 01 | $0.30^{NS}$ | $0.43^{NS}$ |
| | $B_2$ | 53 | 53 | 53 | 53 | – | – | 1 : 00 | – | – |
| PJ × GB (clustered × solitary) | $P_1$ | 10 | 10 | – | – | 10 | 10 | – | – | – |
| | $P_2$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_1$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_2$ | 44 | 78 | 31 | 59 | 13 | 19 | 3 : 01 | $0.48^{NS}$ | $0.02^{NS}$ |
| | $B_1$ | 40 | 33 | 22 | 18 | 18 | 15 | 1 : 01 | $0.40^{NS}$ | $0.27^{NS}$ |
| | $B_2$ | 66 | 41 | 66 | 41 | – | – | 1 : 00 | – | – |
| PS × PC1 (clustered × solitary) | $P_1$ | 10 | 10 | – | – | 10 | 10 | – | – | – |
| | $P_2$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_1$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_2$ | 70 | 80 | 47 | 60 | 23 | 20 | 3 : 01 | $2.30^{NS}$ | $0.00^{NS}$ |
| | $B_1$ | 52 | 50 | 30 | 27 | 22 | 23 | 1 : 01 | $1.23^{NS}$ | $0.32^{NS}$ |
| | $B_2$ | 23 | 35 | 23 | 35 | – | – | 1 : 00 | – | – |
| Heterogeneity $\chi^2$ for fruits node$^{-1}$ @ 2df | | | | | | | | | $0.05^{NS}$ | $0.86^{NS}$ |

**Table 4.** Segregation pattern of fruit orientation in chilli based on 2016 and 2017 rainy-season data

| | | Observed segregation pattern | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total no. of plants | | Pendant fruiting | | Erect fruiting | | | $\chi^2$ | |
| Cross | Generation | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | Expected ratio | 2016 | 2017 |
| PC1 × CMS 10B (erect × pendant) | $P_1$ | 10 | 10 | – | – | 10 | 10 | – | – | – |
| | $P_2$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_1$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_2$ | 53 | 80 | 40 | 57 | 13 | 23 | 3 : 01 | $0.01^{NS}$ | $0.60^{NS}$ |
| | $B_1$ | 52 | 54 | 29 | 27 | 23 | 27 | 1 : 01 | $0.69^{NS}$ | $0.00^{NS}$ |
| | $B_2$ | 23 | 25 | 23 | 25 | – | – | 1 : 00 | – | – |
| PC1 × CMS 6B (erect × pendant) | $P_1$ | 10 | 10 | – | – | 10 | 10 | – | – | – |
| | $P_2$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_1$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_2$ | 32 | 61 | 24 | 44 | 8 | 17 | 3 : 01 | $0.00^{NS}$ | $0.27^{NS}$ |
| | $B_1$ | 42 | 46 | 23 | 25 | 19 | 21 | 1 : 01 | $0.38^{NS}$ | $0.35^{NS}$ |
| | $B_2$ | 52 | 53 | 52 | 53 | – | – | 1 : 00 | – | – |
| PS × PJ (erect × pendant) | $P_1$ | 10 | 10 | – | – | 10 | – | – | – | – |
| | $P_2$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_1$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_2$ | 74 | 80 | 52 | 58 | 22 | 22 | 3 : 01 | $0.88^{NS}$ | $0.27^{NS}$ |
| | $B_1$ | 48 | 53 | 25 | 26 | 23 | 27 | 1 : 01 | $0.08^{NS}$ | $0.02^{NS}$ |
| | $B_2$ | 36 | 55 | 36 | 55 | – | – | 1 : 00 | – | – |
| PL × PJ (erect × pendant) | $P_1$ | 10 | 10 | – | – | 10 | 10 | – | – | – |
| | $P_2$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_1$ | 10 | 10 | 10 | 10 | – | – | – | – | – |
| | $F_2$ | 90 | 64 | 66 | 47 | 24 | 17 | 3 : 01 | $0.13^{NS}$ | 0.08 |
| | $B_1$ | 44 | 49 | 25 | 27 | 19 | 22 | 1 : 01 | $0.82^{NS}$ | $0.51^{NS}$ |
| | $B_2$ | 69 | 50 | 69 | 50 | – | – | 1 : 00 | – | – |
| Heterogeneity $\chi^2$ for fruits orientation @ 3df | | | | | | | | | $0.18^{NS}$ | $0.13^{NS}$ |

**Table 5.** Segregation pattern for fruits node$^{-1}$ and fruit orientation in chilli based on 2016 and 2017 rainy-season data

| | | | | Observed segregation pattern | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cross | Season | Generation | Total no. of plants | SP | CP | SE | CE | Expected ratio | $\chi^2$ |
| PJ × PC1 (CP × SE) | 2016 rainy season | $P_1$ | 10 | – | 10 | – | – | – | – |
| | | $P_2$ | 10 | – | – | 10 | – | – | – |
| | | $F_1$ | 10 | 10 | – | – | – | – | – |
| | | $F_2$ | 40 | 18 | 10 | 8 | 4 | 9 : 3 : 3 : 1 | $2.67^{NS}$ |
| | | $B_1$ | 10 | 6 | 4 | – | – | 1 : 1 : 0 : 0 | $0.40^{NS}$ |
| | | $B_2$ | 35 | 19 | | 15 | – | 1 : 0 : 1 : 0 | $0.49^{NS}$ |
| | 2017 rainy season | $P_1$ | 10 | – | 10 | – | – | – | – |
| | | $P_2$ | 10 | – | – | 10 | – | – | – |
| | | $F_1$ | 10 | 10 | – | – | – | – | – |
| | | $F_2$ | 43 | 22 | 8 | 9 | 4 | 9 : 3 : 3 : 1 | $0.95^{NS}$ |
| | | $B_1$ | 51 | 27 | 24 | – | – | 1 : 1 : 0 : 0 | $0.18^{NS}$ |
| | | $B_2$ | 54 | 29 | – | 25 | – | 1 : 0 : 1 : 0 | $0.30^{NS}$ |
| JL × CMS 10B (CE × SP) | 2016 rainy season | $P_1$ | 10 | – | – | – | 10 | – | – |
| | | $P_2$ | 10 | 10 | – | – | – | – | – |
| | | $F_1$ | 10 | 10 | – | – | – | – | – |
| | | $F_2$ | 114 | 62 | 22 | 22 | 8 | 9 : 3 : 3 : 1 | $0.21^{NS}$ |
| | | $B_1$ | 58 | 17 | 14 | 15 | 12 | 1 : 1 : 1 : 1 | $0.90^{NS}$ |
| | | $B_2$ | 51 | 51 | – | – | – | 1 : 0 : 0 : 0 | – |
| | 2017 rainy season | $P_1$ | 10 | – | – | – | 10 | – | – |
| | | $P_2$ | 10 | 10 | – | – | – | – | – |
| | | $F_1$ | 10 | 10 | – | – | – | – | – |
| | | $F_2$ | 95 | 56 | 5 | 18 | 6 | 9 : 3 : 3 : 1 | $0.57^{NS}$ |
| | | $B_1$ | 52 | 14 | 12 | 15 | 11 | 1 : 1 : 1 : 1 | $0.77^{NS}$ |
| | | $B_2$ | 41 | 41 | – | – | – | 1 : 0 : 0 : 0 | – |
| JL × CMS 8B (CE × SP) | 2016 rainy season | $P_1$ | 10 | – | – | – | 10 | – | – |
| | | $P_2$ | 10 | 10 | – | – | – | – | – |
| | | $F_1$ | 10 | 10 | – | – | – | – | – |
| | | $F_2$ | 105 | 61 | 18 | 21 | 5 | 9 : 3 : 3 : 1 | $0.67^{NS}$ |
| | | $B_1$ | 48 | 12 | 10 | 14 | 12 | 1 : 1 : 1 : 1 | $0.67^{NS}$ |
| | | $B_2$ | 47 | 47 | – | – | – | 1 : 0 : 0 : 0 | – |
| | 2017 rainy season | $P_1$ | 10 | – | – | – | 10 | – | – |
| | | $P_2$ | 10 | 10 | – | – | – | – | – |
| | | $F_1$ | 10 | 10 | – | – | – | – | – |
| | | $F_2$ | 80 | 43 | 15 | 14 | 8 | 9 : 3 : 3 : 1 | $1.96^{NS}$ |
| | | $B_1$ | 30 | 8 | 8 | 8 | 6 | 1 : 1 : 1 : 1 | $0.40^{NS}$ |
| | | $B_2$ | 54 | 54 | – | – | – | 1 : 0 : 0 : 0 | – |
| Heterogeneity $\chi^2$ for fruits node$^{-1}$ @ 2df | | | | | | | | $0.36^{NS}$ (2016) | $0.19^{NS}$ (2017) |
| Heterogeneity $\chi^2$ for fruit orientation @ 2df | | | | | | | | $0.003^{NS}$ (2016) | $0.03^{NS}$ (2017) |

and $F_1$, $F_2$, $B_1$ and $B_2$ generations derived from ten crosses constituted the experimental material.

Forty-day-old seedlings of the eight parental genotypes and their $F_1$, $F_2$, $B_1$ and $B_2$ generations derived from ten crosses were planted during the 2016 and 2017 rainy season by maintaining a spacing of 0.75 m between rows and 0.4 m between plants within a row. The parental genotypes and $F_1$ of the ten crosses were planted in a randomized block design (RBD) with two replicates. The $F_2$, $B_1$ and $B_2$ generations were unreplicated and planted in larger plots. Data were recorded on ten randomly chosen plants in parental genotypes and their $F_1$s, 10–66 plants in $B_1$ and $B_2$ generations, and 40–114 plants in $F_2$ generations for fruiting habit traits. The parental genotypes and their $F_1$s, $F_2$, $B_1$ and $B_2$ generations were phenotyped for fruiting habit as SE, SP, CP, and CE based on visual assessment.

The data were analysed for goodness-of-fit for monogenic Mendelian inheritance of each trait. Heterogeneity $\chi^2$ tests were performed to examine the goodness-of-fit of observed and expected segregation of $F_2$, $B_1$ and $B_2$ generations based on data pooled across the crosses. Similarly, goodness-of-fit was tested for independent inheritance of fruit orientation and fruits node$^{-1}$. The heterogeneity $\chi^2$ test was performed to confirm the goodness-of-fit between observed and expected fruiting pattern of segregation of $F_2$, $B_1$ and $B_2$ generations for the two fruiting habit traits based on data pooled across the three crosses.

The $F_1$ plants of the six types of crosses which were contrasting for fruits node$^{-1}$ produced solitary fruits, suggesting dominance of solitary over cluster fruiting habit (Table 3). Good agreement between observed and expected segregation of $F_2$ (3S : 1C), $B_1$ (1S : 0C) and $B_2$ (1S : 1C) generations of all the six types of crosses confirmed the dominance of solitary over clustered fruiting habit, besides indicating bi-allelic monogenic inheritance of fruits node$^{-1}$. These results are in agreement with those of Gopalakrishnan *et al.*[7], Dhamayanthi and Reddy[8], and Stommel and Griesbach[9], who also reported monogenic control of fruits node$^{-1}$ in chilli. Sergius[10] reported that multiple small fruits node$^{-1}$ (a trait highly preferred by farmers of Western Africa) is dominant over solitary fruits node$^{-1}$ in okra, and is controlled by a single biallelic gene.

The $F_1$s derived from parents contrasting for orientation of fruits produced pendant fruits, suggesting dominance of pendant over erect fruiting habit. The good fit of observed segregation with that expected (3P : 1E in $F_2$, 1P : 0E in $B_1$ and 1P : 1E in $B_2$ generations) (Table 4) confirmed the dominance of pendant over erect fruiting habit, besides suggesting bi-allelic monogenic inheritance of fruit orientation. However, Gopalakrishnan *et al.*[7] and Dhamayanthi and Reddy[8] reported that fruit orientation in chilli is controlled by a pair of dominant genes with inhibitory epistasis. Thus, it appears that the mode of action and number of genes controlling fruit orientation in chilli vary with genetic background of the material used to study the pattern of inheritance.

A good agreement between observed joint segregation of fruits node$^{-1}$ and orientation of fruits in $F_2$, $B_1$ and $B_2$ generations derived from the crosses PJ × PC1, JL × CMS 10B and JL × CMS 8B involving parents which differed for both fruits node$^{-1}$ and fruit orientation with that expected (9SP : 3SE : 3CP : 1CE in $F_2$, 1SP : 0SE : 0CP : 0CE in $B_1$ and 1SP : 1SE : 1CP : 1CE in $B_2$) (Table 5), suggested independent segregation of genes controlling the two fruiting habit traits.

Our results are of strategic importance in chilli-breeding research. Non-linkage of genes controlling fruits node$^{-1}$ and orientation of fruits clearly suggests possibility of developing chilli cultivars with any desired combination of fruiting habit traits preferred by farmers. Further, both fruits node$^{-1}$ and fruit orientation being simply inherited and visually assayable, could be used as diagnostic descriptor traits for identifying and eliminating duplicates and maintaining the identity of germplasm accessions; this is a daunting task, especially if they are in large numbers. The fruiting habit traits are also useful for the identification of true hybrids, and establishing distinctness, uniformity and stability of cultivars, a prerequisite for protecting intellectual property rights associated with the development of cultivars.

Solitary fruits node$^{-1}$ and pendant fruit orientation are dominant over clustered fruiting and erect fruit orientation respectively. Fruits node$^{-1}$ (solitary versus clustered) and orientation of fruits (pendant versus erect) are each controlled by single, bi-allelic, unlinked genes.

1. Poulos, J. M., Problems and progress of chilli pepper production in the tropics. In Proceedings of the Conference on Chilli Pepper Production in the Tropics (eds Hock C. B. *et al.*), Kuala Lumpur, Malaysia, 1992, pp. 98–129.
2. Bosland, P. W. and Bailey, A. L., Iglesias-Olivas, Capsicum Pepper Varieties and Classification, New Mexico Cooperative Extension Service Circle, Las Cruces, New Mexico, 1996, p. 530.
3. Gonzalez, M. and Bosland, P., Strategies for stemming genetic erosion of Capsicum germplasm in the Americas. *Diversity*, 1991, **7**, 52–53.
4. Kim, S. *et al.*, Genome sequence of the hot pepper provides insights into the evolution of pungency in *Capsicum* species. *Nature Genet*., 2014, **46**, 270.
5. Ghasemnezhad, M., Sherafati, M. and Payvas, G. A., Variation in phenolic compounds, ascorbic acid and antioxidant activity of five coloured bell pepper (*Capsicum annuum*) fruits at two different harvest times. *J. Funct. Foods*, 2011, **3**, 44–49.
6. Lee, J. M., Nahm, S. H., Kim, Y. M. and Kim, B. D., Characterization and molecular genetic mapping of microsatellite loci in pepper. *Theor. Appl. Genet*., 2004, **108**, 619–627.
7. Gopalakrishnan, T. R., Gopalakrishnan, P. K. and Peter, K. V., Inheritance of clusterness and fruit orientation in chilli (*Capsicum annuum* L.). *Indian J. Genet.*, 1989, **49**, 219–222.
8. Dhamayanthi, K. P. M. and Reddy, V. R. K., Transfer of clustered and upright fruit characters into two popular chilli cultivars of Tamil Nadu. *J. Spices Aroma. Crops*, 2001, **10**, 41–43.
9. Stommel, J. R. and Griesbach, R. J., Inheritance of fruit, foliar, and plant habit attributes in Capsicum. *J. Am. Soc. Hortic. Sci*., 2008, **133**, 396–407.
10. Sergius, O. U., Inheritance and production of multiple small fruits per node, in *Abelmoschus* species, to meet consumer's demand, in the West African region. *Afr. J. Agric. Res*., 2015, **10**, 1684–1692.

Received 11 October 2018; revised accepted 19 December 2019

doi: 10.18520/cs/v118/i10/1598-1602

# Ladybird, *Menochilus sexmaculatus* (Fabricius) can survive on oophagy but with altered fitness than aphidophagy

**Shashwat Singh, Geetanjali Mishra and Omkar***

Ladybird Research Laboratory, Department of Zoology,
University of Lucknow, Lucknow 226 007, India

**Egg consumption is common among insects, including ladybirds. The consumed eggs may be conspecific or heterospecific. Egg consumption eliminates potential competitors and provides additional nutrients for development and reproduction. In ladybirds, the incidence of cannibalism and intraguild predation has been proven as alternative tactics for the sustenance of life under prey-scarce condition. The consumption of conspecific eggs is known as cannibalism. Thus, in this study we have evaluated the effect of diets, viz. conspecific and heterospecific eggs along with aphids on egg consumption, developmental and reproductive attributes of a ladybird beetle, *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae). We found that all the immature stages and adults prefer and**

*For correspondence. (e-mail: omkar.lkouniv@gmail.com)