ISSN 1479-2621

Plant Genetic Resources: Characterization and Utilization (2020) **18**(1); 28–30
doi:10.1017/S1479262119000418

Short Communication

Genetics of fruit oleoresin and capsaicin contents in chilli inter-species (*Capsicum annuum* × *C. chinense*) cross

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

Department of Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, India

Received 29 July 2019; Accepted 13 December 2019 – First published online 10 January 2020

Abstract

Choice of the most appropriate breeding method hinges on mode of action of genes controlling expression of target traits. Pungency (capsaicin) and colour (oleoresin) are most important fruit quality traits in chilli. Genetics of fruit quality traits was unravelled using a combination of first and second degree statistics. An additive-dominance model was inadequate to explain the inheritance of fruit yield and quality traits. Magnitude of additive genetic effects [a] and their variances [σ^2_A] were higher than those of dominance genetic effects [d] and dominance genetic variances [σ^2_D] suggesting predominance of additive effect genes in the inheritance of both oleoresin and capsaicin contents. These results are discussed in relation to appropriate selection strategy to be followed for genetic improvement of chilli for oleoresin and capsaicin contents.

Keywords: additive-dominance model, capsaicin, genetics, inter-species cross, oleoresin

Introduction

Economic and nutritional importance of chilli is because of two important fruit quality attributes viz., pungency and colour. Pungency of chilli is due to the presence of capsaicin. Capsaicin is a crystalline, colourless alkaloid, which imparts hotness to fruits. Capsaicin is also widely used in pharmacological preparations, diverse prophylactic, therapeutic, allopathic and Ayurvedic medicines and food industries (Saleh *et al*., 2018).

Fruit colour (red) of chilli is attributed to the presence of carotenoid pigments, mainly capsanthin and capsorubin (Kumar *et al*., 2003), collectively called as oleoresin. Concentrated oleoresin is added to processed meat and to beverages to impart attractive colour. Hence, it is considered to be a best substitute of synthetic colour used in food and cosmetic industries (Kumar *et al*., 2006). Enhancing fruit pungency and colour not only ensures better marketability but also easy acceptance of chilli fruits by consumers and food processing industries. Eliciting reliable information on mode of action of genes involved in the expression of oleoresin and capsaicin content is one of the prerequisites for enhancing the efficiency of breeding chilli for oleoresin and capsaicin content. The objective of the present investigation was to decipher genetics of oleoresin and capsaicin content in inter-species cross of chilli based on the combination of first and second degree statistics.

Experimental

Byadagi Kaddi (BK) (*Capsicum annuum* L.) known for its high oleoresin which bears long slender fruits and Bhut Jolokia (BJ) (*Capsicum chinense* Jaq.) regarded as seventh hottest chilli in the world which bears very short stout

*Corresponding author. E-mail: anilcgpb@gmail.com

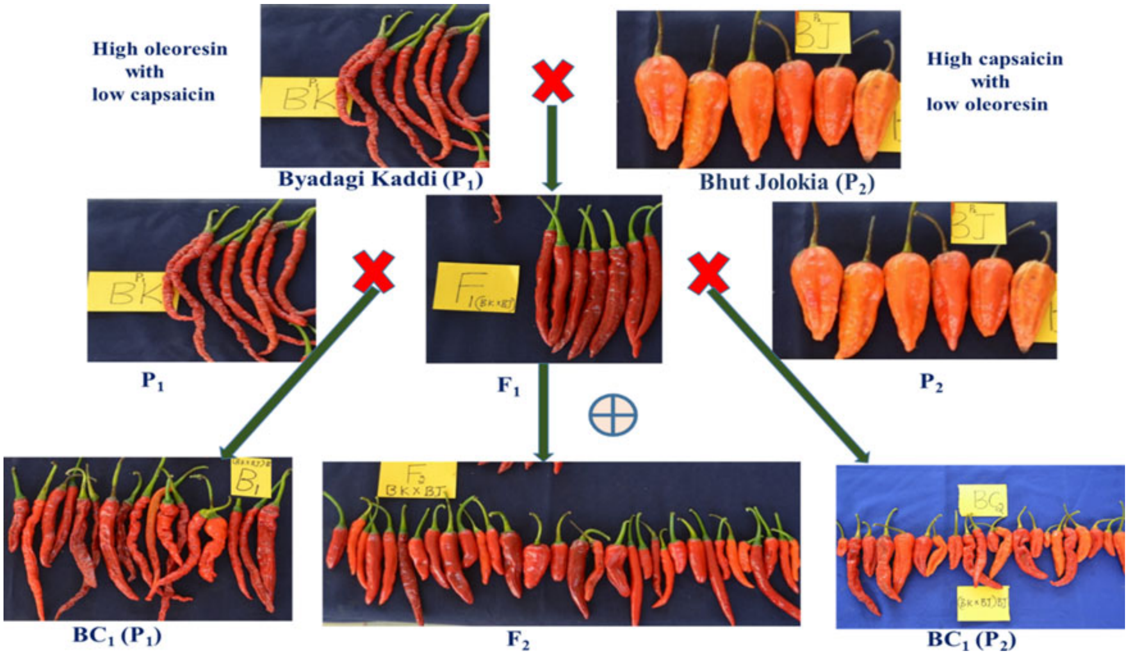

Fig. 1. Procedure describing the development of F_1, F_2 and back crosses involving Byadagi Kaddi (BK) and Bhut Jolokia (BJ).

ovate-shaped fruits constituted the basic material for the study (online Supplementary Table S1). BK (P_1) as a seed parent and BJ (P_2) as a pollen parent were crossed to develop inter-species F_1 hybrid during the 2016 rainy season. The true F_1 hybrids were confirmed through the presence of very short stout ovate-shaped fruit traits typical to pollen parent. Being inter-species cross and due to low cross compatibility, only three seeds could be recovered from the cross. Of the three seeds, one seed germinated and survived to maturity and produced a few seeds. After conforming true hybridity, the survived F_1 (BK × BJ) plant was selfed to derive F_2 and also back-crossed to BK to develop BC_1P_1 and, to BJ to develop BC_1P_2 during 2017 summer (Fig. 1).

Forty-day old seedlings of three segregating generations viz., BC_1P_1, BC_1P_2 and F_2 were planted in contiguous blocks during 2017 rainy season maintaining a spacing of 0.75 m between rows and 0.4 m between plants within a row. Non-segregating generations P_1, P_2 and F_1 were replicated thrice and planted in randomized block design. The experiment was conducted at the experimental plots of Department of Genetics and Plant Breeding, University of Agricultural sciences (UAS), Bengaluru, India. The recommended crop production practices were followed to raise a healthy crop. Due to poor survivability, only 139 F_2, 59 BC_1P_1 and 33 BC_1P_2 plants survived to fruit maturity.

Red-riped fruits sampled from each of the 139 F_2, 59 BC_1P_1 and 33 BC_1P_2 plants and those sampled from five plants chosen at random from P_1, P_2 and F_1 were sun dried. Dried fruits were ground to a fine powder and used for estimating oleoresin and capsaicin contents. Oleoresin was extracted by cold acetone percolation of finely powdered sample of sun-dried fruits and subsequent removal of solvent by evaporation over water bath (online Supplementary Fig. S2). The extracted oleoresin was quantified following a gravimetric method (Ranganna, 1977) as

$$\text{Oleoresin } (\%) = \frac{W_3 - W_2}{W_1} \times 100$$

where W_1 = weight of the sample taken, W_2 = weight of the empty porcelain dish and W_3 = weight of the porcelain dish + sample extract after drying. Capsaicin was estimated by a colorimetric method (Sadasivam and Manickam, 1992) and expressed in per cent.

The average oleoresin and capsaicin contents of six generations were subjected for biometrical genetic analysis. Following weighted least square principle, additive genetic effect [a] and dominance genetic effect [d] and, additive genetic variance [σ^2_A] and dominance genetic variance [σ^2_D] were estimated (Mather and Jinks, 1982). All the biometrical genetic analyses were implemented using WINDOSTAT software version 9.

Discussion

Inference based on only first degree statistics based [a] are not advisable, as the dispersion of positive and negative gene effects in the parents may result in different degrees of cancellation of gene effects in the expression of traits under investigation (Mather and Jinks, 1982). Hence, the

Table 1. Estimates of additive genetic effects [a] and their variance [σ^2_A] and dominant genetic effects [d] and their variance [σ^2_D] in the inheritance of fruit quality traits in chilli

Fruit quality traits	Additive genetic effects [a]	Additive genetic variance [σ^2_A]	Dominance genetic effects [d]	Dominance genetic variance [σ^2_D]	σ^2_D/σ^2_A
Oleoresin (%)	6.99**	43.53**	0.26*	0.91	0.02
Capsaicin (µg/100 mg)	−175.30**	16,549.76**	−224.77**	13,488.95**	0.82

*Significant *P* at 0.05, **significant *P* at 0.01.

magnitude of [a] do not necessarily reflect the magnitude of (σ^2_A). Similarly, magnitude of [d] does not necessarily reflect those of (σ^2_D). Thus, the inference on mode of actions of genes controlling quantitative traits solely based either on first or second degree statistics are often misleading. Hence, inference based on the combination of first and second degree statistics provides complementary and more comprehensive information on the true nature of genetic control of quantitative traits (Kearsey and Pooni, 1996).

Significant but lower magnitude of [a] coupled with [σ^2_A] (Table 1) indicated the possibility of dispersion of increasing and decreasing alleles controlling oleoresin content (%) between parents (Bernardo, 2010, 2014). Significant estimate of [d] and non-significant estimate of [σ^2_D] (Table 1) suggested presence of low magnitude of dominance in the inheritance of oleoresin content. Higher magnitudes of [a] and [σ^2_A] than those of [σ^2_D] suggested predominance of genes with additive effects in the inheritance of oleoresin content. Significant but negative estimates of both [a] and [d] suggested that inheritance of capsaicin content was controlled by genes with both additive and dominance effects. However, genes that decrease capsaicin content were more frequent than those that increase it and were dominant. Further, genes with additive effects were predominant as could be inferred from higher magnitude of the estimates of additive effects than those of dominance effects (Table 1). Predominance of additive effect genes were further confirmed by higher magnitude of [σ^2_A] than that of [σ^2_D]. Thus, both oleoresin and capsaicin contents are controlled by genes with predominantly additive effects. As additive gene effects, are fixable, simple high intense selection for higher oleoresin and capsaicin content in early segregating generations is expected to be effective (Acquaah, 2012). Perhaps, one or two cycles of bi-parental mating in F_2 generation which is expected to enhance additive genetic variability and increase the frequency of genes which control higher expression of oleoresin and capsaicin contents followed by selection is the best strategy to improve them in chilli.

Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1479262119000418

References

Acquaah G (2012) *Principles of Plant Genetics and Breeding*, 2nd edn. Hoboken, USA: John Wiley and Sons, Ltd., pp. 63–75.

Bernardo R (2010) *Breeding for Quantitative Traits in Plants*. Woodbury, Minnesota: Stemma Press.

Bernardo R (2014) *Essentials of Plant Breeding*. Woodbury, Minnesota: Stemma Press.

Kearsey MJ and Pooni HS (1996) *The Genetic Analysis of Quantitative Traits*. London, UK: Chapman and Hall.

Kumar BK, Munshi AD, Joshi S and Kaur C (2003) Note on evaluation of chilli (*Capsicum annuum* L.) genotypes for biochemical constituents. *Capsicum and Eggplant Newsletter* 22: 41–42.

Kumar S, Kumar R and Singh J (2006) Cayenne/American pepper (Capsicum sp.). In: Peter KV (eds) *Handbook of Herbs and Spices*. Cambridge, UK: Wood head Publishing, pp. 299–312.

Mather K and Jinks JL (1982) *Biometrical Genetics*, 3rd edn. London: Chapman and Hall, p. 396.

Ranganna S (1977) *Manual Analysis of Fruit and Vegetable Products*, 2nd edn. New Delhi, India: Tata McGraw Hill Publishing Co. Ltd., p. 81–85.

Sadasivam S and Manickam A (1992) *Biochemical Methods for Agricultural Sciences*. New Delhi: Wiley Eastern Limited and Coimbatore: Tamil Nadu Agricultural University, pp. 178–179 and 187–188.

Saleh BK, Omer A and Teweldemedhin B (2018) Medicinal uses and health benefits of chili pepper (Capsicum spp.): a review. *MOJ Food Processing & Technology* 6: 325–328. Available at https://doi.org/10.15406/mojfpt.2018.06.00183.

https://doi.org/10.1017/S1479262119000418 Published online by Cambridge University Press