Breeding and Biotechnological Approaches for Biotic Stress Resistance in Vegetable Crops

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Abstract

Vegetables are often succulent, herbaceous plants. Since vegetable crops are naturally succulent, a wide range of pests can attack them. Because insects generate comparatively less economic damage than diseases did in the past, insect resistance has not been studied as extensively as disease resistance but vegetables are highly vulnerable to pest and insect attacks. Huge financial losses result from inadequate plant protection methods and a lack of resistant cultivars. Chemical pesticides are the mainstay of crop protection strategies. Pests have developed resistance as a result of repeated pesticide usage, and novel pest biotypes resistant to chemical pesticides have emerged. Additionally, pesticides pollute the environment and can endanger human health. As a result, it is imperative to switch from traditional chemical treatments to safer ones, such as the creation of resilient resistant cultivars. In addition to breeding approaches, selection with marker assistance decrease the amount of time and area required to screen resistant plants by increasing selection efficiency.

Introduction

Growing vegetables is a significant component of different agricultural economies of several developing countries (Srivastava et al. 2016). But massive occurrence of diseases and insect-pests is a problem of paramount importance in cultivation of vegetable crops. It is more difficult to reach the optimum yield potential of vegetable crops because of their increased vulnerability to diseases and insect pests. It is hazardous for human health and the environment to use pesticides indiscriminately to eradicate diseases, insect pests, and nematodes (Dhall, 2015). The establishment of pest and disease-resistant varieties and hybrids will always be more advantageous than chemical control since the resistant varieties limit outbreaks and preserve natural equilibrium. Selection for resistant plant types set in motion around the beginning of twentieth century (Painter, 1995). Since then, a huge number of insect-resistant cultivars have been developed all over the world (Panda et al. 1951). Despite of the fact that insect-pests are responsible for reducing about 40% yield in vegetables, the advancement in the development of insect resistance is very scanty. Host plant resistance is the economical method but the population pressure of pest resurgence affect the stability of the resistant host plants which ultimately aids in pest resurgence and resistance collapse (Dhall, 2015). In this article, important biotic stresses of major vegetable crops, sources of resistance, resistance breeding and biotechnological approaches are discussed.

Resistance Breeding for Biotic Stress:

Tomato fruit worm, beet armyworm, cotton bollworm, southern armyworm, soybean podworm, and egyptian cottonworm, colorado potato beetle and tobacco flea beetle, leaf miners, fruit fly, thrips, sinkbugs, and cutworms are some of the pests capable of causing severe losses in tomato crop. Tomato cultivars vary in levels of resistance as they produce plant peptide hormone system, systemin, after an insect attack (Srivastava et al. 2016). Large number of accessions of tomato have been screened and generally all cultivated varieties were found susceptible. Insect resistance has not been studied as much as disease resistance in tomato. However, two species namely *S. habrochaites* and *S. pennellii* are found to be possessing resistance against some major insect pests of tomato. S. *habrochaites* and *S. penelli* exhibits resistance against atleast 16 and 9 pest species respectively (Dhall, 2015). The three most serious brinjal diseases are wilt, small leaf, and phomopsis blight (Dhall, 2015). Resistance to Fusarium wilt was reported in S. Incanum. One of the major illnesses that affect brinjal in warm, humid climates is bacterial wilt. In wild species of Solanum, such as *S. torvum, S. xanthocarpum, S. nigrum*, and *S. sisymbriifolium*, resistance has been documented (Sugha et al. 2002). Previous workers observed that longer and denser hair on the leaves caused resistance to Jassids. Given the abundance of harmful pests that affect the crop, it is challenging to develop resistance types for particular pests. It makes sense to look for sources of resistance for many pests (Dhall, 2015). While *S. incanum* and *S. sisymbrifolium* species were resistant to minimal leaf disease, the wild species Solanum viarum did not exhibit any symptoms of infection and was immune (Anjaneyulu and Ramakrishnan, 1968, Chakrabarti and Choudhury, 1974). As, there are more harmful pests in the crop than there are resistant varieties, it is challenging to breed resistant varieties for each pest. It makes sense to look for sources that are resistant to multiple pests (Dhall, 2015). In case of chilli, Caleapin Red', 'Chamatkar', 'NP46A', x 1068, x 743, x 1047, 'BG-4', x 226, x 230, x 233 are the sources which have been found resistant against thrips (Tewari et al. 1985). Resistant sources against mites are LEC-1, 'Kalyanpur Red', x 1068, x 204, 'Goli Kalyanpur' -309- 1-1-15, 300-1-5-1, S-118 (Punjab Lal), 635, 565 (Tewari et al. 1985). LEC-28, LEC-30, LEC-34, 'Kalyanpur Red', x 1068 are the accessions possessing resistance against chilli aphid (Tewari et al. 1985).

Further, many insects infect cucurbits, but the two spotted spider mite and fruit fly are mainly responsible for huge losses. Resistance sources are usually observed in landraces and wild relatives. *C. callosus* has resistance against fruit fly. In the matter of cucumber, PI 220860, Hybrid Long Green Pickle are the resistant sources against two spotted spider mite (Robert, 1994).

Omics approaches for resistance against biotic stress

Candidate genes for aphid resistance in cucumber were discovered by using method of SLAF sequencing in conjuction with bulk segregant analysis (Liang et al. 2016). Four additive and two epistatic QTLs were found carrying genes for aphid resistance. The field of biotechnology is also concerned with transcriptomes, which are the total set of RNA transcripts produced in a cell or tissue by genetic code of an organism (Raza et al. 2021). 290 genes are found to be significant in case of viruliferous whitely in tomato (Richard et al. 2014). The plant metabolism can be analysed by performing qualitative and quantitative tests by the use of metabolomics (Dettmer et al. 2007). Proteinase inhibitors (PIs), the most studied defense-related proteins in plants, have been found to be elevated in tomato or pepper plants' responses to attack of different pests (War et al. 2018). Proteomics deals with the examination of proteins. Plant metabolic diversity and stress response are investigated through the application of the proteome approach (Ghosh et al. 2014 and Gong et al. 2015). In relation to thrips attack, it was identified that 52 proteins are present in different genotypes of sweet potatoes (Yang et al. 2013). It is anticipated that these developments will improve breeding efforts and help identify potential genotypes based on their breeding value. It not only creates new genotypes but also elucidates the intricate characteristics of plants in reaction to diseases, pests, and harsh environmental circumstances (Kumar et al. 2023). However, sample collection and analysis need to be done very carefully because transcriptome, proteome, and metabolome data are very inconsistent across time and environmental conditions.

Conclusion

One of the most effective methods to reduce the losses brought on by disease or pest incidence is to develop cultivars that are resistant or tolerant. To make the most use of the germplasm that is now accessible, a comprehensive research program must be implemented. It is anticipated that biotechnological methods would also improve breeding efforts and help determine which genotypes are suitable for breeding.

Declaration

The authors declare no conflict of interest

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