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Deepika Pandita
Division of Plant Biotechnology, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

M Ashraf Bhat
Division of Genetics and Plant Breeding, Faculty of Agriculture, Wadura, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Saba Mir
Division of Plant Biotechnology, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Nayeema Jabeen
Division of Vegetable Science, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Ali Anwar
Division of Plant Pathology, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Khursheed Hussain
Division of Vegetable Science, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Niyaz A Dar
Division of Plant Biotechnology, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Shahid Qayoom Dar
Division of Fruit Science, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

M Younus Wani
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Correspondence
Deepika Pandita
Division of Plant Biotechnology, Faculty of Horticulture, Shalimar, Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir, Srinagar Jammu and Kashmir, India

Screening of traditional chilli cultivars of Kashmir for *Fusarium* wilt resistance

Deepika Pandita, M Ashraf Bhat, Saba Mir, Nayeema Jabeen, Ali Anwar, Khursheed Hussain, Niyaz A Dar, Shahid Qayoom Dar and M Younus Wani

Abstract
Chilli is an important crop grown worldwide for fresh fruits used as vegetable and spice production. The major chilli growing countries are India, China, Korea, Nigeria, U.S.S.R. Mexico, etc. Wilt disease caused by *Fusarium oxysporum* is a major problem in all chilli growing areas of India leading to heavy yield loss. Being a soil-borne pathogen, chemical control is difficult and non-economical. Cultivation of wilt resistant cultivars has proved to be an effective strategy to minimise the loss. *Capsicum* spp. is widely distributed and cultivated in tropical region with 27 species among which *Capsicum annuum* L. is predominately grown across the India and is a major food spices. The production of chilli is devastatingly hindered by the *Fusarium* wilt. A total of 32 local cultivars were collected from the different locations of Kashmir valley including one identified exotic variety and were screened for resistance against *Fusarium* wilt. Out of 32 cultivars six cultivars viz. SKUA-SHC-1, SKUA-SHC-2, SKUA-SHC-14, SKUA-SHC-15, *Arka Lohit* and SKUA-SHC-29 showed highly resistant reaction against the wilt pathogen *Fusarium oxysporum*.

Keywords: *Capsicum annuum*, *Fusarium oxysporum*, cultivars and resistance

Introduction
Capsicum spp., which belongs to the nightshade family Solanaceae is widely distributed and cultivated in tropical regions with 27 species (Costa *et al.*, 2006) [6]. *Capsicum annuum*, *Capsicum frutescense*, *Capsicum chinensis*, *Capsicum pubescence and Capsicum baccatum* (Bosland and Votava, 2000) [4] are widely cultivated and among these, *Capsicum annuum* is predominantly cultivated over a large area of 15 lakh ha of the world which gives the total production of 70 lakh tonne per year (NABARD) and is a major key ingredient of almost each and every delicacy due to its; taste, ordour, colour and pungency. India is the major producer, consumer and exporter of chilli (dry-red and green chilli), while covering the 36% export of the total world export of chilli (Aswini *et al.*, 2016) [2]. *Fusarium* wilt of chilli has emerged as a serious problem in past decade with the disease incidence of 2-85 percent in different regions of India (Anonymous, 2005) [1]. *Fusarium oxysporum* and *Fusarium solani* are reported as the most common species of *Fusarium* found associated with wilt of chilli in India, whereas, *Fusarium moniliforme* and *Fusarium pallidoroseum* as causal agents are found in some parts of India (Naik, 2006) [13]. The yield losses due to the disease is known to vary from 10-80 percent worldwide (Loganathan *et al.*, 2013) [9] depending upon the variety being grown and prevailing climatic conditions. The pathogen is necrotrophic, typically soil-borne (Booth, 1971) [3]. Generally, the dry weather condition and excessive soil moisture enhance the disease development. The characteristic symptoms of the disease are brown vascular discoloration followed by upward and inward rolling of the upper leaves and subsequently wilting of the plant (MacHardy and Beckman, 1981; Rivelli, 1989) [10, 14]. Among the different available options for the management, chemicals are neither economically viable, nor safe for the environment. The best way of management of this disease is only use of resistant cultivars. So, the availability of genetic diversity of *Capsicum* species in both wild and domesticated ecosystem and screening of these elite pepper germplasms/ cultivars resistant to pathogen is the most effective control strategy against the disease (Kelaiya and Parakhia, 2000; Candole *et al.*, 2010; Joshi *et al.*, 2012; Shafique *et al.*, 2015) [8, 5, 7, 15]. Therefore, a large scale screening of the promising chilli germplasm/cultivars is needed as a source of resistance for developing resistant lines/hybrids of chilli against the wilt pathogen.

Material and Methods

Plant Material

All 32 accessions of *Capsicum annuum* were collected from the farmers' fields of Kashmir valley. The accession names have been enlisted in the table 1. The accessions were grown under the controlled conditions for further analysis.

Table 1: List of tested genotypes

Genotype	Genotype
SKUA-SHC-1	*Arka Lohit*
SKUA-SHC-2	SKUA-SHC-17
SKUA-SHC-3	SKUA-SHC-18
SKUA-SHC-4	SKUA-SHC-19
SKUA-SHC-5	SKUA-SHC-20
SKUA-SHC-6	SKUA-SHC-21
SKUA-SHC-7	SKUA-SHC-22
SKUA-SHC-8	SKUA-SHC-23
SKUA-SHC-9	SKUA-SHC-24
SKUA-SHC-10	SKUA-SHC-25
SKUA-SHC-11	SKUA-SHC-26
SKUA-SHC-12	SKUA-SHC-27
SKUA-SHC-13	SKUA-SHC-28
SKUA-SHC-14	SKUA-SHC-29
SKUA-SHC-15	SKUA-SHC-30
SKUA-SHC-16	SKUA-SHC-31

Isolation and inoculation of fungus

An already isolated, identified and purified culture of *Fusarium oxysporum* was provided by Division of Plant Pathology, SKUAST-K, Shalimar. For sub-culturing ready-to-use Potato Dextrose Agar (PDA) medium was used. PDA is a general purpose medium used for cultivation of fungi. The purified culture of *Fusarium oxysporum* was transferred on PDA plate and was placed in an incubator at 22 ± 2^0C for 10-15 days. The pure cultures of the pathogen were stored in a refrigerator at 4±1 ^{0}C for further research work.

Seedlings were inoculated at 35th day after germination. Small (2 mm diameter) blocks of 15 days old culture of the test pathogen grown on PDA served as the inoculum. The tips of the roots (about 5mm in length) were trimmed with the help of a scissor. A suspension of the inoculum was prepared with sterile water and the seedlings were placed in it for about 15-20 minutes and then transplanted in polybags filled with sterilized soil. In control set, seedlings were transplanted without any inoculation. After inoculation the pots were kept in green house. Watering was done regularly to maintain adequate humidity. Distilled water was used for watering the transplanted seedlings.

Screening of genotypes for resistance against *Fusarium* wilt

The screening for disease resistance was done by measuring the disease incidence on a scale of 1 to 5 (table 2), as per mentioned by Marlatt *et al.*, (1996) [12].

Table 2: Score card of disease reaction to *Fusarium oxysporum*

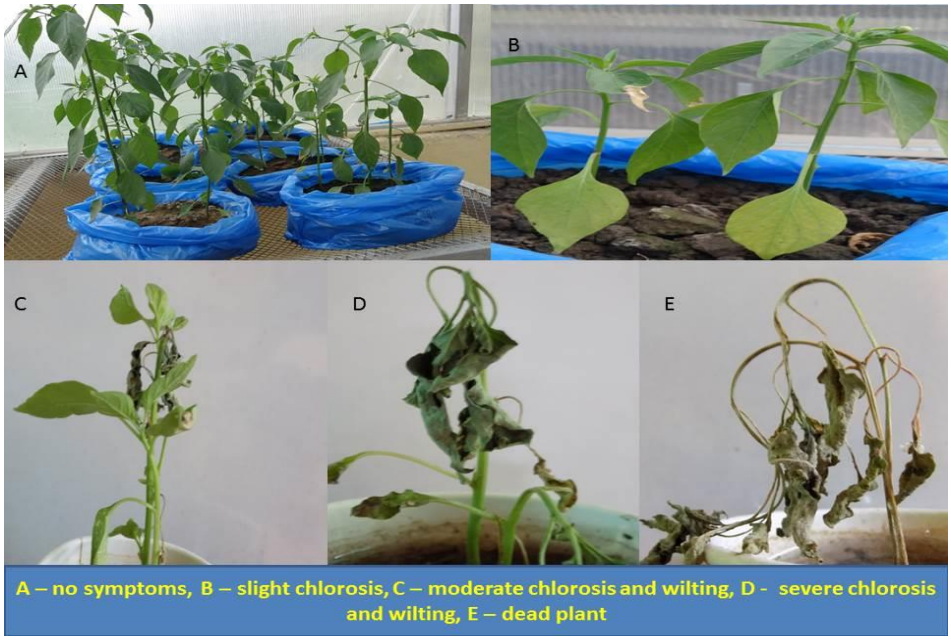
Score	Description
1	No symptoms
2	Slight chlorosis, wilting or stunting of plant
3	Moderate chlorosis, wilting or stunting of plant
4	Severe chlorosis, wilting or stunting of plant
5	Dead plant

Result and Discussion

Breeding for biotic and abiotic stresses is a key concept for enhancing the yield in every crop. *Fusarium* wilt (caused by *Fusarium oxysporum*) is a major biotic stress in chilli that adversely affects its overall yield. The information of this disease in the different genetic background of chilli is still in scarce. The traditional cultivars have wide genetic bases and are the morgue of the valuable hidden genes, providing an adaptation to a wide range of stress environments. Therefore, in the present investigation we collected a total of 32 traditionally cultivated genotypes including an promising wilt resistant released variety of IIHR (Bangalore) namely *Arka Lohit*, from the farmers' fields belonging to the different geographical regions of Kashmir valley, India.

Screening of chilli germplasm for disease incidence.

In this investigation out of 32 a total of six genotypes namely SKUA-SHC-1, SKUA-SHC-2, SKUA-SHC-14, SKUA-SHC-15, *Arka Lohit* and SKUA-SHC-29 showed highly resistant reaction against the wilt pathogen *Fusarium oxysporum*, while the other genotypes showed moderate to nil resistance. These findings are in line with Manu *et al.*, (2014) [11] and Singh *et al.*, (1998) [16].



Conclusion

Based on present findings the resistant genotypes can be further used for selecting and stabilizing suitable genotypes against *Fusarium* wilt and resistance breeding programme in chilli (*Capsicum annuum* L). The wilting symptoms in the plants started within a period of one week after inoculation with *Fusarium oxysporum*. The susceptible genotypes showed typical wilting symptoms such as stunted plant height, yellowing of leaves followed by their drying and blackening of stem. The highly susceptible cultivars can be used as infector rows and the cultivars showing resistant to moderately resistant reaction can be used as donor for resistance in further resistant breeding programmes. However, it would be too much to expect stable resistance against *Fusarium* diseases because of high variability and dynamic nature of the pathogen. The inheritance of *Fusarium* wilt resistance in chilli has been of monogenic dominant in nature; hence, heterosis breeding using the resistant source is advocated to boost the yield potential of the crop and to avoid the use of pesticides in reducing the environmental pollution.

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