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Source of resistance to chickpea (*Cicer Arietinum* L.) Fusarium wilt (*Fusarium Oxysporum* F. Sp. *Ciceris*) under field conditions in Chhattisgarh

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Abstract
One of the economically significant vascular root diseases affecting chickpea is *fusarium* wilt. To find *fusarium* wilt resistant sources in wilt sick plot in naturally infected field, 200 chickpea germplasm samples were evaluated. In the *Rabi* 2021-22 growing season, the genotypes were cultivated using an augmented design without replications, with a highly susceptible differential check (JG-62) replicated as a disease appearance indicator. The genotypes were scored using the ICRISAT rating scale, and the disease occurrences were evaluated five times at various growth stages. The *Fusarium* wilt incidences in *desi* type of chickpea showed that two lines were resistant and fifteen exhibited a moderately resistant reaction. This suggests that the source of the *desi* type chickpea's diversity is resistant to wilt and other serious chickpea illnesses. It is challenging to distinguish delayed wilting type of lines in chickpea since early wilting type accession lines predominate. As a result, the promising genotypes suggest that it is most suitable for use in breeding and can be applied directly in places that are badly impacted by wilt as well as transferred to a commercial cultivar based on resistance type.

Keywords: Chickpea, *Fusarium* wilt-*Fusarium oxysporum*, incidence, inheritance, slow wilting

Introduction
Chickpeas (*Cicer arietinum* L.) are second in popularity among food legumes to common beans in terms of nutritional value (Bharadwaj *et al.*, 2010) [3]. It is a self-pollinating diploid plant with a 740 Mbp genomic size and 2n = 2x = 16. (Varshney *et al.*, 2013) [16], It is widely grown in about 57 different nations in a variety of environmental conditions. It is grown on 13.72 million hectares (Mha) of land and produces 14.25 million tonnes per year globally (MT), (Faostat, 2020) [4].
In terms of biotic stresses, Fusarium wilt (*Fusarium oxysporum f. sp. ciceris*), which is the most serious disease of the chickpea-growing regions of India and widespread in those of Asia, Africa, and Southern Europe where the growing season is dry and warm, is one of the most significant root diseases that affects chickpeas. (Asrat and Tolesa, 2018) [1]. The pathogen is a facultative fungus that lives in soil and causes vascular wilting, which reduces yields by an average of 10 to 30 percent annually and, occasionally, completely. (Sunkad *et al.*, 2019) [15]. Based on varietal susceptibility and shifting climatic conditions, fusarium wilt has been a widespread disease that can lead to up to a 100% yield loss. As a result, a significant portion of the chickpea-growing region has moved from cool, long Northern India to warm, short Central and Southern India. (Patil *et al.*, 2015) [11]. *Fusarium* wilt typically reduces chickpea yields by 10 to 15 percent worldwide, but in some regions, it can completely destroy the crop and result in a 100% yield loss (Navas-Cortés *et al.*, 2000; Sharma *et al.*, 2005) [17, 18]. Race 1 is more prevalent in central India than race 2, which is more prevalent in northern India. The races 3 and 4 in the Indian states of Punjab and Haryana seem to be regionally distinct. All stages of a plant's growth can be affected by this disease, although the flowering and podding stages are when infections are most common (Maitlo *et al.*, 2014) [9].
The use of disease-resistant cultivars is the most effective strategy for managing the condition (Karimi *et al.*, 2012) [8]. The sources of resistance in the current chickpea germplasm should be found and leveraged in order to control these diseases (Bakhsh *et al.*, 2007) [2]. However, the issue is that the emergence of novel pathotypes /isolates has made the resistance mechanism unstable. Utilizing resistant cultivars is the only realistic and cost-effective approach given the nature of the damage and the pathogen's capacity for survival. After a few years, the majority of the resistant types were discovered to be susceptible due to the breakdown of their resistance brought on by the pathogen's evolution of diversity (Arunodhayam *et al.*, 2014) [19].

The use of chickpea wilt resistance, however, is seriously threatened by the emergence of new races. On sandy soil, wilt is more severe, whereas on clay loam soil, it is less severe. As a result, it is constantly necessary to screen new germplasm sources in search of genotypes with slow wilting and durable resilience. The current study pin points the genetic origin of chickpea resistance to *fusarium* wilt.

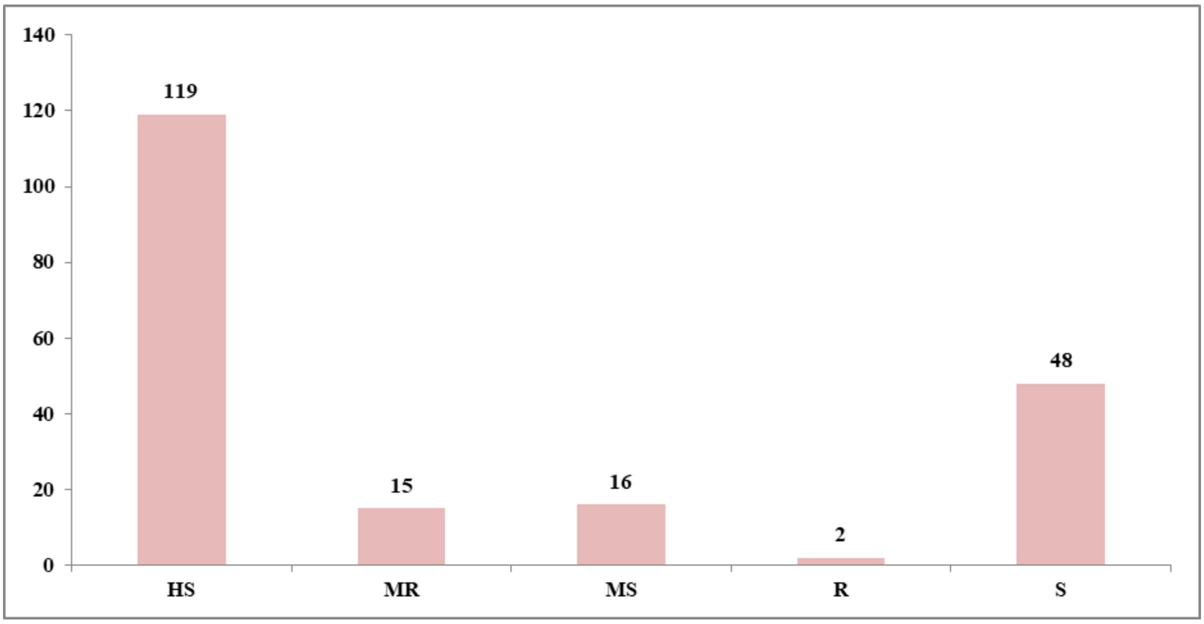
Materials and Methods

The experiment was carried out in a field that had been experimentally infected with wilt during the *Rabi* 2021–2022 crop season. With a variety of isolates reflecting various chickpea growing regions, a wilt-sick plot was created. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi, provided 200 samples of chickpea germplasm for testing on *Fusarium* wilt disease. The design was an augmented with 2m plot was used to plant each genotype without replication. In this experiment, the objective was to screen the chickpea germplasm for fusarium wilt. Thus, JG 315 was taken as the resistant check and JG 62 was the susceptible check. A single row of 4m length was taken for each germplasm and the resistant/susceptible checks were repeated. Plant-to-plant and row-to-row spacing were kept at 10 and 30 cm, respectively. On every four test entries, JG-62, a genotype that is particularly wilt prone, was repeatedly planted. The genotypes were rated using the ICRISAT rating scale: resistant (R) = 0-10% mortality; moderately resistant (MR) = 10.–20% mortality; susceptible (S) = 20-30% mortality; and highly susceptible (HS) > 50% mortality. Disease incidences were measured at various growth stages (30, 45, 60, 75, and 90 days after sowing). JG-315, a recently released variety, was considered to be resistant.

Results and Discussion

In the current screening test, 200 lines were used; of these, two were resistant to Fusarium wilt, fifteen were moderately resistant, sixteen were moderately susceptible, forty-eight were sensitive, and one hundred and nineteen were severely susceptible (Table 1). Lines GP 109 (IC275637) and GP 130 (IC305492) were the resistant accessions (Fig 1). It is not unusual to find Fusarium wilt resistance in chickpea germplasm, and numerous other researchers have also reported encountering Fusarium wilt resistance at high levels (Iqbal *et al.*, 1993; Iftikhar *et al.*, 1997; Chaudhry *et al.*, 2006, 2007) [6, 5, 20]. Variation in pathogen races across various places and their interaction with various environmental conditions over time and space pose the biggest challenge for breeding chickpeas resistant to Fusarium wilt (Sharma *et al.*, 2014). To create varieties that are highly adaptable, stable, high-yielding lines with great disease resistance are needed. (Srivastava *et al.*, 2021) [14]. One of the most successful and environmentally safe methods of integrated disease management that breeders can use is the deployment of resistant varieties. (Sharma *et al.*, 2017) [13]. Iqbal *et al.* (2005) [7] also detail the origins of wilt/root rot resistance in chickpea germplasm from both domestic and foreign research organizations. The findings agree with those made public by Nazir *et al.* (2012) [21], who examined 178 chickpea lines for resistance to Fusarium wilt and found that none of the test lines were. The plant age and growth stage were associated to the resistances, making them an essential source of parental material for determining the slow wilting type.

Similarly, Iqbal *et al.* (2005) [7] also detail the origins of wilt/root rot resistance in chickpea germplasm from both domestic and foreign research organizations. The genotypes that shown resistance, on the other hand, was best suited for use in breeding program or for direct sowing in wilt-prone locations. It is necessary to identify the genetic basis of resistance (vertical or horizontal) against the virulence of *F. oxysporum f. sp. ciceris* before transferring their resistance to a commercial cultivar.



R = Resistant, MR = Moderately Resistant, MS = Moderately Susceptible, S = Susceptible, HS = Highly Susceptible

Fig 1: Reaction level of desi type of chickpea genotypes to *Fusarium* wilt incidence

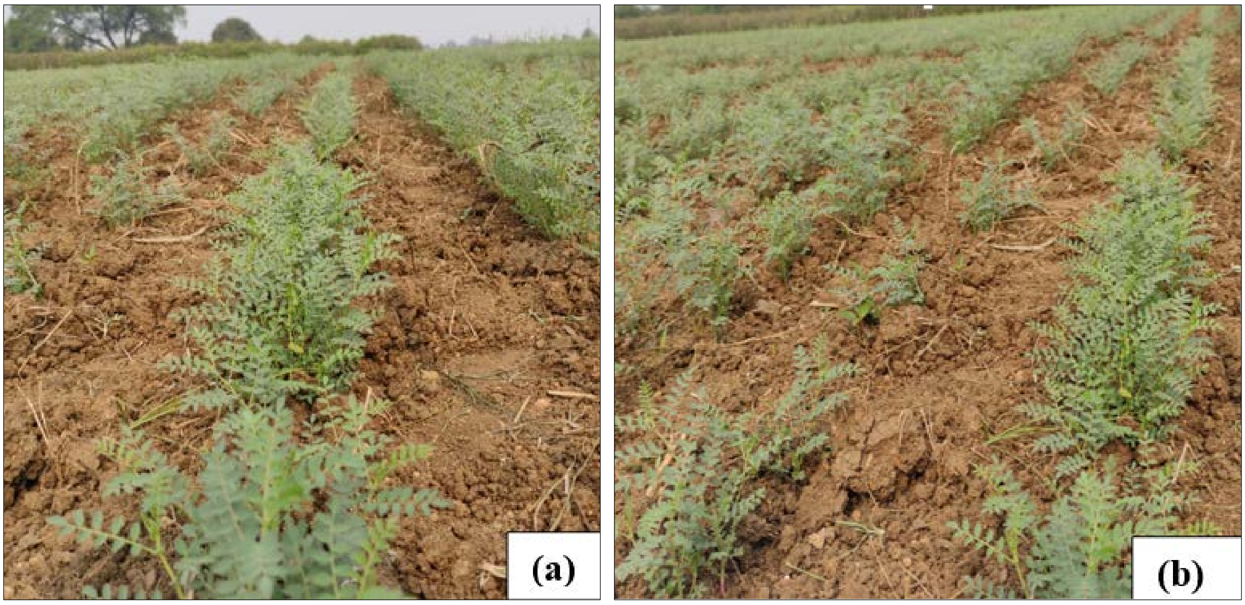


Fig 2: Genotype (a) GP 109 and (b) GP 130 showing resistance to Fusarium wilt

Table 1: Scoring data of chickpea genotypes for *Fusarium* wilt

GP Lines	Acc. No.	PP	Germination %	30 DAS 26/12/21	45 DAS 10/1/2022	60 DAS 25/01/22	75 DAS 10/2/2022	90 DAS 25/02/22	Total Wilted Plants	Wilt Incidence %	Status	Total Healthy Plants	Survival %	Yield (g)
29	IC305477	15	75	3	0	0	0	0	3	20.00	MR	12	80.0	98
35	EC547398	11	55	0	0	0	0	2	2	18.18	MR	9	81.8	24
46	IC408322	17	85	0	1	0	2	0	3	17.65	MR	14	82.4	105
63	ICC3552	20	100	1	1	1	0	0	3	15.00	MR	17	85.0	99
65	IC296084	18	90	0	1	0	1	1	3	16.67	MR	15	83.3	107
68	IC305439	18	90	0	1	0	2	0	3	16.67	MR	15	83.3	33
70	PL830	16	80	0	0	1	2	0	3	18.75	MR	13	81.3	86
73	IC313635	19	95	1	1	0	0	1	3	15.79	MR	16	84.2	105
74	IC299175	20	100	0	1	0	1	1	3	15.00	MR	17	85.0	101
102	IC396751	20	100	0	1	3	0	0	4	20.00	MR	16	80.0	117
109	IC275637	20	100	0	2	0	0	0	2	10.00	R	18	90.0	104
110	ICC12271	20	100	0	0	2	1	0	3	15.00	MR	17	85.0	78
130	IC305492	20	100	0	0	1	1	0	2	10.00	R	18	90.0	132
133	IC261659	20	100	1	0	1	1	0	3	15.00	MR	17	85.0	97
135	IC342699	17	85	0	0	1	1	0	2	11.76	MR	15	88.2	146
168	IC512069	19	95	0	3	0	0	0	3	15.79	MR	16	84.2	35
188	IC284939	18	90	1	1	0	0	1	3	16.67	MR	15	83.3	136

Acc. No. = accession number; PP = plant population; DAS = days after sowing; MR = moderately resistant; R = resistant.

Conclusion

Lines GP 109((IC275637) and GP 130 (IC305492) show resistance against Fusarium wilt disease with average yield of 104 g and 132 g respectively, which are suitable for exploitation in breeding programs or for direct sowing in wilt prone areas whereas, 15 different germplasm lines *viz*., GP 29, GP 35, GP 46, GP 63, GP 65, GP 68, GP 70, GP 73, GP 74, GP 102, GP 110, GP 133, GP 135, GP 168, GP 188 showed Moderately resistance against Fusarium wilt. In order to release cultivars or hybrids that are resistant to diseases, disease-free, resistant lines, and moderately resistant plants can be used in resistance breeding initiatives.

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