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Screening of Chickpea Germplasm / Genotypes against Fusarium Wilt of Chickpea under Field and Artificial Condition

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A B S T R A C T

Fusarium wilt caused by *Fusarium oxysporum* f.sp. *ciceris* is one of the major disease causes upto 90% losses depending on weather conditions. Eighty five germplasm/genotypes of chickpea were screened at wilt sick plot existing at RARS, Nandyal for two *rabi* seasons *i.e*., 2014-15 and 2015-16. Based on the results obtained in two years, 13 entries representing 7 resistant (ICC-294, ICC-6279, ICC-14669, NBeG-3, NBeG-47, NBeG-119 and NBeG-49) and 6 moderately resistant (ICC-1398, NBeG-119, ICC-67, NBeG-458, NBeG-47 and NBeG-452) varieties/ germplasm were selected for green house screening for three virulent *F. oxysporum* f.sp. *ciceris* isolates such as Foc-6, Foc-12 and Foc-17 for confirmation of field screening results. Under artificial screening five entries such as NBeG-3, ICC-14669, NBeG-49, ICC-6279 and ICC-294 were recorded 0% incidence for all the three virulent *F. oxysporum* f.sp. *ciceris* isolates.

Introduction

Chickpea (*Cicer arietinum* L.) is an important pulse crop of India. This grain legume is cultivated in over 50 countries in the world and infested by more than 52 number of pathogens (Nene *et al.*, 1984). Among the diseases, Fusarium wilt caused by *Fusarium oxysporum* f.sp. *ciceris* (Padwick) Matuo and Sato (FOC) is highly destructive and worldwide in occurrence (Nene *et al.*, 1989). The disease can occur at all the stages of plant growth from seedling to maturity and causes an annual yield loss of 10-90% (Jiminez-Diaz *et al.*, 1989). The incidence is more if the crop is subjected to sudden temperature rise and water stress. The fungus enters the vascular tissues of plant via roots. At seedling stage, disease symptoms appear three weeks after sowing. They exhibit drooping and pale coloured leaves and finally collapsed. The affected adult plants showed typical wilt symptoms of drooping of petioles, rachis and leaflets. When uprooted they showed uneven

shrinking of stem below the collar region. The roots of the wilting plants did not show any external rotting, but dark brown discoloration of internal xylem was seen. More yield losses occurred due to early wilting than late wilting. It is a seed borne pathogen. Due to the dynamic nature of this soil borne pathogen, it can be effectively controlled by the exploration of host plant resistance (Jalali and Chand, 1992). Since most of the commercial cultivars in the country have been found susceptible, and extensive screening of germplasm for the identification of resistant sources is required. Development and use of high yielding cultivars resistant to the prevalent pathogen race(s) in a given area is the most practical and cost efficient individual disease control measure for management of the disease.

Materials and Methods

Eighty five lines representing fifty four germ plasm lines (mini core collection) and thirty one advanced genotypes developed by AICRP on Chickpea scheme operated at RARS, Nandyal were screened in wilt sick plot for two *rabi* seasons *i.e*., 2014-15 and 2015-16. The experiment was conducted in randomized block design in two replications. Each germplasm line was sown in 3 m in a single row with 30 × 10 cm spacing. A susceptible check, JG-62 was sown after every two test rows in the whole field. These rows served as checks and will help in monitoring and maintaining the wilt sickness of the plot. For every 10 rows resistant check WR-315 was sown for comparing the level of resistance in these lines. The experiment was conducted by following general agronomic practices. Sowing was done in the month of October and harvesting was done in the month of February. Data on disease incidence was recorded periodically at 30, 60 and 90 days after sowing and final wilt incidence was calculated for all the genotypes screened.

$$\text{Wilt incidence (\%)} = \frac{\text{Number of wilted plants}}{\text{Total number of plants}} \times 100$$

The level of resistance and/or susceptibility for each line was determined by using 1-9 rating scale (Anonymous, 2014).

Local severity index (LSI) was calculated for sickness in wilt sick plot and it indicates severity of the disease at a location. It was calculated by using the below formula.

$$\text{LSI (\%)} = \frac{\text{Total per cent wilt incidence of set of entries in a given location}}{\text{Total number of entries}} \times 100$$

Artificial screening

The entries which were identified as resistant and moderately resistant during natural screening in wilt sick plot were subjected to artificial screening by following root dip inoculation technique given by Pande *et al.*, (2006). These entries were screened for three virulent *Fusarium oxysporum* f.sp. *ciceris* isolates such as Foc-6, Foc-12 and Foc-17 representing three districts such as Kurnool, Prakasam and Anantapuramu districts of Andhra Pradesh respectively. Three *F. oxysporum* f.sp. *ciceris* isolates exhibited 100% wilting on susceptible check JG-62 during pathogenicity test. Susceptible cultivar JG-62 along with the selected 13 germplasm/genotypes were raised in polythene bags filled with sterilised river sand in a greenhouse maintained at 25 ± 1°C for eight days. For artificial screening, inoculum was prepared by inoculating a 7 mm disc of actively growing *F. oxysporum* f. sp. *ciceris* culture in 250 ml conical flask containing 100 ml of sterilized potato dextrose broth. The flasks were incubated for seven days at 25 ± 1°C in an incubator shaker with continuous

shaking (125 rpm). The flask containing inoculum was diluted with sterile water to obtain 6 x 10^5 conidia ml^{-1} with the help of a haemocytometer. Eight day old seedlings of each germplasm line or genotype as well as susceptible line grown in sterilized river sand were uprooted, cleaned with tap water and root inoculated by dipping in inoculum suspension for 1-2 minutes to enable the conidia to adhere to the roots. Then such inoculated seedlings were transplanted in pots containing sterile soil and sand in 3:1 ratio and kept in a greenhouse at 25 ± 3°C. Thirty seedlings of each germplasm line or genotype were tested in three replications. Inoculated seedlings were observed for wilt symptoms upto 60 days and the experiment was repeated once. Data on disease incidence (per cent plant mortality) was recorded using the following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Number of wilted plants}}{\text{Total number of plants}} \times 100$$

The level of susceptibility and resistance of each test line/genotype was determined with the help of above scale.

Results and Discussion

During, *rabi* 2014-15 the results revealed that out of 85 entries screened, 6 entries were found resistant, 9 entries were moderately resistant, 20 entries were moderately susceptible, 32 entries were susceptible and 18 entries were highly susceptible. During *rabi* 2015-16, 8 entries were found resistant, 13 were moderately resistant, 28 were moderately susceptible, 26 entries were susceptible and 10 entries were highly susceptible (Table 1). Pooled data for both the years 2014-15 and 2015-16 indicated that out of 85 germplasm lines and advanced genotypes screened for Fusarium wilt, 7 entries (ICC-294, ICC-6279, ICC-14669, NBeG-3, NBeG-47, NBeG-119 and NBeG-49) were recorded as resistant, 6 entries were moderately resistant (ICC-1398, NBeG-458, ICC-67, NBeG-452, NBeG-177, JG-11) and 26 entries are moderately susceptible, 33 entries were graded as susceptible, 13 entries were highly susceptible (Table 2).

The local severity index of wilt sick plot was recorded as 36.26%. The susceptible check JG-62 was completely wilted out within 18-25 days after sowing, indicating its highly susceptible nature to Fusarium wilt and recorded 98.5% of disease. It was observed that the susceptible check was completely wilted uniformly in the field indicating that uniform distribution of inoculum. Whereas resistant check i.e., WR-315 showed only 7.8% wilt incidence in the field till the time of harvesting indicating its resistance nature.

Based on field screening data in wilt sick plot for two years, seven resistant and six moderately resistant lines (totally thirteen entries) were selected for green house screening to confirm field resistance. Significant differences were observed among the entries pertaining to wilt incidence in statistical analysis (Table 3). The results indicated that out of 13 entries, five entries such as NBeG-3, ICC-14669, NBeG-49, ICC-6279 and ICC-294 were recorded 0% incidence for all the three virulent *F. oxysporum* f.sp. *ciceris* isolates, six entries such as ICC-1398, NBeG-119, ICC-67, NBeG-458, NBeG-47 and NBeG-452 recorded as resistant category (showing 1-10% wilt incidence), two isolates such as NBeG-177 and JG-11 were showed moderately resistant reaction to all the three isolates. Susceptible check (JG-62) was completely wilted out in this screening.

The present study results are in close confirmation with Mehmood and Khan (2016) who screened 318 chickpea genotypes in wilt

sick plot for Fusarium wilt of chickpea for two seasons and found three lines/varieties such as 5006, k021-10 and k035-10 as highly resistant. In the present field experiment three germplasm lines (ICC-294, ICC-6279, ICC-14669) and four advanced genotypes (NBeG-3, NBeG-47, NBeG-49 and NBeG-119) are showing resistant reaction. Similarly Husnain *et al.,* (2016) screened 64 advanced lines of chickpea against the wilt in sick plot and categorized them into highly resistant (7 lines), resistant (11 lines), moderately resistant (10 lines) and susceptible (36 lines).

Fifty large-seeded kabuli chickpea germplasm from ICRISAT's gene bank were evaluated and found that two accessions, ICC 14194 and ICC 17109 showed complete resistance (0% plant mortality) to Fusarium wilt (Gaur *et al.,* 2006).

Saabale *et al.,* (2017) screened 59 land races and 62 elite breeding lines of chickpea against Fusarium wilt (race 2) under sick field at IIPR, Kanpur and observed that eight land races, ten kabuli genotypes, 15 desi genotypes were highly resistant and local severity index (LSI) was higher for land races (71.7%) compared to elite breeding lines (27.8%). In the present experiment, local severity index (LSI) was recorded as 36.26% in the wilt sick plot. Nene and Haware (1980) identified only 14 resistant varieties out of 7000 chickpea accessions screened.

Other factors favouring the development of *F. oxysporum* f.sp. *ciceris* are high temperature, amount of inoculum and excess soil water (Navas-Cortes *et al.,* 2000).

In this study same temperature was observed (19.3^{o}C to 33^{o}C) during crop growth period for both the years, hence it was assumed that the wilting in susceptible cultivars could be due to their inherent susceptibility to pathogen.

In the present study, the screening data of both the years (*rabi* 2014-15 and 2015-16) indicating similar disease pattern or response to Fusarium wilt except some genotypes or germplasm lines showed some variation in disease response to *Fusarium*. This study showed that presence of high to moderate levels of resistance in germplasm against Fusarium wilt of chickpea.

Based on field screening data in wilt sick plot for two years, seven resistant and six moderately resistant lines (totally thirteen entries) were screened artificially in green house for three virulent isolates (Foc-6, Foc-12 and Foc-17). Significant differences were observed among the entries pertaining to wilt incidence. The results indicated that out of 13 entries, five entries such as NBeG-3, ICC-14669, NBeG-49, ICC-6279 and ICC-294 were recorded 0% incidence for all the three virulent *F. oxysporum* f.sp. *ciceris* isolates, six entries such as ICC-1398, NBeG-119, ICC-67, NBeG-458, NBeG-47 and NBeG-452 recorded as resistant category, two isolates such as NBeG-177 and JG-11 were showed moderately resistant reaction to all the three isolates. Susceptible check (JG-62) was completely wilted out in this screening.

All the entries exhibited similar type of disease pattern (wilt incidence) for three virulent isolates used in this study. The present study results are supported by Pande *et al.,* (2006) who screened 211 mini core germplasm collections in green house for multiple disease resistance (Fusarium wilt, Botrytis grey rot, Ascochyta bight and dry root rot) and observed that 21 were asymptomatic (0% incidence), 25 were resistant and 21 were moderately resistant to Fusarium wilt. They grouped the same two entries such as ICC-6279 and ICC-14669 obtained in the present study into asymptomatic category and other two entries such as ICC-1398 and ICC-67 into resistant category.

Table.1 Reaction of chickpea germplasm/genotypes against *Fusarium oxysporum* f.sp. *ciceris* in wilt sick plot

S. No.	Entry name	Wilt incidence (%)			Grade	Disease reaction
		2014-15	2015-16	Average		
1.	ICC-4639	40.64	44.58	42.61	7	S
2.	ICC-16524	48.30	50.83	49.56	7	S
3.	ICC-1397	77.80	26.93	52.36	9	HS
4.	ICC-14778	63.40	56.34	59.87	9	HS
5.	ICC-5879	35.00	32.66	33.83	7	S
6.	ICC-1398	14.00	22.82	18.41	3	MR
7.	ICC-67	11.30	11.17	11.20	3	MR
8.	ICC-1162	28.56	30.24	29.40	5	MS
9.	ICC-294	09.80	04.00	06.90	1	R
10.	ICC-5382	28.65	27.04	27.84	5	MS
11.	ICC-10945	31.70	20.69	26.19	5	MS
12.	ICC-6279	13.30	03.50	08.40	1	R
13.	ICC-12025	35.00	29.80	32.40	7	S
14.	ICC-697	41.70	29.38	35.54	7	S
15.	ICC-12037	66.70	54.30	60.50	9	HS
16.	ICC-2942	50.00	42.80	46.40	7	S
17.	ICC-3512	65.00	33.33	49.16	7	S
18.	ICC-5383	36.70	33.45	35.07	7	S
19.	ICC-12328	60.00	49.46	54.73	9	HS
20.	ICC-6816	73.40	32.70	53.05	9	HS
21.	ICC-12524	78.30	87.65	82.97	9	HS
22.	ICC-1194	73.40	65.32	69.36	9	HS
23.	ICC-14669	05.00	05.93	05.46	1	R
24.	ICC-3510	51.70	41.15	46.42	7	S
25.	ICC-13219	50.00	27.76	38.88	7	S
26.	ICC-13863	51.70	32.16	41.93	7	S
27.	ICC-9755	48.40	20.06	34.23	7	S
28.	ICC-14402	73.60	61.66	67.63	9	HS
29.	ICC-14051	40.00	36.66	38.33	7	S
30.	ICC-13124	43.40	26.50	34.95	7	S
31.	ICC- 867	73.40	58.56	65.98	9	HS
32.	ICC-15618	35.00	38.46	36.73	7	S
33.	ICC-1230	26.70	28.57	27.63	5	MS
34.	ICC-5845	40.00	36.61	38.30	7	S
35.	ICC-4872	45.00	39.35	42.17	7	S
36.	ICC-1923	28.40	69.02	48.71	7	S
37.	ICC-14831	43.40	40.90	42.15	7	S
38.	ICC-2580	73.40	62.00	67.70	9	HS
39.	ICC-9942	56.70	24.81	40.75	7	S
40.	ICC-9862	100.0	90.00	95.00	9	HS
41.	ICC-9895	58.30	18.76	38.53	7	S
42.	ICC-13764	70.00	56.52	63.26	9	HS

43.	ICC-16915	35.00	19.94	27.47	5	MS
44.	ICC-283	30.00	21.85	25.92	5	MS
45.	ICC-5434	45.00	44.26	44.63	7	S
46.	ICC-1882	75.00	30.30	52.65	9	HS
47.	ICC-8607	56.70	42.02	49.36	7	S
48.	ICC-8621	46.70	32.10	39.40	7	S
49.	ICC-15567	30.00	43.68	36.84	7	S
50.	ICC-4593	30.00	22.82	26.41	5	MS
51.	ICC-14815	13.40	30.35	21.87	5	MS
52.	ICC-1171	36.70	34.20	35.45	7	S
53.	ICC-1163	43.60	23.45	33.52	7	S
54.	ICC-1883	14.30	25.95	20.62	5	MS
55.	NBeG-168	41.70	40.44	41.07	7	S
56.	NBeG-164	41.70	27.18	34.44	7	S
57.	NBeG-158	30.00	30.00	30.00	5	MS
58.	NBeG-159	31.20	29.26	30.23	7	S
59.	NBeG-170	26.70	19.80	23.25	5	MS
60.	NBeG-169	36.70	21.24	28.97	5	MS
61.	NBeG-161	31.81	31.81	31.81	7	S
62.	NBeG-157	34.40	22.61	28.50	5	MS
63.	NBeG-160	42.43	17.14	29.75	5	MS
64.	NBeG-156	16.80	26.92	21.86	5	MS
65.	NBeG-454	26.92	22.45	24.68	5	MS
66.	NBeG-471	34.10	09.21	21.65	5	MS
67.	NBeG-177	18.60	10.81	14.70	3	MR
68.	NBeG-452	09.80	14.27	12.05	3	MR
69.	NBeG-460	42.90	21.21	32.05	7	S
70.	NBeG-3	08.20	10.30	09.25	1	R
71.	NBeG-458	15.10	06.30	10.70	3	MR
72.	NBeG-179	27.90	15.24	21.57	5	MS
73.	NBeG-119	08.30	11.11	09.70	1	R
74.	NBeG-453	31.30	05.50	24.00	5	MS
75.	NBeG-399	28.50	30.35	29.42	5	MS
76.	NBeG-780	24.70	20.60	22.65	5	MS
77.	NBeG-506	33.90	17.08	25.49	5	MS
78.	NBeG-510	31.60	12.69	22.14	5	MS
79.	NBeG-49	04.50	06.50	05.50	1	R
80.	NBeG-47	10.50	09.00	09.75	1	R
81	NBeG-451	21.20	20.64	20.92	5	MS
82.	NBeG-507	37.30	17.20	27.25	5	MS
83.	JG-11	12.00	20.00	16.00	3	MR
84.	KAK-2	28.80	45.00	36.90	7	S
85.	NBeG-511	21.50	29.50	25.50	5	MS
	JG-62 (S check)	99.00	98.00	98.50	9	HS
	WR-315 (R check)	07.60	08.00	07.80	1	R

R-Resistant, MR-Moderately resistant, MS-Moderately susceptible, S-Susceptible and HS-Highly susceptible

Table.2 Categorization of chickpea germplasm/genotypes against *Fusarium oxysporum* f.sp. *ciceris* at wilt sick plot (Average of two years)

S. No.	Disease reaction	No. of entries	Entries name
1.	Resistant	07	ICC-294, ICC-6279, ICC-14669, NBeG-3, NBeG-49, NBeG-47, NBeG-119
2.	Moderately resistant	06	ICC-67, ICC-1398, NBeG-177, NBeG-452, NBeG-458, JG-11
3.	Moderately susceptible	26	ICC-1162, ICC-5382, ICC-10945, ICC-1230, ICC-16915, ICC-283, ICC-14815, ICC-1883, ICC-4593, NBeG-157, NBeG-160, NBeG-158, NBeG-170, NBeG-169, NBeG-156, NBeG-454, NBeG-471, NBeG-179, NBeG-453, NBeG-399, NBeG-506, NBeG-510, NBeG-511, NBeG-451, NBeG-507, NBeG-780
4.	Susceptible	33	ICC-4639, ICC-16524, ICC-5879, ICC-12025, ICC-697, ICC-2942, ICC-3512, ICC-5383, ICC-3510, ICC-13219, ICC-13863, ICC-9755, ICC-14051, ICC-13124, ICC-15618, ICC-5845, ICC-4872, ICC-1923, ICC-14831, ICC-9942, ICC-9895, ICC-5434, ICC-8607, ICC-8621, ICC-15567, ICC-1171, ICC-1163, NBeG-168, NBeG-164, NBeG-159, NBeG-161, NBeG-460, KAK-2.
5.	Highly susceptible	13	ICC-1397, ICC-14778, ICC-12037, ICC-12328, ICC-6816, ICC-12524, ICC-1194, ICC-14402, ICC-867, ICC-2580, ICC-9862, ICC-13764, ICC-1882

Table.3 Evaluation of chickpea germplasm/advanced genotypes to *Fusarium wilt* in green house conditions

S. No.	Entry name	Wilt incidence (%)			
		Field screening	Artificial screening (%)		
			Foc-6	Foc-12	Foc-17
1.	NBeG-3	09.25 (17.72)	00.00 (0.00)	00.00 (0.00)	00.00 (0.00)
2.	ICC-1398	18.40 (25.41)	10.00 (18.44)	10.00 (18.44)	10.00 (18.44)
3.	NBeG-119	09.70 (18.12)	06.66 (14.49)	10.00 (18.44)	10.00 (18.44)
4.	ICC-14669	05.46 (13.52)	00.00 (00.00)	00.00 (0.00)	00.00 (0.00)
5.	NBeG-458	10.70 (19.10)	10.00 (18.44)	10.00 (18.44)	10.00 (18.44)
6.	NBeG-49	05.50 (13.57)	00.00 (0.00)	00.00 (0.00)	00.00 (0.00)
7.	NBeG-47	09.75 (18.20)	03.33 (10.52)	03.33 (10.52)	10.00 (18.44)
8.	ICC-6279	8.4 (16.86)	00.00 (0.00)	00.00 (0.00)	00.00 (0.00)
9.	ICC-67	11.20 (19.56)	10.00 (18.44)	10.00 (18.44)	10.00 (18.44)
10.	ICC-294	06.90 (15.24)	00.00 (0.00)	00.00 (0.00)	00.00 (0.00)
11.	NBeG-177	14.70 (22.56)	20.00 (26.58)	19.80 (26.43)	18.93 (25.79)
12.	NBeG-452	12.00 (20.28)	10.00 (18.44)	10.00 (18.44)	09.80 (18.23)
13.	JG-11	16.00 (23.59)	12.50 (20.72)	11.50 (20.65)	12.50 (20.72)
	JG-62	95.00 (77.12)	100.00 (90.05)	100.00 (90.05)	100 (90.05)
	SEm±	**2.51**	**0.74**	**0.35**	**0.37**
	CD at 5%	**7.67**	**2.18**	**1.03**	**1.07**
	CV (%)	**15.13**	**7.7**	**3.6**	**3.66**

Figures in parenthesis are angular transformed values

The level of resistance and/or susceptibility for each line was determined by using 1-9 rating scale (Anonymous, 2014)

Scale	PDI	Disease reaction
1	1-10%	Resistant
3	11-20%	Moderately resistant
5	21-30%	Moderately susceptible
7	31-50%	Susceptible
9	51-100%	Highly susceptible

Similar work was carried out by Sharma *et al.,* (2010) who screened twenty five lines each of desi and of kabuli chickpea for Fusarium wilt resistance during 2008-09 in the field (wilt sick plot) and greenhouse at the ICRISAT. Among 25 desi lines screened, 15 lines and 24 lines were found resistant in wilt sick plot and green house respectively. Among 25 kabuli types, seven lines were found resistant in the field and nine lines (including seven resistant lines in the field) showed resistant reaction in the green house.

During 1976 to 1985, more than 13,500 germplasm accessions available at the ICRISAT gene bank were screened in the wilt sick plot against race 1 of *F. oxysporum* f.sp. *ciceris* (Haware *et al.,* 1992) and reported 160 accessions resistant to Fusarium wilt through field and greenhouse screening.

When field screening was compared with green house screening, it was found that seven entries such as NBeG-3, NBeG-47, ICC-14669, NBeG-119, NBeG-49, ICC-6279, ICC-294 showed resistant reaction in the field and among them five entries such as NBeG-3, ICC-14669, NBeG-49, ICC-6279 and ICC-294 recorded 0% incidence in green house screening and remaining two entries such as NBeG-47 and NBeG-119 exhibited resistant reaction in the green house screening. Four entries such as ICC-1398, NBeG-458, ICC-67 and NBeG-452 showed moderately resistant reaction in the field and resistant reaction in the green house screening. The entries NBeG-177 and JG-11 exhibited moderately resistant reaction in both screening methods.

The variation in the resistance/susceptibility of chickpea germplasm and genotypes in the field and polyhouse screening may be due to the prevalence of other soil borne diseases *i.e.*, dry root rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsii*) and wet root rot (*Fusarium solani*) in wilt sick plot. These are the major diseases of chickpea apart from Fusarium wilt prevalent at RARS, Nandyal. Haware *et al.,* (1992) mentioned that wilt resistant lines often showed some mortality in the field due to the presence of other soil borne pathogens particularly *Rhizoctonia bataticola* and *Sclerotium rolfsii*. Sometimes it also might be due to the contamination of one germplasm seed with other germplasm seeds.

Though number of resistance sources identified against wilt across the globe, as mentioned above, continuous change in the genetic makeup of pathogen warrants continuous search for host resistance.

Maitlo *et al.,* (2014) screened 31 cultivars of chickpea against *F. oxysporum* f.sp. *ciceris* and found no cultivar was completely immune to Foc and cultivars used for screening showed significantly higher plant mortality and pathogen infection. But in the present work there are five germplasm lines/genotypes such as NBeG-3, NBeG-49, ICC-6279 and ICC-294 and ICC-14669 were

showed complete resistance against *F. oxysporum* f.sp. *ciceris*.

Among chickpea germplasm/genotypes screened for both natural and artificial methods, the genotypes such as NBeG-3, NBeG-49, NBeG-47, NBeG-119, NBeG-458 and NBeG-452 were recommended for cultivation where Fusarium wilt is the major problem. Germplasm lines such as ICC-14669, ICC-6279, ICC-294, ICC-1398 and ICC-67 can be used for Fusarium wilt resistance breeding programme based on their yield potential.

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