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Research Article

Evaluation of Chickpea Varieties and Fungicides for the Management of Chickpea Fusarium Wilt Disease *(Fusarium oxysporum* f.sp. *ciceris)* at Adet Sick Plot in Northwest Ethiopia

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A 2-year experiment was conducted at wilt sick plot infested with natural occurring *Fusarium oxysporum* f.sp. *ciceris* at Adet Agricultural Research Center in northwestern Ethiopia with an aim to evaluate effective chickpea varieties and fungicides for the management of chickpea fusarium wilt in order to integrate chickpea varieties and fungicides. Four varieties, namely, Shasho, Arerti, Marye, and local, two fungicides, namely, Apron Star and mancozeb, and untreated local chickpea were used as treatments. Treatments were arranged in a factorial combination in randomized complete block design in three replications. There were significant differences at $p < 0.05$ in the overall mean of fusarium wilt disease incidence, area under disease progress curve %-day, yield and yield components among varieties and fungicides treatments. Data were analyzed using SAS system version 9.2. The results indicated that the maximum disease incidence and area under disease progress curve values 65.62% and 578.5%-day, respectively, were recorded from untreated local chickpea, while the minimum disease incidence and area under disease progress curve values 23.41% and 147%-day, respectively, were recorded from Shasho variety treated with Apron Star. The maximum biomass and grain yield of 6.71 t/ha and 4.6 t/ha, respectively, were recorded from Shasho variety treated with Apron Star while the minimum biomass and grain yield of 0.62 t/ha and 0.21 t/ha, respectively, were recorded from untreated local chickpea. Thus, the experiment results suggested that the variety of Shasho treated with fungicide Apron Star caused significant reduction in chickpea fusarium wilt incidence leading to a corresponding increase in grain yield of chickpea.

1. Introduction

The average productivity of chickpea in Ethiopia is much lower than the world's average and is also lower as compared to other chickpea-growing countries such as Egypt and Turkey [1]. This low productivity is mainly due to a number of biotic and a biotic stresses. Among the biotic stresses, fusarium wilt, ascochyta blight, pod borer, and cutworm and abiotic stresses, drought, heat, soil salinity, low soil fertility, and poor crop management practices are the most important limiting factors in crop production [2]. However, fusarium wilt, caused by *Fusarium oxysporum* f.sp. *ciceris*, is one of the most important biotic stresses of chickpea (*Cicer arietinum* L.), and the average annual yield losses due to wilt have been estimated to 10 to 90% and sometimes escalate to 100% when the relative humidity is greater than 60% and temperature ranges between 10 and 25°C [3]. The disease is prevalent in the Indian subcontinent, Ethiopia, Mexico, Spain, Tunisia, Turkey, and the United States [4]. *Fusarium oxysporum* f.sp. *ciceris* is a vascular pathogen that perpetuates in seed and soil and hence is difficult to manage by the use of single control method [5].

Fusarium wilt of chickpea can be managed by using resistant varieties, healthy chickpea seed, crop rotation, biological control, and fungicides, adjusting sowing dates, and adopting integrated management practices [6]. Seid and Melkamu [7] reported that growing resistant and moderately resistant varieties treated with fungicides sown at recommended seeding rate could reduce mortality caused by chickpea fusarium wilt. In spite of the occurrence of fusarium wilt in commonly grown varieties in most parts of the country every year, limited research efforts have been made to find out sources of resistance and develop suitable methods for its management in Ethiopia. Therefore, the main objective of this study was to evaluate the effects of chickpea varieties and seed dressing with fungicides on fusarium wilt development.

2. Materials and Methods

2.1. Description of Study Area, Treatments, and Experimental Design. The field experiment was conducted during 2015 and 2016 cropping seasons on fusarium wilt sick plot at the Adet Agricultural Research Center (AARC) in the northwestern part of Ethiopia. The center is located 11° 17'N latitude, 37° 43'E longitude and lies at an altitude of about 2150 m.a.s.l. According to the meteorological data of the center, the average annual rainfall is 1250 mm ranging between 860 mm and 1771 mm with the average maximum and minimum temperature 27.5°C and 12.2°C, respectively [8].

The treatments were consisted of four chickpea varieties, namely, Shasho, Arerti, Marye, and local, two seed dressing fungicides, namely, Apron Star and mancozeb, and untreated local chickpea (control). The design was Randomized Complete Block Design (RCBD) with three replications. The gross plot size was $4\,m^2$ (1.6 m × 2.5 m), and the path plots and between blocks were 1 m and 1.5 m, respectively. Plots were prepared and fertilized with $100\,kg{\cdot}ha^{-1}$ diammonium phosphate at planting. The seeds were planted at spacing of 10 cm between plants and 40 cm between rows. Both the fungicides were used at the rate of 3 g for a kg of seeds, and the treated seeds were shade-dried overnight before sowing. All the recommended cultural practices were also applied in the field.

2.2. Data Collection. In the experiment, field observations of naturally occurring fusarium wilt incidence were done at 7-day interval at sick plot based on percent of wilt incidence in each plot. Initial recording data for fusarium wilt disease incidence was done when wilting symptoms were visible on the three to five basal leaves of the plants.

Disease incidence (DI) on each experimental unit was calculated by using the following formula:

$$\mathrm{DI}\,(\%) = \left(\frac{\text{number of plants that shows wilt symptoms}}{\text{number of both disease infected plants and healthy plants}}\right) \times 100. \tag{1}$$

Area under disease progress curve (AUDPC) was calculated for each treatment from the assessment of disease incidence by using the following formula:

$$\mathrm{AUDPC} = \sum_{i-1}^{n-1} 0.5\left(x_{i+1} + x_i\right)\left(t_{i+1} - t_i\right), \tag{2}$$

where x_i is the disease incidence in percentage at i_{th} assessment, t_i is the time of the i_{th} assessment in days from the first assessment date, and n is the total number of disease assessments [9].

Relative yield loss (RYL) was calculated using the formula of Robert and James [10]:

$$\mathrm{RYL} = \frac{\mathrm{YP} - \mathrm{YUP}}{\mathrm{YP}} \times 100, \tag{3}$$

where RYL = relative yield loss (reduction of the yield and yield component), YP = yields which were obtained from plots with maximum protection, and YUP = yields which were obtained from plots with minimum protection. Relative yield loss with different treatments was calculated with reference to the best protected plot.

2.3. Statistical Analysis. Analyses of variance (ANOVA) for the effects of varieties and fungicides on fusarium wilt disease incidence, AUDPC %-day, relative yield loss, and grain yield were used to compare the level of resistance among evaluated varieties and fungicides. All analyses were performed using statistical package SAS system, version 9.2 [11]. Least significant difference (LSD) values were used to separate differences among treatments means at 5% probability level.

3. Results and Discussion

The data of two cropping seasons were analyzed separately, but the result showed that there was no significant difference between the two season outputs in the experiments, so that the two season data were combined and analyzed together.

3.1. Disease Incidence. Significant differences at $p < 0.05$ were observed among varieties and fungicides on disease incidence percentage. Among the main effects, the maximum disease incidence of 53.45% was recorded from local chickpea while the minimum disease incidence of 29.41% was recorded from Shasho variety (Table 1). Shasho variety followed by Arerti had lower wilt incidence over the local [12]. On the contrary, the maximum disease incidence of 52.31% was recorded from untreated plots while the minimum disease incidence was ranged from 32.76% to 37.38% recorded from Apron Star and mancozeb treated plots, respectively (Table 1).

Landa et al. [13] pointed out seed dressing chemical is one of the most important factors that reduces the effects of fusarium wilt disease. The chickpea plants treated with fungicides gave 26–34% disease incidence of fusarium wilt as compared to untreated plants, which have 80% incidence. Similarly, the application of fungicides brought tremendous increment in plant growth as well as grain yield. Kamdi et al. [14] stated that seed dressing fungicide applications in chickpea plants were very effective; they have not only suppressed the pathogen activities but also increased the

Table 1: Main effects of chickpea varieties and fungicides on disease incidence of chickpea fusarium wilt.

Variety	Incidence (%)	Fungicides	Incidence (%)
Shasho	29.41a	Apron Star	32.76a
Arerti	34.83a	Mancozeb	37.38a
Marye	45.56b	Untreated	52.31b
Local	53.45b		
Mean	40.81		40.82
LSD	5.46		4.92
CV (%)		11.68	

LSD = least significant difference; CV = coefficient of variation; means followed by the same letter did not show significant difference at $p < 0.05$ according to least significant difference.

Table 2: Two-way interaction effects of chickpea varieties and fungicides on disease incidence of chickpea fusarium wilt.

Chickpea varieties	Disease incidence percentage			
	Seed dressing fungicides			
	Apron Star	Mancozeb	Untreated	Mean
Shasho	23.41a	26.68ab	40.15de	30.08a
Arerti	28.39ab	32.67bc	43.43e	34.83a
Marye	36.33cd	40.31de	60.03g	45.56b
Local	44.91ef	49.84f	65.62g	53.46c
Mean	33.26a	37.38a	52.31b	
LSD (5%)		6.125		
CV (%)		13.65		

LSD = least significant difference; CV = coefficient of variation; means followed by the same letter did not show significant difference at $p < 0.05$ according to least significant difference.

plant growth and grain yield (almost double than the control plants).

Analysis of variance showed that disease incidence was significantly affected by chickpea varieties, fungicides, and their interaction at $p < 0.05$ (Table 2). Among the interaction effects, the maximum disease incidence of 65.62% was obtained from untreated local chickpea, followed by untreated Marye variety while the minimum disease incidence of 23.41% was recorded from Shasho variety treated with Apron Star but they did not show any significant difference among Shasho variety treated with mancozeb and Arerti variety treated with Apron Star fungicides that of 26.68% and 28.39%, respectively (Table 2).

3.2. Effect of Varieties and Fungicides on the Progress of Fusarium Wilt. The disease progress curve on chickpea varieties at two seed dressing fungicides, i.e., Apron Star and mancozeb and untreated is given in Figure 1. The fusarium wilt incidence increased from the initial to final assessment dates, and the curve showed an increasing trend of disease development for effects of four chickpea varieties in each seed dressing fungicide in the assessments. Hence, the result showed that the rate was slower on Shasho followed by Arerti variety compared to local and Marye variety (Figure 1).

On the contrary, the disease progress curve on fungicides at four chickpea varieties, i.e., Shasho, Arerti, Marye, and local is given in Figure 2. The curve showed an increasing trend of disease development for effects of seed dressing fungicides in each chickpea variety in the assessments. Hence, the result showed that the rate was slower on chickpea treated with Apron Star, followed by the ones treated with mancozeb fungicides compared to untreated plots (Figure 2).

3.3. Area under Disease Progress Curve (AUDPC). Among the main effects, the minimum AUDPC %-day value were recorded from Shasho variety, followed by Arerti and Marye varieties while the maximum AUDPC %-day value was recorded from local chickpea (Figure 3). These mean that Shasho variety has more resistance against to the fusarium wilt disease compared to other tested varieties.

On the contrary, the minimum AUDPC %-day value was recorded from the chickpea variety treated with Apron Star, followed by mancozeb fungicides while the maximum AUDPC %-day value was recorded from untreated plots (Figure 3). This is because the chickpea variety treated with Apron Star fungicides had more resistance against to the fusarium wilt disease incidence compared to mancozeb and untreated.

Analysis of variance showed that AUDPC %-day was significantly affected by chickpea varieties, fungicides, and their interaction at $p < 0.05$. Among the interaction effects, the maximum AUDPC %-day value was recorded from untreated local chickpea, followed by local chickpea treated with mancozeb fungicides while the minimum AUDPC %-day value was recorded from Shasho variety treated with Apron Star fungicides, followed by Arerti treated with Apron Star and Shasho treated mancozeb fungicides (Figure 4).

3.4. Grain Yield of Chickpea. Grain yield was significantly affected by chickpea varieties, fungicides, and their interaction at $p < 0.05$. Among two-way interaction effects, the maximum grain yield of 4.55 t/ha was recorded from Shasho variety treated with Apron Star, followed by Arerti variety treated with Apron Star which resulted in grain yield of 3.94 t/ha while the minimum grain yields of 0.21 t/ha were recorded from untreated local chickpea, followed by untreated Marye variety which resulted in grain yield of 0.75 t/ha (Table 3).

Yigitoglu [15] reported that the maximum grain yield was obtained from resistant variety treated with seed dressing fungicides. Apron Star seed-treatment gave minimum disease incidence of fusarium wilt and maximum grain yield [14]. Similarly, Subhani et al. [16] reported that applications of seed dressing fungicide significantly increased the plant growth and yield and also decreased chickpea fusarium wilt incidence.

3.5. Relative Losses in Grain Yield. Among two way interaction effects, the maximum relative grain yield losses of 95.38% and 83.52% were obtained from untreated local chickpea and untreated Marye variety, respectively, while the minimum relative grain yield loss was obtained from Shasho variety treated with Apron Star fungicides which result of insignificance loss, followed by Arerti variety treated with Apron Star fungicides, which result of 13.41%

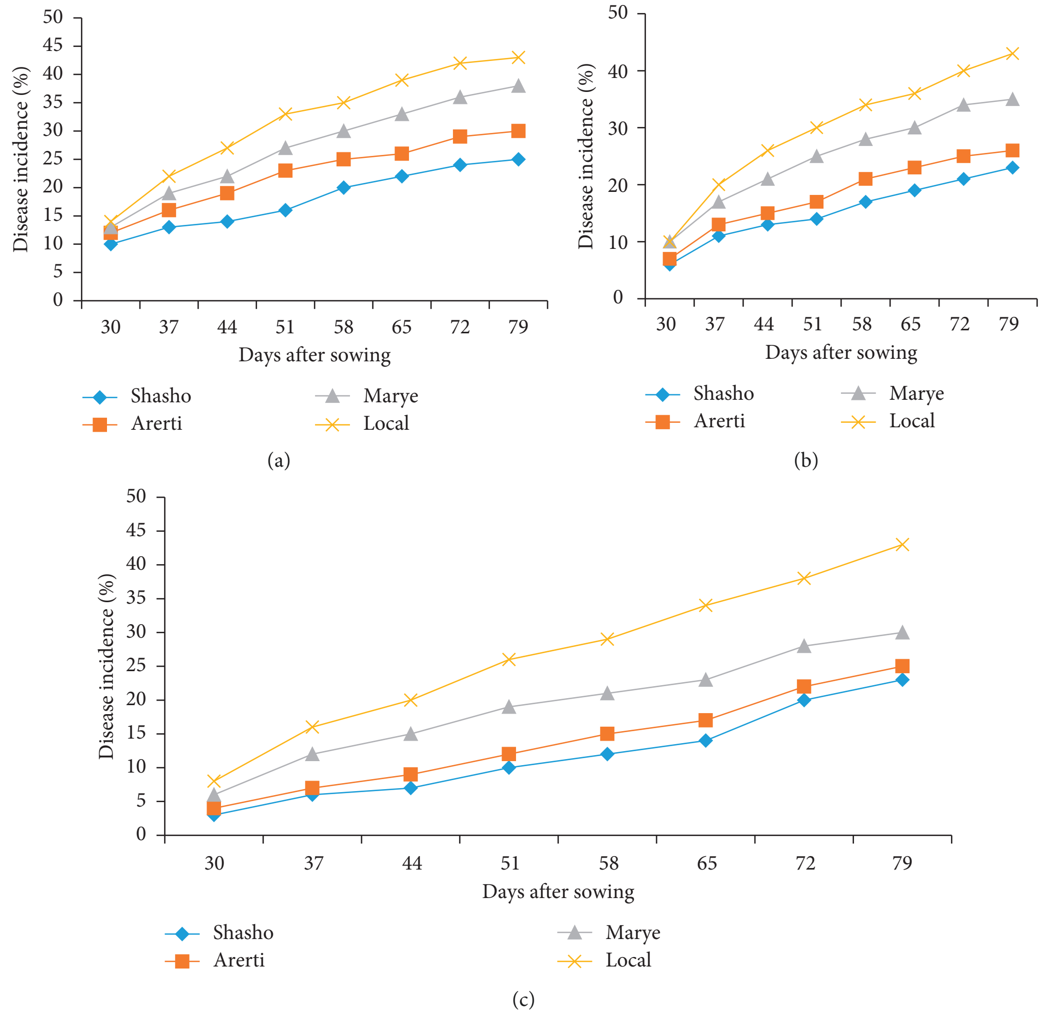


Figure 1: Response of different chickpea varieties to fungicides: (a) untreated; (b) mancozeb; (c) Apron Star, on disease progress curve of fusarium wilt incidence.

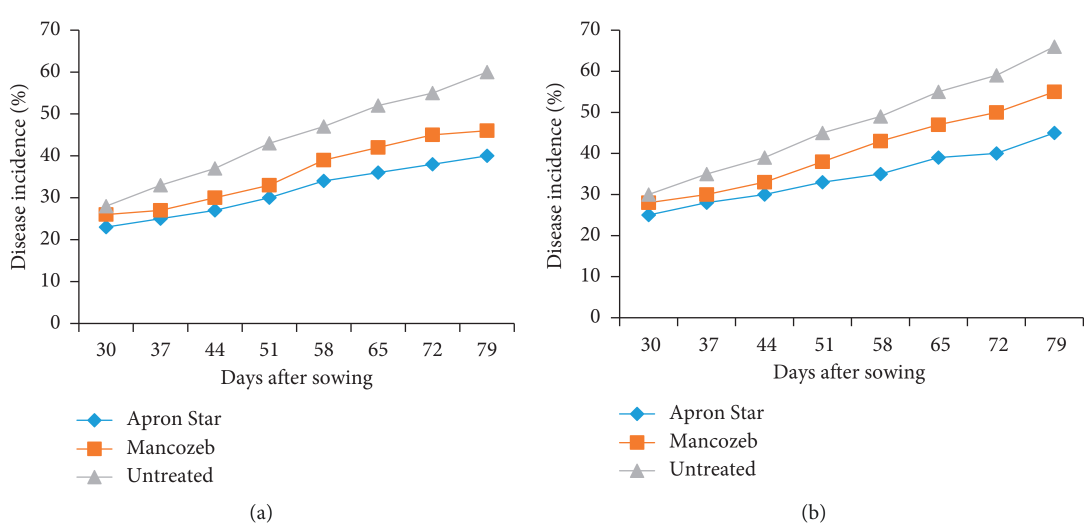
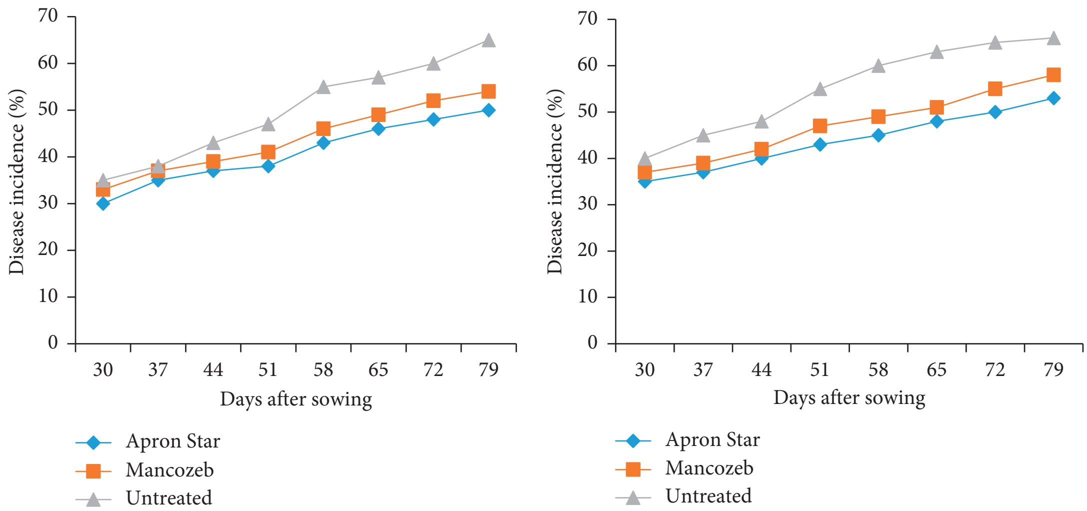


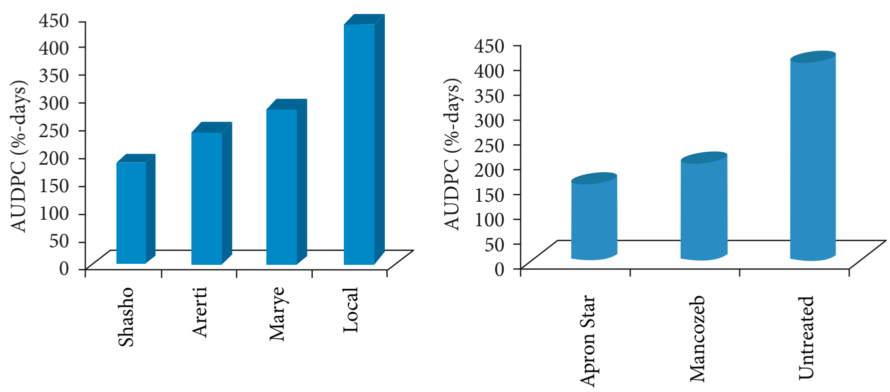
Figure 2: Continued.



(c)

(d)

Figure 2: Response to different fungicides by the four varieties of chickpea: (a) Shasho, (b) Arerti, (c) Marye, and (d) local check variety, on disease progress of fusarium wilt incidence.



(a)

(b)

Figure 3: The main effects of (a) varieties and (b) fungicides on AUDPC (%-day values) of fusarium wilt of chickpea.

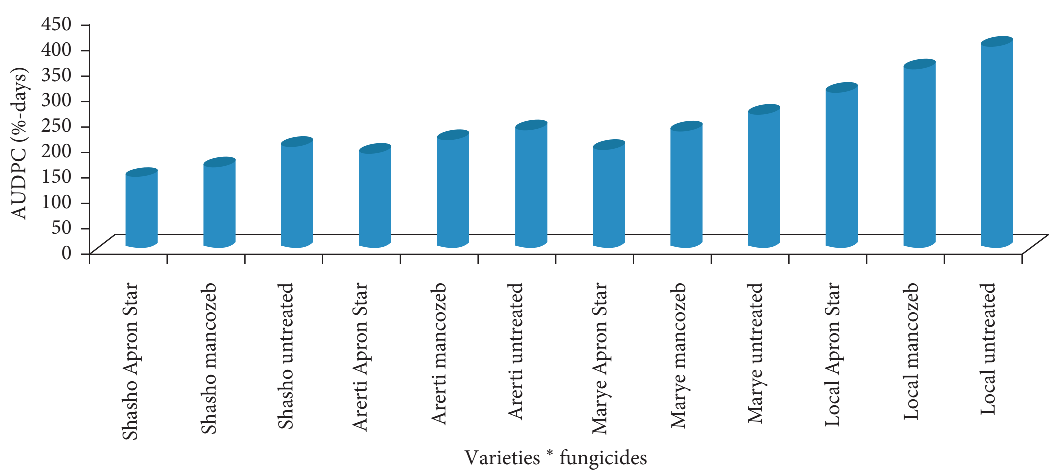


Figure 4: Interaction effects of varieties and fungicides on AUDPC (%-day values) of fusarium wilt disease.

Table 3: Two-way interaction effects of chickpea varieties and fungicides on grain yield of chickpea and their corresponding losses due to chickpea fusarium wilt.

Variety	Fungicides	Grain yield (t/ha)	Relative grain yield loss (%)
Shasho	Apron Star	4.55a	0.0
	Mancozeb	3.31bc	27.25
	Untreated	2.08de	54.29
Arerti	Apron Star	3.94ab	13.41
	Mancozeb	2.75cd	39.56
	Untreated	1.54ef	66.15
Marye	Apron Star	2.71cd	40.44
	Mancozeb	1.52ef	66.59
	Untreated	0.75fg	83.52
Local	Apron Star	2.16de	52.52
	Mancozeb	1.51ef	66.81
	Untreated	0.21g	95.38
LSD (5%)		0.812	
CV (%)		11.25	

LSD = least significant difference; CV = coefficient of variation; means followed by the same letter did not show significant difference at $p < 0.05$ according to least significant difference.

(Table 3). Grain yield losses were reduced through chickpea seeds treated with seed dressing fungicide as compared to untreated check of the respective variety [3].

4. Conclusion

The findings of the present study suggest that the adoption of resistant variety Shasho with fungicide Apron Star seed-treatment may result in reduced fusarium wilt disease progress with a corresponding increased grain yield of chickpea. Further, undoubtedly the fusarium wilt appears to be an important disease that calls for better attention in the study area in terms of economical management with fungicide seed-treatment and use of resistant varieties. The variety Shasho appears to have better resistance against the fusarium wilt disease; therefore, its genetic resistance needs to be investigated further by repeating the experiment for one more cropping season.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

Figure 1: the data in the three tables indicate the effect of different chickpea varieties (Shasho, Arerti, Marye, and local) with the same untreated, treated with mancozeb, and treated with Apron Star on disease incidence progress on 7 days' interval. This mean that even though the chickpea varieties with the same untreated, treated with Mancozeb, and treated with Apron Star it shows difference among varieties in fusarium disease incidence progress. Hence, we have to relate these data with Figure 1. Figure 2: the data in four tables indicate the effect of the same chickpea variety with different fungicides Apron Star and mancozeb and the same untreated on disease incidence progress in 7 days' interval. This means that even though the same chickpea variety treated with different fungicides it shows difference performance among fungicides in fusarium disease incidence progress. Hence, we have to correlate these data with Figure 2. Figure 3: the data in two tables indicate the main effect of chickpea varieties and fungicides and its interaction effect on disease incidence progress. On these row data, I get good results which perform good resistance for fusarium wilt incidence per days. Hence you have to check on Figures 3 and 4. NB: even though all these agronomical parameter data were collected on the field and included in the paper, the selected data were included in the manuscript such as fusarium wilt disease incidence and grain yield of chickpea and their losses due to fusarium wilt disease. Hence, we have to check on Tables 2 and 3. (*Supplementary Materials*)

References

[1] N. S. Jodha and K. V. Subba, "Chickpea: world importance and distribution," in *The Chickpea*, M. C. Sexena and K. B. Singh, Eds., pp. 1–10, CABI, Walling ford, UK, 2012.

[2] J. B. Smithson, J. A. Thompson, and R. J. Summerfield, "Chickpea (*Cicerarietinum* L.)," in *Grain Legume Crops*, R. J. Summerfield and E. H. Roberts, Eds., pp. 312–390, Collins, London, UK, 2009.

[3] J. A. N. Cortes, B. Hav, and R. M. Jimenez-Diaz, "Yield loss in chickpea in relation to development of *Fusarium* wilt epidemics," *Phytopathology*, vol. 90, no. 11, pp. 1269–1278, 2012.

[4] Y. L. Nene, M. V. Reddy, M. P. Haware, A. M. Ghanekar, and K. S. Amin, "Field Diagnosis of Chickpea Diseases and their Control," *Information Bulletin No. 28*, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Hyderabad, 2011.

[5] D. Cook, E. Barlow, and L. Sequeira, "Genetic diversity of *Fusariumoxysporum f. sp. ciceris:* detection of restriction fragment length polymorphisms with DNA probes that specify virulence and the hypersensitive response," *Molecular Plant-Microbe Interactions*, vol. 2, pp. 113–121, 2012.

[6] R. Kakuhenzire, J. J. Hakiza, G. T. BergaLemaga, and F. Alacho, "Past, present and future srategies for integrated management of chickpea *fusarium* wilt disease in Uganda," *African Potato Association Conference Proceedings*, vol. 5, pp. 353–359, 2010.

[7] A. Seid and A. Melkamu, "Chickpea, Lentil, Grasspea, Fenugreek and Lupine Disease Research In Ethiopia," in *Food and forage legume*, K. Ali, G. Kenneni, S. Ahmed et al., Eds., p. 351, Alleppo, Syria, 2003.

[8] Y. Gelanew, "Selected chemical and physical characteristics of soils of Adet agricultural research center and its testing sites in Northwest Ethiopia," *Ethiopian J Natural Resource*, vol. 4, pp. 199–215, 2013.

[9] C. L. Campbell and V. L. Madden, *Introduction to Plant Disease Epidemiology*, John Wiley and Sons, Inc., New York, NY, USA, 1990.

[10] G. D. Robert and H. T. James, *A Biometrical Approach: Principles of Statistics*, McGraw-Hill, New York, USA, 2nd edition, 1991.

[11] SAS Institute, *SAS Technical Report, SAS system for windows V8, SAS/STAT Software Release 8.02 TS Level 02 M0*, SAS Institute Inc., Cary, NC, USA, 2001.

[12] A. Merkuz and A. Getachew, "Influence of chickpea fusarium wilt (*Fusariumoxysporum* f.sp. *ciceris*), on *Desi* and *Kabuli*-type of chickpea in integrated disease management option at wilt sick plot in North western Ethiopia," *International Journal of Current Research*, vol. 4, no. 4, pp. 46–45, 2012.

[13] B. B. Landa, J. A. Navas-Cortes, and R. M. Jimenez-Diaz, "Integrated management of *Fusarium* wilt of chickpea with host resistance, biological control and seed dressing fungicides," *Phytopathology*, vol. 94, pp. 946–960, 2014.

[14] D. R. Kamdi, M. K. Mondhe, G. Jadesha, D. N. Kshirsagar, and K. D. Thakur, "Efficacy of botanicals, bio-agents and fungicides against *Fusariumoxysporum f. sp. ciceris*, in chickpea wilt sick plot," *Annals of Biological Research*, vol. 11, pp. 5390–5392, 2012.

[15] D. Yigitoglu, *Research on the effect of different fungicides on the yield and yield components of some chickpea (Cicerarietinum L.) cultivars that treated in different fungicides in kahramanmaras region*, PhD Thesis, Department of Field Crops Institute of Natural and Applied Science University of Cukurova, Adana, Turkey, 2006.

[16] M. N. Subhani, S. T. Sahi, S. Hussain, A. Ali, J. Iqbal, and K. Hameed, "Evaluation of various fungicides for the control of gram wilt caused by *Fusariumoxysporum* f. sp. *ciceris*," *African Journal of Agricultural Research*, vol. 6, no. 19, pp. 4555–4559, 2011.