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RESEARCH ARTICLE

EPIDEMIC OF FUSARIUM WILT (*FUSARIUM OXYSPORUM* F.SP.*CICERIS*) OF CHICKPEA AT WILT SICK PLOT IN ADET-ETHIOPIA

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ABSTRACT

A 2-year experiment was conducted at wilt sick plot infested with *Fusarium oxysporum* f. sp. *ciceris* at Adet research center in northwestern Ethiopia in order to assess efficacy of an integrated management strategy for *Fusarium* wilt of chickpea that combined the effect of varieties, sowing dates and seed bed preparation methods on fusaruim wilt on chickpea. Four varieties, i.e., JG-62 (susceptible check), *Adet* local (control), Marye and Shasho (both improved); three sowing dates at 15-day intervals, i.e., at Adet 12th Sept., (early), 27th Sept. (farmers') and 12th Oct. (late) and three seed bed preparation methods including flat bed, raised bed and ridge and furrow were used as treatments. Treatments were arranged in a factorial combination in a Randomized Complete Block Design in three replications. The number of seedlings emerged, dead plants due to wilt, soil temperature and soil moisture were recorded at 15-day intervals for each variety of chickpea. Data were analyzed using the SAS system for windows V8. Percent, Disease progress curve and AUDPC%/day was also computed. In the experiments the results indicated that the disease progress rate was significantly different among varieties and management practices and showed Shasho was the most resistant variety to wilt, followed by Marye. Among the sowing dates it was observed a reduction in the rate of epidemic development over time, a reduction of disease intensity, and the farmer sowing date exhibited relatively lower rate of mortality. AUDPC%/day value was higher on flat bed and ridge and furrow than on raised bed. Among the varieties lower AUDPC%/day value was recorded on Shasho followed by Marye in both seasons. The AUDPC%/day value was higher in early and late sowing dates than the farmers' sowing date. The results indicate the advantage of using cultural management as integrated as a sustainable and environmentally friendly option to control chickpea fusarium wilt disease and boost the production of chickpea. The importance of integrating existing cultural control practices, partially effective by themselves, with other control measures to achieve appropriate management of Fusarium wilt and increase of its productivity in chickpea in East African-type environments is demonstrated by the results of this study.

INTRODUCTION

Fusarium wilt, caused by *Fusarium oxysporum* Schlechtend.:Fr. f. sp. *Ciceris* (Padwick) Matuo & K. Sato, is one of the most important biotic stresses of chickpea (*Cicer arietinum* L.) and has the potential to cause 100% yield losses. An annual loss in chickpea grain yield of about 10 to 15% has been reported for this disease (Jalali and Chand 1992). The disease is prevalent in the Indian subcontinent, Ethiopia, Mexico, Spain, Tunisia, Turkey, and the United States (Halila and Strange 1996; Nene *et al*., 1989; Westerlund, 1974). *F. oxysporum* f. sp. *ciceris* is a vascular pathogen that perpetuates in seed and soil, and hence is difficult to manage by the use of chemicals (Haware and Nene 1982; Rubio et al., 2003; Sivaramakrishnan *et al.,* 2002). The average productivity of chickpea in Ethiopia is much lower than world average and is lower as compared to other chickpea growing countries such as Egypt and Turkey (Jodha and Subba, 1987). This low productivity is due mainly to a number of biotic and abiotic stresses. Among the biotic stresses, soil-borne and foliar diseases are most important in limiting the production (Merkuz, 2011; Merkuz and Getachew, 2012a). In Northwestern Ethiopia, the distribution and incidence of chickpea fusarium wilt is also currently increasing. Bahirdar Plant Health Clinic (BPHC), in the spot survey in two administrative zones of three districts reported the incidence of this disease from 50 to 100% (Merkuz et al., 2011; Merkuz and Getachew, 2012b). Fusarium wilt of chickpea can be managed using resistant cultivars, adjusting of sowing dates, fungicidal seed treatments, biocontrol agents, biofumigation, and crop rotation (De *et al*., 1996; Merkuz *et al*., 2011a, b; Navas-Cortes *et al*., 1998). *Brassica spp*. had been reported to suppress soil borne fungal pathogens (Chan and Close, 1987; Merkuz *et al*., 2011a, b). Resistant varieties can be highly economical and practicable method of disease management,

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but varieties should be resistant to all the races prevalent in the area (Jimenez-Diaz *et al*, 1993; Kelly *et al*, 1994). Choice of proper sowing time can be useful for the management of Fusarium wilt of chickpea. For chickpeas in southern Spain, advancing the sowing date from early spring to early winter significantly delays epidemic onset, slows epidemic development, and reduces the final disease incidence and severity, and yield loss (Navas-Cortés *et al*., 1998, Merkuz and Getachew, 2012a). In Ethiopia agronomic work done on the effect of sowing dates on growth of chickpea resulted farmer sowing dates were better than early and late planting (Merkuz and Getachew, 2012a) and Seid and Melkamu (2003) reported that growing resistant and moderately resistant cultivars on raised bed that drain excess water with recommended seeding rate could reduce mortality caused by chickpea wilt/ root rots. The experiment to evaluate at sick plot and under naturally wilt infested farmer is also important to compare the results with artificially inoculated highly disease pressurized field (Merkuz *et al.,* 2011c). So developing suitable management practices of fusarium wilt for the Amhara National Regional State (ANRS) will boost chickpea production substantially. The main objective of this study was to evaluate the effects of sowing dates, varieties and seed bed preparation methods on fusarium wilt development.

MATERIALS AND METHODS

The experiment was conducted during 2007 and 2008 cropping seasons on fusarium wilt sick plot at Adet Research Center (ARC) in Northwestern part of Ethiopia. The center is located $11^0$17'N latitude, $37^0$43'E longitude and 2150 m.a.s.l. and according to the meteorological data of the center the average annual rainfall is 1100 mm with the average maximum and minimum temperature 25.5^0C and 9.2^0C respectively. Soil type was vertisol. The design was randomized complete block design with three replications with factorial combination of treatments. The plot size were $12m^2$ (3mx4m) and the path between plots in each block and between blocks were 0.5m and 1m, respectively. The treatments were three sowing dates that is early sowing (12^{th} Sept.), farmers' sowing (27^{th} Sept.) and late sowing date (12^{th} Oct.) respectively. The early sowing date was 15 days before and the late sowing date 15 days later than the farmers' sowing date and three seed bed preparation methods (raised bed, ridge and furrow and flat bed) with four chickpea varieties JG-62, Marye, Shasho (improved varieties) and *Adet* local were used. Plots were prepared and fertilized with 100 kg/ha DAP at planting. The seeds were planted at spacing of 10 cm between plant and 30 cm between rows, and were covered with fine layer of soil. The two surface drain practices raised bed and ridge and furrow were constructed by hand and ridge and furrow was prepared with oxen drawn local implement. All recommended cultural practices were also applied in the field.

Data collection and analyses

In the experiment observations on fusarium wilt development were made at 15-days interval (by counting the healthy) 7 times at sick plot based on percent of wilt incidence in each plot. At wilt sick plot soil moisture and temperature were recorded. Soil moisture was recorded at 15-days interval at 20 and 40 cm depth using auger. Soil was dried at 105^0C for 24 hours. Soil moisture (%) was calculated as:-

Percent soil moisture = Wi - Wfx100/Wi

Wi = initial soil weight
Wf = final soil weight

The soil temperature was recorded from sowing at 10, 20 and 30cm depth three times daily that is morning (7 am), at noon (1 pm) and in the afternoon (6pm) by inserting soil thermometer in the ground as that of depths. The average of 15 days of daily soil temperature was used. Data were analyzed using the SAS system for windows V8 with ANOVA and means were compared using least significant difference (LSD) (SAS, 2001). Disease incidence data were transformed using monomolecular, ln (1/1-y) transformation (Campbell and Madden, 1990). Transformed data were subjected to linear regression to determine disease progress rate. The disease progress rate for each treatment was estimated as the slope of the regression line of the disease progress data. Area under progress curve (AUDPC) was calculated for each treatment from the assessment of disease incidence using the formula:-

$$AUDPC = \sum [(1/2(x_i+x_i+1)][t_i+1-t_i]$$

Where xi = disease incidence in percentage at i_{th} assessment, t_i = time of the i_{th} assessment in days from the first assessment date (Campbell and Madden, 1990). Correlation analysis was done between mean percent incidence and soil moisture and temperature.

RESULTS

The two cropping seasons data was analyzed separately for each season and data was tested using statistical model for difference in season and the result showed that there were no significance difference between the two season output in the experiments, so that, for the experiments the two season data was combined and analyzed together.

Disease incidence

Significant differences ($P< 0.05$) were observed among varieties, sowing dates and seed bed preparation methods on disease mean incidence percent (Table 1). The percent wilt incidence ranged from 52.4 to 68.9% on Shasho and JG-62 varieties, respectively. However Shasho was the best in reducing the disease incidence (Table 1). The highest disease incidence was observed in early sowing date and the lowest disease incidence was recorded on raised bed during the cropping seasons (Table 1).

Significant differences ($P< 0.05$) were observed in interaction of variety x sowing date (2 way), variety x seed bed preparation method (2 way) and sowing date x seed bed preparation method (2 way) in diseases incidence. There were also observed that a significant differences ($P< 0.05$) in interaction of variety x sowing date x seed bed preparation methods (3 way) in disease incidence. The combination of Shasho x farmers' sowing date x raised bed (3 way) followed by Marye x farmers' x raised bed (3 way) and Shasho x early sowing date x raised bed (3 way) respectively were the best in reducing chickpea wilt incidence (Table 2).The highest disease incidence were observed with the combination of JG-62 x early x flat bed (3 way) followed by JG-62 x late sowing date x flat bed (3 way)and JG-62 x early x ridge and furrow (3 way) respectively in chickpea wilt incidence (Table 2).

Table 1. Major effects of variety, sowing date and seed bed preparation method on incidence of chickpea wilt

Variety	Incidence (%)	Sowing date [1]	Incidence (%)	Seed bed preparation	Incidence (%)
JG-62	68.9^{a}	Early	62.4^{a}	Flat	63.4^{a}
Local	60.1^{b}	Farmers'	55.3^{c}	Raised	55.1^{c}
Marye	57.1^{c}	Late	61.2^{b}	Ridge &furrow	60.4^{b}
Shasho	52.4^{d}				
Mean	59.6		59.6		59.6
LSD (P‹ 0.05)	0.38		0.33		0.33

* ^{abc} means sharing the same letter in the same column are not significantly different each other (P>0.05)
*[1] Early, 12 September 2007 and 2008; Farmers', 27 September 2007 and 2008; Late, 12 October 2007 and 2008
* Values for incidences are mean incidence values taken at 15 days intervals

Table 2. The interaction effect of variety, sowing date and seed bed preparation method on the wilt incidence of chickpea at Adet wilt sick plot

Variety	Sowing date [1]	Seed bed preparation method	Incidence (%)
	Early	Flat	76.1^{a} ±0.15
		Raised	69.7^{d} ±0.34
		Ridge & furrow	72.7^{b} ±0.62
JG-62	farmers'	Flat	65.2^{f} ±0.50
		Raised	59.2^{jk} ±0.37
		Ridge & furrow	61.8^{gh} ±0.23
	Late	Flat	75.1^{a} ±0.23
		Raised	69.0^{d} ±0.23
		Ridge & furrow	71.5^{c} ±0.75
	Early	Flat	67.4^{e} ±0.40
		Raised	55.4^{n} ±0.51
		Ridge & furrow	65.1^{f} ±0.04
Adet local	farmers'	Flat	64.3^{f} ±0.52
		Raised	48.7^{r} ±0.28
		Ridge & furrow	56.8^{m} ±0.98
	Late	Flat	60.9^{hi} ±0.22
		Raised	60.1^{ij} ±0.64
		Ridge & furrow	62.6^{g} ±0.28
	Early	Flat	65.0^{f} ±0.16
		Raised	52.8^{pq} ±0.59
		Ridge & furrow	60.2^{hi} ±0.24
Marye	farmers'	Flat	58.8^{kl} ±0.51
		Raised	47.3^{s} ±0.34
		Ridge & furrow	54.4^{n} ±0.45
	Late	Flat	57.7l^{m} ±0.24
		Raised	54.7^{n} ±0.30
		Ridge & furrow	62.9^{g} ±0.08
	Early	Flat	61.3^{h} ±0.16
		Raised	48.4^{rs} ±0.20
		Ridge & furrow	55.2^{n} ± 0.37
Shasho	farmers'	Flat	54.7^{n} ±0.36
		Raised	43.6^{t} ±0.19
		Ridge & furrow	49.0^{r} ±0.43
	Late	Flat	54.3^{no} ±0.38
		Raised	51.9^{q} ±0.22
		Ridge & furrow	53.2^{op} ±0.30
Mean			59.64

* Means sharing the same superscript in the same column are not significantly different each other (P›0.05)
* ± = standard error
* Values for incidences are mean incidence values taken at 15 days intervals
* [1]Early, 12 September 2007 and 2008; Farmers', 27 September 2007 and 2008; Late, 12 October 2007 and 2008

Disease progress rate and curve

Parameter estimates of wilt disease incidence in the two seasons indicated that the disease progress rate of variety JG-62 in early sowing date on flat bed, raised bed, and ridge and furrow were 0.0824, 0.0604 and 0.0678 units day^{-1} respectively. For Shasho the disease progress rate in early sowing date on flat bed, raised bed and ridge and furrow were 0.0529, 0.0291, and 0.0420 units' day^{-1} respectively. The disease progress rate was significantly different among varieties and management practices (Table 3). The disease progress rate of varieties JG-62 and Shasho during farmers' sowing date on flat bed, raised bed and ridge and furrow were 0.0416, 0.0328 and 0.0362; and 0.0297, 0.0223 and 0.0250 units' day^{-1} respectively (Table 3). The disease progress curve on the varieties at three sowing dates and three seed bed preparation methods is given in Figure 1 and Figure 2. The fusarium wilt incidence increased from the initial to final assessment dates and the curve show an increasing trend of disease development for the four varieties in each sowing dates in the assessments. The analysis of incidence for disease progress rate from the assessment indicated significant differences among sowing dates and varieties in the two years P‹0.05, R^2=68.6-100, 86.7-98.3 and 86.8-100 for early sowing date, farmers' sowing date and late sowing date respectively. When the four varieties planted at farmers' sowing date on raised bed, the rate of disease progress was on Shasho (0.0223 units day $^{-1}$), Marye (0.0270 units day $^{-1}$), *Adet* local (0.0274 units day $^{-1}$), and JG-62 (0.0328 units day $^{-1}$) respectively was calculated (Table 3). The rate of disease development was

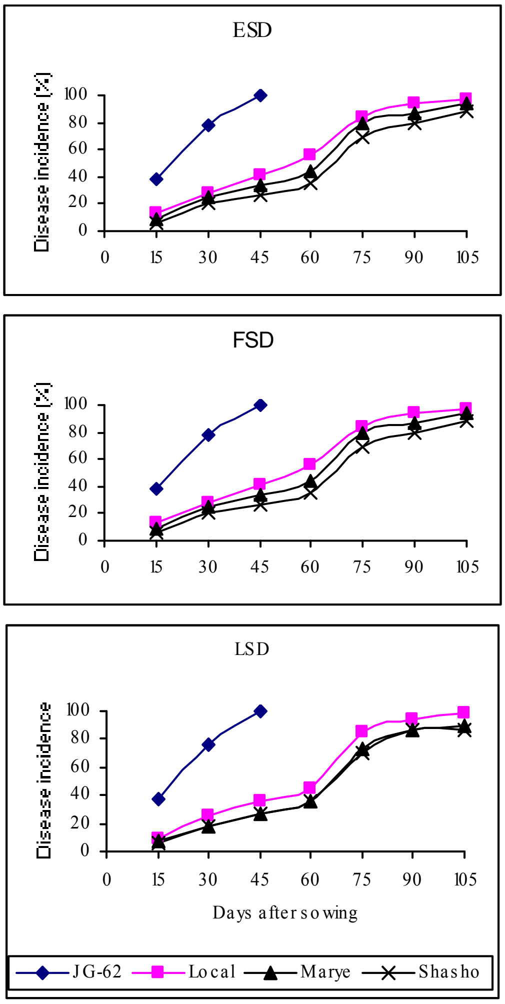

Fig.1. Disease progress curves of fusarium wilt (*Fusarium oxysporum*) incidence on four varieties in three sowing dates (ESD, early sowing date (September 12); FSD farmer sowing date (September 27) and LSD (late sowing date (October 12) during 20007 and 2008 cropping seasons at wilt sick plot, Ethiopia

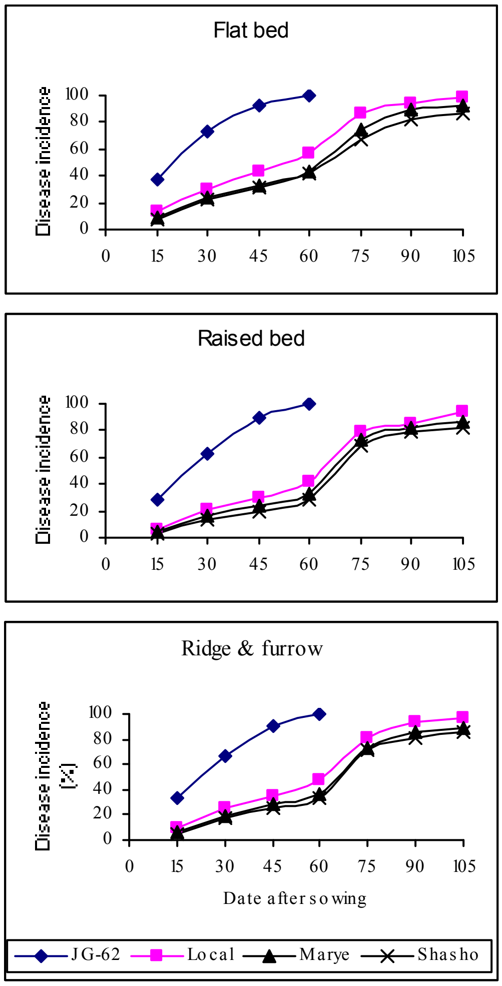

Fig.2. Disease progress curves of fusarium wilt (*Fusarium oxysporum*) incidence on four varieties in three seed bed preparation methods (Flat bed, Raised bed and Ridge and furrow) during 2006/07 and 2007/08 cropping seasons at Adet wilt sick plot

faster for all varieties in early and late sowing dates than the farmers' sowing dates in both seasons. The analysis of incidence for disease progress rate from the assessment indicated significant differences among seed bed preparation methods and varieties in the two seasons ($P<0.05$, R^2=81.1-100, 88.0-100 and 84.0-100) for flat bed, raised bed and ridge and furrow respectively. When the varieties planted early on raised bed the rate of disease progress was calculated on Shasho (0.0291 units day^{-1}), Marye (0.0331 units day^{-1}), *Adet* local (0.0508 units day^{-1}), and JG-62 (0.0604 units day^{-1}). In late sowing date the disease progress rate was faster on Adet local and JG-62 in all seedbed preparation methods. Generally the result showed that the rate was slower on Shasho followed by Marye compared to *Adet* local and JG-62 (Table 3).

Area Under Disease Progress Curve

AUDPC%/day value was higher on flat bed and ridge and furrow than on raised bed (Fig. 3). Among the varieties lower AUDPC value was recorded on Shasho followed by Marye in both seasons. The AUDPC value was higher in early and late sowing dates than the farmers' sowing date (Fig. 3).

Wilt incidence association with soil moisture and temperature at wilt sick plot

Correlation analysis showed significant positive association ($P< 0.05$) between percent incidence and soil moisture at depth 20 and 40 cm and were had a significant positive association. Fig.4 indicates the linear regression of the wilt incidence and soil moisture at depth of 20 and 40 cm. Significant differences ($P< 0.05$) were observed in correlation between mean percent incidence and temperature in the morning (7:00am), at noon (1:00pm) and after noon (6:00pm) at depth 10, 20 and 30 cm respectively, in which the mean values were lied between 23 to 31^{0}C and the correlation matrix showed that incidence was had positive association with temperature value.

DISCUSSION

Disease incidence

On the basis of the studies undertaken at wilt sick plot, it was observed that there were significant differences among the varieties in percent wilt incidence. However variety Shasho followed by Marye had lower wilt incidence over the control (Landa *et al*., 2001; Pande *et al*., 2006; Merkuz, 2011; Merkuz and Getachew, 2012a). JG-62 susceptible check was observed completely wilted. Among the sowing dates in the two experiments, it was also indicated that there were significant differences in reducing wilt incidence. The farmer's sowing

Table 3. Parameter estimates of chickpea *Fusarium* wilt disease incidence at wilt sick plot in 2007 and 2008

No.	Variety	sowing date[1]	Seed bed preparation method	Intercept	SE of intercept	Disease progress rate (units day^{-1})	SE of rate	R^2 (%) [2]	P-value
1	JG – 62	Early	Fat bed	-0.6448	-	0.0824	-	100.00	-
2	*Adet* local	Early	Flat bed	-0.8232	0.5870	0.0559	0.0135	87.90	0.0389
3	Marye	Early	Flat bed	-0.7974	0.3370	0.0407	0.0058	92.62	0.0038
4	Shasho	Early	Flat bed	-1.3589	0.9087	0.0529	0.0154	81.10	0.0211
5	JG – 62	Early	Raised bed	-0.4708	-	0.0604	-	100.00	-
6	*Adet* local	Early	Raised bed	-1.2764	0.5554	0.0508	0.0091	87.96	0.0038
7	Marye	Early	Raised bed	-0.8757	0.3552	0.0331	0.0051	89.69	0.0027
8	Shasho	Early	Raised bed	-0.7897	0.3135	0.0291	0.0046	89.56	0.0013
9	JG – 62	Early	Ridge & furrow	-0.5077	-	0.0678	-	100.00	-
10	*Adet* local	Early	Ridge & furrow	-1.4547	0.6621	0.0635	0.0115	88.30	0.0070
11	Marye	Early	Ridge & furrow	-0.9699	0.3146	0.0395	0.0044	93.53	0.0002
12	Shasho	Early	Ridge & furrow	-1.1964	0.5920	0.0420	0.0086	83.96	0.0052
13	JG – 62	Farmer's	Flat bed	-0.3596	0.2338	0.0416	0.0072	97.08	0.1092
14	*Adet* local	Farmer's	Flat bed	-1.2401	0.5219	0.0582	0.0083	90.22	0.0020
15	Marye	Farmer's	Flat bed	-0.7294	0.2474	0.0334	0.0034	93.27	0.0004
16	Shasho	Farmer's	Flat bed	-0.6816	0.2404	0.0297	0.0035	93.45	0.0005
17	JG – 62	Farmer's	Raised bed	-0.3055	0.1714	0.0328	0.0053	97.45	0.1008
18	*Adet* local	Farmer's	Raised bed	-0.8373	0.3030	0.0274	0.0050	92.29	0.0016
19	Marye	Farmer's	Raised bed	-0.7346	0.3006	0.0270	0.0043	88.87	0.0012
20	Shasho	Farmer's	Raised bed	-0.5910	0.2542	0.0223	0.0037	87.95	0.0014
21	JG – 62	Farmer's	Ridge & furrow	-0.3174	0.1908	0.0362	0.0059	97.43	0.1025
22	*Adet* local	Farmer's	Ridge & furrow	-1.0629	0.4004	0.0471	0.0066	92.14	0.0014
23	Marye	Farmer's	Ridge & furrow	-0.6313	0.2090	0.0286	0.0030	94.29	0.0002
24	Shasho	Farmer's	Ridge & furrow	-0.5991	0.2166	0.0250	0.0031	92.61	0.0006
25	JG – 62	Late	Fat bed	-0.5431	-	0.0714	-	100.00	-
26	*Adet* local	Late	Flat bed	-1.1801	0.5270	0.0515	0.0085	88.58	0.0028
27	Marye	Late	Flat bed	-0.9144	0.3280	0.0388	0.0048	92.36	0.0004
28	Shasho	Late	Flat bed	-0.8230	0.3363	0.0335	0.0049	90.33	0.0007
29	JG – 62	Late	Raised bed	-0.5458	-	0.0634	-	100.00	-
30	*Adet* local	Late	Raised bed	-1.3498	0.5868	0.0553	0.0092	88.21	0.0030
31	Marye	Late	Raised bed	-0.9030	0.2979	0.0343	0.0042	92.51	0.0007
32	Shasho	Late	Raised bed	-0.8045	0.2898	0.0308	0.0042	91.35	0.0006
33	JG – 62	Late	Ridge & furrow	-0.4860	-	0.0643	-	100.00	-
34	*Adet* local	Late	Ridge & furrow	-1.2032	0.5842	0.0567	0.0092	88.59	0.0029
35	Marye	Late	Ridge & furrow	-0.5211	0.3262	0.0366	0.0047	92.04	0.0004
36	Shasho	Late	Ridge & furrow	-0.9558	0.3982	0.0360	0.0058	88.88	0.0013

*[1] Early, 12 September 2007 and 2008; Farmers', 27 September 2007 and 2008; Late, 12 October 2007 and 2008.
*[2] -- Indicates R^2 (%) = 100

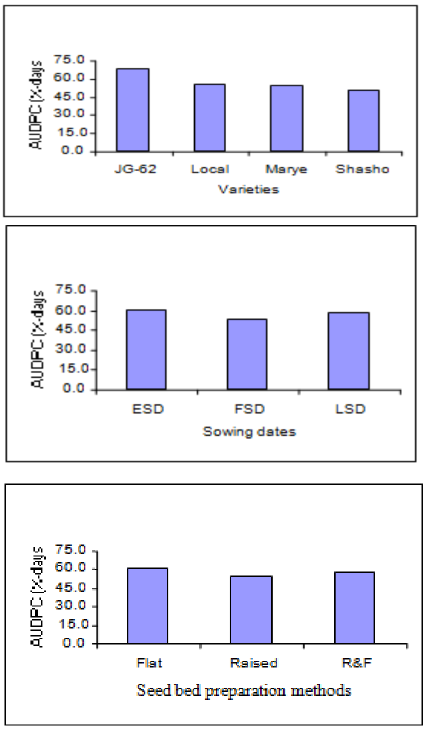

Fig.3. Area under disease progress curves (AUDPC) for wilt (*Fusarium oxysporum*) of chickpea in four varieties, three planting dates (ESD, (September 12); FSD, (September 27)and LSD, (October 12) and three seed bed preparation methods at Adet wilt sick plot during 2007 and 2008 cropping seasons. Values are means calculated from disease incidence%-days assessed 7 times at 15 days interval

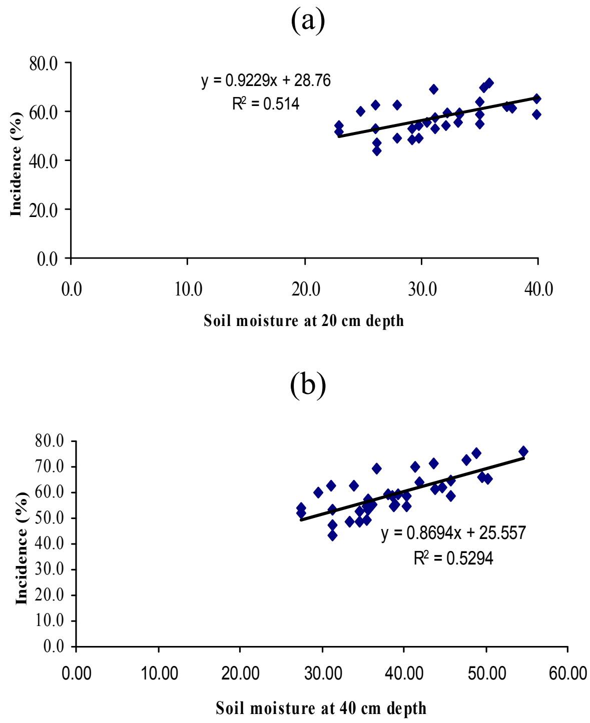

Fig.4. Relationships between chickpea wilt incidence and soil moisture% at depth of 20 (a) and 40cm (b)

date was better in lowering chickpea mortality compared to the other two sowing dates. This date agreed with sowing date agronomic experiment result on chickpea variety conducted at Adet and recommended for intervals of sowing date (Landa *et al*., 2004; Merkuz and Getachew, 2012a). Landa *et al*., (2004) and Hillocks and Waller (1997) indicated that disease severity might be minimized by careful selection of time of planting. Landa *et al*. (2004) pointed out planting date is one of the most important agronomic factors affecting chickpea productivity.

In the two experiments it was observed that there was significant difference among the seed bed preparation methods in lowering wilt incidence. The raised bed was better than other beds in managing wilt incidence. The result agree with the report of Seid and Melkamu (2003) and Hillocks and Waller (1997) showed that growing resistant and moderately resistant cultivars on raised bed that drain excess water with recommended seeding rate could reduce mortality caused by chickpea wilt and root rots. Interaction of variety, sowing date and seed bed preparation methods were significant at wilt sick plot and farmer field. The combination of Shasho, with farmer's sowing date on raised bed, followed by Shasho with farmer's sowing date and ridge and furrow and Marye, farmer's sowing date and raised bed were the best combinations in reducing chickpea wilt incidence in that order. The finding is in agreement with that of Negussie *et al.* (2006) and Palti and Katan (1997) substantial reductions in plant mortality due to wilt were recorded when a combination of moderately resistant varieties, drainage methods that are raised beds (ridge, broad bed and furrow), and recommended seed rate was used, compared to flat planting.

Disease Progress rate and curve

Parameter estimates values unit's day $^{-1}$ indicates disease progress rate was slower on raised bed, on Shasho variety and at farmer's sowing dates compared to other varieties, sowing dates and seed preparation methods in the two cropping season. The disease progress curves showed that the influence of variety, sowing date and seed bed preparation method in all combination of the treatments showed that in the early and late crop stage assessments the wilt incidence rate increases. This agrees with the finding Nene *et al. (*1996) in Hillocks and Waller (1997) who explain that the two stages of wilt epidemics as early and late wilts which are distinguished according to the time as early wilt develops at the seedling stage and late wilt after flowering.

Area Under Disease Progress Curve

AUDPC%/day value was higher on flat bed and ridge and furrow than on raised bed. Among the varieties lower AUDPC%-day value was recorded on Shasho followed by Marye in both seasons. The AUDPC%-day value was higher in early and late sowing dates than the farmers' sowing date. The result is agreed with the report of Campbell and Madden (1990). Correlation analysis showed that incidence had positive association with the soil temperature in the two seasons recorded at three different soil depths, which indicates disease is influenced by temperature of the soil. The finding is similar with Landa *et al*. (2006) who indicate the development of Fusarium wilt causing pathogens is strongly associated with soil temperature and moisture, as well as inoculum level of the specific pathogen in the soil and crop age. Chauhan (1962) in Hillocks and Waller (1997) indicated disease incidence is influenced by sowing date which reflects changes in soil moisture and temperature. The incidence was also highly significant and positive association with soil moisture which indicates the effects in the development of the disease (Landa *et al*., 2006; Summerfied *et al*., 1990). This perhaps was due to excess moisture that favored the crop to be susceptible or weak for the disease and for the pathogen in spore germination and penetration/infection of host. Purss (1979) and Hillocks and Waller (1997) indicated that stress factors play a role in the epidemiology of many diseases. The results indicate the advantage of using cultural management as integrated as a sustainable and environmentally friendly option to control chickpea fusarium wilt disease and boost the production of chickpea. The importance of integrating existing cultural control practices, partially effective by themselves, with other control measures to achieve appropriate management of Fusarium wilt and increase of its productivity in chickpea in East African-type environments is demonstrated by the results of this study.

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