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Verification of integrated management of chickpea *Fusarium* wilt (*Fusarium oxysporum* f.sp. *ciceris*) in major chickpea growing areas of East Shewa Zone, Ethiopia

Asrat Zewdie

Ethiopian Institute of Agricultural Research, Debre Zeit Agricultural Research Center, P. O. Box 32, Debre Zeit, Ethiopia.

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***Fusarium* wilt is caused by *Fusarium oxysporum* f.sp. *ciceris*, a major limiting chickpea productivity in Ethiopia. The present study was to validate the integrated management of chickpea *Fusarium* wilt. The verifications were conducted in Adea, Lume and Gimbichu districts. The experiment was laid out as a factorial combination a farmer's field was used as replications. The management package consists of two varieties (Arerti and Habru), seed treatment with protective fungicides a rate of 2 g (a.i) kg/seed) and without and two seed bed type (raised and flat). There were three verifications per site. The pod borer management consists of timely insecticide application lambda cyhalothrin. The 2016 result showed significant variations among the treatment on *Fusarium* wilt and hundreds of seed weight. The lowest *Fusarium* wilt incidence (1.5%) was found on variety Arerti by raised bed and fungicide treated seed. The optimum yield (1747.5 kg/ha) obtained on flat plot with variety Habru use moisture in field, perhaps raised bed drain moisture. The correlation revealed that there was negative relationship between *Fusarium* wilt and yield. While, in 2017 significant variation is on *Fusarium* wilt and number of pods per plant. The highest *Fusarium* wilt incidence (24%) was on variety Arerti by flat plot without fungicide. Whereas, the highest pod per plant (54.4%) was on variety Arerti by raised bed with fungicide treated. There was clear difference among the seasons on *Fusarium* wilt incidences and yield. Thus, combining resistant cultivars by raised bed and fungicides treatment will reduce the *Fusarium* wilt incidence and optimize planting time to obtain attainable yields and ploughing interval in severely infected field reduces primary sources of inoculum.**

Key words: Chickpea, fungicides, *Fusarium* wilt, incidence, yield.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the second most important cool season food legume crop after common

E-mail: asratzew@gmail.com.

bean (*Phaseolus vulgaris* L.) followed by field pea (*Pisum sativum*) and third in production worldwide (Diapari et al., 2014). Currently, one of the widely cultivated crops at the global level on 13.5 million hectares of area with 13.1 million tons of grain legume is produced (FAOSTAT, 2014). The food legumes grown in different agro-ecological zones of the central, north, northwest, south and eastern highlands of Ethiopia (Merkuz et al., 2011). It is the main food legume in the northern and central highlands of Ethiopia (Keneni et al., 2012). The total area covered by chickpea in Ethiopia is estimated at 258,486.43 ha and from this a corresponding mean annual production of 472,611.4 tons of chickpea grain is produced (CSA, 2017).

An average chickpea yield in Ethiopia on field is usually below 2 t/ha although potential yield is 6 t/ha (Asnake, 2016). These huge gap between the potential yield were due to biotic and abiotic factors with current climate change scenario. This resulted from susceptibility of landraces to terminal drought, heat and no protection against weeds, diseases and insect pests (Asfaw et al. 1994). Although, more than 70 pathogens have been reported so far on chickpea from different parts of world and a few of them are currently recognized as significantly important to chickpea production (Pande et al., 2010).

One of the greatest biotic stress reducing potential yields in chickpea is chickpea *Fusarium* wilt caused by *Fusarium oxysporum* f. sp *ciceris* causing is a serious problem in rainfed area. Is one of the major asexual soil or seed borne disease of chickpea worldwide (Jalali and Chand, 1992; Kaiser et al., 1994). This fungus is pathogenic only on *Cicer* species (Jimenez-Díaz et al., 2015) of which chickpea is the only cultivated species.

Early wilting is reported to cause more yield loss (77-94%) than late wilting (24-65%), but seeds from late-wilted plants are lighter, rougher, and duller than those from healthy plants (Haware and Nene, 1980). In Ethiopia, about 30% yield loss of chickpea due to chickpea wilt has been reported (Meki et al., 2008).

According to Geletu et al. (1996) the disease caused yield loss of 50-80% in some farmers' fields. In addition to yield reduction, it also adversely affected the quality of grains by shrivelling the seed. The distribution and incidence of chickpea *Fusarium* wilt currently increasing annual loss estimated to 80% on North Shewa, West Gojjam (Personal observation).

Considering the nature of the damage and survival mechanism of the pathogen, management of the disease is difficult either through crop rotation or application of fungicides (Bakhash et al., 2007). The most practical and cost-effective method for management of chickpea wilt is the use resistant cultivars (Nene and Reddy, 1987). Resistant varieties can be economical and practicable method of disease management, but not be resistant to all the races prevalent in the area (Jimenez-Diaz et al., 1993; Meki et al., 2008).

Merkuz et al. (2011) reported that *Fusarium* wilt incidence was reduced with different doses of green manure and dried plant residue. The recovery of the pathogens causing wilt/root rots decreased with delayed sowings (Seid et al., 1990). *Trichoderma* species are more effective when integrated with moderately resistant cultivars-controlled *Fusarium* wilt by 30 to 46% (Meki et al., 2008).

Fungicides like Thiram and Apron star offer a good protection against wilt (DZARC, 2005). Merkuz and Getachew (2012) reported that raised bed preparation, tolerant variety and optimum time of planting managed the wilt incidence. Effective microorganism, neem seed extracts and resistant variety had significant effects suppressive to *Fusarium* wilt. The EM-fortified compost tested in this study helped in controlling chickpea wilt (Negussie, 2012). Several studies have shown that soils containing beneficial microorganisms such as those found in the culture of effective microorganisms (EM) become suppressive to soil-borne diseases including *F. oxysporum* (Filion et al., 1999). Cultural practice like ploughing frequencies play great role in disturbing the pathogen life cycle, survival mechanism of pathogen. Verify integrated management for *Fusarium* wilt of chickpea on farmer's field in major chickpea growing regions and to attain optimum productivity of chickpea.

The objective of this study was to verify integrated management of chickpea *Fusarium* wilt and its yield components.

MATERIALS AND METHODS

The verification experiments were conducted in Adea, Lume and Gimbichu districts. The experiment was laid out as a factorial combination; farmer's field was used as replication with 10 m ×10 m plot sizes. The integrated management for *Fusarium* wilt consists of: two varieties with different reaction level moderately resistant to resistant type (Arerti and Habru), seed treatment with fungicides and control (42WS% Apron Star at rate of 2 g (a.i) kg/seed) and two seedbed preparation (raised bed and flat). In each districts there were three verifications per sites. The pod borer management consist of timely insecticide application (lambda cyhalothrin). Disease incidence (%) was collected on plot based after onset of disease symptoms. All disease incidence and yield and yield components data were subjected to analysis of variance (ANOVA) using SAS version 9.1. (SAS, 1997) using General Linear Model. Mean separation was based on the LSD at the 5% probability level.

RESULTS AND DISCUSSION

In 2016 cropping season, chickpea by raised bed and seed dressed with fungicide treatment combination showed statistically significant difference ($p<0.05$) for *Fusarium* wilt disease and hundreds of seed weight. The lowest *Fusarium* wilt incidence (1.5%) was recorded on variety Arerti by raised bed treatment and fungicide treated seed. Similarly, lowest *Fusarium* wilt incidence (3.5%) was on Habru by raised bed type while the

Table 1. Mean summary of seven traits recorded from on farm Integrated Pest Management verification chickpea tested in 2016 main cropping season at Lume and Gimbichu Woredas.

Treatment	FW (%)	PLHT (cm)	NPP	NSPlt	BMY (kg/ha)	HSW (g)	YLD (kg/ha)
Arerti + Flat + control	2.0	35.8	36.4	39.3	4662.5	26.83	1292.5
Arerti + Raised Bed + treated fungicides	1.5	40.0	38.0	38.6	4080.0	26.8	1512.5
Habru + Flat + control	5.0	39.3	29.9	33.5	3507.5	32.2	1747.5
Habru + Raised Bed+ treated fungicides	3.5	41.8	34.3	38.4	4285.0	30.4	1582.5
Grand Mean	3.0	39.2	34.6	37.4	4133.8	29.1	1533.7
CV (%)	19.2	19.9	13.9	12.96	25.6	3.1	24.1
LSD (0.05)	1.0	NS	NS	NS	NS	1.6	NS

FW= *Fusarium* wilt incidence (%), PLHT=plant height (cm), NPP: number of pods per plant, NSPlt= number of seeds per plant, BMY= biomass yield (kg/ha), HSW= hundred seed weight (g), YLD= grain yield (kg/ha).

Table 2. Correlation matrix (Pearson) between *Fusarium* wilt (FW) and yield and yield components trial planted in 2016 main cropping season at Lume and Gimbichu Woredas.

Variable	WRR	PLHT	NPP	NSPlt	BMY	HSW
PLHT	-0.201					
NPP	-0.409	0.550*				
NSPlt	-0.360	0.557*	0.988*			
BMY	-0.441	0.328	0.766*	0.778*		
HSW	0.699*	-0.335	-0.208	-0.132	-0.069	
YLD	-0.142	0.383	0.717*	0.741*	0.830*	0.233

FW= *Fusarium* wilt incidence (%), PLHT=plant height (cm), NPP: number of pods per plant, NSPlt= number of seeds per plant, BMY= biomass yield (kg/ha), HSW= hundred seed weight (g), YLD= grain yield (kg/ha).

highest *Fusarium* wilt incidence (5%) on variety Habru with flat plot (Table 1) implying that *Fusarium* wilt incidence is lower on raised bed than flat plot. The recovery of the pathogens causing wilt/root rots decreased with delayed sowings. However, early sowing (end of July) provided higher grain yields as compared to late sowings (Seid et al., 1990).

Although hypothetically higher yield was expected from chickpea cultivars with raise bed and fungicide treated seed (where *Fusarium* wilt occurrence was lower) though significant difference was not observed (Table 1). Lowest yield (15825 kg/ha) obtained on variety Habru by raised seed bed while the highest yield (17475 kg/ha) was harvested from Habru with flat practices plot (Table 1). *Fusarium* wilt of chickpea can be managed using resistant cultivars, adjusting sowing dates and fungicidal seed treatment (Navas-Cortes et al., 1998). However, the impact of variety and raised bed treatment did not affect significantly chickpea yield and yield components except hundred seed weight due to terminal stress.

The correlation matrix (Table 2) clearly revealed that there was negative relationship between *Fusarium* wilt and yield and yield components (yield, plant height, number of pods per plant, Number of seeds per pod, biomass yield) though weak in its magnitude. And hence consolidates theoretical justification of the objective of the study. Practically, however, the ANOVA output of yield failed to justify the fact that higher seed yield of chickpea variety will be obtained on plots with lower *Fusarium* wilt incidence. In this season, more yield on flat than raised bed which might be the stress as moisture drained from raised bed and flat plot retain moisture in the field as well as root growing depth to absorb water from depth. Planting of seeds at proper depth (10-12 cm) was helpful in reducing the disease incidence while shallow sown crop seemed to attract more disease (IAR, 1977). Whereas, variety by seed bed and fungicides treated seed combination showed statistically significant variations ($p<0.05$) for *Fusarium* wilt and number of pods per plant (Table 3) in 2017 season. The lowest *Fusarium* wilt incidences (8.0 and 8.6%) recorded on variety Habru by raised bed and fungicide treated seed followed by Arerti by raised bed type with seed treatment, respectively. The highest *Fusarium* wilt incidence (24.0%) obtained on combination of variety Arerti by flat plot and without fungicides treated seed. The highest pod per plant (54.4%) displayed on Arerti by raised bed with fungicide treated seed. Merkuz and Getachew (2012) reported that raised bed preparation, tolerant variety and optimum time of planting managed the wilt incidence and

Table 3. Mean summary of seven traits recorded from on farm Integrated Pest Management verification chickpea tested in 2017 main cropping season at three Woredas.

Treatment	WRR (%)	NPP	BMY (kg/ha)	HSW (g)	YLD (kg/ha)
Ararti + Flat+ Control	24.0	34.4	2800	14.8	800.0
Ararti + Raised Bed + Treated fungicides	8.6	54.4	3320	18.8	1360
Habru + Flat + Control	20.0	29.4	3452	14.8	1160
Habru + Raised Bed+ Treated fungicides	8.0	46.6	4342	21.0	1460
Mean	15.2	41.2	3478	17.4	1195
CV (%)	45.4	33.6	35.5	20.7	30.7
LSD (0.05)	10.39	19.09	170	9.16	506

FW= *Fusarium* wilt incidence (%), PLHT=plant height (cm), NPP: number of pods per plant, NSPlt= number of seeds per plant, BMY= biomass yield (kg/ha), HSW= hundred seed weight (g), YLD= grain yield (kg/ha).

reduce mortality of wilt.

Conclusion

Chickpea production and productivity were hindered due to *Fusarium* wilt disease among major biotic stress currently. The experiment was laid out as a factorial combination; a farmer's field was used as replication. The integrated *Fusarium* wilt management package consists two cultivars, seed treatment with and without fungicides and two seed type of bed preparation. The result verified that integrating tolerant cultivar by raised bed and fungicide treated seed at recommended rate will reduce the *Fusarium* wilt incidences and optimize the attainable yields in lack of resistant cultivar. The integrated pest management package should be practicable under farmer's practices and possible popularity especially high disease infestation area. Integrated disease management packages minimize the primary source of inoculums in soil as cultural control. Seed treatment improves germination and increases the plant stand uniformity. It needs more attention on frequency of ploughing to reduce inoculum source. Phenotyping of major races in the country needs focus. Seed inspection needs attention as diseases are seed borne while seed exchanging/seed system scheme.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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