



RESEARCH ARTICLE

**Influence of chickpea Fusarium wilt (*Fusarium oxysporum F.Sp.Ciceris*) on Desi and Kabuli-type of chickpea in integrated disease management option at wilt sick plot in North Western Ethiopia**

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**ABSTRACT**

Field experiment was carried out for two years at artificially Fusarium pathogen infested field at Adet research center in North Western Ethiopia, to determine the effect of chickpea fusarium wilt on desi and kabuli-type of chickpea using integrated disease management option that is varieties, planting dates and seed bed preparation methods. Four varieties, i.e., Kabuli type (Shasho) and three desi type Marye, JG-62 and Adet local were used as, JG-62 (susceptible check), Adet local (control), Marye and Shasho (both improved); three planting dates at 15-day intervals, i.e., early, farmers and 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, and grain yield per plot were recorded for each desi and kabuli type of chickpea. Data was analyzed using the SAS system for windows V8. The results indicated that compared with the control. The kabuli type Shasho was the most resistant variety to wilt, followed by desi-type Marye. Mortality of the susceptible check, JG-62, due to wilting was 100%. The 2<sup>nd</sup> planting date and the raised bed exhibited relatively lower rate of mortality. Interactions of desi and kabuli type of chickpea variety, planting date and seed bed preparation were significant. Desi and kabuli type varieties varied in grain yield significantly. The kabuli type Shasho and desi type Marye gave better yield than the Adet local (desi type). The farmer planting date gave better yield than early and late plantings. Seed bed preparation methods did not significantly vary in grain yield. Although not statistically significant, raised beds and ridge and furrow plots gave better yield than flat beds. Raised beds gave 31% more yield than the flat bed and close to 27.8% more yield than the ridge and furrow. The results indicate that kabuli type Shasho was the most resistant variety to wilt compare with desi types and advantage of using cultural management as a sustainable and environmentally friendly option to control chickpea fusarium wilt disease. It is concluded that the kabuli type Shasho better than desi type varieties, planting dates and to some extent seed bed preparation methods contribute to the management of wilt disease and so enhance productivity of chickpeas in northwestern Ethiopia.

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**INTRODUCTION**

Chickpea (*Cicer arietinum* L.) is an annual grain legume or 'pulse crop' that is used extensively for human consumption and is grown in the tropics, sub-tropics and temperate regions of the world (Geletu and Ketema, 2003). Ethiopia is the largest producer of chickpea in Africa accounting for about 46% of the total production of the continent (Kassie *et al.*, 2009). It is also the 6<sup>th</sup> largest producer worldwide and contributes about 2% of the total world chickpea production. In terms of production, chickpea is the second most important legume crop after faba beans, while in terms of area coverage it is the third one after faba beans and field peas (Kassie *et al.*, 2009). The small-seeded desi types, which account for about 85 percent of world production, are grown in the Indian subcontinent, Ethiopia, Australia, Mexico, Afghanistan, and

Iran. Some farmers in the Mediterranean, Mexico, and India plant the large-seeded kabuli types. In the tropics and sub-tropics with summer rainfall, chickpea is mostly grown on residual soil moisture or sometimes under irrigation. In the sub-tropics with winter rainfall, farmers generally sow the crop during the spring (Geletu and Ketema 2003; Merkuz, *et al.*, 2011a). In Ethiopia, desi-type chickpea accounts for more than 90% and kabuli chickpea is only grown in small plots in some pocket areas or in mixture with desi-type chickpeas (Bejiga *et al.*, 1995; Merkuz *et al.*, 2011a). The crop is cultivated as rain fed crop on vertisols between altitudes of 1400-2300 m during the main rainy season with annual precipitation of 700-800 mm (Bejiga *et al.*, 1995; Merkuz *et al.*, 2011d). Different fungal, viral and bacterial diseases attack chickpea in different parts of the world. One of the most, important diseases is fusarium wilt (*Fusarium*

*oxysporum f. sp. ciceris* (Nene *et al.*, 1996; Merkuze *et al.*, 2011b). The average productivity of chickpea in Ethiopia (964 kg/ha) is much lower than world average and is lower as compared to other chickpea growing countries such as Egypt (1652 kg/ha) and Turkey (1164 kg/ha) (CSA 2010; Jodha and Subba, 1987; Merkuze *et al.*, 2011c). 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. In North Western Ethiopia (west Amhara), the distribution and incidence of chickpea fusarium wilt is also currently increasing (Merkuze *et al.*, 2011c).

*Fusarium* wilt of chickpea can be managed using resistant cultivars, adjusting of sowing dates, fungicidal seed treatments, biocontrol agents and crop rotation (De *et al.*, 1996; Navas-Cortes *et al.*, 1998; Merkuze *et al.*, 2011a). Resistant varieties can be highly economical and practicable method of disease management, but varieties should be resistant to all the races prevalent in the area (Jimenez-Diaz *et al.*, 1993; Kelly *et al.*, 1994). 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 desi and kabuli-type of chickpea using integrated disease management option that is varieties planting dates and seed bed preparation methods on fusarium wilt development and yield of chickpea types.

## MATERIALS AND METHODS

The field trial was conducted during 2006/2007 and 2007/2008 under artificially *Fusarium* pathogen infested field (sick plot) at Adet research center Amhara National Regional State (ANRS) in Northwestern part of Ethiopia. The experimental site was located 11°17'N latitude, 37°43'E longitude and 2240 m.a.s.l. The experiment was conducted under rain fed conditions on vertisol. The design was factorial combinations of four varieties, i.e., Kabuli type (Shasho) and three desi type Marye, JG-62 and Adet local; as, JG-62 (susceptible check), Adet local (control), Marye and Shasho (both improved); three planting dates with 15-day intervals, i.e., early, farmers and late planting; and three seed bed preparation methods including flat bed, raised bed and ridge and furrow were used as treatments and were evaluated in randomized complete block design with three replications.

The plot size was 12m<sup>2</sup> (3mx4m). Early planting, farmers planting date and late planting were 12<sup>th</sup> September, 27<sup>th</sup> September and 12<sup>th</sup> October respectively at 15 days interval. Plots were prepared and fertilized with 100 kg/ha DAP at planting. The two surface drain practices raised bed and ridge and furrow were constructed by hand and ridge and furrow with oxen drawn local implement. Observations on wilt development were made and the percentages of wilted plants were calculated based on the stand count recorded at 15-days interval and finally yield was recorded. Data was analyzed using the SAS system for windows V8 and in all the analysis where differences existed between treatments, means were compared using student-Newman-keuls multiple-range test. (SAS, 2001).

## RESULTS

### Influence of desi and kabuli-type of chickpea varieties, planting date and seed bed preparation method in the incidences of chickpea fusarium wilt disease

Significant differences ( $P < 0.05$ ) were observed among varieties on disease incidence% in the two years. However the kabuli type Shasho was the best in reducing the disease incidence (Table 1). It was also observed significant differences ( $P < 0.05$ ) among planting dates in disease incidence% in the two years. However a 2<sup>nd</sup> planting date was the best in reducing the disease incidence (Table 2). Significant differences ( $P < 0.05$ ) were observed among seed bed preparation methods in disease incidence% in two years. However raised bed was observed the best in reducing the disease incidence (Table 3). Significant differences ( $P < 0.05$ ) were observed among desi and kabuli-type of chickpea varieties interacts with all seed bed preparation methods in 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> planting dates in incidences of wilt. However the kabuli type Shasho interacts with all seed bed preparation methods in all planting dates was the best in reducing the disease incidence (Table 4). There were no significant differences ( $P > 0.05$ ) the desi and kabuli type that is Adet local, Marye and Shasho interacts with all planting dates in all seed bed preparations methods respectively. However the kabuli type Shasho interacts significantly ( $P < 0.05$ ) difference with all planting dates on raised bed (Table 4). There were significant differences ( $P < 0.05$ ) some types of varieties interact with all seed bed preparation methods in 1<sup>st</sup> and 2<sup>nd</sup> planting dates. However the kabuli type Shasho interacts with raised bed in 2<sup>nd</sup> planting date was best in reducing the disease incidence (Table 4). Influence of desi and kabuli-type of chickpea varieties, planting date and seed bed preparation method on the yield of chickpea fusarium wilt. Significant differences ( $P < 0.05$ ) were observed among desi and kabuli-type of chickpea varieties on yield in the two years. However highest yield was recorded on kabuli-type Shasho (Table 5). It was also observed significant differences ( $P < 0.05$ ) among planting dates on yield in the two years. However highest yield was recorded in the second planting date (Table 6). The result showed that there were no significant ( $P > 0.05$ ) difference among seed bed preparation methods in two years at sick plot (Table 7). Significant differences ( $P < 0.05$ ) were observed among desi and kabuli-type of chickpea varieties that is Adet local, Marye and Shasho interacts with all seed bed preparation methods in the 2<sup>nd</sup> planting date on flat and ridge and furrow, in the 3<sup>rd</sup> planting date on raised bed in yield (Table 8). Both desi and kabuli-type of chickpea varieties that is Local, Marye and Shasho were not interacts significantly ( $P > 0.05$ ) difference with all planting dates in all seed bed preparations methods respectively (Table 8). There were not significant differences ( $P > 0.05$ ) desi and kabuli-type of chickpea varieties interact with all seed bed preparation methods in all planting dates in yield. However the kabuli type Shasho interacts significantly with all seed bed preparation methods in the 1<sup>st</sup> planting date (Table 8).

## DISCUSSION

Effect of desi and kabuli-type of chickpea varieties, planting date and seed bed preparation method on the incidence of chickpea fusarium wilt. On the basis of these studies it was observed that there were significant differences among the

**Table 1: The effect of desi and kabuli type varieties on incidence of chickpea fusarium wilt at wilt sick plot**

Variety	Incidence % <sup>a</sup>		
	2006/2007	2007/2008	Mean
JG-62	100.0a	100.0a	100.0a
Local	99.0a	91.3b	95.2b
Marye	94.4b	85.6c	90.0c
Shasho	92.1c	80.8d	86.5d
P-value	<.0001	<.0001	<.0001

<sup>a</sup> Disease incidence at 90 days after planting

**Table 2: The effect of planting date on incidence of chickpea fusarium wilt at wilt sick plot**

Sowing date	Incidence % <sup>a</sup>		
	2006/2007	2007/2008	Mean
12 <sup>th</sup> September	97.7a	90.2ab	93.4a
27 <sup>th</sup> September	94.1b	86.3b	90.2b
12 <sup>th</sup> October	97.3a	91.8a	94.6a
P-value	0.0019	0.0239	0.0016

\*<sup>a</sup> Disease incidence at 90 days after planting

\*Numbers with different letter within a column are significantly difference at P< 0.05

**Table 3: The effect seed bed preparation method on incidence of chickpea fusarium wilt at wilt sick plot**

Seedbed preparation method	Incidence % <sup>a</sup>		
	2006/2007	2007/2008	Mean
Flat bed	98.2a	91.7a	95.0a
Raised bed	94.1b	86.4b	90.2b
Ridge & furrow	96.9a	90.2ab	93.5a
P-value	0.0006	0.0298	0.0010

\*<sup>a</sup> Disease incidence at 90 days after planting

\*Numbers with different letter within a column are significantly difference at P< 0.05

**Table 4: The interaction effects of desi and kabuli type varieties, planting date and seed bed preparation method on the incidences of fusarium wilt disease at wilt sick plot in 2006/2007 and 2007/2008**

	12 <sup>th</sup> September				27 <sup>th</sup> September				12 <sup>th</sup> October			
	Flat bed	Raised	R&F	P-Value	Flat bed	Raised	R&F	P-value	Flat bed	Raised	R&F	P-value
JG – 62	100.0a	100a	100.0a		100.0a	100.0a	100.0a		100.0a	100.0a	100.0a	
Local	100.0a	92.4ab	98.8a		96.2ab	86.5b	92.4ab		94.9ab	96.7b	98.6a	
Marye	96.7ab	85.8b	92.4b		92.3b	82.2b	86.6bc		92.1ab	90.0c	92.0b	
Shasho	89.9b	82.9b	88.5b		86.9c	77.2b	82.3c		90.7b	89.0c	90.9b	
P- value	0.0233	0.0018	<.0001		<.0001	0.0001	0.0003		0.0391	<.0001	0.0040	
	Flat bed				Raised bed				Ridge & furrow			
	12 <sup>th</sup> Sept.	27 <sup>th</sup> Sept.	12 <sup>th</sup> Oct.	P-value	12 <sup>th</sup> Sept.	27 <sup>th</sup> Sept.	12 <sup>th</sup> Oct.	P-value	12 <sup>th</sup> Sept.	27 <sup>th</sup> Sept.	12 <sup>th</sup> Oct.	P-value
JG-62	-	-	-	-	-	-	-	-	-	-	-	-
Local	100.0a	96.2a	94.9a	0.0772	92.4a	86.5a	96.7a	0.1381	98.8a	92.4a	98.6a	0.0405
Marye	96.6a	92.3a	92.1a	0.2174	85.8a	82.2a	90.0a	0.0991	92.4a	86.6a	92.0a	0.1784
Shasho	89.9a	86.9a	90.7a	0.6927	82.9ab	77.2b	89.0a	0.0079	88.5a	82.3a	90.9a	0.1207
	12 <sup>th</sup> September				27 <sup>th</sup> September				12 <sup>th</sup> October			
	Flat bed	Raised	R&F	P-value	Flat bed	Raised	R&F	P-value	Flat bed	Raised	R&F	P-value
JG – 62	-	-	-	-	-	-	-	-	-	-	-	-
Local	100.0a	92.4b	98.8a	0.0298	96.2a	86.5a	92.4a	0.1573	94.9a	96.7a	98.6a	0.2417
Marye	96.7a	85.8b	92.4ab	0.0114	92.3a	82.2b	86.6ab	0.0183	92.1a	90.0a	92.0a	0.7776
Shasho	89.9a	82.9a	88.5a	0.3684	86.9a	77.2b	82.3ab	0.0439	90.7a	89.0a	90.9a	0.7893

\*Numbers with different letter within a row or column are significantly difference at P< 0.05

**Table 5: The effect of variety on yield of chickpea at Adet wilt sick plot**

Variety	Yield kg/ha		
	2006/2007	2007/2008	Mean
JG-62	-	-	-
Local	1.5b	4.2c	3.3c
Marye	4.7b	18.5b	13.1b
Shasho	8.9a	37.1a	26.7a
P-value	0.0004	<.0001	<.0001

Numbers with different letter within a column are significantly difference at P< 0.05

**Table 6: The effect of planting date on yield of chickpea at Adet wilt sick plot**

Planting date	Yield kg/ha		
	2006/2007	2007/2008	Mean
12 <sup>th</sup> September	4.7a	16.8b	14.1ab
27 <sup>th</sup> September	7.4a	30.4a	21.6a
12 <sup>th</sup> October	4.1a	15.4b	10.6b
P-value	0.1266	0.0109	0.0143

Numbers with different letter within a column are significantly difference at P< 0.05

**Table 7: The effect seed bed preparation method on yield of chickpea at Adet wilt sick plot**

Seedbed preparation method	Yield kg/ha		
	2006/2007	2007/2008	Mean
Flat bed	3.6a	18.3a	13.4a
Raised bed	7.2a	27.8a	19.3a
Ridge & furrow	4.9a	18.7a	14.0a
P-value	0.1879	0.1815	0.2939

Numbers with different letter within a column are significantly difference at P< 0.05

**Table 8: The effect of seed bed preparation, desi and kabuli-type of chickpea varieties and planting date on the yield kg/ha of chickpea at Adet-wilt sick plot in 2006/2007 and 2007/2008**

	Flat bed				Raised bed				Ridge & furrow			
	12 <sup>th</sup> Sept	27 <sup>th</sup> Sept.	12 <sup>th</sup> Oct.	P-value	12 <sup>th</sup> Sept	27 <sup>th</sup> Sept.	12 <sup>th</sup> Oct.	P-value	12 <sup>th</sup> Sept	27 <sup>th</sup> Sept.	12 <sup>th</sup> Oct.	P-value
JG-62	-	-	-	-	-	-	-	-	-	-	-	-
Local	-	1.0aB	1.2aA	0.4676	5.3aA	8.0aB	1.1aC	0.1160	0.8aA	4.0aB	0.7aA	0.1321
Marye	-	11.5aB	9.7aA	0.6615	16.4aA	23.0aAB	8.0aB	0.2934	4.6aA	16.4aB	9.5aA	0.1395
Shasho	-	29.4aA	20.7aA	0.4353	31.0aA	44.4aA	15.0aA	0.1438	10.0bA	40.0aA	17.6abA	0.0488
P-value	-	0.0189	0.07556	-	0.0671	0.0490	0.0007	-	0.2113	0.0162	0.0817	-
	19 <sup>th</sup> September				27 <sup>th</sup> September				12 <sup>th</sup> October			
	Flat bed	Raised bed	R & F	P-value	Flat bed	Raised bed	R & F	P-value	Flat bed	Raised bed	R & F	P-value
JG-62	-	-	-	-	-	-	-	-	-	-	-	-
Local	-	5.3aA	0.8aA	0.4070	1.0aB	8.0aB	4.0aB	0.0640	1.2aA	1.1aC	0.7aA	0.3689
Marye	-	16.4aA	4.6aA	0.0653	11.5aB	23.0aAB	16.4aB	0.4646	9.7aA	8.0aB	9.5aA	0.8838
Shasho	-	31.0aA	10.0bA	0.0344	29.4aA	44.5aA	40.0aA	0.6891	20.7aA	15.0aA	17.6aA	0.7585
P-value	-	0.0671	0.2113	-	0.0189	0.0604	0.0162	-	0.0756	0.0007	0.0817	-

\*Capital Letters represents column wise values \* Small letters represents row wise values

\*Numbers with different letter within a row or column are significantly difference at P< 0.05

desi and kabuli-type of chickpea varieties in managing the wilt incidence. However kabuli-type variety Shasho followed by desi-type variety Marye performs better in managing wilt incidence over the control. JG-62 susceptible check (desi-type) was observed completely wilted. This result is agreed with that of Merkuze *et al.*, (2011a) and (2011b). Among the planting dates it was also observed that there were significant differences in reducing wilt incidence.

However 2<sup>nd</sup> planting date was observed better in lowering mortality rate managing the wilt incidence. This date agreed with what has been recommended earlier for other agronomic characters with in date intervals (Alemayehu *et al.*, 1997). Purss, (1979) and Hillocks and Waller (1997) indicated that disease severity might be minimized by careful selection of time of planting which is similar with the finding of Dahiya *et al.*, (1988). Summerfield *et al.*, (1990), Hillocks and Waller (1997) and Merkuze *et al.*, (2011c) pointed out planting date is one of the most important agronomic factors affecting chickpea productivity. It was observed that there was significant difference among the seed bed preparation methods in managing wilt incidence. However raised bed observed 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/ root rots.

The influence of desi and kabuli-type of varieties, planting 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 was had significant difference among the treatments and high in wilt incidence. This may indicate that the disease was more develop early and late growth stage of the plant. This agrees with the finding Nene *et al.*, (1980) in Hillocks and Waller, (1997) that the two stages of wilt epidemics as early and late wilts are distinguished according to the time as early wilt develops at the seedling stage and late wilt after flowering. In the interaction of desi and kabuli-type of chickpea varieties, planting date and seed bed preparation method, there were a significant difference among the varieties in all planting dates in all seed bed preparation methods in reducing fusarium wilt incidence. 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 /root rots 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.

Effect of desi and kabuli-type of chickpea varieties, planting date and seed bed preparation method on the yield of chickpea. In the study it was observed that the efficient of desi and kabuli-type of chickpea varieties on yield of chickpea at wilt sick plot showed there were significant differences among desi and kabuli-type of chickpea varieties. Shasho (kabuli-type) followed by Marye (desi-type) gave better yield over the Adet local variety (desi-type). Planting the chickpea varieties in the 2<sup>nd</sup> planting date were observed gave better yield than the early and the late planting. Saxena, (1990) pointed out the inadequate plant stand due to early or late planting of chickpea

are the adverse environmental conditions which do not permit yield compensation by increased per plant productivity. Among the seed bed preparation methods it was observed there was no significance difference in yield. However raised bed followed by ridge and furrow was better than the flat bed. Raised bed was having exceeded on yield with 5.44% from flat bed 2.92% from ridge and furrow. The interaction of four varieties, three sowing dates and three seed bed preparation methods were showing with different possible combination that highly significant, significant and non significant difference among the treatments in yield. Haware and Nene, (1980) and Kumar *et al.*, (1981) indicates incidence of resistance being commoner among *desi* than among *kabuli*-types for wilt. In the current work it was observed Shasho which is *kabuli*-type performs better than *desi*-types in resisting the wilt disease. The *kabuli* type shasho followed by *desi*-type Marye were observed better in manage the disease and increase yield per ha at Adet wilt sick plot experiment.

Complete control of chickpea wilt disease is not achieved with a single management alone so integrated such cultural practices as a component for integrated disease management is important. The results indicate that kabuli type Shasho was the most resistant variety to wilt compare with desi types and advantage of using cultural management as a sustainable and environmentally friendly option to control chickpea fusarium wilt disease. It is concluded that the kabuli type Shasho better than desi type varieties, planting dates and to some extent seed bed preparation methods contribute to the management of wilt disease and so enhance productivity of chickpeas in northwestern Ethiopia.

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#### REFERENCES

- Alemayehu A. Minale L. and Yeshanew A. (1997) The effect of planting date on the yield of chickpea, (mariye variety) in Northwestern Ethiopia. Third annual conference crop protection society Ethiopia, (3<sup>rd</sup> ACPSE) May 1997
- Bahirdar Plant Health Clinic (BPHC). (1997) Disease survey report, Amhara Regional State Bureau of Agriculture (Unpublished). pp. 25.
- Bejiga G. Abou-Zeid S.W. Ahmad S. and Hassanein A. (1995) Managing Wilt and Root rots Food Legumes in the Nilevalley countries Cravan15 <http://www.icarda.org/publications/Cravan/cravan15/managing/managing.htm>
- Campbell C.L. and Madden, V.L. (1990) Introduction to Plant Disease Epidemiology. New York. John Wiley and Sons, INC. USA. 532pp.
- Chan M.K.Y. and Close R.C. (1987) *Aphanomyces* root rot of peas. Control by the use of cruciferous amendments. Netherlands. *Journal of Agriculture Research*. 45: 529-45.

- CSA (Central Statistics Authority). (2010) Report on area and crop production forecast for major grain crops for private peasant Holdings, Meher season. Forecast sample survey 2009/2010 (2002 E.C.) Statistical bulletin, 409. Addis Ababa. pp. 29 – 52.
- De R. K., Chaudhary K.G. and Naimuddin J. (1996) Comparative efficacy of biocontrol agents and fungicides for controlling chickpea wilt caused by *Fusarium oxysporum* f.sp. *ciceris*. *Indian J. Agric. Sci.* 66: 370-73.
- Geletu B. and Ketema D. (2003) Breeding chickpea for wide adaptation. In Ali K., Kenneni G., Ahmed S., Malhotra R., Rajendra B., Beniwal S., Makkouk K. and Halila, M.H. (Eds) Food and forage legume, 22-26 September 2003, Addis Ababa, Ethiopia. EIAR and ICARDA, Aleppo, Syria. pp.351.
- Geletu B., Million E. and Yadeta A. (1996) Improved cultivars and production technology of chickpea in Ethiopia. *Research Bulletin* No. 2. Debre-Zeit Agricultural Research Center, Alemaya University of Agriculture, Debre-Zeit, Ethiopia. pp. 60.
- Haware M.P. Jimenez-Diaz R.M. Amin K.S. Philips J.C. and Halila J.C. (1990) Integrated Management of wilt and root rot of chickpea. In: Walby B.J., Hall S.D. (Eds.). *Proceeding of the second International workshop on chickpea improvement, Chickpea in the Nineties*, 4-8 Dec. 1989, ICRISAT center, India. pp. 129 – 32
- Haware M.P. and Nene Y.L. (1980) Sources of resistance to wilt and root rots of chickpea. *International Chickpea Newsletter* 3, 11-12.
- Hillocks R.J. and Waller J.M. (1997) *Soilborne diseases of tropical crops*. CAB International, Wallingford, Oxon OX10 8DE UK. pp.452.
- Jimenez-Diaz R.M. Alcalá-Jimenez A.R. Hervas A. and Trapero-Casas J.L. (1993) Pathogenic variability and host resistance in the *Fusarium oxysporum* f.sp. *ciceris/Cicer arietinum* pathosystem. In: "Proc. 3<sup>rd</sup> Eur. Semin. *Fusarium* Mycotoxins, Taxonomy, Pathogenicity and Host Resistance". Plant Breeding and Acclimatization Institute, Radzikov, Poland. pp. 87-94.
- Jodha N.S. and Subba K.V. (1987) Chickpea: World importance and distribution. In: Sexena, M.C. and K. B. Singh (eds.). "The chickpea". CABI, Wallingford, UK. pp. 1-10.
- Kelly A. Alcalá-Jimenez A.R. Bainbridge B.W. Heale J.B. Perez-Artes E. and Jimenez-Diaz R.M. (1994) Use of genetic fingerprinting and random amplified polymorphic DNA to characterize pathotypes of *Fusarium oxysporum* f.sp. *ciceris* infecting chickpea. *Phytopathology*. 84: 1293-98.
- Kumar J. Haware M.P. and Nene Y.L. (1980) *Fusarium* wilt resistant lines developed at ICRISAT. *International Chickpea Newsletter* 3, 5.
- Menale K. Bekele S. Solomon A. Tsedeke A. Geoffrey M. Setotaw F. Million E. and Kebebew A. (2009) Current Situation and Future Outlook of the Chickpea Sub-sector in Ethiopia. ICRISAT, Nairobi. 39pp
- Merkuz A. Seid A. Chemed F. Sakhujia P.K. and Getachew A. (2011a) Effect of mustard green manure and dried plant residue on chickpea wilt (*Fusarium oxysporum* f.sp. *ciceris*). *Archives of Phytopathology and Plant Protection*. 44 (9): 821 – 831
- Merkuz A. Seid A. Chemed F. Sakhujia P.K. and Getachew A. (2011b) Effect of *Brassica carinata* (L.) biofumigants (seed meal) on chickpea wilt (*Fusarium oxysporum* f.sp. *ciceris*), growth, yield and yield component in Ethiopia. *Archives of Phytopathology and Plant Protection*. 44 (18): 1785 – 1795.
- Merkuz A. Sakhujia P.K. Chemed F. and Seid A. (2011c) Status of chickpea fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris*) in northwestern Ethiopia. *Archives of Phytopathology and Plant Protection*. 44:13, 1261 – 1272.
- Merkuz A. and Getachew A. (2011d) Evaluation of improved and local/landrace/sorghum varieties for covered kernel smut. *Archives of Phytopathology and Plant Protection* 1: 1 – 7.
- Navas-Cortes J.A. Hau B. and Jimenez-Diaz R.M. (1998) Effect of sowing date, host cultivar, and race of *Fusarium oxysporum* f.sp. *ciceris* on development of *Fusarium* wilt of chickpea. *Phytopathology*. 88: 1338-46.
- Negussie T. Seid A. Dereje G. Tesfaye B. Chemed F. Adane A. Melkamu A. Abiy T. Fekede A. and Kiros M. (2006) Review of research on diseases of legumes. In Abrham T. (eds.) *Increasing crop production through improved plant protection-Volume 1*. Proceedings of the 14<sup>th</sup> annual conference of the plant protection society of Ethiopia (PPSE), 19-22 December 2006. Addis Abeba, Ethiopia. PPSE and EIAR, Addis Ababa, Ethiopia. 598pp.
- Nene Y.L. Sheila V.K. and Sharma S.B. (1996) *A World List of Chickpea and Pigeon pea pathogens*, 5<sup>th</sup> eds Patancheru 502 324, Andhra Pradesh, India: ICRISAT. (Semi – formal publication.). pp.6 – 25.
- Palti J. and Katan, J. (1997) Effect of cultivation practices and cropping systems on soilborne diseases. In Hillocks R.J. and Waller, J.M. (eds.) *Soilborne diseases of tropical crops*. CAB International, Wallingford, Oxon OX10 8DE UK. pp.452.
- Purss G.S. (1979) Chickpea root disease management. In proceeding of the consultants' group discussion on the resistance to soil-borne disease of legumes, 8-11 January 1979 Patancheru, A.P. India
- SAS Institute. 2001. SAS Technical Report, SAS system for windows V8, SAS/STAT Software Release 8.02 TS Level 02 M0. SAS Institute Inc. Cary, NC, USA.
- Saxena M.C. (1990) Problems and potential of chickpea production in the nineties. In Walby B.J. and Hall S.D. (eds). *Chickpea in nineties: Proceedings of the second international workshop on chickpea improvement*. 4-8 December 1989, ICRISAT Center, India.
- Seid A. and Melkamu, A. (2003) Chickpea, lentil, grasspea, fenugreek and lupine disease research in Ethiopia. In Ali K. Kenneni G. Ahmed S. Malhorta R. Beniwal S. Makkouk K. and Halila M.H. (eds). Food and forage legume, 22-26 September 2003, Addis Ababa, Ethiopia. Sponsors: EIAR and ICARDA. International Center for Agricultural Research in the Dry areas (ICARDA), Aleppo, Syria. 351pp.
- Summerfield R.J. Virmani S.M. Roberts E.H. and Ellis R.H. (1990) Adaptation of chickpea to agroclimatic constraints. In Walby B.J. and Hall S.D. (eds) *Chickpea in the nineties: Proceedings of the second international workshop on chickpea improvement*. 4-8 December 1989, ICRISAT Center, India.