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RESEARCH ARTICLE

Evaluation of fungicides sprays frequency for the management of chickpea *Ascochyta* blight (*Ascochyta rabiei* (Pass.) Lab.) in Alemtena, East Showa, Ethiopia

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ABSTRACT

Chickpea (*Cicer arietinum* L.) is one of the most important grain legume crops in Ethiopia which widely grown in marginal soils and usually as rotational crops in highland and semi-highland regions of the country. Despite the large area under chickpea cultivation, total production and productivity is quite low. *Ascochyta* blight is one of the most important diseases of chickpea in Ethiopia that affects the quantity and quality of chickpea yield. Foliar application of fungicides with different spray frequencies are commonly recommended for *Ascochyta* blight management. Therefore, an experiment was conducted in Alemtena, East Showa, Ethiopia during the main cropping season of 2015 to evaluate three fungicides (Mancozeb, Mancolaxyl and Othello Top) sprays frequencies for the management of chickpea *Ascochyta* blight *(Ascochyta rabiei* (Pass.) Lab.) on growth parameters, yield and yield components and yield losses of chickpea cultivar, Natoli under field conditions. The experiment was randomized complete block design in factorial arrangement with three replications. It consisted of three levels of spray frequencies (spray every one week, spray every two weeks and spray every three weeks) of three fungicides and control (untreated) treatments. The analysis of variance showed significant differences among the treatments except for days to maturity. There was a significant difference in *Ascochyta* blight disease incidence, severity, and infected pods per plant, infected seeds and Area under Disease Progressive Curve (AUDPC) among treatments. The comparison of means showed that application of fungicides was a suitable strategy for reduction of *Ascochyta* blight incidence, severity and AUDPC values as well as the maximizing seeds per pod, pods per plant, plant height, hundred seed weight and seed yield. Seed yield on sprayed plots, ranged from 1793-2261.4 kg ha^{-1} with mean values of 2061.3 kg ha^{-1} while, the seed yields measured from unsprayed (control) plots were smaller than sprayed plots (1046.7 kg ha^{-1}). Disease severities and AUDPC rates had negative correlations with seed yield and hundred seed weight in comparison to their correlations with yield. Optimum net benefits of Ethiopian Birr, 50098.5 ha^{-1} and 47922.2 ha^{-1} were obtained from Mancozeb and Othello Top fungicides sprayed every three weeks, respectively and recorded highly effective in decreasing *Ascochyta* blight disease symptoms in chickpea cultivar Natoli and increased yield. Therefore, Mancozeb and Othello Top fungicides sprayed every three weeks are economically beneficial compared to the other treatments. Further, the effective and feasible integrated management options need to be developed on chickpea *Ascochyta* blight disease in the country.

Keywords: Chickpea, *Ascochyta* blight, *Ascochyta rabiei,* Fungicides, Spray frequency.

INTRODUCTION

Chickpea is one of the important grain legume crop in Africa particularly in Ethiopia which widely grown in marginal soils and usually as rotational crops in highland and semi-highland regions of the country (Asfaw, 1993). Because of its importance, the crop is widely produced by the Ethiopian farmers. According to FAOSTAT, (2015), it is produced on 11 million hectares with annual production of 9.7 million tons worldwide. However, among the pulse crops, chickpea is consistently maintained a much more significant status, ranking second in area (15.3% of total) and third in production (14.6%) after dry beans and dry peas (FAOSTAT, 2015).

There are two types of chickpea: the 'Desi' type (mostly brown seeded), traditionally grown in warmer climates of Asia and Africa including in Ethiopia; and the 'Kabuli' type (white-seeded), a large-seeded variety more suited to the temperate climates (Singh and Melhotra, 1984). The 'Kabuli' type constitutes 15% of global chickpea production and the 'Desi' type constitutes the remaining 85% (Singh and Melhotra, 1984; Muehlbauer and Singh, 1987). The national average yield of chickpea, 'Desi' type is 8.14 tones ha $^{-1}$; and Kabuli type is more than 15 tons ha^{-1}. Despite the large area under chickpea cultivation, total production and productivity is quite low in most chickpea growing countries and there is a wide gap between potential yield (5 t ha^{-1}) and actual yield (0.8 t ha^{-1}) (Menale *et al.,* 2009).

Chickpea is widely used for food because of its high protein content and also cash for the farmers in the country. Chickpea is not only an important source of proteins in human diets, but it also plays a significant role in maintaining soil fertility, through biological nitrogen fixation (Kantar et *al*., 2007). Chickpea is a good source of energy, protein (19.5%), carbohydrates (57 to 60%), fats (1.4%), ash (4.8%) and (4.9 to 15.59%) moisture, minerals (especially potassium, phosphorus, calcium, magnesium, copper, iron and zinc), vitamins (especially B vitamin) and also contains potentially health-beneficial phytochemicals. (Kantar et *al*., 2007). Ethiopia is the largest producer of chickpea in Africa, accounting for about 46% of the continent's production during 1994-2015. It is also the seventh largest producer worldwide and contributes about 2% to the total world chickpea production (Menale *et al*., 2009). The total annual average during 1999 - 2008 chickpea production is estimated at about 173 thousand tons (Menale *et al*., 2009). The national average yield of chickpea in Ethiopia under farmers' production condition remains less than 1.5 tons ha^{-1}(CSA, 2010). On the other hand, the potential of the crop under improved management condition is more than 3 tons ha^{-1} (Legesse *et al*., 2006). A number of limiting factors contribute to low productivity of chickpea. The primary cause of low yields in chickpea is its susceptibility to a number of biotic and abiotic stresses. In Ethiopia, 16 diseases were reported in chickpea (Tadesse *et al.,* 1998). The crop suffers from serious diseases that affect it in all growth stages. About 50 and 38% of these diseases are caused by fungal and viral pathogens, respectively. The major threats to the production of the chickpea crops are the diseases of fungal origin particularly *Fusarium* wilt and *Ascochyta* blight (Tadesse *et al.,* 1998).

Among biotic stresses, *Ascochyta* blight caused *by Ascochyta rabiei* (Pass.) Lab. recently renamed, *Phoma rabiei* is a wide spread foliar disease especially in areas where cool, cloudy, and humid weather persists during the crop season and constrained chickpea production in Ethiopia and that causes extensive crop losses up to 100% in most regions of the world where the crop is commonly grown (Haware, 1998; Tadesse *et al.,* 1998; Pande *et al.,* 2011). *Ascochyta rabiei* is the most serious disease of chickpea, which causes considerable degradation in quality and yield of the crop stand in Ethiopia (Tadesse *et al*., 1998). *Ascochyta* blight disease occurs in epidemic form during the year receiving more than 350 mm rain fall (Nene and Reddy, 1987; Jimenez-Diaz et al., 1993; Acikgoz *et al.,* 1994; Mucella *et al.,* 2004). It has been reported to cause 50 -70% crop losses (Malik and Bashir, 1984) under favorable atmospheric condition for the disease development. *Ascochyta* blight infection and disease progression occur from 5^{o} to 25^{o}C with an optimum temperature of 16^{o} -20^{o}C, and a minimum of 6 hour leaf wetness (Pande *et al.,* 2005). Disease severity increases with the increase in relative humidity (Trapero-Casas and Kaiser, 1992). Cloudiness and prolonged wet weather favor rapid development and spread of diseases. The pathogens survive on infected or contaminated seeds, infected chickpea debris which causes *Ascochyta* blight, produces both rain splashed conidia and windblown ascospores. When the conditions are favorable for disease development, wilt causes up to 50% yield losses and the *Ascochyta* blight causes up to 60 % losses (Mengistu and Negussie, 1994).

Despite extensive pathological and molecular studies, the nature and extent of pathogenic variability and management of *A. rabiei* have not been clearly established. The control strategies of *A. rabiei* are required to prevent major crop losses. The disease can effectively be managed by the foliar application and seed dressing fungicides (Reddy and Singh, 1984; Rauf *et al.,* 1996), use of disease free seed, destruction of plant disease debris (Chaube and Pandey, 1986) and host plant resistance (Iqbal *et al*., 2002; Ahmad *et al*., 2006). However, due to lack of durable resistance in commercial chickpea cultivars (Iqbal *et al.,* 1989) because the virulence's of the pathogen are constantly changing in nature, previously released resistant cultivars have become susceptible due to appearance of new virulent strains/races (Jamil *et al.,* 1995; Armstrang *et al.,* 2001). Thus, there is a need to continuously explore and identify the sources of resistance in chickpea germplasm and its incorporation into high yielding quality commercial chickpea varieties (Bashir *et al.,* 1997).

Seed treatment and foliar application of fungicides are commonly recommended for *Ascochyta* blight management. Chemical pesticides and diverse antibiotics were widely used to achieve high level of crop protection (Gaur *et al.,* 2010). As reported by Gaur *et al.,* (2010), 2-3 foliar sprays with captan, mancozeb or chlorothalonil at 2-3 g L^{-1} water can effectively manage *A. rabiei*. An adequate level of genetic resistance is not available in the cultivated genotypes of chickpea in Ethiopia and fungicide become ineffective under the high disease pressure. Production of chickpea in the rainy season (main cropping) in Ethiopia could not be envisaged without fungicide application to control *A. rabiei.* There is inadequate information with regard to the plant growth promotion, use of chickpea cultivar combination with fungicides and sprays frequency level against *Ascochyta* blight of chickpea in Ethiopia. Hence, susceptible chickpea cultivar combination with various fungicides with different spray intervals is available management of an option and essential to successfully manage the disease and mitigate yield losses. The application was judicious as there was no alternative to shift to new fungicides. But, in Ethiopia, chickpea cultivar integrated with spray frequency of fungicides at different intervals has received comparatively little attention and not been studied so far. Therefore, the present study was carried out to determine the efficacy of fungicides at three spray intervals for the control of chickpea *Ascochyta* blight and their assessment of yield and yield components and yield loses under field conditions in Alemtena, East Showa, Ethiopia and also to identify the most effective fungicide against chickpea *Ascochyta* blight and assess the economics of fungicides on chickpea.

MATERIALS AND METHODS

Description of the study area

The experimental study was conducted during the main cropping season (July - November) of 2015 in DZARC cultivated fields at Alemtena, Ethiopia. Alemtena is located 70 km South from Debre Zeit east. The mean annual temperature of Alemtena ranged between 12.9 -29.8^{0} C with an elevation of 1754 - 2200 m. a. s. l. and Latitude of 8^{0} 18' 24.4" North and also Longitude 38^{0} 57' 5.3" East. The annual rain fall is 728 mm and the soil type is light black sandy loam with pH 6.4.

Experimental materials used

The chickpea cultivar used in this experiment was an improved Desi type variety, 'Natoli' which was released by Debre Zeit Agricultural Research Center (DZARC) in 2009 (MoARD, 2010). This variety was susceptible to *Ascochyta* blight (MoARD, 2013) and the agronomic characteristic of the cultivar is given in table 1.

Three fungicides, Mancozeb (Unizeb 80% WP), Mancolaxyl 72 WP (Mancozeb + Metalaxyl) and newly registered and recommended fungicide, Othello-Top (Azoxystrobin + Difenoconazole) were used in this experimental study. All the three fungicides were obtained from the Department of Plant Sciences, Ambo University and DZARC. The fungicide, Mancozeb was used as a standard control check.

Experimental design, treatments and applications

An experiment was conducted in DZARC cultivated fields at Alemtena, during the main cropping season (July - November) of 2015. The field trial consists of single susceptible cultivar of chickpea, Natoli and three recommended fungicides, Mancozeb (Unizeb 80% WP), Mancolaxyl 72 WP (Mancolaxyl) and Othello-Top (Azoxystrobin + Difenoconazole). Mancozeb (Unizeb 80% WP) fungicide was applied by foliar spraying at the rate of 2 kg ha^{-1}; Mancolaxyl 72 WP at the rate of 3.0 kg ha^{-1} and the newly registered and recommended fungicide, Othello Top were applied by foliar spraying at the rate of 3.5 kg ha^{-1}. They were applied at three sprays frequency intervals (every one week, every two weeks, every three weeks) and unsprayed control check against chickpea *Ascochyta* blight (Table 2; Figures 1 and 2). Spacing between blocks measured 1 m and between adjacent plots 0.9 m. Each plot has a size of 1.20 m x 3 m and contained four rows (with two harvestable central rows) of the chickpea plants. Space between rows and plants was 40 cm and 10 cm, respectively. Planting was done at the end of July 2015 at the site of Alemtena under DZARC. The experimental field plots were free of chickpea cultivation for several years. The cultivated field soil was sandy loam soil with pH 6.4, (P (Na HCo3 extractable) 12.5 mg /kg, and total N 0.3g /kg, clay 140g/ kg). Seeds were planted at the rate of two seeds per hole and thinned to one plant, 15 days after sowing (DAS) to insure 120 plants per plot. This means, one line contains 30 plants and then plants per plot were 120. The experiments were conducted using factorial, Randomized Complete Block Design (RCBD) with three replications of each treatment. Unsprayed plots were used as control. The fungicide, Mancozeb sprayed treatment plots were used as a standard check. All recommended agronomic practices were followed uniformly for all treatments. No fertilizer was applied for all the treatments. Weeding was performed twice, after 15 and 25 days after emergence.

Table 1. Variety of chickpea used in this experimental study with its agronomic characteristics.

Variety	Year released	Area of adaption		Maturity days	Yield (kg ha^{-1})	
		Altitude(M)	Rain fall(mm)		On-research field	On-farm field
Natoli	2009	1800-2700	700-1200	136	22-26	20-25

Source: MoARD, (2010).

Table 2. Treatments involved in the experiment.

	Treatments
T1	Natoli + Mancozeb +Every one week spray interval
T2	+Every two weeks' spray interval
T3	+Every three weeks' spray interval
T4	Natoli + Mancolaxyl + Every one week spray interval
T5	+ Every two weeks spray interval
T6	+ Every three weeks spray interval
T7	Natoli + Othello Top + Every one week spray interval
T8	+ Every two weeks spray interval
T9	+ Every three weeks spray interval
T10	Natoli + Unsprayed Control.

Disease assessment

Disease incidence and severity

Ascochyta blight incidence and severity on infected plants were assessed at 7 days' intervals from 10 pre-tagged plants in the two central rows of each plot starting from 36 to 57 days after planting. At this stage the first *Ascochyta* blight lesion was observed on upper and lower surface of the leaves, especially on leaf lamina and veins of susceptible cultivar. The number of plants showing symptoms of *Ascochyta* blight was counted and the Percentage Disease Incidence (PDI) was calculated according to the formula by Wheeler (1969).

$$PDI = \frac{\text{Number of plants infected}}{\text{Total number of plants inspected}} X\ 100$$

Where; PDI= Percentage Disease Incidence

The severity of *Ascochyta* blight on the leaves was scored using the standard disease scale 1-9 (Reddy and Singh, 1984) (Table 3) and then the severity grades were converted into Percentage Severity Index (PSI) according to the formula by Wheeler (1969).

$$PSI = \frac{\text{Sum of individual numerical rating}}{\text{Total no. of plants assessed X Max. Score in Scale}} X\ 100$$

Where, PSI= Percentage Severity Index.

Figure 1 Experimental fields with different fungicide treatments on chickpea cultivar, Natoli at Alemtina.

Figure 2 Experimental field has sprayed with different fungicides on after 36 the day on chickpea cultivar, Natoli at Alemtina.

Table 3. Severity scale and its description

Scale	Description
1	No lesion is visible on the whole of the plants.
3	Visible lesions on less than 10% of the plants, the stems are not reached.
5	Lesions on 25% of the plants, with damage on approximately 10% of the stems.
7	Lesions on all the plants, approximately 50% of the stems are covered, which results in the death of certain plants because of serious damage.
9	Lesions diffused on all the plants, the stems are reached in proportions higher than 50% with the death of the majority of the plants.

Source: Reddy and Singh (1984).

The area under the disease progress curve and disease progress rates

The efficacy of fungicides on disease severity data were calculated into Area under Disease Progress Curve (AUDPC) as described by Campbell and Madden (1990). The AUDPC values (%-day) were calculated byaccording to the mid-point rule formula (Campbell and Madden, 1990).

$$AUDPC = \sum_{i=1}^{n-1} 0.5(x_{i+1} + x_i)(t_{i+1} - t_i)$$

Where n was the total number of assessments, t_i was the time of the i^{th} assessment in days from the first assessment date, x_i was percentage of disease severity at i^{th} assessment.

AUDPC was expressed in percent-days because the severity (x) was expressed in percent and time (t) in days. The rates of disease progress in time was determined by recording the severity of *Ascochyta blight* at 7 days' interval right from the appearance of the first disease symptoms till the maturity of the crop in the different treatments. The rates of disease progress rate was obtained from the regression of the PSI data fit to the appropriate model that best fitted the disease parameter (PSI) with dates of assessments.

Assessment of crop growth, yield and yield components and yield loss

The harvested pods were sun dried and the respective seed yield (kg ha^{-1}) of each treatment was measured. Chickpea yield data was adjusted at 10 or 20 % moisture content after measuring using a moisture tester. Seed yield per plot was converted into yield of kg ha^{-1}. The weight of hundred seeds was obtained for each treatment. The relative yield loss due to chickpea *Ascochyta* blight was assessed using the following formula:

$$\text{Relative Yield loss (\%)} = \frac{PY - AY}{PY} \times 100$$

Where, PY=potential yield; AY= Actual yield. The relative hundred seed weight losses would be similarly calculated.

Cost benefit analysis

Price of chickpea seeds (Birr kg $^{-1}$) was assessed from the local market and total price of the commodity obtained was computed on hectare basis. Input costs like fungicides and also labor costs ha^{-1} were recorded. The price of fungicides was calculated based on their frequencies used on plot basis and were converted into a hectare. The total amount of these materials used for the experiment was computed and their price was converted into hectare basis. Cost of labor for spraying these fungicides application from the first day to final were calculated and then converted on hectare basis. The net return for each fungicide treatment was obtained by deducting total cost of fungicide protection from total return. Increase in net return (net benefit) due to fungicide application was assessed by deducting the net return from the unsprayed plot. The rate of return to investment was computed by dividing the net benefit by net variable cost. The fungicide that yielded the highest rate of return was generally recommended for the use by farmers. Since there were significant differences between mean yields of treatments, the obtained data was analyzed using the partial budget analysis method (CIMMYT, 1998). Then, the treatment with the highest rate of return was recommended for use by the farmers. Marginal rate return was calculated using the formula:

$$MRR = \frac{DIC}{DNI}$$

Where, MRR was marginal rate of returns, DNI, difference in net income compared with control, DIC, difference in input cost compared with control.

Statistical analysis

Analysis of variance (ANOVA) was performed for the disease parameters; incidence, PSI, AUDPC, disease progress rates and percentage, yield parameters using Statistical Analysis System (SAS) version 9.13 software (SAS, 2007). The rates of disease progress was obtained from the regression of PSI data fit to the Gompertz model, [-ln (lnY)] with dates of assessments. Least significant difference (LSD) was used to separate treatment means (P<0.05). Correlation analysis was performed to examine the relationship between severity of the disease (AUDPC, the independent variables) and the change in yield and yield components.

RESULTS AND DISCUSSION

Chickpea *Ascochyta* blight incidence

There was a significant (P< 0.05) *Ascochyta* blight incidence difference between plots treated with Mancozeb, Mancolaxyl and Othello Top fungicides and no spray at the first, second and fourth date of disease assessment (Table 4). The difference between the levels of disease incidence remained statistically non-significant on third (50 DAP) date of disease assessment. Plots sprayed with Mancolaxyl every once and two weeks showed significantly lower disease incidence than the other plots after a week when it was first treated with the fungicide. The unsprayed plot had the maximum disease incidence levels consistently for the last four assessment dates (Figure 3 B). Disease incidence was reduced significantly with Othello Top and Mancozeb fungicides spray at all the date of disease assessment in comparison with un treated plots (100 %) (Table 5; Figure 3A). On the third date of disease assessment i.e. on the 50 DAP, the mean incidence level of the disease on unsprayed and sprayed plots were obtained the same results statistically. Similarly, this results are in agreement with experiments previously reported by Ahmed and Beniwal (1991) and Chongo *et al*., (2003) who reported that the chlorothalonil and mancozeb have been widely used and the former has performed consistently well against *Ascochyta* blight on a range of pulse crops (Gan *et al*., 2006; McMurray *et al*., 2006; Shtienberg *et al*., 2006). Chickpea varieties susceptible to AB have been successfully grown by strategically applying foliar fungicides such as chlorothalonil and mancozeb several times during the growing season (Bretag *et al*., 2006). Treatment sprayed with fungicide can greatly help in reducing the initial inoculum level and preventing the spread of the disease or races into new areas (Kaiser and Hannan, 1988). Similarly; Bashir *et al*., (1987) who reported that *Ascochyta* blight is a seed-borne and infected seed is an important source of primary inoculum in the field.

Table 4. Evaluation of fungicides Spray Frequency on *Ascochyta* blight disease percentage incidence on Chickpea.

		Percentage disease incidence (%)			
Fungicides	Frequency	36 DI	43 DI	50 DI	57 DI
Mancozeb	Once	60.00^{bc}	33.33^{e}	66.67^{b}	60.00^{bc}
	Twice	30.00^{e}	56.67^{cd}	76.67^{ab}	73.33^{ab}
	Three times	66.67^{ab}	76.67^{abc}	80.00^{ab}	80.00^{ab}
Mancolaxyl	Once	30.00^{e}	60.00^{bcd}	86.67^{ab}	40.00^{c}
	Twice	30.00^{e}	76.67^{abc}	90.00^{ab}	40.00^{c}
	Three times	36.67^{de}	80.00^{ab}	86.67^{ab}	70.00^{b}
Othello Top	Once	53.33^{bcd}	46.67^{de}	66.67^{b}	63.33^{bc}
	Twice	40.00^{cde}	66.67^{bcd}	73.33^{b}	76.67^{ab}
	Three times	43.33^{cde}	73.33^{bc}	90.00^{ab}	83.33^{ab}
Control (unsprayed)		88.89^{a}	98.89^{a}	97.78^{a}	100.00^{a}
Mean		47.9	66.9	87	68.7
LSD (0.05)		22.56	23.3	Ns	29.38
CV (%)		27.5	20.3	17.0	24.9

Means within the same column followed by the same letters are not significantly different at 5 % probability level.

Ns= non-significant difference at 5 % probability level. Where, 36 PDI =Percentage of Disease index take at 36 DAP, 43PDI =Percentage of Disease index take at 43 DAP, 50PDI =Percentage of Disease index take at 50 DAP, 57 PDI =Percentage of Disease index take at 57 DAP.

A

B

Figure 3 :
A. Symptoms of disease incidence on chickpea plants at Othello Top sprayed plots in experimental field.

B. Symptoms of maximum disease incidence on chickpea plants at unsprayed control plots in experimental field.

Foliar application of Proponeb (Antracol), Bordeaux mixture, Chlorothalonil, Zineb, Ferbam, Maneb, Captan, Captafol, Dithianon, Propiconazole, Penconazole, Sulfur, and Thiabendazole were also effective in control of AB and the application of these fungicides onto the infected crop was effective in reducing furzier development and secondary of AB (Bashir *et al.*, 1987; Nene and Reddy, 1987; Kaiser and Hannan, 1988; Gan *et al.*, 2006; McMurray *et al.*, 2006; Shtienberg *et al.*, 2006).

Chickpea *Ascochyta* blight severity

Chickpea *Ascochyta* blight severity was first observed on 29 days after planting (DAP). However, disease assessment was started at 36 DAP. The three fungicides were significantly ($P < 0.05$) different in terms of their respective reaction to the disease ($P < 0.05$). The plots showed significantly ($P < 0.05$) different levels of *Ascochyta* blight severity at all dates of assessment (36, 43, 50 and 57 DAP). On the first date of severity assessment, the lowest average

Table 5. Evaluation of fungicides spray frequency on percentage severity index and area under disease progress curve of chickpea

Fungicides	Frequency	Percentage severity index (%)				AUDPC
		36 PSI	43 PSI	50 PSI	57 PSI	
Mancozeb	Once	73.33^{ab}	50.22^{de}	53.33^{c}	52.59^{b}	2042^{cd}
	Twice	53.33^{d}	71.11^{ab}	54.67^{c}	56.76^{b}	2085^{bcd}
	Three times	77.78^{a}	74.44^{a}	57.9^{c}	57.78^{b}	2400^{b}
Mancolaxyl	Once	53.33^{d}	55.11^{bcde}	62.67^{bc}	49.33^{bc}	1968^{d}
	Twice	53.33^{d}	57.33^{bcde}	60.76^{bc}	38.96^{c}	1919^{d}
	Three times	57.78^{cd}	66.67^{abcd}	64.04^{bc}	50.48^{bc}	2297^{bc}
Othello Top	Once	68.89^{abc}	41.33^{e}	51.26^{c}	50.86^{bc}	1879^{d}
	Twice	60.00^{bcd}	57.33^{bcde}	62.67^{bc}	44.44^{bc}	2032^{cd}
	Three times	62.22^{bcd}	66.67^{abcd}	64.04^{bc}	56.3^{b}	2091^{bcd}
Control (unsprayed)		68.89^{abc}	69.91^{abc}	94.56^{a}	99.01^{a}	2839^{a}
Mean		62.9	59.7	64.1	55.7	2155
LSD (0.05)		15.54	16.69	20.48	13.61	318.7**
CV (%)		14.4	16.3	18.6	14.3	8.6

Means within the same column followed by the same letters are not significantly different at 5 % probability level,

Ns= non-significant difference at 5 % probability level. Where, 36 PSI =Percentage Severity index taken at 36 DAP, 43 PDI =Percentage Severity index taken at 43 DAP, 50PSI =Percentage Severity index taken at 50 DAP, 57 PSI =Percentage Severity index taken at 57 DAP and AUDPC =Area under Diseases Progress Curve severity level of *Ascochyta* blight was recorded on Mancozeb with twice and Mancolaxyl once and twice sprayed frequencies (53.33 %) and followed by Mancolaxyl with three times (57.78%) fungicide sprayed plots while the maximum level of severity was scored on Mancozeb followed by Othello Top (62.22%) with three times plot (77.78 %). Moreover, the maximum (99.01 %) and minimum (38.96 %) severity were recorded on control and Mancolaxyl spray every two weeks' plots, respectively on the last date of severity assessment (Table 5). The unsprayed plots showed the maximum disease severity index for the last two successive assessment dates when final disease severity index was compared, there was significant difference between treated and untreated plots. The least percent disease severity index was recorded in Mancolaxyl spray every two weeks at 56 PSI DAP, with mean value of (38.96 %). In comparison, the highest severity index of 99.01% from untreated plots was recorded at final date (Table 5). This might be due to the fact that Mancolaxyl fungicide has ability to reduce primary infection and at the same time it is able to manage spreading of *Ascochyta* blight secondary inoculum between neighboring plants. Based on a study conducted in Canada stated that although genetic resistance is available in some cultivars, it is only partial and starts to break down at flowering (Armstron *et al.*, 2008). Lack of resistance in chickpea cultivars helps fungicide to play an important role in the management of disease. Foliar application with protectant fungicides such as Bordeaux mixture (copper sulphate + hydrated lime), wettable Sulphur, Maneb and Captan can resulted in reduced disease levels (Reddy and Singh, 1984).

Area under Disease Progress Curve (AUDPC)

The (AUDPC) is a very convenient summary of plant disease epidemics that incorporates initial intensity, the rate parameter, and the duration of the epidemic which determines final disease intensity (Bellido Lopez, 2008). Effect of fungicides (Othello Top, Mancozeb and Mancolaxyl) foliar sprays were highly significant ($P < 0.01$) differences in terms of reducing AUDPC when compared to control (untreated) plot (Table 5). Lower value of AUDPC was calculated from Othello Top spray every one week (1879%), followed by Mancolaxyl spray every two weeks (1919%) and Mancolaxyl spray every one week (1968%) while the maximum AUDPC was recorded from control plot (2839%) (Table 5). Davidson and Kimber, (2007) claim that the benefits of using seed treatments to control *Ascochyta* infection on field pea are inconclusive, possibly because of airborne inoculum has a greater influence on the *Ascochyta* disease on this crop, than seed borne inoculum.

Phenology and growth parameters

Days to flowering and maturity

The days to 50% flowering differed significantly due to different treatments. Mancozeb spray every week and Mancolaxyl spray every one, two and three weeks took significantly lesser days for 50% flowering by 1.67 days compared to other treatments which may be due to better early and faster emergence. While, plots treated with Othello Top spray every one week took longest days to 50% flowering. Othello Top spray every two and three weeks and untreated control were recorded almost equal number of days for 50% flowering (Table 6). This finding is as par with Mucella *et al.* (2004) who found that seed priming resulted in earlier crop flowering on chickpea. With respect to days to 95% physiological maturity treatments was not significantly affected time to 95% physiological maturity.

Plant height (cm)

The data on plant height (cm) at harvest as influenced by treatments are presented in Table 7 and Appendix Section- Table 4. Highly significant differences were observed ($P<0.01$) due to the treatments for plant height at harvest. Mancozeb, Mancolaxyl and Othello Top spray every one, two and three weeks were significantly higher for plant height while the untreated plots recorded the shortest plant height at harvest. The mean plant height was increased by 48.9% under Othello Top spray every two weeks as compared to control (Table 6). However, in all plots treated by fungicides recorded statistically similar plant height at harvest. Plant height measured on sprayed plots was larger than those from unsprayed plots. Height measurements of plant height on sprayed plots, ranged from 23.53-28.47cm with mean values of 26.39cm. While, the plant height measured from unsprayed plots were smaller than sprayed plots (19 cm) The better crop growth due to treatment may be attributed to the fact that treatments activate the synthesis of proteins, RNA, free amino acids and soluble sugars in the first phase of germination which could be advantages for subsequent phases of growth Muehlbauer and Singh, (1987). The results showed that, under severe *Ascochyta* blight, infection the plant

Table 6. Evaluation of fungicides sprays frequency of *Ascochyta* blight on phenology and growth parameters on chickpea.

		Phenology and growth parameters		
Fungicides	Frequency	Days to Flowering	Days to Maturity	Plant Height (cm)
Mancozeb	Once	42.33[c]	75.00[a]	26.4[a]
	Twice	42.67[bc]	76.33[a]	24.93[a]
	Three times	42.67[bc]	75.00[a]	27.60[a]
Mancolaxyl	Once	42.33[c]	75.33[a]	26.73[a]
	Twice	42.33[c]	74.33[a]	28.13[a]
	Three times	42.33[c]	75.33[a]	24.93[a]
Othello Top	Once	44.00[a]	75.33[a]	26.87[a]
	Twice	43.67[ab]	74.67[a]	28.47[a]
	Three times	43.33[abc]	75.00[a]	23.53[ab]
Control (unsprayed)		43.00[abc]	75.44[a]	19.00[b]
Mean		42.87	75.18	25.66
LSD (0.05)		1.007	ns	5.262
CV (%)		1.4	1.8	12

Means within the same column followed by the same letter are not significantly different at 5 % probability level, Ns= non-significant difference at 5 % probability level.

height was affected. The plant height obtained from all treated plots was significantly higher than that of untreated plots. This indicated that, *Ascochyta* blight has a great effect upon plant growth.

Effect of fungicide spray frequency on yield components, grain yield and loss of chickpea

Bellido Lopez, (2008) stated that various agronomic characters like pods plant^{-1}, seeds pod^{-1}, hundred seed weight, days to flowering, and days to maturity play an important role in the severity of *Ascochyta* blight in chickpea.

Pods per plant

Effect of Othello Top, Mancolaxyl and Mancozeb foliar sprays was significantly ($P < 0.05$) different in terms of enhancing pods per plant. Plots treated with Othello Top fungicides spray every two weeks showed the highest pods per plant (13.03). Whereas, the lowest pods per plant (5.57) was recorded on Mancozeb spray every one week and Mancolaxyl spray every one, two and three weeks (Table 7). The increased seed yield with high plant population is attributable to the production of more pods (Gan *et al*., 2003) and more seeds per unit area (Regan *et al*., 2003), despite more disease on individual plants (Chang *et al*., 2007).

Seeds per pod

Number of seeds per pod significantly varied with *Ascochyta* blight infection. The highest number of seeds per pod (2.0) was recorded from fungicide sprayed plots with Mancozeb spray every one and two weeks, Mancolaxyl spray every one week and Othello Top spray every three weeks. The lowest (1.0) number of seeds per pod was recorded from unsprayed plots. The seed per pod estimation reduction of 66% was recorded from unsprayed plots compared with sprayed plots (Table 7). Elucidating that the *Ascochyta* blight had deleterious effect on number of seeds per pod. Disease severity increases the seed per pod decreases. This result is in line with Amin and Fufa (2014) who reported that maximum seeds per pod were recorded on sprayed plots by Othello Top and Mancozeb While, the minimum seeds per pod was scored on plot without fungicide treatment.

Hundred seed weight

The data from the experiment showed that hundred seed weight had significant difference between the treatments. The weight of 100 seeds recorded from both sprayed and unsprayed plots revealed that the highest 100 seed weight was obtained from fungicide sprayed plots with range of 28.6 – 30.8g and the lowest 100 seed weight was obtained from unsprayed plot (20g) (Table 7). In general, the average mean of 100 seed weight was 20 g for unsprayed (control) plots and 29.7 g for sprayed plots. From the fungicides sprayed plots, plots which received Mancozeb every two weeks (30.8g) recorded the highest 100 seed weight while the lowest was recorded from control (unsprayed) plot (20 g) (Table 7). According to this result, the *Ascochyta* blight had effect on the weight of the seed. The hundred-seed weight loss was recorded from this experiment was 45.5%. Fungicides application has significantly increased seed weight over the unsprayed treatments. Similarly; Amin and Fufa (2014) who reported that the maximum hundred seed weight was recorded on sprayed plots by fungicides.

Relative yield losses

The relative yield losses due to *Ascochyta* blight on the seed yield of chickpea are presented on Table 7. Relative yield losses due to *Ascochyta* blight reached 59.27 % on control and 11.97 % on Othello Top spray every two weeks treated plot, respectively. The variation in yield losses was observed between treatments. In untreated (control) plots, the yield losses were distinctly higher than in protected plots. Yield losses were substantially, reduced with the application of fungicides relative to untreated plots. The disease development was the highest in untreated (control) plots. This result is in agreement with experiments previously conducted by Amin and Fufa (2014) Ascochyta blight disease can cause serious yield losses which ranged from 10.9 - 41.3%. When the conditions are favorable for disease development, the *Ascochyta* blight causes up to 60 % losses (Mengistu and Negussie, 1994).

Seed yield

Grain yield was significantly ($P < 0.05$) increased by fungicide sprays. Othello Top fungicide sprayed every two weeks' treatment significantly increased grain yield (2261.4kg ha^{-1}) and followed by Mancozeb sprayed every three weeks (2209.5 kg ha^{-1}). Nonetheless, the lowest grain yield was recorded on control plot (1046.7 kg ha^{-1}) (Figure 4). However, there was no significant difference in fungicides spray plots. Compared to the control, the mean seed yield was increased by 96.9% due to the fungicides treatments. Seed yield measured on fungicides sprayed plots were larger than those from unsprayed (control) plots. Seed yield on sprayed plots, ranged from 1793-2261.4 kg ha^{-1} with mean values of 2061.3 kg ha^{-1}. While, the seed yield measured from un sprayed (control) plots were smaller than sprayed plots (1046.7 kg ha^{-1}). The better crop growth due to treatment may be attributed to the fact that treatments activate the synthesis of proteins, RNA, free amino acids and soluble sugars (Amin and Fufa, 2014). The results showed that, under severe *Ascochyta* blight, infection the seed yield was affected. The seed yield obtained from all treated plots was significantly higher than that of untreated plots. This indicated that, *Ascochyta* blight has a great effect upon seed yield (Table 5). Chongo *et al.* (2003) proved that the fungicide applications in chickpea have had a substantial impact on seed yield. This result was in line

Table 7. Effect of fungicides spray frequency on yield and yield components of chickpea

Fungicides	Frequency	Yield and yield components			
		Seeds per pod	Pods per plant	Hundred seed weight(g)	Relative yield loss (%)
Mancozeb	Once	2.0^{a}	5.57^{c}	30.00^{a}	23.73^{b}
	Twice	2.0^{a}	8.1^{abc}	30.80^{a}	20.13^{b}
	Three times	1.3^{bc}	8.8^{abc}	28.97^{a}	13.97^{b}
Mancolaxyl	Once	2.0^{a}	5.67^{c}	29.63^{a}	15.70^{b}
	Twice	1.3^{bc}	5.97^{c}	30.77^{a}	16.43^{b}
	Three times	1.7^{ab}	5.33^{c}	29.10^{a}	19.37^{b}
Othello Top	Once	1.3^{bc}	11.67^{ab}	28.60^{a}	30.20^{b}
	Twice	1.29^{bc}	13.03^{a}	29.53^{a}	11.97^{b}
	Three times	2.0^{a}	8.03^{abc}	29.90^{a}	26.03^{b}
Control (unsprayed)		1.0^{c}	7.13^{bc}	20.53^{b}	59.27^{a}
Mean		1.56	7.93	28.78	21.61
LSD (0.05)		0.53(*)	5.06(*)	2.57(**)	24.77(*)
CV (%)		19.84	37.24	5.4	30.9

Means within the same column followed by the same letters are not significantly different at 5 % probability level, Ns= non-significant difference at 5 % probability level.

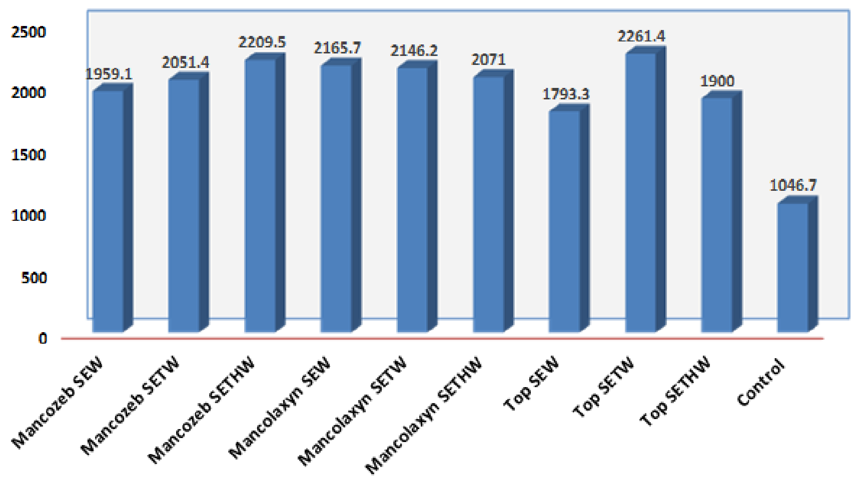

Figure 4. Effect of fungicides spray frequency on seed yield of chickpea
Whereas; CV (%) = 18.92, LSD (5%) = 636.45,

SEW= Spray every week, SETW= Spray every two weeks and SETHW= Spray every three weeks.

with Amin and Fufa (2014) who reported that the highest seed yield obtained from Othello Top fungicide treatment significantly increased grain yield (4790 kg ha^{-1}) and followed by Mancozeb (4430 kg ha^{-1}).

Correlation coefficient (r) between yield, yield components and disease parameters

Chickpea yield was correlated with different disease parameters. Disease severity values assessed on 57 DAP plots treated with different fungicide treatments had highly significant ($P \leq 0.01$) and negative correlation ($r = -0.61^{**}$) with grain yield (Table 8). This indicates that the observed levels of the disease had a considerable adverse effect on grain yield of the crop. Hundred seed weight was also highly significant ($P \leq 0.01$) and negatively associated ($r = -0.63^{**}$ and -0.79** taken at 50 & 57 DAP) with *Ascochyta* blight severity. Disease severities and AUDPC rates in general had higher negative correlations with hundred seed weight in comparison to their correlations with yield. Since grain yield and hundred seed weight had highly significant positive correlation ($r = 0.59^{**}$) with each other, the high negative correlation observed between disease parameters and hundred seed weights would indicate the extent to which the disease may affect grain yield of the crop. Thus, a significant effect of the disease on hundred seed weight can result in a considerable reduction in grain yield of the crop.

Likewise, correlations between AUDPC values and seed yields ($r = -0.68^{**}$) were highly significant and negatively correlated. AUDPC is an integral descriptive for the epidemic, which is comparable to the multiple point models to measure crop losses; however, AUDPC cannot distinguish between early and late occurring epidemics which result in the same areas under disease progress curve without applying weighting factors to assessments at different growth stages. On the other hand, the correlations observed between disease parameters (Severities and AUDPC values) were positive. The correlation coefficient ($r = 0.84^{**}$) between severity and AUDPC was highly significant (Table 8). This indicates that although the area under the disease progress curve was steadily increasing after disease has reached higher severity levels.

Cost benefit analysis

The price of chickpea yield in Ethiopian birr Kg^{-1} was computed based on the current price of 100Kg obtained from a hectare basis, input costs like fungicides and labor cost ha^{-1} was taken into account. The total amount of those materials utilized for the experiment was computed and their price converted. Before doing the economic analysis (partial budget) the statistical analysis was done on the collected data to compare the average yield between treatments and untreated, respectively. The difference between treatments and economic data were subjected to analyses using the partial budget analysis method (CIMMYT, 1988). The price of chickpea at Alemtena was assessed and average price of 25 birr kg^{-1} was used to compute the total sale (gross return) and net return from the total produce obtained. The data indicated that fungicide treated plots have recorded the highest total variable costs than untreated. Likewise, minimum variable costs were observed in untreated plots. Nevertheless, the highest gross return was obtained (EB 50818.5ha^{-1}) from fungicide treated plots. In addition, the data analyses indicated that the highest net return was also obtained from plots

Table 8. Correlation coefficient (r) between yield, yield components and disease parameters

	36PSI	43PSI	50PSI	57PSI	AUDPC	SY	PP	PH	HSW
36PSI	1								
43PSI	-0.11ns	1							
50PSI	0.05ns	0.33ns	1						
57PSI	0.29ns	0.32ns	0.49**	1					
AUDPC	0.17ns	0.28ns	0.67**	0.84**	1				
SY	-0.09ns	-0.1ns	-0.33ns	-0.61**	-0.68**	1			
PP	-0.08ns	-0.16ns	-0.04ns	-0.06ns	-0.02ns	0.14ns	1		
PH	-0.22ns	-0.13ns	-0.64**	-0.49**	-0.64**	0.46**	0.25ns	1	
HSW	-0.28ns	-0.23ns	-0.63**	-0.79**	-0.84**	0.59**	-0.05ns	0.53**	1
SP	-0.09ns	-0.2ns	-0.08ns	0.02ns	-0.18ns	0.05ns	-0.42*	-0.21ns	0.37*

36PSI = Percentage Severity Index taken at 36 DAP, 43PSI =Percentage Severity index taken at 43 DAP, 50PSI =Percentage Severity index taken at 50 DAP, 57PSI =Percentage Severity index taken at 57 DAP, HSW: Hundred Seed Weight, PH: Plant Height, PP: Pods per plant, SY: Seed yield, SP: Seed per pod and AUDPC: Area under Disease Progress Curve.

Table 9. Partial budget analysis of fungicides sprays frequency versus unsprayed treatments.

Fungicides	Frequency	AGY (kg ha-1)	TR (Birr)	TVC(Birr)	Net return (TR-TC) (Birr)
Mancozeb	Once	1959.1	45059.3	1440	43619.3
	Twice	2051.4	47182.2	720	46462.2
	Three times	2209.5	50818.5	720	50098.5
Mancolaxyn	Once	2165.7	49811.1	4280	45531.1
	Twice	2146.2	49362.6	2190	47172.6
	Three times	2071	47633	2190	45443
Othello Top	Once	1793.3	41245.9	8180	33065.9
	Twice	2261.4	52012.2	4090	47922.2
	Three times	1900	43700	4090	39610
Control (unsprayed)		1046.7	24074.1	0	24074.1

Where, AGY= Adjusted Grain Yield, TVC=Total Variable Cost, TR= Total Revenue, 1 kg chickpea=25 birr kg^{-1}, 1kg Mancozeb= 155 birr, 1kg Mancolaxyl= 340 birr & 1kg Top= 570 birr, daily labour = 25 day $^{-1}$

treated by Mancozeb sprayed per three weeks with mean value of EB 50098.5 ha^{-1}. The least net benefit was obtained from untreated plots with a value of EB 24074.1 ha^{-1} (Table 9). Fungicides are used because they provide effective and reliable disease control, deliver production in the form of crop yield and quality at an economic price and can be used safely (Rechcing and Rechcing, 1997). In Canada, the timely and efficient use of fungicides has remained a major factor in the successful management of *Ascochyta* blight and the economic viability of pulse crops (Rechcing and Rechcing, 1997)

CONCLUSION

Chickpea is the most important staple pulse crop in Ethiopia. Despite the large area under chickpea cultivation, total production and productivity is quite low. The primary cause of low yields in chickpea is its susceptibility to a number of biotic and abiotic stresses. Among biotic stresses, *Ascochyta* blight is one of the most important diseases of chickpea in Ethiopia that affects the quantity and quality of chickpea yield. An experiment was conducted in Alemtena, East Showa, during the main cropping season of 2015 to evaluate the fungicides spray frequencies for the management of chickpea *Ascochyta* blight on growth parameters, yield components and yield losses. The analysis of variance showed that highly significant differences among the treatments except for days to maturity. There was a significant difference in *Ascochyta* blight disease incidence, severity, and infected pods per plant, infected seeds and Area under Disease Progressive Curve (AUDPC) among treatments. The comparison of means showed that application of fungicides was a suitable strategy for reduction of *Ascochyta* blight severity, incidence and AUDPC as well as the maximum seeds per pod, pods per plant, plant height, hundred seed weight and seed yield. The phenological and growth parameters of chickpea also showed significantly ($P<0.05$) difference due to the treatment application except for days to maturity. Mancozeb spray every week and Mancolaxyl spray every one, two and three weeks took significantly lesser days for 50% flowering by 1.67 days compared to other treatments, while, plots treated with Othello Top spray every one week took longest days to 50% flowering. The highest plant height was observed at Mancozeb, Mancolaxyl and Top spray ever one, two and three weeks. Othello Top fungicides spray every two weeks showed the highest pods per plant (13.03). The highest number of seeds per pod (2.0) was recorded from fungicide sprayed plots with Mancozeb spray every one and two weeks, Mancolaxyl spray every one week and Othello Top spray every three weeks. Mancozeb every two weeks (30.8g) recorded the highest 100 seed weight. Relative yield losses due to *Ascochyta* blight reached 59.27 % on control and 11.97 % on Othello Top spray every two weeks treated plot, respectively. Seed yield on fungicide sprayed treatments, ranged from 1793-2261.4 kg ha^{-1} with mean values of 2061.3 kg ha^{-1} while, the seed yield measured from unsprayed (control) plots were smaller than sprayed plots (1046.7 kg ha^{-1}). Disease severities and AUDPC rates had negative correlations with seed yield and hundred seed weight in comparison to their correlations with yield. Disease severities and AUDPC rates had highly significant positive correlation ($r = 0.59^{**}$) with each other. Optimum net benefits of Ethiopian Birr, 50098.5 ha^{-1} and 47922.2 ha^{-1} were obtained from Mancozeb and Othello Top fungicides sprayed every three weeks, respectively and recorded highly effective in decreasing *Ascochyta* blight disease symptoms in chickpea cultivar Natoli and increased yield. Therefore, Mancozeb and Othello Top fungicides sprayed every three weeks are economically beneficial compared to the other treatments. Further, the effective and feasible integrated management options need to be developed on chickpea *Ascochyta* blight disease in the country. Mancozeb and Othello Top fungicides sprayed frequencies every three weeks are economically beneficial for the management of chickpea *Ascochyta* blight and increased yield. Further experiment has to be repeated with over locations and seasons to reach at more reliable recommendation..

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