Evaluation of Fungicides and Fungicidal Spray Schedule for the Management of Angular Leaf Spot of Common Bean

Canadian Journal of Agriculture and Crops
Vol. 2, No. 2, 74-83, 2017
e-ISSN: 2518-6655
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Shiferaw Mekonen[1]

[1]*Southern Agricultural Research Institute (SARI), Awassa Agricultural Research Center, Awassa, Ethiopia*

ABSTRACT

Angular Leaf Spot (ALS), caused by Phaeoisariopsisgriseola (Sacc.), is one of the major diseases of common bean in the Southern Ethiopia.The objective of the experiment was to select fungicides and spray intervals to recommend low cost management options for the control of ALS disease. The experiment was carried out under natural epidemic at Awassa Agricultural Research Center in Southern Ethiopia during 2013 -2014. The study consisted of five different fungicides (Ridomil Gold, Penncozeb, Curzate, Tilt 250 EC and Bumper 25 EC) in combination with two spray intervals (7 and 14 days) using two common bean varieties (HawassaDume and Red Wolaita) having dissimilar levels of reaction to ALS. The treatments were laid using Randomized Complete Block Design (RCBD) in factorial arrangement. All fungicides tested were found to be effective in controlling the ALS disease as compared to unsprayed treatment. Ridomil Gold was the most effective fungicide in reducing the disease severity and yield loss,followed by Curzate and Penncozeb, where asPropiconazole fungicides (Tilt 250 and Bumper) showed high AUDPC value as compared to the other fungicides. Ridomil Gold reduced the AUDPC value by 75% and 40% on susceptible and moderately resistant varieties, respectively. Grain yield loss was estimated to be 35 to 40 % and 74 to 85 % in moderately resistant and susceptible variety, respectively. There was not significance difference ($p < 0.05$) observed between spray intervals in controlling ALS and increasing grain yield. This study indicated that, use of fungicides most effective in controlling ALS causing agent, reducing yield loss and obtaining net return. Therefore, integrating selected fungicides with other management options is very important to obtain optimum economic return from common bean production.

Keywords: *Angular Leaf Spot, AUDPC, fungicides, Grain yield, , Phaseolus Vulgaris.*

DOI: 10.20448/803.2.2.74.83
Citation | Shiferaw Mekonen (2017). Evaluation of Fungicides and Fungicidal Spray Schedule for the Management of Angular Leaf Spot of Common Bean. Canadian Journal of Agriculture and Crops, 2(2): 74-83.

Funding: The research was supported by Southern Agricultural Research Institute (SARI), Ehiopia.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.
History: Received: 11 April 2017/ Revised: 6 June 2017/ Accepted: 22 June 2017/ Published: 10 July 2017
Publisher: Online Science Publishing

1. INTRODUCTION

Common bean(*PhaseolusVulgaris*L) is one of the major pulses grownin Ethiopia [1]. Southern Nation, Nationalities and People's Regional State (SNNPRS) is one of the major common bean producing regions in Ethiopia. Out of the areas covered by pulses in SNNPRS, 43% is occupied by common bean. The region contributes 41% of the national volume of common bean production [2].

Common bean is an important food for people of all income categories and especially for the poor as a source of dietary protein. The crop is increasingly becoming a significant source of income for smallholder farmers and plays a significant role in the livelihoods of smallholder farmers, serving also as food security crop. Even though the crop is very important, the national average yield of common bean in Ethiopia is very low at 0.5-0.8 ton/ha [1] compared to the potential of the crop and the yield obtained from experimental plots, which is 2.9-3.5 tones.

Internationally, several constraints were identified as the cause for the low yields of common bean [3]. Among these disease and insect pests are the major ones. Common bean diseases such as Angular Leaf Spot (ALS) caused by *Phaeoisariopsisgriseola* (Sacc.) is one of the most widely distributed and damaging diseases of common bean, causing yield losses as high as 80% [4]. When weather conditions are favorable for its development, ALS is a very destructive disease with crop losses resulting mainly from premature defoliation [5]. The disease affects foliage and pods throughout the growing season and is particularly destructive in areas where warm and moist conditions are accompanied by abundant inoculum from infected plant residues and contaminated seeds. ALS incidence and severity became increased in many areas where beans are cultivated [6]. In Africa, particularly in Kenya, Malawi, Ethiopia, Uganda and Tanzania, the disease is considered the number one constraint to bean production [7] with annual losses estimated at 374,800 tonnes Wortmann, et al. [8]. Habtu, et al. [9] explained that ALS caused by *Phaeoisariopsisgriseola* (Sacc.) is one of the major diseases of common bean in tropical regions including Ethiopia.
Survey has been conducted to determine the severity and incidence of the disease in Gurage, Silte, Wolaita and Sidama administrative zones of SNNPRS, in Ethiopia in 2011 and 2012 cropping seasons. ALS was occurred and recorded on 84% of the surveyed fields [10]. The incidence and severity was ranged from 75 to100% and 35 to 53%, respectively across the surveyed sites [10]. Even the moderately resistant common bean varieties such as Nasir, HawassaDume, and Ibado were affected by this disease.

Different management options, such as use of resistant varieties, use of disease free seed and crop rotation are knownto be the ideal way to manage this disease. However, the disease became one of the worst diseases, affecting almost every released and registered variety in the country. Under such condition, when the inoculum level is very high, the use of fungicide is mandatory to obtain optimum yield. However, there were no registered fungicides that were recommended for the control of ALS in Ethiopia. Therefore, there was a need to evaluate fungicides which have been registered for other crops in Ethiopia with unknown efficacy on ALS of common bean. In addition, evaluating spray interval to attain a low cost management, with minimum environmental pollution, to increase the efficacy of fungicide and to sustain bean production while controlling ALS is very important. Thus, this study was carried out to investigate the effect of fungicides and spray intervals low cost management options for the control of the disease.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The experiment was carried out at Awassa Agriculture Research Center during 2013 and 2014 main cropping season (end of June to November). The site is located 7° 4' N latitude and38° 31' E longitude and an altitude of 1700 meters above sea level. The soil texture of the experimental site is sandy loam. The total annual rainfall of the area ranged from 1000-1200 mm.

2.2. Treatments and Experimental Design

Two common bean varieties, namely HawassaDume and Red Wolaita, which are moderately resistant and susceptible to ALS, respectively were used for the experiment. HawassaDume variety was released in 2002 for its high yield and disease tolerance in SNNPRS. The local variety, Red Wolaita, which is widely grown in Sidama and Wolaita areas of Southern Ethiopia, is known for its high susceptibility to ALS. Both varieties have wide-range of environmental adaptation in the region. The other factors are fungicide efficacy (Table 1) and determination of spray intervals at (7 and 14 days). A factorial randomized complete block design (RCBD) was used with three replications. Plots consisted of 4 rows with spacing of 0.1 m between plants and 0.4 m between rows with a plot size of 4 m x 1.6 m. Fertilizer rate and crop husbandry practices, such as cultivation and weeding were carried out according to the recommended practices.

2.3. Fungicides

Each fungicide was applied as per manufacturer recommendation rate. Manually-pumped knapsack sprayer having 15 liter capacity was used during the experimental period.

Table-1. Trade and common name of fungicides and dosage applied

Fungicides			
No	Product name	Active ingredient	Dosage
1	Ridomil Gold MZ 68 WP	M etalaxyl – M 4% + Penncozeb64%	2 kg ha-1
2	Curzate M 68 WP	Cymoxanil 45 gm/lt + Penncozeb680 gm/lt	2 kg ha-1
3	Penncozeb 80 WP	Penncozeb80 WP	2.5 kg ha-1
4	Tilt 250 EC	P ropiconazole	0.5 litre ha-1
5	Bumper 25 EC	P ropiconazole	0.5 litre ha-1

Source: Ministry of Agriculture in Ethipa. 2012. List of registered pestides leaflet

2.4. Spray Interval

Spraying was conducted at seven and fourteen dayintervals for each variety and data were collected before and after spray for each fungicide.

2.5. Production Costs

To investigate the production costs and net-benefits of each treatment, the amount of fungicides used for each plot and all other expenses were recorded in each season. Accordingly, the quantity and the price of each fungicide and labor expenses were calculated per hectare and displayed bellow in Table 2.

Table-2. Average cost of production of common bean for different fungicides and rate of application

	Fungicides and labor costs (ETB) on hectare base					
Cost	Ridomil	Curzate	Pencozeb	Tilt	Bumper	Untreated
Fungicides	1300	1200	800	1800	1600	0
Labor and spray rent	630	630	630	630	630	0
Total cost	1930	1830	1430	2430	2230	0

- 1 ETB = USD 0.05, price of common bean =-8 ETB kg^{-1}

2.6. Data Collection and Statistical Analysis

Disease assessment: ALS disease severity was assessed at seven days interval using CIAT standard scale (1-9) [11]

Yield assessment: At harvesting, grain yield data was taken from two middle rows excluding one border rows on both sides to minimize border effects. Grain yield per plot was recorded at 10 % seed moisture content.

2.7. Data Analysis

ALS disease severity: Disease Assessment Index (DAI) were used as key reference points for calculation of Area Under Disease Progress Curve (AUDPC). In order to compare treatments, the disease severity data was integrated to the AUDPC as described by midpoint rule method [12]. The AUDPC was calculated using a formula: $AUDPC = \Sigma_{i=1}^{n-1} [(t_{i+1} - t_i)(y_i + y_{i+1})/2]$

Where,t = is time in days of each reading, y = is the percentage of affected foliage at each reading and n = is the number of readings.

Grain yield: The grain yield of each treatment was converted to hectare and analyzed. The yield loss was calculated for each treatment using the best fungicide and the untreated check plot as control.Yield losses of common bean due to ALS were estimated based on ((X-Y)*100)/X where X= the mean grain yield (kg ha^{-1}) of totally protected plot and Y = grain yield of the untreated plot.

The obtained AUDPC value and grain yield was subjected to analysis of variance (ANOVA) using SAS software version 8 [13].

Furthermore, regression analysis was performed to identify the relationship between disease severity and grain yield and to predict that yield loss is fitted as a function of severity for the two varieties known to have different disease reactions.

Cost Analysis: The gross return obtained from each treatment was calculated using 15% adjusted grain yield obtained per hectare and multiplying each yield by average existing price of common bean. The net gross return was calculated by subtracting the total variable cost (TVC) from gross return. Finally, the net benefit for each treatment was calculated using the best controlled treatment and untreated plot.

To identify how the net benefits from an investment increase as the amount invested increases the marginal analysis calculated according to CIMMYT [14]. Treatments arrange in order of ascending total costs that vary, with corresponding net benefits. the dominated treatment eliminated. A marginal analysis presents non dominated treatments on a net benefit curve and calculates the marginal rates of return between pairs of adjacent treatments

3. RESULTS AND DISCUSSION

Natural infestation of ALS disease was appeared during the study period on both varieties. However particularly note that in neither year in our study did the unsprayed susceptible control not reached 100% disease severity level, probably due to a change in weather conditions during the evaluation.

In the unsprayed plot the moderately resistant variety showed intermediate disease response and 4 to 5 disease score observed in both seasons, whereas in the susceptible cultivar 6 to 8 disease score is recorded. This leads to sort out the efficacy of fungicides on the control of ALS.

3.1. Reaction of Varieties to ALS

There was a significant variation ($p < 0.05$) among the two varieties for disease severity and grain yield during each cropping season (Table 3).The improved variety, HawassaDume, significantly ($p < 0.05$) reduced the severity of the disease as compared to the local variety, Red Wolaita. Higher AUDPC values of 298.5 and 289.0 were recorded on Red Wolaita in 2013 and 2014, respectively. On the other hand, lower AUDPC values of 180.4 and 210.1 were recorded on HawassaDume in 2013 and 2014, respectively (Table 3). The higher AUDPC values recorded on the local variety indicate the presence of higher disease score as compared to the moderately resistant variety (HawassaDume) .Consequently higher yields of 1970 and 2618 kg ha^{-1}, were obtained from HawassaDume in 2013 and 2014 respectively. Whereas, for Red Wolaita, lower yields of 786 and 593 kg ha^{-1}, were obtained in 2013 and 2014 respectively. However the obtained grain yield variation for the two varieties may not be only due to impact of varieties to ALS, since HwassaDume is released high yielder variety and Red wolaita known as low yielder and susceptible. The obtained better yield might be contributed from varieties genetically yield potential.

3.2. Effect of Increasing the Spray Interval

The effect of increasing spray interval was consistent for each fungicide. The effect of spray interval alone, interaction by variety, and fungicides were not significant at both seasons in reducing disease severity and yield loss. The obtained result on both varieties irrespective of 7 and 14 days of spray intervals.Our findings in line with the previous study, Fikre, et al. [15] reported that more percent yield increase was obtained after 21 and 28 days than the sprays every week and fortnightly. This may be because more frequent fungicide applications can affect the health of the crop through toxicity in addition to affecting the pathogen. Besides the other reason might be the rainfall, temperature and humidity pattern between two spray intervals might not influence the pathogen development in the study period.

3.3. The Influence of Fungicides on Disease Control and Grain Yield

Significance difference ($p < 0.05$) was observed between fungicide sprayed and unsprayed plot in controlling the disease (Table 3). Lower disease severity and high yield was recorded in plots sprayed with Ridomil, Cruzate and Penncozeb in 2013 and 2014 cropping seasons, respectively. (Table 3).

Table-3. Effect of fungicides, varieties and spray intervals on the control of ALS

		AUDPC		Grain yield ($kgha^{-1}$)	
		2013	2014	2013	2014
Variety	HawassaDume	235b	220b	1970a	2618a
	Red Wolaita	298a	289a	786b	593b
Spray interval	7 days	276a	241a	1456a	1702a
	14days	289a	269a	1282a	1509a
Fungicides	Ridomil	180 c	175c	1708a	1823a
	Curzate	215c	181c	1641a	1943a
	Penncozeb	220c	206c	1608ab	1717ab
	Tilt 250 EC	259b	256b	1350ab	1723ab
	Bumper 25 EC	280b	257b	1280b	1577ab
	Unsprayed	409a	425a	1100c	953c
CV %		12	15.5	25	26

Values followed by the same letter were not significantly different ($p < 0.05$)

In the sprayed plot, lowest AUDPC value of 224 to 280 and 175 to 257 were recorded in 2013 and 2014 cropping seasons, respectively. Whereas in the unsprayed plots, 409 and 425 AUDPC values were obtained in 2013 and 2014 cropping seasons, respectively. Similarly, for grain yield, significant difference (P<0.05) was observed between fungicides treated and untreated plots. Depending on the fungicides efficacy, grain yields of 1250 to 1708 kg $ha^{-1}$and 1477 to1823 kg ha^{-1}were obtained from sprayed plot in 2013 and 2014, respectively. On the other hand, in unsprayed plots, 953 kg and 1100 kg ha^{-1}were obtained in 2013 and 2014 cropping seasons, respectively. In general, the mean yield advantage of fungicide sprayed plots for both varieties was 60 % as compared to the unsprayed plot. This indicates that the need for supplementary fungicides in areas where ALS diseases severity is high.

3.4. Influence of Variety by Fungicide Combination on Grain Yield

The interaction between fungicide and variety was significant (p <0.05) indicating that the effect of fungicides varies depending on type of varieties used (Table 4). Penncozeb containing fungicides (Ridomil, Cruzate and Penncozeb) showed better control than Propiconazole (Tilt and Bumper) fungicides. Highest yields of 1167 to 1180 kg ha^{-1} and 2100 to 2283kg ha^{-1}were obtained from the susceptible and moderately resistant varieties, respectively. Whereas in propiconazole treated plots, yields of 400 to 683 kg ha^{-1} and 1900 to 2067 kg ha^{-1}were obtained from susceptible and moderately resistant varieties, respectively in 2014 cropping season.Regarding yield loss, 40 and 42% yield loss was recorded for HawassaDume in 2013 and 2014, respectively while on Red Wolaita, 74 and 85% yield loss was recorded in 2013 and 2014 cropping seasons, respectively (Table 4). . Our findings in line with the previous research reports of yield loss on common bean 80% [4].This indicates the need of fungicide spray for ALS diseases in areas having similar Agroecology especially on the local variety to obtain optimum yield.

Table-4. The interaction of varieties and fungicide spray on the control of ALS as expressed on yield (kg ha^{-1}) in 2013 and 2014 cropping seasons

		2013		2014	
Variety	**Fungicides**	**Yield (kgha-1)**	**Yield loss (%)**	**Yield (kgha-1)**	**Yield loss (%)**
Hawassa Dumme	Ridomil	2283a		2985a	-
	Curzate	2233a	-2.19	2913a	-2.41
	Penncozeb	2100a	-8.02	2821a	-5.49
	Tilt 250 EC	2067a	-9.46	2705a	-9.38
	Bumper 25	1900b	-16.78	2526b	-15.38
	No fungicide	1133b	-43.06	1763c	-40.94
Red Wolaita	Ridomil	1180 b	0	973c	0
	Curzate	1167b	-1.10	673cd	-30.83
	Penncozeb	1050bc	-11.02	614cde	-36.90
	Tilt 250 EC	683cd	-42.12	740cd	-23.95
	Bumper 25 EC	400cd	-66.10	427ed	-56.12
	No fungicide	250de	-78.81	145e	-85.10

Values followed by the same letter were not significantly different (p< 0.05)

3.5. The Interaction of Variety and Fungicides on the Control of ALS

The two way interactions between variety and fungicides is shown in Table 5. There was a significant difference fungicide by cultivar interaction for disease control. This indicated the disease response to treatment varied from cultivar to cultivar.

During the two cropping seasons, the different fungicides significantly reduced the disease severity than the untreated plot on both varieties. The AUDPC value in sprayed plots was consistently smaller than unsprayed plots. The AUDPC values for fungicide sprayed plots were 133 to 257 and 245 to 333 for HawassaDume and Red Wolaita, respectively compared to untreated plots where AUDPC values of 372 to 399 and 450 to 465 were recorded for HawassaDume and Red Wolaita, respectively (Table 5). The susceptible variety was more sensitive to fungicides response than resistant variety [16].This was evidenced in our study the best fungicide lowers the AUDPC value by 75 % and 40% on susceptible and moderately resistant respectively.

Table-5. The interaction of variety and fungicide spray on the control of ALS as expressed with AUDPC values

Variety	Fungicides	Year	
		2013	2014
HwassaDume	Ridomil gold	198fg	163gh
	Curzate	180g	133h
	Penncozeb	194fg	182fg
	Tilt 250	220ef	215.83ef
	Bumper	257de	227.5ef
	unsprayed	372b	399b
Red Wolaita	Ridomil gold	145f	156f
	Curzate	250e	230e
	Penncozeb	289cd	228e
	Tilt 250 EC	245e	295c
	Bumper 250 EC	303c	285cd
	un sprayed	450a	465a

Values followed by the same letter were not significantly different ($p< 0.05$)

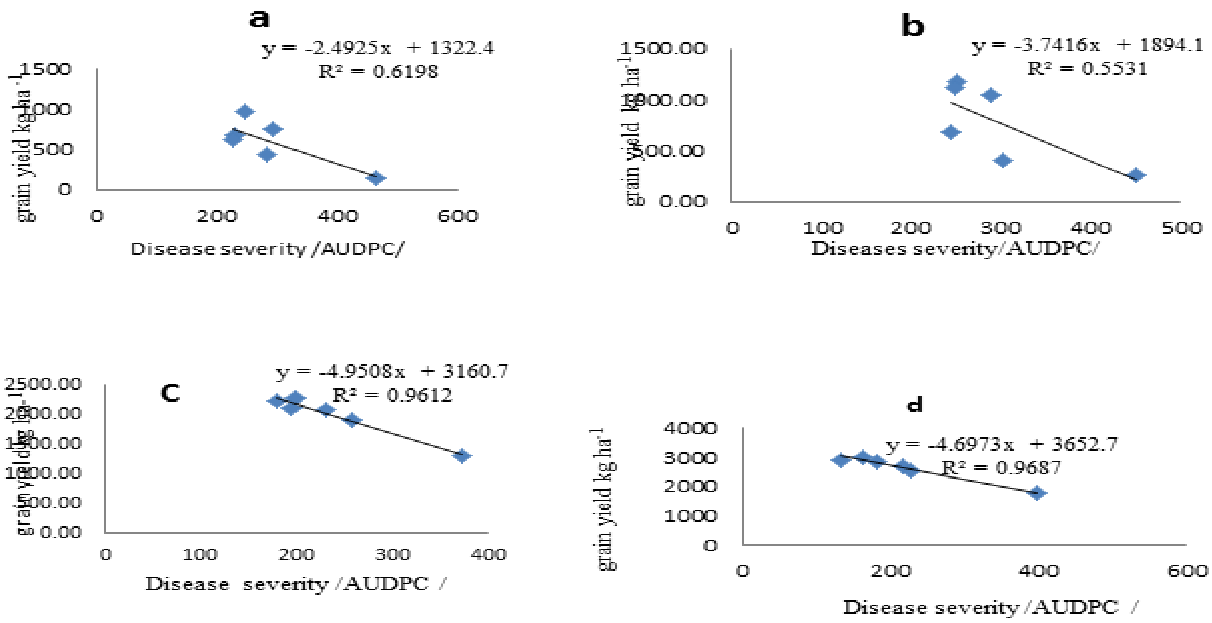

Fig-1. (a-d): Relationship between ALS disease severity and grain yield (kg ha^{-1}) for Red W olaita (a, b) in 2013 (a), 2014 (b) forHawassaDume (c d), in 2013 (c) and 2014(d).

3.6. Regression Analysis

The regression equation of grain yield on disease severity for moderately resistance was observed as high R^2 (0.96 and 0.97) indicates that much of the variability in yield could be attributed to Angular leaf spot. In the susceptible variety R^2 (0.62 and 0.56) and relatively low indicates some of the variability in yield might be attributed due to variety effect rather than ALS. The estimates predict that for every AUDPC value ALS severity increase, 2.4 to 3.74 kg ha^{-1} and 4.5 and 4.7 kg ha^{-1} yield reduction occur in Hawassa Dume and Red wolaita respectively (Fig. 1).

3.7. Marginal Analysis

The result of the marginal analysis is indicated in Table 6. It showed that the marginal rate of return for application of Penncozeb on HawassaDume variety is about 420%. Similarly, the marginal rate of return (MRR) for using Ridomil, Cruzate and Tilt fungicides is about 125, 388 and 148%, respectively. This shows that one investment to spray Penncozeb ,Cruzate, Ridomil and Tilt on moderately resistant variety HawassaDume would result about 4.2, 1.25, 3.88 and 1.48 extra net benefit. Similarly, application of these fungicides on local cultivar, susceptible Red Wolaita resulted in a MRR of obtained 255, 79, 1088 and 190 % for Penncozeb , cruzate, Ridomil and Tilt, respectively. This also shows that a one EtB investment to spray Penncozeb , Cruzate, Ridomil and Tilt on Red Wolaita would result in about 2.55, 7.9, 10.88 and 1.90 extra net benefit Ethiopian Birr (EtB)

Table-6. Average gross return, net return and marginal analysis of common bean under variety and fungicide combination in 2013 and 2014 cropping seasons

			EtB			
Varieties	Treatments	Grain yield (Kg)	Gross return	TVC	Net return	MRR (%)
HawassaDume	Untreated	1531.5	12252	0	12252	0
	Penncozeb	2460.5	19684	1430	18254	420
	Cruzate	2573	20584	1830	18754	125
	Ridomil	2634	21072	1930	19142	388
	Bumper	2213	17704	2230	15474	-1222
	Tilt 250	2275	18200	2430	15770	148
Red Wolaita	Untreated	197.5	1580	0	1580	0
	Penncozeb	832	6656	1430	5226	255
	Cruzate	921.5	7372	1830	5542	79
	Ridomil	1070	8560	1930	6630	1088
	Bumper	639	5112	2230	2882	-1249
	Tilt 250	711.5	5692	2430	3262	190

* Unit price of Common bean 8 EtB kg^{-1} or USD 0.4 kg^{-1}

* One EtB = USD 0.05, *TVC= Total variable cost

4. CONCLUSION AND RECOMMENDATION

The three way interactions between variety, fungicide and spray intervals on disease severity and grain yield were not significant in the study period. There was a significant difference for fungicide by cultivar interaction on controlling the disease and in reducing grain yield loss. This indicated the yield or disease response to treatment varied from variety to variety. The susceptible variety showed greater yield depression at high ALS severities. The reaction varieties in reducing ALS disease severity and grain yield loss were significant. Yield loss variation was observed among treatments in this study. The degree of variation in yield loss was dependant on the resistance level of cultivars and disease severity.

The present findings were indicated that use of fungicides most effective at inhibiting ALS causal agent in terms severity of disease without reference to the pathogenic cycle development. In this study the four fungicides Ridomil, CruzatePenncozeb and Tilt sprayed plots showed better result as compared the remaining treatments in reducing the disease severity and yield loss Ridomil was most effective in reducing the disease severity and yield loss, followed by Cruzate, Penncozeb and Tilt 250 fungicides. Ridomil, Cruzate and Penncozeb have provided better net benefit to produce common bean, however the most effective fungicide Ridomil provided higher net return on both susceptible and moderately resistant varieties

According to the marginal analysis result Ridomil, Penncozeb and Cruazte have showed better economic return as compared to other fungicides. Therefore farmers can use one of the three fungicides according to their availability and affordability to users.

In general the obtained fungicides can be used for optimum sustainable productivity and profitability for common bean production if integrated with other protection management option. In addition developing resistance variety and evaluate other group of fungicides under study is suggested, since the ALS causing races variability. Efficacy depends upon proper application timing, rate, and application method to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Therefore farmers or users should be trained how to use pesticides and careful to achieve the efficacy of chemicals.

5. ACKNOWLEDGMENTS

I am very much greate full to Mrs. Alemnesh G/wold, Mrs, Tsehay Mengesha and Mr. Tegegn Zewde for their assistance during data collection and spraying of fungicides on time.

REFERENCES

[1] EPPA, *Ethiopian pulses proceedings of the workshop on food and forage legumes, 22 - 26 september 2003.* Ethiopia: Addis Ababa, 2004.

[2] CSA, *Agricultural sample survey 2014/2015. Report on area and production of major crops. Central statistical agency of Ethiopia.* Ethiopia: Addis Ababa, 2015.

[3] C. W. Wachenje, "Bean production constraints, bean seed quality and effect of intercropping on floury leaf spot disease and yields in Taita Taveta district, Kenya," M.Sc. Thesis, University of Nairobi, 2002.

[4] H. F. Schwartz, M. A. Pastor-Corrales, and S. P. Singh, "Newsources of resistance to anthracnose and angular leaf spot of beans (Phaseolus Vulgaris L.)," *Euphytica*, vol. 31, p. 741—754, 1982. *View at Google Scholar | View at Publisher*

[5] A. W. Mwangombe, P. M. Kimani, and J. W. Kimenju, "Evaluationof advanced bean lines for resistance to 6 major diseases in Kenya," presented at the During the Workshop for Bean Research Collaborators, 1994.

[6] S. A. Stenglein, D. Ploper, O. Vizgarra, and P. Balatti, "Angular leaf spot: A disease caused by the fungus phaeoisariopsisgriseola (Sacc.) Ferraris on phaseolus vulgaris L.," *Advances in Applied Microbiology*, vol. 52, pp. 209-243, 2003. *View at Google Scholar | View at Publisher*

[7] M. A. Pastor-Corrales, C. Jara, and S. P. Singh, "Pathogenic variation in sources of and breeding for resistance to phaeoisariopsisgriseola causing angular leaf spot in common bean," *Euphytica*, vol. 103, pp. 161-171, 1998. *View at Google Scholar*

[8] C. S. Wortmann, R. A. Kirkiby, C. A. Elude, and D. J. Allen, *Atlas of common bean (.Phaseolus Vulgaris L.) Production in Africa.* Africa: CIAT Publications, 1998.

[9] A. Habtu, I. Scache, and J. C. Zadoks, "A survey of cropping practices and foliar diseases of common bean in Ethiopia," *Crop Protection*, vol. 15, pp. 179-186, 1996. *View at Google Scholar | View at Publisher*

[10] Anonymous, Awassa Agricultural Research Center Crop Protection Progress Report, 2012.

[11] A. Van Schoonhoven and M. A. Pastor-Corrales, "Standard system for the evaluation of bean germplasm. CIAT, Cali, Colombia.Schwartz, H.F., V.F. Correa, D.D.A. Pineda," 1987.

[12] C. L. Campbell and L. V. Madden, *Introduction to plant disease epidemiology*. New York: John Wiley and Sons, 1990.

[13] SAS Institute Inc, *SAS onlineDoc®, version 8*. Cary, NC: SAS Institute Inc, 1999.

[14] CIMMYT, *From agronomic data to farmer recommendations: An economics training manual. Completely revised edition*. Mexico. D.F., 1988.

[15] L. Fikre, S. Waktole, and W. Mulatu, "Association between angular leaf spot (Phaeoisariopsisgriseola(Sacc.) Ferraris) and common bean (Phaseolus Vulgaris L.) Yield Loss at Jimma, South Western Ethiopia," *Plant Pathology Journal*, vol. 10, pp. 57-65, 2011. *View at Google Scholar* | *View at Publisher*

[16] M. Shiferaw, A. Tameru, K. Bekele, and F. Greg, "Evaluation of contact fungicide sprays regimes for control of late blight (Phytophthora Infestans) in Southern Ethiopia using potato cultivars with different levels of host resistance," *Tropical Plant Pathology*, vol. 36, pp. 21-27, 2011. *View at Google Scholar* | *View at Publisher*