
Fungicide evaluation for the management stemphylium leaf blight (*Stemphylium vesicarium*) on onion (*Allium cepa* L.)Yitayih Gedefaw^{1*}, Abebe Gezahegn¹, and Gebeyehu Wondimu¹^{1*}Ethiopian Institute of Agricultural Research, Melekassa Agricultural Research CenterCorresponding author email: yitayihg@gmail.com

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ABSTRACT**Received:** August 12, 2021**Revised:** November 21, 2021**Accepted:** December 14, 2021**Available online:** December 27, 2021**Keywords:** Fungicide, Management, *Stemphylium* leaf blight, Yield loss

Onion (Allium cepa L.) is among the most important cash crops in Ethiopia. Over 97% of the harvest is meant for sales, it is commercially driven. Despite this huge economic value its production and productivity are hampered by disease and insect pests. Stemphylium leaf blight (Stemphylium. vesicarium Wallr E.G.(Simmons), among others, is a newly recurring foliar disease that caused significant yield loss since its recognition in the country. Yet, there is no well-established management option. Therefore, this study was conducted to evaluate fungicides as an urgent means to mitigate its impact. Field experiment consisting of 12 selected fungicides along with unsprayed control were evaluated at Melkassa agricultural research center in 2020 and 2021. Percent disease index (PDI) and area under disease progress curve (AUDPC) were used to measure the disease suppression effect of the fungicides. The potential onion bulb yield loss due to the disease was estimated. Essence 38 WG highly suppressed the disease (PDI=51.54%, 44.00%) in 2020 and 2021 years, respectively, where consistently highest onion bulb yield of 359.56 Ql/ha and 257.58 Ql/ha was attained from. It was found at par with Diprocon (PDI=53.53% in 2020 and 48.0% in 2021). The apparent infection rate was steady in Essence 38 WG, Diprocon 30 EC and Rova 75% WP sprayed plots. The disease progress curve attained sigmoid shape in most of the tested products. The disease could cause an estimated potential onion bulb yield loss of 31.9% to 39.0% if not managed. Therefore, this huge yield loss could be reduced if the above promising fungicides are augmented with other disease management options, for instance, resistant varieties like Nafis red which the research system is currently pushing to popularize to end users.

1. INTRODUCTION

Vegetable crops are among the major priority commodities of Ethiopia used to alleviate food insecurity and malnutrition. Vegetables accounted for approximately 1.64% of the area under all crops and contributed 2.08% of production of the total crops at the national level (CSA 2020). Tomato, pepper, Ethiopian cabbage and onion are among the predominant and most popular vegetables in the country. Onion (*Allium cepa* L.), among other vegetables, is the most important crop produced both on a small and large scale in Ethiopia. The area under onion production is increasing from time to time mainly due to its high profitability per unit area, ease of production and increased small-scale irrigation (Nigussie et al 2015). It is produced mainly for commercial purpose where over 97% of the harvested onion is meant for sales (Emana et al 2017). Despite, its increment in production area (22,036 ha in 2010 to 36373 ha in 2019), onion productivity has been decreasing during these times, 107516 Kg ha⁻¹ to 75292 Kg ha⁻¹ (FAOSTAT 2021). This is attributed to many biotic and physical factors. Phytopathogens, insect pests, and limited availability of quality seeds and associated production technologies are the major production bottlenecks.

Stemphylium leaf blight caused by *Stemphylium vesicarium* (Wallr.) E.G. Simmons (teleomorph: *Pleospora allii* (Rabenh.) Ces. and De Not), a new disease in Ethiopia (Yitayih et al 2019) is the most recent destructive disease in the country, especially of the central rift valley. The pathogen infects the leaves and flower

stalks of onion plants. The disease presents as elongated lesions on the leaves and as a severe leaf dieback (Hay et al 2019; Stricker et al 2020; Dumin et al 2021). The disease spreads quickly in fields through rain splash and can result in reduced bulb and limited yield if untreated, thus affecting onion bulb yield and seed production (Hay et al 2021). Sustainable control of the disease requires the integration of many, if not all disease management options including, fungicide application. So far, there is no registered fungicide to be used as a complementary in this disease management regime. Furthermore, judicious use of fungicides remains to play an important role in reducing the amount of yield losses. Therefore, this study was conducted with the objective of evaluating and producing local efficacy data of selected fungicides intended for the treatment of onion SLB disease.

2. MATERIAL AND METHODS

On station field trials consisting of 11 fungicidal treatments and one untreated for mock control (Table 1) was laid on randomized complete block design at Melkassa agricultural research center (MARC) of the Ethiopian institute of agricultural research institute (EIAR). The treatments were evaluated on (2.4*3) m² plot area with three replications using the most popular onion variety, Bombay-red, for two consecutive years (2020 and 2021).

Table 1: Treatments and treatment descriptions

Name of fungicides		Rate of Application
Trade name	Common name	
Liveshow 173 SE	Pyraclostrobin 125.7 gL-1 + Epixiconazole 47.3 gL-1	600-750 mLha-1
Circular Extra 280 SC	Azoxistrobin 200 gL-1 + Cyproconazole 80 gL-1	500 mLha-1
Fivestar 325 SC	Azoxystrobin 200 gL-1 + Difenoconazole 125 gL-1	625 mLha-1
Scala 400 SC	Pyrimethanil 400 gL-1	1.0 Lha-1
Rova 75% WP	Chlorothalonil	4.4 Kgha-1
Ridomil Gold MZ 68 WG	Mefenoxam M 4gKg-1 + Mancozeb 640 gKg-1	2.5-3.0 Kgha-1
Carnonchlor 50 SC	Carbendazim 250 gL-1 + Chlorothalonil 250 gL-1	2.5 Lha-1
Diprocon 30 EC	Difenoconazole 15% + Propiconazole 15%	450 mlha-1
Arozol 25 EC	Propiconazole 250 gL-1	650 mLha-1
Twinstar 75 WG	Tebuconazole 50% + Trifloxystrobin 25%	250 gmha-1
Essence 38 WG	Boscalid 25.2 % + Pyraclostrobin 12.8%	300 gmha-1
Control	-	-

Four foliar sprays of fungicides in 10-days interval beginning from 48-days after transplanting during 2020 and five foliar sprays in 8-days interval during 2021 were conveyed. Data on SLB disease severity were recorded starting from a day before the first spray and then ten-and eight-days after each spray in 2020 and 2021, respectively. Therefore, four consecutive disease severity scores were taken in 2020 and five in 2021 based on a visual disease rating scale of 0-5 on the basis of percent infected leaf area (where: 0= no disease; 1= minute pinhead size spots, 1-10% diseased leaf area; 2= 11-20% diseased; 3= 21-40% diseased; 4= breaking of leaves from center, 41-75% diseased leaf area; 5= coalescing lesions with > 75% diseased area (Sharma 1986). The disease severity was monitored on twenty randomly selected and labeled plants per plot. The arbitrary graduation of 10 class scale of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, and 5.0 were used for accurate measurement of the SLB disease severity (Jenkins and Robert, 1961). The severity scores were used to calculate the percent disease index (PDI) and area under disease progress curve (AUDPC) using the following formula given by Wheeler (1969) and Shaner and Finney (1977), respectively. The PDI and AUDPC values herein are therefore the values computed from four- and five-disease severity score in ten- and eight-days interval in 2020 and 2021, respectively.

$$PDI = \frac{\text{sum of all disease rating}}{\text{Total no. m of rating} \times \text{maximum disease grade}} \times 100$$

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

Statistical Analysis

Data was subjected to analysis of variance procedure (ANOVA, $P < 0.05$), and the means were compared by LSD test using SAS software version 9.2.

3. RESULTS AND DISCUSSION

3.1. Effect of Selected Fungicides on SLB Disease Suppression

The results of the trial presented in Table 2 indicate significantly ($P < 0.05$) different disease suppression effects of the fungicides as measured in terms of percent disease index (PDI) and area under disease progress curve (AUDPC). Percent disease index was used to determine the difference in disease control ability of the evaluated fungicides and to select the most effective ones. Small, light-yellow lesions symptoms of disease, usually on the inner side of the leaf were evident at 48-days after transplanting (DAT). The disease pressure was high in 2020 (PDI-97.02%) as compared to the year after (PDI-54.667%). However, the AUDPC values are in contrast to these PDIs, which might be attributed to the number of disease recordings taken, that is, five times, which otherwise the higher disease pressure in 2020 is the reality, as the result of disease progress rate also confirms. Despite the variable severity of the disease over the years, disease control efficacy of the fungicides was consistent. Most fungicides significantly reduced disease severity in 2020 with exception of Propiconazole, Tebuconazole + Trifloxystrobin, Carbendazim + Chlorothalonil, and Mefenoxam M + Mancozeb (Table 2). In 2021, Chlorothalonil (PDI-40%), among other, was statistically reduced the disease severity as compared to the control (PDI-54.667%). In fact, Boscalid + Pyraclostrobin had numerically the lowest disease severity (PDI-44.00%) next to Chlorothalonil. Several fungicides were statistically at par with these two fungicides in reducing SLB disease severity in both years. Mefenoxam M +

Mancozeb was found to be the least effective (PDI-90.45% in 2020 & 52.0% in 2021), which is statistically at par with the control. The highest disease severity was obtained from the control, as expected, with PDI values of 97.02% in 2020 and 54.667% in 2021.

The highest disease suppression effect of the fungicide Boscalid + Pyraclostrobin in this experiment is also true in the previous findings of Holmes and Kemble (2008); Gálvez et al (2016) and Wang et al (2021). It has been reported to be very effective in reducing the mycelial growth of *S. vesicarium* *in vitro* and providing protection against to Stemphylium leaf blight and stalk rot diseases in field condition. This fungicide is a constituent of Boscalid-carboxamides (succinate dehydrogenase inhibitors) and Pyraclostrobin-quinone outside inhibitors (Gálvez et al 2016). The ineffectiveness of the fungicide (Mefenoxam M + Mancozeb) is contrary to the previous findings of Holmes and Kemble (2008), which probably be due to the evolution of (Mefenoxam M + Mancozeb)-insensitive *S. vesicarium* phenotypes as it has been extensively used for the management of downy mildew diseases (*Peronospora destructor*) for more than a decade in the country. However, (Boscalid + Pyraclostrobin), is a new fungicide for the country that is going to be registered hereafter to quickly confront the ever-increasing onion production losses caused by this disease. However, pesticides are not a first choice, and hence unless they are not integrated with other management options, they will drive for more difficult sanctions than the disease itself.

Table 2: Stemphylium leaf blight disease suppression effect of selected fungicides in onion

Treatment	PDI		AUDPC	
	2020	2021	2020	2021
Untreated check	97.02 ^a	54.667 ^a	60.833 ^a	86.667 ^a
Mefenoxam M + Mancozeb	90.45 ^{ab}	52.000 ^a	55.000 ^{ab}	83.333 ^{ab}
Carbendazim + Chlorothalonil	86.22 ^{abc}	48.000 ^{ab}	53.333 ^{ab}	75.333 ^{abcd}
Tebuconazole + Trifloxystrobin	81.28 ^{abcd}	52.000 ^a	49.167 ^{abc}	80.667 ^{abc}
Propiconazole	79.68 ^{abcdef}	49.333 ^{ab}	45.000 ^{ab}	76.667 ^{abcd}
Pyrimethanil	67.88 ^{cdef}	46.667 ^{ab}	42.500 ^{bcd}	72.000 ^{abcd}
Azoxystrobin + Difenoconazole	64.74 ^{cdef}	45.333 ^{ab}	38.333 ^{cde}	70.000 ^{abcd}
Pyraclostrobin + Epixiconazole	58.91 ^{def}	45.667 ^a	36.667 ^{cde}	63.333 ^{bcd}
Chlorothalonil	58.85 ^{def}	40.000 ^b	35.000 ^{de}	61.333 ^d
Azoxistrobin + Cyproconazole	57.18 ^{ef}	48.000 ^{ab}	34.444 ^{de}	76.000 ^{abcd}
Difenoconazole + Propiconazole	53.53 ^f	48.000 ^{ab}	31.667 ^{de}	78.000 ^{abcd}
Boscalid + Pyraclostrobin	51.54 ^f	44.000 ^{ab}	30.000 ^e	65.333 ^{bcd}
LSD (P≤0.05)	3.85	1.49	4.33	1.54
CV (%)	19.54	13.30544	19.57082	14.92546

NB: means followed by the same letter (s) within a column in each parameter are not significantly different at 5% level of significance. LSD (5%) - Least significant difference at the 5% level of significance; CV(%) - Coefficient of variation; PDI- percent disease index and AUDPC - area under disease progress curve.

Disease Progress Curve

Stemphylium leaf blight progressed differently depending up on the type of fungicides used. It was progressed gradually from first date of disease assessment in most of the fungicides evaluated. The overall progression of the disease was high in the control, Carnonchlor 50 SC, Ridomil Gold MZ 68 WG, Twinstar 75 WG, and Arozol 25 EC, regardless of the seasonal variation; while the development was slow in other treatments (Figure 1 and 2). The disease progression in the treatments sprayed with Essence 38 WG, Diprocon 30 EC, and

Rova 75% WP were relatively very slow at all dates of evaluation and attained a sort of straight line in response to all tested years. Stemphylium leaf blight was progressed increasingly and attained closely sigmoid shape in most of the test fungicides and untreated check, except some effective fungicides. Such disease progress curves are characteristic to the disease (Hay et al 2021). The rate of development is rapid at particular time and then became slowly increased to the final epidemic level.

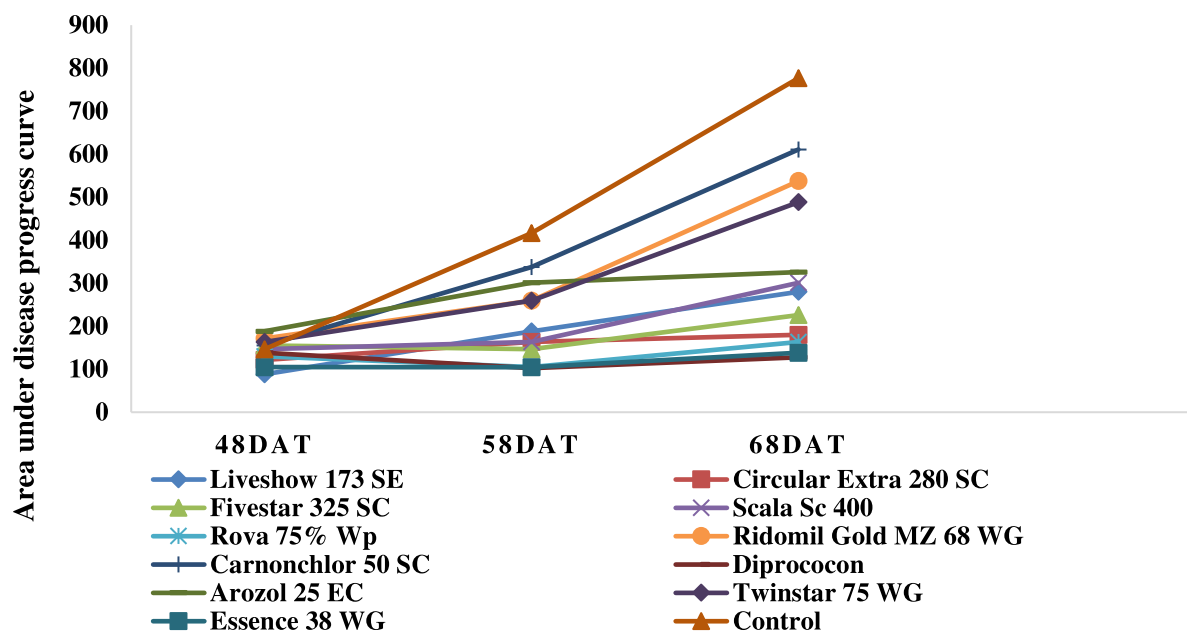


Figure 1. Stemphylium leaf blight (*S. vesicarium*) disease progress curves on onion in response to fungicide management in field condition in 2020.

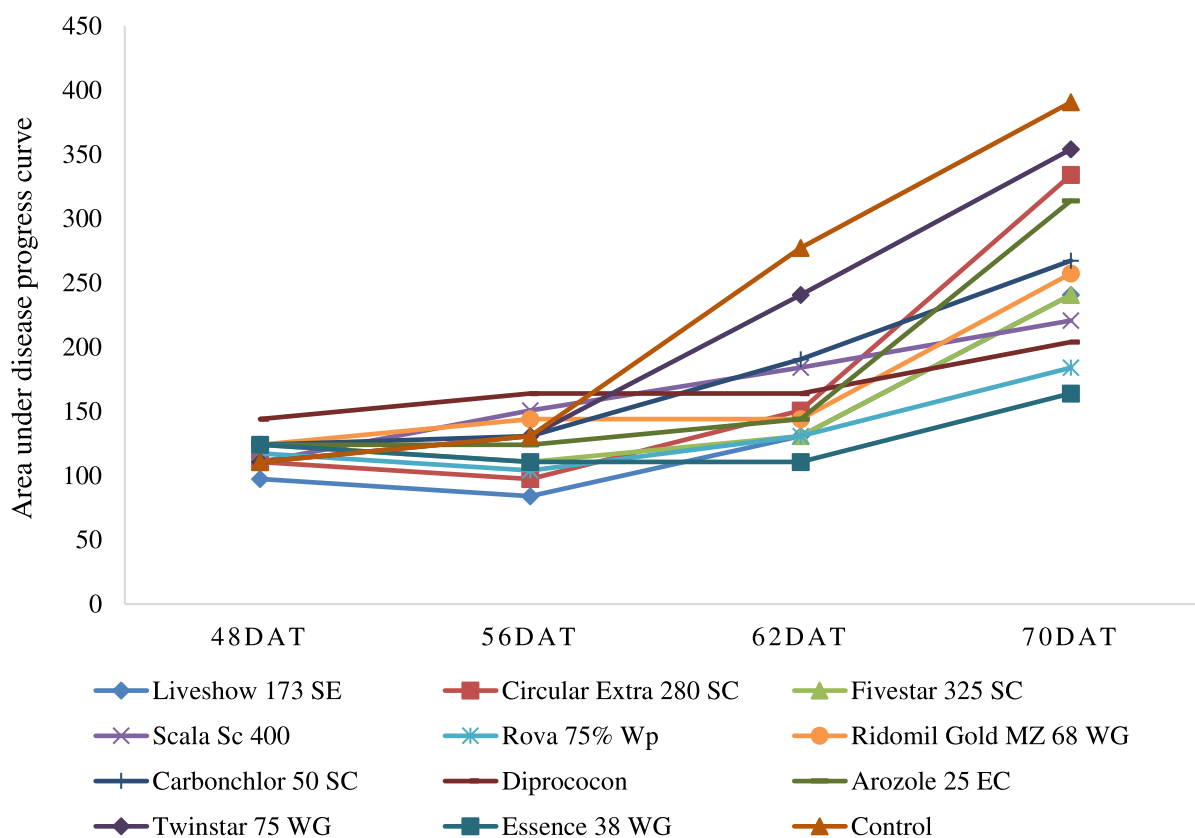


Figure 2. Stemphylium leaf blight (*S. vesicarium*) disease progress curves on onion in response to fungicide management in field condition in 2021

Disease Progress Rate (R)

The disease controlling level of the fungicides tested also revealed different apparent infection rates. The apparent infection rate was inversely proportional to the efficacy of the fungicide. That is to say, the mean rate was high in fungicides with low efficacy as compared to those fungicides which gave better protection. The disease progress rates, and the parameter estimates of the severity of SLB are presented in the Table 2. The computed disease progress rates showed wide variations among treatments. Stemphylium leaf blight progressed at a rate of more than 0.15 units day⁻¹ (upd) in all treatments, except for the fungicides Diprocon 30 EC (0.025 upd), Essence 38 WG and Rova 75% WP (0.128 upd each) in the year 2020. Faster disease progress was recorded on the control (1.802), as expected, followed by Carnonchlor 50 SC (1.29 upd) and Ridomil Gold MZ 68 WG and (1.068 upd) than the rates found on other fungicides in the same year. Surprisingly, SLB progressed at rate of

more than 0.30 upd in all treatments, except the treatment sprayed with Essence 38 WG (0.196 upd), Rova 75% WP (0.232 upd) and Diprocon 30 EC (0.284 upd) fungicides in the year 2021. The disease progress rate of SLB in the treatments sprayed with Diprocon 30 EC, Essence 38 WG and Rova 75% WP was about 98.61, 92.9, and 92.9 % steady than the rates calculated on the control treatments in 2020. Similarly, there was approximately 68.23, 78.08, and 78.08% slower disease development in the treatments which were receiving Diprocon 30 EC, Rova 75% WP, and Essence 38 WG fungicides, respectively, than disease progression in the untreated check for the year 2021. A steady disease progression per day on some of fungicides namely, Essence 38 WG, Diprocon 30, and Rova 75% WP, as compared to faster disease progress rate in the treatments sprayed with Carbonchlor 50 SC, Ridomil Gold MZ 68, Twinstar 75 WG fungicides and the untreated check clearly depicts their efficacy in the management of SLB disease on onion.

Table 3: Disease progress rate (units day⁻¹) was obtained from regression line of disease severity against time (in days) after transplanting

Fungicide	2020				2021			
	Rate	SE of rate	SE of interc ept	R ² (%)	Rate	SE of rate	SE of intercept	R ² (%)
Liveshow 173 SE	0.7	0.102	-19.8	82.52	0.564	0.183	-10.3	91.42
Circular Extra 280 SC	0.163	0.128	12.19	92.13	0.867	0.196	-25.9	90.05
Fivestar 325 SC	0.287	0.263	6.6	91.10	0.485	0.163	-4.1	80.34
Scala Sc 400	0.53	0.215	-6.2	86.37	0.414	0.182	1.0	82.46
Rova 75% Wp	0.128	0.188	13.6	73.40	0.232	0.154	8.74	86.14
Ridomil Gold MZ 68 WG	1.068	0.295	-31.8	65.56	0.714	0.13	-14.68	81.69
Carnonchlor 50 SC	1.29	0.436	-44.2	62.46	0.497	0.196	-3.5	80.33
Diprocon	0.025	0.165	22.4	80.23	0.284	0.109	9.5	87.34
Arozol 25 EC	0.322	0.225	9.5	71.03	0.777	0.177	-19.6	79.56
Twinstar 75 WG	0.878	0.216	-21.6	62.22	0.824	0.178	-21.2	92.34
Essence 38 WG	0.128	0.122	11.9	90.00	0.196	0.105	11.64	91.12
Control	1.802	0.255	-71.3	83.33	0.894	0.195	-24.5	85.61

NB: SE = Standard error of parameter estimates, R²= coefficient of determination of the model

Yield and Yield Loss Associated with Stemphylium Leaf Blight Disease

The yield performance of onion as influenced by the SLB disease is presented in (Table 3) and the year 2020 was relatively better than the year 2021 which might be associated with the relative advantage of the cool dry season (Lemma and Shimelis 2003) in 2020 where the experiment was executed as compared to the main rainy season of 2021. This could probably foretell that planting in the cold dry season will give an outweighed yield compared to the rainy season even with the existing disease problem. The highest

actual onion bulb yield was recorded from the treatment Boscalid + Pyraclostrobin (359.56 Ql/ha and 257.58 Ql/ha) in 2020 and 2021, respectively. The lowest yield of onion bulbs, 262.71 Ql/ha in 2020 and 220 Ql/ha in 2021), was obtained from the control, as expected. In this experiment, an estimated reduction in total onion bulb yield ranging from 37.78-96.85 Ql/ha was observed if the fungicide Boscalid + Pyraclostrobin was not used (Table 3). The amount of potential onion bulb yield loss incurred by the disease ranged from 31.9% to 39.0% if unmanaged.

Table 4: Yield performance and yield loss as influenced by SLB diseases.

Treatment	Yield (Quintal/hactar)		Percent yield loss	
	2020	2021	2020	2021
Tebuconazole + Trifloxystrobin	380.81 ^a	230 .00 ^{ns}	24.398 ^{ab}	28.412 ^{bc}
Boscalid + Pyraclostrobin	359.56 ^{ab}	257.78	24.719 ^{ab}	28.708 ^{bc}
Pyraclostrobin + Epixiconazole	353.85 ^{ab}	260.00	23.786 ^b	28.134 ^{bc}
Azoxistrobin + Cyproconazole	332.1 ^{abc}	252.22	27.373 ^{ab}	26.572 ^{bc}
Azoxystrobin + Difenconazole	325.41 ^{abc}	245.56	28.083 ^{ab}	32.193 ^{bc}
Carbendazim + Chlorothalonil	308.59 ^{abc}	224.44	28.381 ^{ab}	31.152 ^{bc}
Chlorothalonil	317.14 ^{abc}	214.44	28.795 ^{ab}	27.101 ^{bc}
Propiconazole	307.63 ^{abc}	238.89	29.784 ^{ab}	35.658 ^{abc}
Difenconazole + Propiconazole	298.37 ^{bc}	223.33	30.794 ^{ab}	36.111 ^{abc}
Mefenoxam M + Mancozeb	290.44 ^{bc}	243.33	31.047 ^{ab}	48.017 ^a
Pyrimethanil	281.46 ^{bc}	241.11	31.048 ^{ab}	23.81 ^c
Untreated check	262.71 ^c	220.00	31.882 ^a	38.999 ^{ab}
LSD (P≤0.05)	1.5	0.54	1.05	1.75
CV (%)	15.22774	14.41787	16.66958	27.38904

NB: means followed by the same letter (s) within a column in each parameter are not significantly different at 5% level of significance; ^{ns}-not significant; LSD (5%) - Least significant difference at 5% level of significance; CV (%) - Coefficient of variation.

4. CONCLUSION AND RECOMMENDATION

As of today, the impact of SLB dully known, with no empirically quantified amount of loss incurred and became a problem without solution for farmers who

engaged in onion production. There is no any fungicide registered for the management of this disease in Ethiopia. Through a literature inventory of the types

of fungicides that other world is using, fungicides, both registered and non-registered were selected and evaluated. The fungicide Boscalid + Pyraclostrobin, Difenconazole 15% + Propiconazole 15% and Chlorothalonil were relatively effective that if not managed, the disease could cause up to 39.0% onion bulb yield. However, since synthetic chemicals did not deliver only the intended purpose, further research study on the seasonal variability of the diseases and nonchemical disease management options like selection or development of resistant variety are quite important in reducing its impact meaningfully.

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