Integrated Management of Faba Bean Chocolate Spot (*Botrytis Fabae Sard.*) Through Host Resistance, Intercropping and Fungicide Applications in Arsi, Ethiopia

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Abstract- Chocolate spot causes substantial yield losses in various cropping seasons in Ethiopia and in many parts of the world wherever faba bean grows. Thus, integrated management of faba bean chocolate spot (Botrytis fabae Sard.) was studied using the moderately tolerant variety, 'Degaga' (R-878-3) and local cultivar during the 2012/13 main cropping season at Bekoji and Kulumsa Agricultural Research Centers in Arsi, Ethiopia. The experiment was laid out in a randomized complete block design in a factorial combination of two faba bean cultivars, two cropping systems (Degaga- and Local-barley intercropping in 1:1 ratio) and four spray intervals of fungicide (Chlorothalonil) applied at 7, 14 and 21 days after the onset of disease at a rate of 2.5kg a.i ha-1 and unsprayed control with three replications. Chocolate spot infection was more prevalent at Kulumsa with a significant ($P<0.001$) amount of disease observed as compared with Bekoji ($P < 0.05$). Applications of fungicide and cropping systems considerably reduced disease incidence, severity, area under the disease progress curve, disease progress rate, and increased faba bean grain yield and system productivity by a mean relative yield advantage of 31 and 39% at Bekoji and Kulumsa, respectively. Reduction in disease severity was observed in all fungicide sprayed intercropping systems and sole crops compared with the corresponding unsprayed intercrops and sole controls, with a general disease reduction from 35.4 to 23.4% at Bekoji and 68.9 to 40.9% at Kulumsa. However, considering the economics of fungicide application against the faba bean chocolate, maximum net profit was recorded from medium spray intervals (Local FB:BA 14-days) as compared with the other treatments at both locations. Faba bean-barley integrated management practice proved to help in reducing chocolate spot and increasing productivity and income especially under subsistence farming conditions in the country.

Index Terms- Botrytis fabae; Chocolate spot; Epidemics; Fungicide; Intercropping; Vicia fabae

I. Introduction

Faba bean (*Vicia fabae* L.) is one of the major pulse crops grown in the highlands of Ethiopia and covers nearly 370,000 hectares of land with annual production of about 450, 000 metric tons. The crop grows from middle to high altitude areas of Ethiopia, 1800 to 3000 m a s l with annual rainfall of 700-1000 mm [11]. The growing importance of faba bean as an export crop in Ethiopia has led to a renewed interest by farmers to increase the area under production [14]. However, the average yield of this crop under small-holder farmers in Ethiopia ranges from 1.0 to 1.2 t ha^{-1} [1], as compared with its potential (3 t ha^{-1}) under farmers' conditions that employ improved crop management [8].

In spite of its huge importance, the productivity of faba bean has been constrained by several biotic and abiotic factors. Among the biotic factors chocolate spot of faba bean is considered to be the most important and destructive in Ethiopia causing the yield loss of up to 61% on susceptible cultivars [5]. In unprotected crops, the disease can reduce yields by 30-50 per cent under conditions favorable for disease development [13].

Varied cropping systems and production situations can also influence disease occurrence, epidemic development and damage to crops. The mixed cropping of faba bean with barley and maize contributed to the slowing of chocolate spot epidemics and increased yield of faba bean [15].

Early sowing integrated with fungicide application can be recommended for effective management of chocolate spot on faba bean [4, 6]. Fungicides are used because they provide effective and reliable disease control, deliver production benefits in the form of crop yield and quality at an economic price, and can be used safely [12]. Chlorothalonil should provide a base of preventative fungicide control with applications made two or more usually three sprays throughout the season [10]. Short fungicide spray intervals (7-days) reduced the disease epidemics and increased faba bean grain yield and system productivity [15, 17].

Therefore, this experiment was designed to evaluate the effect of host resistance; intercropping and fungicide applications alone and in integration on epidemics of faba bean chocolate spot management and yield of faba bean as well as land equivalent ratio, and cost and benefit of fungicide application.

II. MATERIALS AND METHODS

Experimental site

Field experiment was conducted at Bekoji and Kulumsa Agricultural Research Centers (KARC), Arsi Zone, Oromia Regional State during the 2012/13 main cropping season. Agro-ecological and edaphic data of the study sites are indicated in the table below.

Table 1. Description of the study sites

Description	Bekoji	Kulumsa
Altitude (m.a.s.l)	2800	2200
Latitude and Longitude	7^0 32'N and 39^0 15'E	8^0 02'N and $39^0$10'E
Temperature (^{0}C) (min. and max.)	7.9 and 18.6	9.1 and 23.1
Average Annual Rainfall (mm)	1015	787
Soil Type	Reddish brown to clay	Verticluvisol and Luvsols
Distance from A.A and Asella (km)	231 and 56 South-east	167 South-east and 9 North

$$PSI = \frac{\text{Sum of numerical ratings x 100}}{\text{No. of leaves scored x max. score on scale}}$$

Source: Kulumsa Agricultural Research Center

Experimental design and treatments

The experiment was laid down in a randomized complete block design (RCBD) in a factorial combination of two faba bean cultivars (Degaga, and local), two cropping systems (intercropping and sole faba bean) and four levels of fungicide sprays with three replications. Improved faba bean cultivar, Degaga (R-878-3) which is moderately tolerant to chocolate spot and improved six-row food barley (EH-1307) that was used as a component of the experiment for intercropping were planted. The treatments were intercropping of faba bean with barley in 1:1 ratio i.e. between each row of faba bean 1 row of barley at the recommended seed rate of 200kg ha^{-1} for faba bean in both sole and intercrop culture. One faba bean seed per hole was planted at 0.4m distance between rows and 0.1m within a row. Barley seed was sown in rows at a distance of 0.2m between the rows. Each treatment assigned randomly to each plot. Each plot has an area of 6.4m^2 (4.0m length and 1.6m width) and contained a total of 4 rows of faba bean with two harvestable central rows. Standard agronomic practices were followed and 100kg ha^{-1} of fertilizer (DAP) was applied for all treatments.

Table 2. Description of the cultivars

Disease assessment

Cultivar	Year released	Plant height (cm)	Days to maturity	Yield (t ha^{-1})
Degaga (R-878-3)	2002	122	125	3.2
Local	DNA	109	130	1.0
Barley (EH-1307)	2006	106	137	4.0

DNA = Data not available
Degaga = moderately tolerant faba bean (FB)
Local = susceptible local faba bean (FB)
Barley = Improved food barley (BA)

Disease severity assessment was estimated at weekly intervals. A pictorial key or standard area diagram (1%, 5%, 10%, 20% and 30%) have been used to define the amount of disease as percent leaf area with necrosis. Each leaf of 10 tagged plants in each plot was assessed and the mean of all infected leaves was considered as the value for a plot using a 1-9 scale, where 1 indicates no visible symptom and 9 represents extensive lesion and severe defoliation of the foliar tissue [7]. Disease severity scores were converted into percentage severity index (PSI) for analysis [20]:

Area under the disease progress curve (AUDPC) values was calculated for each treatment by mid point rule between assessed dates [2] using the following formula.

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

Where, n = the total number of observation, t_i = the time of the ith assessment in days from the first assessment date and x_i = disease severity index at ith assessment. Disease severity was expressed in percentage and AUDPC in %-days. Apparent infection rate was obtained from disease progress curve after disease severity data fit to Logistic Model Ln [y/(1-y)] [18].

Grain yield assessment

Faba bean grain yield was harvested from two middle rows of each plot, leaving two outer rows on both sides to avoid the border effect. The yield data of each plot was converted to tones per hectare. The yields of faba bean and barley were used to calculate Land Equivalent Ratio (LER), Partial LER (individual crop's LER) and total LER (sum of individual crop LER) as indices to evaluate the productivity of cropping system using the following formula [19]:

Partial LER = Y_{ii} /$Y_{jj,}$ Total LER = Y_{ij}/Y_{ii} + $Y_{ji}/Y_{jj,}$ Where Y_{ii} and Y_{jj} denote yields of crops i and j in sole culture, and Y_{ij} and Y_{ji} the corresponding yields of intercropping.

Cost and benefit analysis

Prices of grain per 100 kg and total sale from one hectare, price of Chlorothalonil to spray one hectare for each treatment, and cost of labor for spray were considered. Prices of grain were obtained from local markets and total average sale from one hectare was computed. Price of Chlorothalonil was birr 287.50 kg^{-1}. The total price incurred to spray one hectare land in every 7, 14 and 21 days intervals was also calculated. Cost of labor rent for fungicide spray was 28 birr per man-days. Based on the recorded data, cost and benefit analysis was performed using partial budget analysis [9].

Data analysis

Analysis of variance was performed for disease parameters (percentage severity, AUDPC and disease progress rate), seed yield and 100-seed weight to know the effect of main treatments and their interactions. The progress of disease severity for different treatments was analyzed after it was transformed using logistic model ln [y/(1-y)] [2] to determine the disease progress rate from the linear regression. The initial and final percentage severity values presented in the tables were based on the transformed data. Linear regression and ANOVA were analyzed using the SAS GLM procedure [16]. Means were separated using least significant differences (LSD).

III. RESULTS

Disease assessment

Chocolate spot severity

Variation among the mean initial and final disease severities indicated in Table 3. Faba bean chocolate spot severity on moderately tolerant, Degaga and local susceptible cultivars at different DAP (Days after planting) had shown in Table 4.

Analysis of variance for mean final disease severity resulted in a significant difference (P < 0.05) at Bekoji and (P < 0.01 and 0.001) initial and final disease severities at Kulumsa among the treatments. Maximum mean final disease severities (35.4) at Bekoji and (68.9) at Kulumsa were observed on Local:BA unsprayed treatments.

AUDPC and disease progress rate

Significant variations (P < 0.001) were observed among the cultivars, cropping systems and fungicide applications in AUDPC during the crop season at the two locations (Table 3). The highest AUDPC (28.2%) at Bekoji and (45.8%) at Kulumsa were recorded on local FB:BA unsprayed treatments. The rate of disease progress was also significantly varied among the treatments at the two locations in most of the days after planting. The highest disease progress rates (0.059 and 0.058 units per day) had shown from cultivar Local:BA unsprayed and Local:BA:21-days spray interval, respectively, at Bekoji. Similarly, the highest rate (0.105 units per day) was recorded at Kulumsa. The lowest disease progress average rates (0.032 and 0.034 units per day) and (0.060 and 0.064 units per day) were observed on sole Local:7- and 14-days spray interval, and non-intercropped Degaga:7- and 14-days spray interval at Bekoji and Kulumsa, respectively.

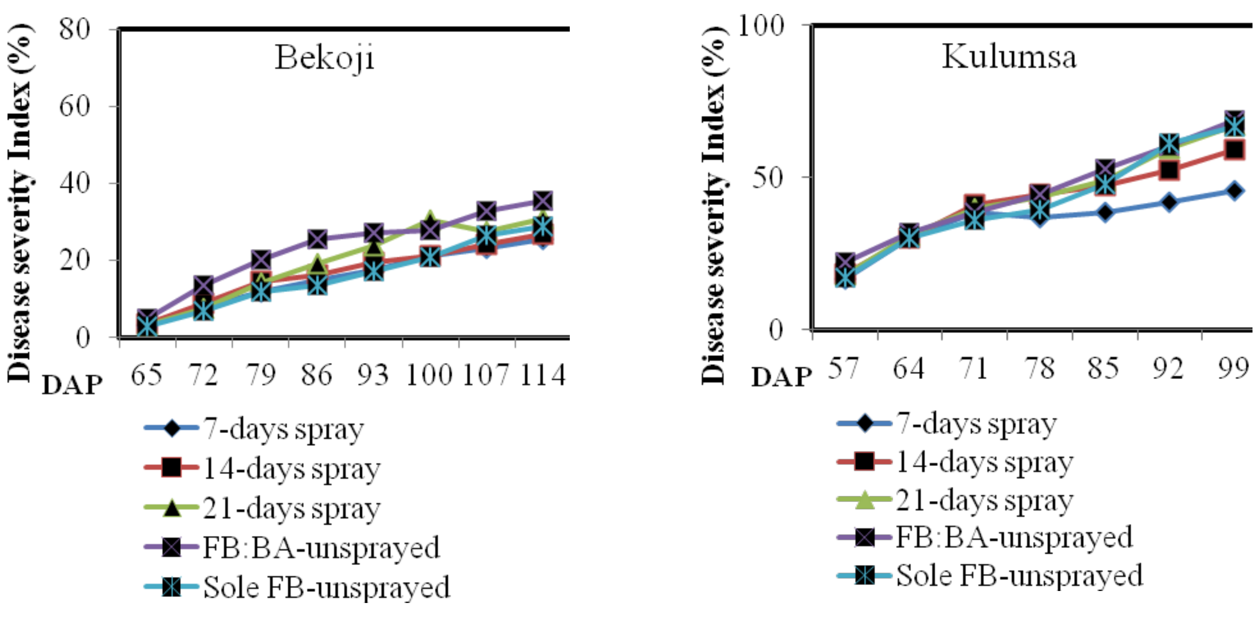
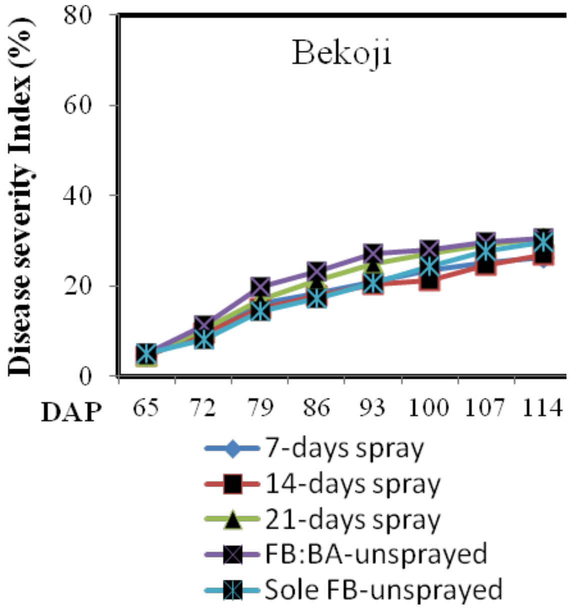
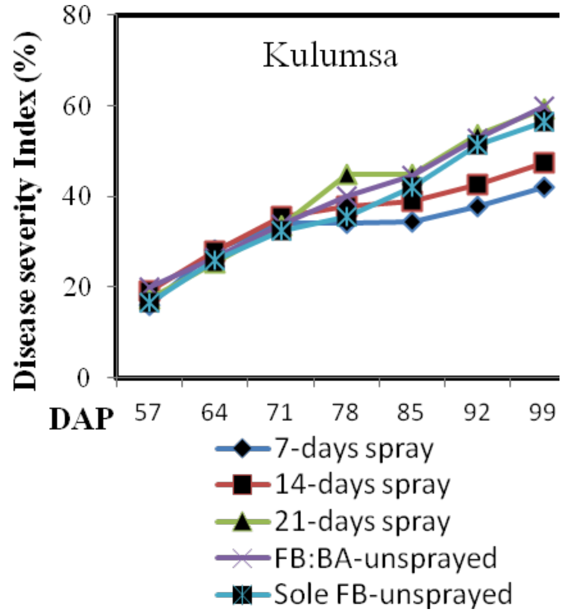


Figure 1. Faba bean chocolate spot (*Botrytis fabae*) progress curves on susceptible local cultivar as affected by cropping systems and different levels of chlorothalonil application at Bekoji and Kulumsa during the 2012/13 cropping season





DAP: Days after planting

Figure 2. Faba bean chocolate spot (*Botrytis fabae*) progress curves on moderately tolerant cultivar as affected by cropping systems and different levels of chlorothalonil application at Bekoji and Kulumsa during the 2012/13 cropping season

Table 3. Effect of cropping systems and different levels of chlorothalonil application on faba bean chocolate spot (*Botrytis fabae*)
severity, AUDPC and disease progress rate

Cultivar	Cropping System	Spray Frequency	BEKOJI				KULUMSA			
			(PSI)[i]	(PSI)[f]	AUDPC (%-days)	Average (r)	(PSI)[i]	(PSI)[f]	AUDPC (%-days)	Average (r)
Local	Sole Faba bean	7-day	2.9	23.4	16.8	0.034	14.7	49.0	37.0	0.074
	,, ,, ,,	14-day	2.8	24.1	15.1	0.032	18.7	59.9	42.6	0.091
	,, ,, ,,	21-day	2.5	29.1	17.5	0.035	16.9	65.7	42.9	0.095
	Faba bean Barley	7-day	3.5	27.4	19.3	0.041	19.3	42.6	35.4	0.068
	,, ,, ,,	14-day	4.1	29.4	23.9	0.050	17.8	58.1	42.2	0.089
	,, ,, ,,	21-day	4.0	32.6	28.2	0.058	19.1	68.4	45.8	0.105
	,, ,, ,,	Unsprayed	4.8	35.4	27.2	0.059	22.1	68.9	45.5	0.105
	Sole Faba bean	Control	3.0	28.8	18.4	0.038	17.4	66.6	42.8	0.099
Degaga	,, ,, ,,	7-day	4.0	25.1	19.6	0.042	13.5	43.2	31.6	0.060
	,, ,, ,,	14-day	3.3	25.2	16.6	0.035	18.1	42.9	33.3	0.064
	,, ,, ,,	21-day	4.8	29.6	22.4	0.048	14.4	57.2	37.2	0.078
	Faba bean Barley	7-day	5.1	27.5	22.7	0.049	18.8	40.9	34.3	0.065
	,, ,, ,,	14-day	5.7	28.4	23.8	0.052	19.8	51.6	38.6	0.078
	,, ,, ,,	21-day	4.3	31.6	25.7	0.054	22.1	61.3	43.1	0.099
	,, ,, ,,	Unsprayed	5.1	30.5	25.6	0.055	19.9	59.9	39.7	0.085
	Sole Faba bean	Control	4.9	29.7	21.1	0.046	16.7	56.4	37.3	0.078
Mean			4.0	28.6	21.5	0.03	17.9	55.8	39.3	0.08
LSD (0.05)			NS	2.2*	3.7***	4.05**	2.8**	4.9***	7.6***	6.0***
C.V			41.8	14.9	16.6	17.2	13.8	12.7	6.6	11.9

[i] Initial percent severity index at 65 and 57 DAP at Bekoji and Kulumsa, respectively
[f] Final ,, ,, ,, ,, 114 and 99 DAP at ,, ,, ,, ,,
AUDPC: Area under disease progress curve
(r): Disease progress rate
NS: Non-significant

Grain yield

Faba bean grain yield was significantly affected ($P < 0.001$) by the cropping systems and spray intervals at Bekoji and Kulumsa (Table 4). The highest yield (4.1 t ha^{-1}) was obtained from Degaga:7-days spray interval at Bekoji and (3.1 t ha^{-1}) both from Degaga:7- and 14-days spray interval at Kulumsa. The lowest yields (1.2 and 0.3 t ha^{-1}) at Bekoji and Kulumsa were obtained from Local:BA unsprayed similar treatments, respectively.

Table 4. Effect of chocolate spot on faba bean grain yield and 100SW under intercropping and chlorothalonil applications at Bekoji and Kulumsa

TREATMENT	BEKOJI		KULUMSA	
	Grain yield (t/ha)	100 SW (g)	Grain yield (t/ha)	100 SW (g)
Local:7d	3.0[b]	61.8[a]	1.7[cd]	60.4
Local:14d	3.1[b]	59.4[ab]	1.5[de]	61.8
Local:21d	2.6[bcd]	60.1[ab]	0.7[gh]	60.0
Local:BA:7d	1.4[ef]	55.1[bc]	0.9[fgh]	60.4
Local:BA:14d	1.3[ef]	54.5[bc]	0.6[gh]	61.0
Local:BA:21d	1.3[f]	54.5[bc]	0.4[h]	59.4
Local:BA	1.2[f]	58.7[ab]	0.3[h]	58.7
Local (Sole)	3.2[b]	58.7[ab]	0.9[fgh]	61.2
Degaga:7d	4.1[a]	54.9[bc]	3.1[a]	59.1
Degaga:14d	3.4[ab]	55.0[bc]	3.1[a]	58.6
Degaga:21d	3.3[b]	55.4[bc]	2.3[b]	60.8
Degaga:BA:7d	1.9[def]	50.4[c]	1.8[cd]	56.7
Degaga:BA:14d	2.2[cde]	50.4[c]	1.6[cde]	56.1
Degaga:BA:21d	1.8[def]	50.8[c]	1.1[efg]	56.4
Degaga:BA	1.9[def]	49.7[c]	1.3[def]	55.7
Degaga (Sole)	2.9[bc]	57.3[ab]	2.0[bc]	59.5
Mean	2.4	55.4	1.5	59.1
LSD (0.05)	11.7 ***	4.0 ***	20.5 ***	NS
C.V	18.8	5.5	20.9	28.3

100SW: Hundred seed weight

100 seed weight was also significantly affected (P < 0.001) at Bekoji whereas it wasn't at Kulumsa (Table 4).

Partial and total LERs for faba bean and barley were significantly varied (P < 0.001) at both locations except the total LER at Bekoji (Table 5). The highest total LER of 1.36 was recorded from Degaga:BA:14-days spry interval followed by 1.27 from both Degaga:BA and Local:BA:7-days spray interval at Bekoji and the highest LERs of 1.65 and 1.41 were obtained from Local:BA:7- and 14-days spray interval, respectively, at Kulumsa.

Table 5. Effect of cropping systems (FB cultivars and barley) on partial and total land equivalent ratios (LERs)

Treatments	Bekoji			Kulumsa		
	Partial LER			Partial LER		
	FB	BA	Total	FB	BA	Total
Local:BA:7d	0.44	0.83	1.27	1.04	0.61	1.65
Local:BA:14d	0.43	0.72	1.15	0.73	0.68	1.41
Local:BA:21d	0.40	0.93	1.32	0.49	0.63	1.12
Local:BA	0.40	0.58	0.98	0.45	0.66	1.06
Local (Sole)	1.00	0.00	1.00	1.00	0.00	1.00
Barley (Sole)	0.00	1.00	1.00	0.00	1.00	1.00
Degaga:BA:7d	0.67	0.61	1.27	0.88	0.48	1.36
Degaga:BA:14d	0.76	0.60	1.36	0.80	0.49	1.29
Degaga:BA:21d	0.63	0.46	1.09	0.53	0.44	0.97
Degaga:BA	0.66	0.41	1.06	0.69	0.53	1.22

Degaga (Sole)	1.00	0.00	1.00	1.00	0.00	1.00
Barley (Sole)	0.00	1.00	1.00	0.00	1.00	1.00
Mean	0.5	0.6	1.1	0.6	0.5	0.1
LSD (0.05)	31.7 ***	5.5 ***	NS	23.4 ***	15.0 ***	13.6 ***
C.V	19.6	18.3	26.5	20.2	16.3	8.3

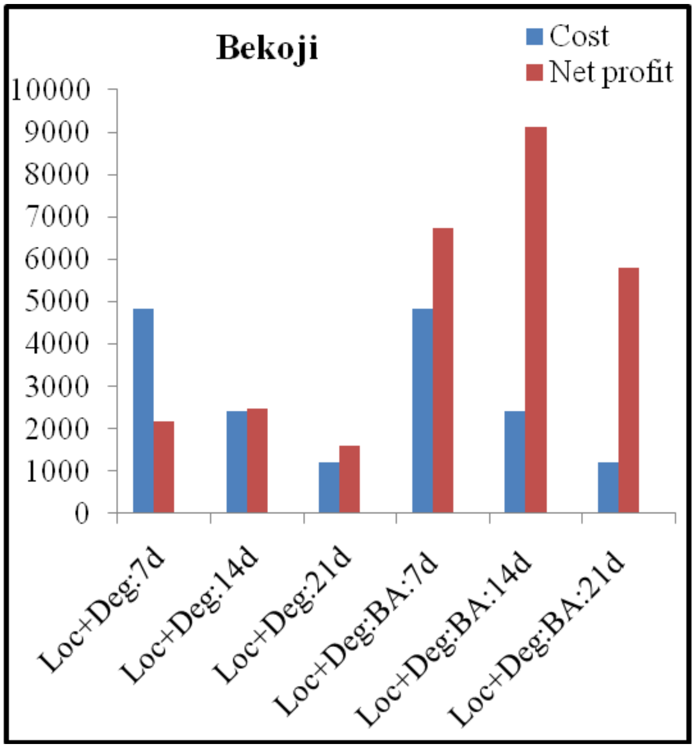
Location	Treatment	No. of Sprays	Yield (t/ha)		Total Yield (t/ha)	Difference (t/ha)	Benefit over control (ETB ha^{-1})	Cost (ETB ha^{-1})	CBR	Net Profit
			FB	BA						
Bekoji	Local:7d	7	3.0	0.0	3.0	0.8	5600	4827	1:1.2	773
	Local:14d	3	3.1	0.0	3.1	0.9	6300	2414	1:2.6	3886
	Local:21d	2	2.6	0.0	2.6	0.4	2800	1207	1:2.3	1593
	Local:BA:7d	7	1.4	2.9	4.3	2.1	14700	4827	1:3.0	9873
	Local:BA:14d	3	1.3	2.7	4.0	1.8	12600	2414	1:5.2	10186
	Local:BA:21d	2	1.3	2.3	3.6	1.4	9800	1207	1:8.1	8593

	Local:BA	0	1.2	2.1	3.3	1.1	7700	-	-	-
	Local (Sole)	0	2.2	0.0	2.2	-	-	-	-	-
	Degaga:7d	7	4.1	0.0	4.1	1.2	8400	4827	1:1.7	3573
	Degaga:14d	3	3.4	0.0	3.4	0.5	3500	2414	1:1.5	1086
	Degaga:21d	2	3.3	0.0	3.3	0.4	2800	1207	1:2.3	1593
	Degaga:BA:7d	7	1.9	2.2	4.1	1.2	8400	4827	1:1.7	3573
	Degaga:BA:14d	3	2.2	2.2	4.4	1.5	10500	2414	1:4.4	8086
	Degaga:BA:21d	2	1.8	1.7	3.5	0.6	4200	1207	1:3.5	2993
	Degaga:BA	0	1.9	1.5	3.4	0.5	3500	-	-	-
	Degaga (Sole)	0	2.9	0.0	2.9	-	-	-	-	-
	Mean		2.4	1.2	3.6	-	-	-	-	-
	LSD (0.05)		***	***	NS	-	-	-	-	-
Kulumsa	Local:7d	7	1.7	0.0	1.7	0.8	5600	4827	1:1.2	773
	Local:14d	3	1.5	0.0	1.5	0.6	4200	2414	1:1.7	1786
	Local:21d	2	0.7	0.0	0.7	-0.2	-56	1207	1:0.0	-1263
	Local:BA:7d	7	0.9	2.3	3.2	2.3	16100	4827	1:3.3	11273
	Local:BA:14d	3	0.6	2.5	3.1	2.2	15400	2414	1:6.4	12986
	Local:BA:21d	2	0.4	2.3	2.7	1.8	12600	1207	1:10.4	11393
	Local:BA	0	0.3	2.3	2.6	1.7	11900	-	-	
	Local (Sole)	0	0.9	0.0	0.9	-	-	-	-	
	Degaga:7d	7	3.1	0.0	3.1	1.1	7700	4827	1:1.6	2873
	Degaga:14d	3	3.1	0.0	3.1	1.1	7700	2414	1:3.2	5286
	Degaga:21d	2	2.3	0.0	2.3	0.3	2100	1207	1:1.7	893
	Degaga:BA:7d	7	1.8	1.7	3.5	1.5	10500	4827	1:2.2	5673
	Degaga:BA:14d	3	1.6	1.9	3.5	1.5	10500	2414	1:4.4	8086
	Degaga:BA:21d	2	1.1	1.6	2.7	0.7	4900	1207	1:4.1	3693
	Degaga:BA	0	1.3	1.8	3.1	1.1	7700	-	-	-
	Degaga (Sole)	0	2.0	0.0	2.0	-	-	-	-	-
	Mean		1.5	1.0	2.5	-	-	-	-	-
	LSD (0.05)		***	***	***	-	-	-	-	-

Table 6. Partial budget analysis for integrated management of chocolate spot on faba bean cultivars

Cost and benefit ratio

Significant variation ($P < 0.001$) was obtained from total yield at Kulumsa (Table 6). The CBR (1:8.1 & 1:10.4) was recorded from similar treatments (Local



BA:21-days spray interval) at bekoji and Kulumsa, respectively. However, maximum net profit (10186 ETB) was recorded at bekoji and (12986 ETB) at Kulumsa both from Local:BA:14-days chlorothalonil spray treatments (Table 6 and Fig 3).

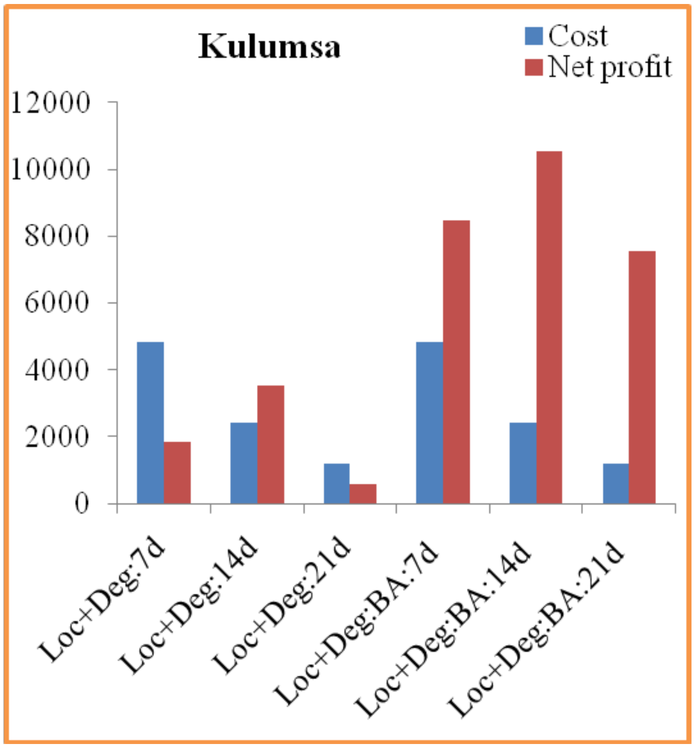


Fig. 3 Mean cost and benefit ratio of fungicide application on chocolate spot at Bekoji and Kulumsa

IV. DISCUSSION

Chocolate spot occurrence was detected at the two locations during the experimental period, but a faster at Kulumsa than Bekoji. Foliar sprayed chlorothalonil and the cropping systems had significantly reduced the disease severity, AUDPC, disease progress rate and thereby increased faba bean grain yield. The magnitudes of disease severity were significantly different among the cultivars, cropping systems and chlorothalonil spray intervals. Short day spray intervals were significantly reduced final disease severity from 35.4% to 23.4% on Local FB:BA unsprayed and sole local FB:7-days spray interval, respectively at Bekoji. Similarly, Degaga:BA integrated with short day spray intervals had reduced the final disease severity from 68.9% on Local FB:BA unsprayed to 40.9% at Kulumsa. This showed that short day chlorothalonil application resulted in a reduced disease severity in both locations as compared to the other treatments. This result is in agreement with previous research document [15, 17] that faba bean-barley intercropping without the application of Chlorothalonil as a part of an integrated disease management resulted in the aggravation of chocolate spot severity as compared to the sole controls.

It was also observed that the AUDPC was reduced from the highest value 28.2 %-days to the lowest 15.1 %-days at Bekoji and from 45.8 %-days to 31.6 %-days at Kulumsa using the integrated chocolate spot management. The above maximum AUDPC values were recorded from Local FB:BA-21days spray interval and Local FB:BA unsprayed similar treatments at both locations. However, the lowest AUDPC was obtained from sole Local:14-days spray at Bekoji and Degaga:BA:7-days spray interval at Kulumsa. Study by Samuel *et al.* [15] also revealed that short day spray interval (7-days) had a lower AUDPC than the other fungicide spray intervals. Shiferaw [17] also reported the same result that the highest AUDPC was recorded from local-barley unsprayed treatments while the lowest from sole Degaga integrated with 7-days spray. Chlorothalonil application was found to be reduced disease progress rates in integration with faba bean cultivars. Spray intervals at 7- and 14-days had significantly affected mean disease progress rates on sole local and moderately tolerant cultivars at the two locations. This is because the lowest mean disease progress values (0.032 and 0.034 units per day) were recorded on local cultivar at Bekoji and (0.060 and 0.064 units per day) on Degaga at Kulumsa. In comparison, the fastest mean chocolate spot progress rates (0.059 and 0.058 units per day) at Bekoji and (0.105 units per day) at Kulumsa were recorded from same sole local and Local FB:BA unsprayed plots. Rates of disease progress were relatively slower at Bekoji as compared with Kulumsa. This shows that chocolate spot developed at a faster rate may be due to favorable environmental conditions at Kulumsa than Bekoji.

This study showed that a short day (7-days) fungicide spray intervals had significantly influenced chocolate spot epidemics and faba bean grain yield similar report [15]. Higher grain yield was also obtained from short day fungicide spray intervals followed by medium (14-days) at both locations when integrated with moderately tolerant cultivar, Degaga. The moderately tolerant cultivar gave the highest mean yields of 4.1 and 3.1 t ha^{-1} with short day spray intervals than the Local FB:BA unsprayed plots (1.2 and 0.3 t ha^{-1}) at Bekoji and Kulumsa, respectively.

The highest grain yield (4.7 t ha^{-1}) was recorded at Bekoji from Degaga-barley intercropping combined with short day spray intervals as compared with local-barley unsprayed intercrop [17]. In contrast to faba bean grain yield, the highest 100 seed weight (61.8 g) was obtained from Local FB:7-days spray interval at Bekoji and Local FB:14-days spray interval at Kulumsa. Thus, it is possible to see that higher grain yield and 100 seed weight were obtained from chlorothalonil sprayed plots than unsprayed intercropping of the two cultivars.

In this study, applications of fungicide and cropping systems considerably reduced disease severity and increased faba bean grain yield and system productivity (LER) by a mean relative yield advantage of 31 and 39% at Bekoji and Kulumsa, respectively. It was also reported [17] that faba bean barley intercropping and fungicide spray intervals reduced the disease epidemics and increased faba bean grain yield and yield components, and system productivity by a mean relative yield advantage of 32% at Bekoji. As the reduction in arable land is unavoidable, increasing LER and food production per unit area is crucial for securing food supply [3]. It is crucial that such a simple, effective approach to boosting crop yields and increasing LERs is widely adopted in the global challenge of securing the food supply. Considering the economics of fungicide application against the faba bean chocolate spot, maximum net profit (10186 ETB) was obtained at Bekoji and (12986 ETB) at Kulumsa both from Local:BA:14-days fungicide spray treatments.

V. CONCLUSION

Chocolate spot causes substantial yield losses in various cropping seasons in Ethiopia and in many parts of the world wherever faba bean grows. Thus, host resistance, cropping systems and fungicide applications were considered to enhance chocolate spot control and reduce yield losses. Reduction in disease was observed in all fungicide sprayed intercropping systems and sole crops compared with the corresponding unsprayed intercrops and sole controls in this study. Intercropping also resulted in a mean relative yield advantage of 31% and 39% at Bekoji and Kulumsa, respectively. As the reduction in arable land is unavoidable in this days agriculture, increasing land equivalent ratio and food production per unit area is crucial for securing food supply. Intercropping practices offer many advantages when associated with planned spatial diversity and so that it is needed to enhance the benefits achieved. The integrated system in general increased faba bean productivity and income benefit which can be recommended especially under subsistence farming system in Ethiopia.

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