ORIGINAL ARTICLE

Management of faba bean chocolate spot (*Botrytis fabae* Sard.) using compost tea under *in vitro* and *in vivo* conditions

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ABSTRACT

The aim of this study was to determine alternative management options against faba bean chocolate spot by applying different concentrations of compost tea. The experiment was conducted at Holeta Agricultural Research Center, during the main cropping season of 2019/20. The compost tea was prepared by mixing mature compost with distilled water. Experiment on antifungal activity was conducted under laboratory conditions. Treatments and experimental design under in vivo conditions were laid out in a randomized complete block design with three replications having 48 total plots. The experiment was repeated twice. The results showed that the highest inhibition rate was recorded at 50% and 35% compost tea concentrations with 5.1 cm and 4.3 cm, respectively. There was a significant difference ($P < 0.05$) between compost tea concentrations that applied as a foliar spray and soil drench against chocolate spot disease. The compost tea concentrations applied by combining both foliar spray and soil drench 50% showed less incidence and severity (13.3% and 18.3%, respectively). The maximum severity of 96.3% was recorded on the control (0%) 98 days after planting. Compost tea with high concentrations of 50% provided the highest number of yield per hectare (0.09367 tons/ha) as compared with untreated plots (0%) that showed 0.03453 tons/ha. The combination of compost tea concentrations 50% as a foliar spray and 50% as a soil drench showed promising results both under laboratory and field conditions. Further study is needed on time of application for increasing the efficiency of compost tea.

Keywords*: Botrytis fabae*, compost tea, disease severity, faba bean, soil

INTRODUCTION

Ethiopia is the largest producer of faba bean in Africa, and second after China in the world (FAO, 2019). It is Ethiopia's primary legume crop which is cultivated in the highlands often in rotation with wheat, barley or teff. It is the most important pulse crop in terms of area coverage and volume of annual production with average productivity of 1.9 tons per hectare in Ethiopia (CSA, 2016). Faba bean is adversely affected by numerous fungal diseases, such as chocolate spot (*Botrytis fabae*), rust (*Uromyces viciae fabae)*, black root rot (*Fusarium* spp.) and downy mildew (*Pernospora viciae)*. Chocolate spot is the most important disease affecting faba bean in Ethiopia, causing considerable reduction in seed yield (Dagne *et al.,* 2017). It is a highly prevalent and destructive disease, causing yield loss up to 61% on a susceptible and 34% on tolerant faba bean genotypes in the central highland of Ethiopia (Mesele, 2018).

Different management options have been tried to reduce the yield losses in faba bean due to chocolate spot worldwide. These include the use of chemical fungicides, resistant varieties, the use of certain cultural practices such as crop residue management and altering planting date, the use of bio-agents and using a botanical plant product. The use of pesticides for controlling various plant diseases is still common practice especially in developing countries. Although with the application of fungicides, plant diseases can be controlled, but the hazardous impacts of such products on human health and the environment are well known (Zaker, 2016).

Compost tea is an organic extract produced from composted organic matter and containing a diversity of naturally occurring microbes and soluble micronutrients and their ability to reduce plant diseases when used as soil drenches or foliar sprays (Haba, 2018). In addition, compost tea has beneficial effects on plant growth by providing plant nutrients directly, enhance the life in the soil and on plant surfaces, used as an organic foliar fertilizing material, inoculates the leaf surface and soil with beneficial microorganisms and to add soluble nutrients to the foliage or to the soil for organisms and the plants present. Previous studies were investigating the potential of compost tea to reduce chocolate leaf spot disease in faba bean, its possibility to induce resistance, and at the same time estimate the effect on yield parameters of faba bean plants (Haba, 2018). But, the effect on soil-borne diseases varies greatly depending on the properties of the compost as affected by compost formulation, the composting and brewing process, and the environmental conditions in which the material is used (Litterick *et al.,* 2009).

However, the use of compost tea has not been explored as management options for faba bean chocolate spot disease and has not been studied so far under *in vitro* and *in vivo* conditions for the management of faba bean chocolate spot using different concentrations of compost tea in the central highlands of Ethiopia. Therefore, this research work was carried out to assess antifungal activity of compost tea against *B. fabae* under *in vitro* conditions and evaluate different tea compost rates against faba bean chocolate spot under field conditions.

MATERIALS AND METHODS

Description of the study area and experimental materials

The experiment was conducted at Holeta Agricultural Research Center field site and in lab during 2019/20 cropping season. Holeta Agricultural Research Center found in Walmera Wareda in Holeta town. It is located 29 km West of Addis Ababa at 9º 00′ N latitude and 38 º 30′ E longitudes. It has a total geographical area of 396 ha, with elevation of 2400 m.a.s.l. Annual rainfall 1144 mm and temperature (min/max) 6 ºC and 22 ºC. The soil type of the study site is Nitosols and Vertisols with a pH value of 6.8 (EARO, 2004). One susceptible variety, CS-20-DK released by Holeta Agricultural Research Center in 1977 was used. Non-aerated compost taken from Holeta Agricultural Research Center was prepared and used as organic fertilizer.

Compost tea preparation and application

Compost tea was prepared by mixing mature compost (non-aerated compost) with distilled water at a ratio of 1:2(w/v) (Al-Dahmani *et al.,* 2003) and supplemented with 2% molasses for microbial growth stimulation for 7-14 days. Application of compost tea 50 L/ha for foliar application and 150 L/ha for a soil drench were followed. It was applied starting from disease onset and repeated as required using atomizers up to sufficiently flooding of each plant part (Al-Mughrabi *et al.,* 2008).

Chemical analysis of compost

Non-aerated compost that taken from Holeta Agricultural research center that prepared for-organic fertilizer was analyzed at Holeta Agricultural Research Center /Soil and Plant Analysis Laboratory (Table 2). The chemical properties include, total nitrogen, total phosphorus, total potassium, total calcium, total sodium, PH, CEC, total organic matter and Ex. Acidity (meq/100g) that available in compost. PH was measured using pH meter (Model ORION 230A – Range -2 – 19.99 ± 0.01, USA). Total organic matter was measured by combustion at 550C for 8 h according to TMECC (2001) and total nitrogen (TN) by Kjeldahl digestion Bremmer JM, Mulvaney CS (1982). Potassium (K) was determined by atomic absorption and phosphorus (P) was determined calorimetrically following the Murphy and Riley (1962) method, and total calcium, total sodium, CEC, total organic matter and Ex. Acidity (meq/100g) was measured according to Motsara (2008).

Antifungal activity under *in vitro* conditions

Experiment on antifungal activity of compost tea on radial growth of *B. fabae* on FDA medium was conducted under laboratory conditions using 20%, 35%, 50% and 0% as treatments, respectively. It was replicated three times and reaped twice. The experiments were arranged in the CRD. After diluting compost tea to different concentration (20%, 35% and 50 %), they were poured into plates on warm FDA medium. And then, 5-7 days old virulent *B. fabae* isolate, which was identified based on cultural and morphological characteristics, cut with 6 mm^2 cork borers, and inoculated into the center of Petri plates. Plates inoculated with free of compost tea were served as control. The plates were incubated at 22 °C. Antifungal activity in percent was determined against untreated control (Ibrahim, 2008). The antagonistic effect of compost tea was taken growth as diameter starting from 3 days after inoculation until the colony covers the entire plates.

Study under field conditions

The experiment was laid out in a randomized complete block design with three replications having 48 totals of plots. Uniform and healthy faba bean seeds were planted with 40 cm between rows and 10 cm between plants in the row. The size of each plot was 2 m by 2 m (4 m^2) with 0.75m space between plots and 1 m between blocks. One plot had 5 rows and each row accommodated 20 plants. Disease assessments were carried out on 15 pre-tagged plants from the three central rows. Four concentrations of compost tea as a soil drench (SD20%, SD35%, SD50% and SD0%) and four concentrations of compost tea as a foliar spray (FS20%, FS35%, FS50% and FS0%) forming a total of 16 combinations were used.

Chocolate spot disease and yield loss assessment

Disease assessment was taken from 15 pre-tagged plants from the three central rows of each plot starting from the onset of the disease and continued every seven days till the crop reached maturity stage. Both diseased and healthy plants were counted from the pre-tagged plants and the percentage of disease incidence (PDI) was calculated according to the formula developed by Wheeler (1969).

Disease severity was recorded started from disease onset at 7 days' intervals. It was recorded using 1–9 scale: where 1 = No disease symptoms or very small specks; 3 = Few small discrete lesions; 5 = Some coalesced lesions with some defoliation; 7 = Large-coalesced sporulation lesions, 50% defoliation and some dead plant; and 9 = Extensive lesions on leaves, stems and pods, severe defoliation, heavy sporulation, stem girdling, blackening and death of more than 80% of the plants.

The severity grades were converted into Percentage Severity Index (PSI) according to the following formula (Van der, 1963):

$$PSI(\%) = \frac{\sum \text{Individual numerical ratings}}{(\text{Total number of plants assessed x Maximum score in the scale})} \text{ x } 100$$

The area under the diseases progress curve (AUDPC) from PSI was computed using the following formula (Campbell and Madden, 1989).

$$AUDPC = \sum_{i=1}^{n-1} (0.5(xi+1 + xi)(ti+1 - ti))$$

Where "t" is the time of each reading, "x" is the percentage of disease severity at each reading and "n" is the number of readings

Data related to Growth, yield components and yield

The height of the plants from the ground to the tips of five random plants was measured at maturity; number of pods per plant were counted on five randomly taken plants from three central rows; number of seeds per pod taken from 13 pre-tagged plants from three central rows; the grain yield per plot was recorded from the three central rows; the grain yield per plot was calculated per hectare basis; the weight of 100 randomly taken seeds from the yield of each plot was recorded; Biomass yields of faba bean in plots were measured.

The relative loss in yield of each treatment was determined as percentage of that of protected plots of the experiment. Losses were calculated separately for each treatment and yield component of faba bean was determined as a percentage of the protected plots and the yield loss was calculated based on the formula of Robert and Janes (1991):

$$\mathbf{RYL\ (\%) = \frac{(Yp - Yt)}{Yp}\ x\ 100}$$

Where, RYL = relative yield loss in percent, Yp = yield from the maximum protected plots and Yt = yield from other plots. Percent yield recovery was calculated to compare the yield differences among foliar spray and soil drench application of compost tea concentration using the formula

Data analysis

The analysis of variance (ANOVA) was performed for the disease parameters (incidence, severity and AUDPC) and yields parameters (yield per hectare and yield loss) as well as correlation between disease and yield parameters were computed using Statistical Analysis System (SAS) version 9.4 software (SAS Institute, 2019). Least significance difference (LSD) values were used to separate treatment means among the treatments.

RESULTS AND DISCUSSION

Chemical analysis

The chemical analysis of compost showed that the % of N,P ,K, Mg, Ca and Na Were 0.51, 25.593 ,15.8759, 7.8055, 48.4601 and 0.2265 respectively, and the % of pH value, CEC, OC and Ex. Acidity were 7.66, 34.10, 1.142 and 0.434 respectively (Table 1).These results were in agreement with Rodriguez-Ortiz *et al.* (2006) who reported that, altered solubility of mineral nutrients occurred and manifested as an increased content of easily available forms of microelements, heavy metals and trace elements in soil. As a result, water-based compost tea enhanced the uptake and accumulation of nutrient elements in the plant.

Table 1. Chemical analysis of compost tea

Result/parameter tested									
N (%)	P ppm	K meq/100g	Mg meq/100g	Ca meq/100g	Na meq/100g	pH	CEC (meq/100g)	OC (%)	Ex.Acidity (meq/100g)
0.5	25.5	15.8	7.8	48.4	0.2	7.6	34.1	1.1	0.4

From this experiment, compost tea could be used as options for conventional and organic grower's consideration to enhance crop fertility by adding soluble nutrients. Moreover, these nutrients might be induced the host crop resistance against this fungus. Similar to this, Jeanine *et al.* (2002) also reported that physical or chemical aspects of composts that reduce disease severity directly or indirectly affecting the pathogen or host growth and examples of these include nutrient levels, organic matter, moisture, pH, and other factors (Whipps, 1997).

Evaluation of antifungal activity of compost tea under *in vitro* conditions

The antagonistic potential of tea compost concentration against chocolate spot of faba bean under in-vitro condition was presented in Figure 1. From this result, the highest inhibition rate was recorded on 50% and 35% tea compost concentration (5.1 cm and 4.3 cm, respectively) whilethe lowest was recorded on 20% of tea compost concentration (3.8 cm). These results are in agreement with study performed by Haba (2018), the antifungal activity of compost tea was increased with brewing time against chocolate spot of faba bean. This might be tea compost limited growth and development of and or had killed the *B. fabae*. As Abdrahmn *et al.* (2016) reported, both aerated tea compost and molasses aerated tea compost apparently inhibited *in vitro* growth of *Grammothele lineata*as compared to control. From this experiment, the antagonistic potential of tea compost against chocolate spot of faba bean was increase as the concentration rate of tea compost increased.

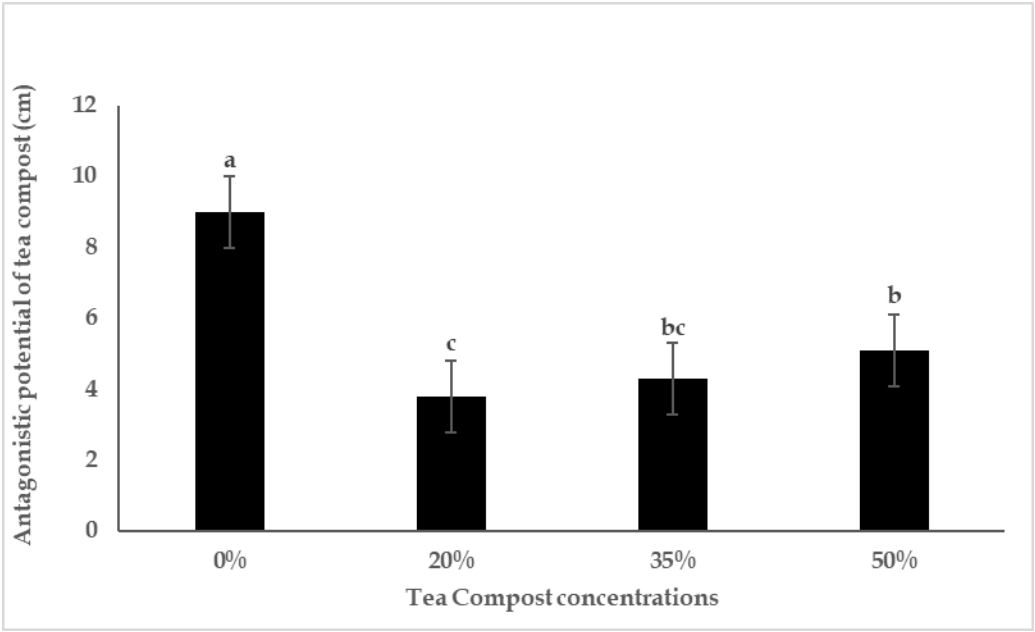

Figure 1. Antagonistic potentials of compost tea against chocolate spot of faba bean under *in vitro* conditions

Effects of tea compost on chocolate spot disease incidence

There was significant difference (P < 0.05) among the compost tea concentrations on chocolate spot incidence recorded during all assessment dates. From this study, compost tea concentrations applied as FS50% and SD50% reduced the disease incidence (13.3%) up to final date of disease assessment. However, the medium compost tea concentrations did not significantly reduce (Table 2) the disease incidence. Moreover, the compost tea able to suppressed the *Botrytis fabea*, and thus it could have had able to reduced disease incidence of faba bean treated by FS50% SD50%. Nevertheless, the suppressive abilities of compost tea vary due to variations of compost tea concentrations. From this experiment, application of compost tea like FS50%SD20% and FS50% SD50% showed different suppression of *Botrytis fabea* (13.3%) and (36.6%), respectively. This might be due to the fact that tea composts concentration has antifugal property that inhibited the the development of the *B. fabae* and limited the further dissemination. These results are in agreement with the finding of Fuchs (2002), all compost tea treatments significantly reduced the mean powdery mildew leaflet incidence compared to the water control.

Effects of tea compost on chocolate spot disease severity

There was a significant difference (P < 0.05) among compost tea concentrations in all plots on disease severity. Maximum disease severity of 96.3% and 87.5% respectively were on treatment of FS0% SD0% and FS0% SD20% 98 days after planting. The minimum disease severity (18.3%) was recorded the plots treated by compost tea, FS50% SD50% (Table 2).

Table 2. Percentage severity index of chocolate spot of faba bean treated by compost tea concentrations with different application methods during 2019/20 season

Foliar spray	Soil drench	Incidence (%)		Severity index (%)		AUDPC(%_days)
		Initial (70 DAS	Final 91DAS	Initial (70 DAS	Final 91DAS	
0%	0%	75 ^{a}	100^{a}	59.3^{a}	85.3^{a}	1684.7^{ab}
	20%	75^{a}	100^{a}	42.5^{b}	80.5^{a}	1907.5^{a}
	35%	53.3^{abc}	100^{a}	38.3^{bcd}	58.7^{b}	1373^{abcd}
	50%	45^{cbd}	100^{a}	22.0^{fg}	56.3^{b}	1330.0^{bcde}
20%	0%	65^{ab}	100^{a}	42^{bc}	56.0^{bc}	1479.3^{abc}
	20%	58.3^{ab}	100^{a}	33.7^{bcdef}	48.7^{bcd}	1271.7^{bcdef}
	35%	71.7^{a}	75^{b}	37.7^{bcde}	56.3^{b}	1377.8^{abcd}
	50%	23.3^{ed}	75^{b}	27.0^{cdefg}	59.7^{b}	1230.8^{bcdefg}
35%	0%	26.7^{ed}	75^{b}	15.3^{g}	48.3^{bcd}	991.7^{cdefgh}
	20%	25^{ed}	51.6^{de}	25.0^{defg}	35.7^{def}	935.7^{cdefgh}
	35%	25^{ed}	58.3^{cd}	18.7^{fg}	23.7^{fg}	673.2^{gh}
	50%	21.67^{ef}	46.6^{def}	23.0^{efg}	36.0^{cdef}	836.5^{defgh}
50%	0%	33.3^{cde}	40^{ef}	30.3^{cdefg}	45.0^{bcde}	1008.9^{cdefgh}
	20%	15.00^{ef}	36.6^{f}	20.0^{fg}	35.0^{def}	745.5^{fhg}
	35%	35^{cde}	81.6^{ab}	23.7^{defg}	27.7^{efg}	780.5^{efgh}
	50%	0.0^{f}	13.3^{f}	14.0^{g}	14.7^{g}	463.2^{h}
LSD (5%)		22.9	11.7	15.0	20.0	563.8
CV (%)		34.1	9.71	30.8	25.2	30.2

Das=days after sowing, LSD= Least significant difference, CV= Coefficient of variations, means with the same letter are not significantly different at P<0.05

This observation is in line with the finding of Haba (2018), compost tea at 50% and 75% concentrations, significantly decreased the chocolate spot disease severity by 59% and 50%, respectively as compared with control and with the finding of Al-Mughrabi (2007) who reported that compost tea reduced severity by 29 and 27%, when applied on foliar against late blight (*Phytophthora infestans*) of potato. From this experiment, the highest disease severity was observed on the plots treated with less compost tea concentrations (FS0SD0 and FS0SD20). This study showed that tea compost concentrations reduced the disease severity this could be due to antifungal nature of the tea compost limited secondary infection as well as the progress of epidemic.

Area under Disease Progress Curve (AUDPC)

There were highly significant differences (P < 0.05) among the treatments on AUDPC of faba bean that treated with different compost tea concentrations. Plots treated with compost tea concentrations like FS0% and SD0%; FS0%SD20% showed the highest AUDPC (1684.7 and 1907.5%_days, respectively) and plots that treated with compost tea concentrations like FS50SD50% showed the lowest AUDPC (463.2 %_days) Table 3).

This study is in agreement with the finding of Scheuerell and Mahaffee (2002), the microbial communities present in compost tea may also encourage disease resistance as well as stimulate nutrient uptake and plant growth. Similarly, plots treated with the high concentrations of compost tea (FS50% SD50%) able to reduce the progress of *B. fabea*, and showed the lowest AUDPC (463.2 %_ days).

Yield components

There was significant difference ($P < 0.05$) among the treatments on plant height of faba bean treated by compost tea concentrations those that applied as foliar spray and soil drench (Table 3). From this result, FS0SD0% and FS0SD20% compost tea concentrations showed the plant height (97.143 cm and 95.807 cm), respectively. But, FS50% SD50% and FS35%SD20% compost tea concentrations gave the highest plant height (119.923 cm and 116.877 cm) respectively (Table 3). These results are in agreement with the finding of Haba (2018), compost tea improves almost all yield parameters of faba bean and also this finding are in line with the finding of Kim *et al.* (2015), applications of the mixture of oriental medicinal herbs compost and vermin compost tea significantly increased shoot and root growths of the tested plant such as red leaf lettuce, sweet corn and soybean compared to the untreated control.

The result revealed significant difference ($P < 0.05$) on number of pods per plants as treated by compost tea concentrations. The result showed that the FS0% SD0% and FS0SD20% compost tea concentrations showed the lowest number of pods per plant (3) respectively. But, FS50% SD50% and FS50% SD35% gave the highest number of pods per plants (8) respectively (Table 3). From this experiment, compost tea able to increase the growth and development of pods plant^{-1} and due to this, treatments those that treated by high concentrations of compost tea. These results are in agreement with the finding of Haba (2018), applying compost tea to faba bean enhanced the number of pods per plant.

Table 3. Effects of different compost tea concentrations with different application methods on yield components of faba bean

Foliar spray	Soil drench	Plant height(cm)	Pods /plant	Leaf /plant
0%	0%	97.1^{c}	3^{f}	19^{b}
	20%	113.1^{abc}	3^{f}	18^{b}
	35%	98.8^{ab}	4^{ef}	19.7^{b}
	50%	95.807^{c}	4^{def}	18.3^{b}
20%	0%	106.8^{ab}	4de	19^{b}
	20%	106.7^{abc}	5^{cde}	22^{b}
	35%	115.6^{ab}	5^{cde}	21.7^{b}
	50%	110.5^{abc}	5^{cd}	22^{b}
35%	0%	103.13^{bc}	5^{cde}	18^{b}
	20%	116.8^{a}	5^{cd}	23^{b}
	35%	98.7^{bc}	7^{ab}	19.7^{b}
	50%	103.6^{abc}	6^{bc}	19.6^{b}
50%	0%	98.8^{bc}	5^{cd}	18.5^{b}
	20%	110.8^{abc}	7^{ab}	19.6^{b}
	35%	102.1^{bc}	8^{a}	22.3^{b}
	50%	119.9^{a}	8^{a}	28^{a}
LSD (5%)		17.8	1.1	5.3
CV (%)		9.9	13.2	15.6

LSD= Least significant difference, CV= Coefficient of Variations, means with the same letter are not significantly different

There was no significant difference ($P < 0.05$) on number of leaf per plant among compost tea concentrations applied (Table 4). However, compost tea concentrations applied as FS50SD50 provided maximum number of leaves per plant (28) (Table 4). These results are in line with the finding of Haba (2018), foliar spray and soil drench treatments with compost tea at 25% and 75% concentrations significantly increased number of leaves comparing with control and also in agreement with the finding of Kim *et al.* (2015) who reported that, applications of the mixture of oriental medicinal herbs compost and vermin compost tea significantly increased shoot and root growths of the tested plant such as red leaf lettuce, sweet corn and soybean compared to the untreated control. From this experiment, treatment that treated by compost tea concentrations like FS50SD50 gave the heights leave number per plants of faba bean.

Yield and relative yield loss

There was no significant difference on yield per hectare treated by compost tea concentrations. However,

compost tea that had high concentrations like FS50%SD50% provided the highest number of yield per hectare (0.09367 tons/ha) followed by FS50%SD20% (0.06012 tons/ha) (Table 4). These results are in agreement with Gonález *et al.* (2010), misting plants with compost tea is a more effective method for delivering nutrients there by boosting than drenching the soil. It is also in line with the finding of Rodríguez-Ortíz *et al.* (2006), water-based compost tea enhanced the uptake and accumulation of nutrient elements in the plant and increases the yield of the crop and it in agreement with the finding of Gaius (2020) who reported that compost tea concentration and application rate both influenced lettuce yield and productivity. From this experiment, treatments treated by compost tea concentrations like FS50%SD50% gave the highest yield per hectare (0.09367 tons/ha) due to optimum availability of nutrients for faba bean crops.

Yield losses were calculated comparative to the average yield from plots with the maximum protection against the disease (i.e. plots with highest yield and lowest disease severity in each treatment). However, the grain yield losses were reduced by all compost tea concentrations treated plots as compared with the untreated control plots (Table 4). The highest relative yield losses (63%) was computed on plots treated by compost tea concentrations as FS0% SD0% (control plot) and plots that treated by compost tea concentrations as FS0% SD50% (less concentrations of compost tea) showed the second highest relative yield losses (59.18%). On the other hand, the lowest yield loss of 22% was recorded from plots that treated by compost tea concentrations of FS50% SD50% (Table 4). These results are in line with the report of green book (2003); herb flats that were treated with tea lost only 5% of the plants and untreated cucumbers had an approximate loss of 50% due to damping off. From this study, it was noted that as compost tea concentrations increased, the yield loss of faba bean could be decreased

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Table 4. Effects of different compost tea concentrations with different application methods on yield of faba bean

Foliar spray	Soil drench	Yield (tons/ha)	RYL (%)	100 seeds weight (gm)	Biomass yield(kg)
0%	0%	0.03453^{c}	63.08^{a}	66.0^{bc}	0.3^{cd}
	20%	0.04300^{bc}	55.10^{a}	63.7^{cde}	0.3^{cd}
	35%	0.04556^{bc}	51.60^{a}	62.8^{cde}	0.1^{d}
	50%	0.03905^{bc}	58.19^{a}	58.4^{e}	0.3^{cd}
20%	0%	0.04923^{bc}	47.31^{a}	61.6^{cde}	0.4^{c}
	20%	0.04585^{bc}	50.9^{a}	62.0^{cde}	0.4^{c}
	35%	0.04887^{bc}	47.52^{a}	61.3^{cde}	1.1^{a}
	50%	0.04830^{bc}	48.37^{a}	0.1^{de}	0.8^{ab}
35%	0%	0.05180^{bc}	44.6^{a}	60.9^{cde}	0.3^{cd}
	20%	0.04228^{bc}	55.34^{a}	64.8^{cd}	0.8^{b}
	35%	0.04709^{bc}	49^{a}	71.5^{b}	0.3^{cd}
	50%	0.05269^{bc}	43.23^{a}	61^{cde}	1.1^{a}
50%	0%	0.05935^{bc}	41.98^{a}	62.5^{cde}	0.9^{ab}
	20%	0.06012^{b}	35.62^{ab}	62.5^{cde}	1^{ab}
	35%	0.05743^{bc}	38.76^{ab}	61.9^{cde}	1.0^{ab}
	50%	0.09367^{a}	12.3^{b}	87.9^{a}	1.1^{a}
LSD(0.05)		0.026	28.41	64.38	0.29
CV (%)		19.50	26.73	5.70	26.40

LSD= Least significant difference, CV= Coefficient of Variations, means with the same letter are not significantly different

There was significant difference on weight of 100 seed ($P < 0.05$) among the compost tea concentrations likes FS0%SD0%, FS0%SD50%, FS20%SD50%, FS35%SD20%, FS35%SD35% and FS50%SD50% (Table 5). Under this experiment, FS50% SD50% showed the highest 100 seed weight (87.967 gm) and FS0SD0 showed the lowest 100 seed weight (66 gm) (Table 5). These results are in agreement with the findings of Haba (2018), seed yield weight increased significantly with 50% as integrated foliar spray and soil drench treatment and with 75% compost tea as integrated foliar and soil drench. Treatment treated by compost tea had able to uptake and accumulate optimum amount of nutrient inside their body. Due to this, treatments those that treated by compost tea concentrations (FS50% SD50%) provided the highest 100 seed weight (87.967 gm).

There was high significant difference on biomass yield ($P < 0.05$) between compost tea concentrations of FS50%SD50% and FS0%SD0%. Under this study, FS50%SD50% showed the highest number of biomass yield (1.1) and FS0%SD0% showed the lowest biomass yield (0.3 kg) (Table 5). These results are in line with the findings of Gaius (2020), application of 200 cm^3 $plant^{-1}$ day^{-1} of 5 % m/v compost tea resulted in the highest

yield and dry matter of lettuce. Compost tea concentrations (FS50% SD50%) able to accumulated more nutrients (1.1) than treatments untreated by compost tea, like FS0%SD0% and gave minimum yield per plot (0.3 kg).

Correlation between disease and yield parameters

Correlation analysis of severity, AUDPC and biomass yield exhibited highly significant ($P < 0.01$) association with different compost tea concentrations and applications treatments (Table 5). The value of severity and AUDPC had strongly positive correlation each other. However, biomass yield of faba bean were strongly negative correlation with all disease severity days after sowing. Plant height, number of pods and number of leaf per plants were non-significant with all disease assessment severity assessment days, AUDPC and biomass yield respectively. Both yield per plot and yield per hectare were negative non-significant at 84 DAS (-0.3), negative significant with 91 DAS and 94 DAS (-0.3), negative non-significant with both AUDPC and plant height, strongly positive correlation with both biomass yield and weight of hundred seed and non-significant with leaf number per plants. Weight of hundred were positive non-significant correlation 70DAS, 77 DAS and 84 DAS but strongly positive and strongly negative correlations (0.4 and -0.4) with 91 DAS and 94 DAS respectively and also strongly negative correlations with AUDPC (-0.3).

Table 5. Correlation coefficient disease parameters and yield component under field conditions.

	Disease severity days after sowing					
Parameters	70DAS	77DAS	84DAS	91DAS	98DAS	AUDPC
AUDPC	0.7^{**}	0.7^{**}	0.8^{**}	0.8^{**}	0.8**	1
WTH	0.2^{ns}	0.7^{ns}	0.3^{ns}	0.4^{**}	-0.4**	-0.3^{**}
BMY	-0.4^{**}	-0.5^{**}	-0.5^{**}	$-.5^{**}$	-0.5**	-0.4^{**}
PHT	0.1^{ns}	0.1^{ns}	0.04^{ns}	0.1^{ns}	0.1^{ns}	0.1^{ns}
NP	0.1^{ns}	0.1^{ns}	0.2^{ns}	0.2^{ns}	0.2^{ns}	0.1^{ns}
LN	-0.1^{ns}	-0.1^{ns}	-0.1^{ns}	-0.1^{ns}	-0.1^{ns}	-0.03^{ns}
YPP	-0.3^{*}	-0.2^{ns}	-0.3^{ns}	-0.3^{*}	-0.3*	-0.2^{ns}
YPH	0.3^{*}	0.2^{ns}	-0.3^{ns}	-0.3^{*}	-0.3*	-0.2^{ns}

AUDPC= area under disease progress curve, WTH= weight of 100 seed, BMY= biomass yield, PHT= plant height, NP= number of pod, LN= leaf number, YPP= yield per plot, YPH= yield per/ha **, *, Correlation is highly significant at the ($p < 0.01$) significance level respectively, and ns= non-significant

Cost benefit analysis

The net benefit exhibited variation among compost tea concentration those that applied as foliar spray and soil drench treated plots. Partial budget analysis was calculated based on cost of variable inputs of the year 2019 cropping season and net benefit was estimated based on mean of local market price and farmers supplied produce to the market). Compost tea concentration that an applied as FS50% SD50% gave maximum partial cost benefit from all plots that means the highest (231ETB ha^{-1}) was recorded followed by FS50% SD20% (152 ETB ha^{-1}) (Table 6).

CONCLUSIONS

From this study, the disease control ability of compost tea was decreased when dilution rate increased. Therefore, during compost tea applications, dilution by 1:2 (1 for fermented compost tea and 2 for clean water) was used. Study results could be useful for the farmers to control the chocolate spot disease on faba bean and for getting high yield from this crop in central high land of Ethiopia by using the combination compost tea concentrations of 50% as foliar spray and 50% as soil drench. Depending on crop stage and occurrences of chocolate spot of faba bean disease, further study is needed on times of application for increasing the efficiency of compost tea.

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Table 6. Partial budget analysis for Faba bean cultivars due to chocolate spot disease after treated with fungicides

and bio-control agents under field conditions.

Foliar spray	Soil drench	General cost benefit						
		(A) Adj. yield(t.ha-1)	(B) Price (ETBt-1)	(C) Sale revenue (A*B)	(D) Marginal cost (ETBha-1)	(E) Net profit (ETB) (C-D)	(F) Marginal benefit (ETB)	MRR (F/D) (%)
0%	0%	0.09322	1014	94	0	94	0	0
	20%	0.13356	1014	135	10	125	150	15%
	35%	0.123	1014	124	20	104	300	15%
	50%	0.10543	1014	106	15	91	260	17.3%
20%	0%	0.13292	1014	134	10	124	150	15%
	20%	0.1238	1014	125	10	115	200	20%
	35%	0.13194	1014	133	15	118	220	14.6%
	50%	0.1304	1014	132	10	122	150	15%
35%	0%	0.13986	1014	141	20	126	450	22%
	20%	0.11415	1014	115	25	90	300	12%
	35%	0.12714	1014	128	26	102	300	11.5%
	50%	0.14226	1014	144	28	116	280	10%
50%	0%	0.1575	1014	159	12	149	250	20.8%
	20%	0.16232	1014	164	12	152	250	20.8%
	35%	0.15507	1014	157	17	140	300	17.64%
	50%	0.2529	1014	256	19	231	500	26.31%

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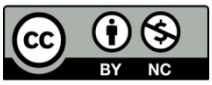

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