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Research Article

Effects of Fungicides and Seedbed Preparations Methods on Seed Borne Fungi and Different Growth Stages of Hot Pepper Diseases in Ilu Aba Bor and Buno Bedele Zones

Takele Kusa*, Alemayehu Abdeta

Oromia Agricultural Research Institute (OARI), Bedele Agricultural Research Center (BeARC), Bedele, Ethiopia

Abstract

Effect of various hot pepper diseases management tools on seedling emergence, wilt incidence and yield of hot pepper was studied as part of integrated management strategies under both fungicide treatment and seedbed types. Different fungicides were tested against the hot pepper diseases. The fungicides viz, Apron star (seed treatment) and Mancozeb which were found effective under field conditions. Seed treatment followed by seedling treatment with fungicides proved ineffective in controlling hot pepper disease, however, besides seed treatment and seedling treatment when fungicides were sprayed at crown region of the plant, hot pepper diseases were significantly reduced. The effect of seed treatment, different seed bed types and fungicide applications methods were affected the performance of Hot pepper. Seed bed types had significant effect on Days to 50% emergence, Days to 50% flowering, Days to 90% physiological maturity, plant height, NFPP, FL and DFY of Hot pepper. Integration of Apron star + Mancozeb with different seedbed types also proved superior compared to their individual treatments. The applied fungicides were significantly affect severity of hot pepper diseases when compared with unsprayed check. The maximum mean severity of Cercospora leaf spot, Bacterial leaf spot, Fusarium wilting, Blossom end rot and Anthracnose were recorded on the unsprayed plots with Mancozeb 80WP at flat and furrow seedbed types, while the lowest mean severity were recorded on the plot sprayed with Mancozeb 80WP at ridge seedbed type at Bure and Dabo Hana districts. Seed treatment with Apron Star followed by seedling treatment and foliar spraying of fungicide Mancozeb 80 WP at recommended rate (after transplanted with interval of two weeks) and sowing of hot pepper on raised seedbed and transplanted on Ridge seedbed can be applied to manage the devastating Hot pepper diseases.

Keywords

Hot Pepper, Seed Treatment, Fungicide

1. Introduction

Vegetables represent a fundamental component of Ethiopia's agricultural sector, contributing significantly to the national economy [8]. Across the country, these crops serve as a vital source of nutrition and income, cultivated extensively by both smallholder farmers and large-scale state enterprises [25]. Expanding and diversifying vegetable cultivation offers a dual benefit: it addresses malnutrition and rural poverty by improv-

*Correspondence: Takele Kusa (takelekusa01@gmail.com)

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ing home consumption while simultaneously creating lucrative market avenues for smallholders. Furthermore, the broader vegetable value chain generates fresh employment and revenue opportunities in commercial trading and processing sectors [11, 37]. At the national level, vegetables account for 1.08% of the total land dedicated to crop production, with hot pepper occupying the majority share at 69.31% [5]. Hot pepper (Capsicum frutescens) stands out as the country's most essential vegetable, forming a mainstay in the daily diet of virtually all Ethiopian households [25].

Hot pepper (Capsicum annuum) holds substantial economic and cultural significance in Ethiopia, where local cuisine is widely considered incomplete without its inclusion [4]. When processed into a fine, pungent powder, it functions as an indispensable flavoring and coloring agent in "Wot" (the standard traditional stew). Beyond its dietary importance, capsicum is a high-value commercial crop for both domestic markets and export trade. According to data from the Central Statistical Agency's Agricultural Sample Survey [6], hot pepper accounts for 69.31% of the total land under vegetable cultivation in Ethiopia. Furthermore, report estimates indicate that the average daily consumption of hot pepper by an Ethiopian adult is roughly 15 grams exceeding that of tomatoes and most other vegetables [21].

Despite its agricultural importance, hot pepper production remains severely constrained by recurrent disease outbreaks, leading to substantial annual yield declines [25]. The national productivity for both green and red pods remains below potential, averaging 64.20 qt/ha for fresh green pods and 21.96 qt/ha for dried red pods [5]. Multiple compounding factors contribute to these yield losses, including low-quality seed stock, suboptimal agronomic practices, and infections from viral pathogens, collar rot, and Phytophthora root rot [9]. Pest and pathogen pressures cause steady annual declines in crop output, further undermining farmer profitability by shortening the effective harvesting window [9]. For instance, pepper anthracnose can cause total crop failure (up to 100% loss) [23], while bacterial spot (Xanthomonas campestris pv. vesicatoria)—a seed-borne pathogen—causes severe defoliation that drastically reduces harvestable yields [32].

Post-harvest challenges further exacerbate these field losses; improper handling accounts for up to a 30% reduction in Ethiopian vegetable harvests [10]. Additionally, insufficient localized research regarding crop adaptability and inadequate management practices lead to suppressed yields and inflated production expenses [13]. In severe cases, extreme disease pressure forces regional growers to abandon fields entirely due to widespread crop failure [33]. Hot pepper is particularly susceptible to various pathogenic fungi, bacteria, viruses, and nematodes. As a warm-season crop, its seeds frequently fail to germinate in cold, wet conditions, leaving them highly vulnerable to soil-borne pathogens [29].

To manage these seed-borne threats, conventional approaches have relied heavily on synthetic chemical treatments [17, 36]. However, growing environmental and health considerations have shifted research focus toward eco-friendly alternatives, including natural compounds, biostimulants, and biological control agents [19, 30]. Recently, pre-sowing interventions like seed priming have gained attention for their ability to enhance seed vigor and accelerate seedling emergence [7, 20]. Controlled imbibition using various priming agents presents a viable method for fortifying crops against both biotic and abiotic stressors [2, 18]. Despite these advancements, pre-sowing treatments for hot pepper seeds remain unexplored in the study area, and optimized seedbed management techniques for sowing and transplanting hot pepper continue to be a challenge. Therefore, the objectives of this study were to evaluate the effect of seedbed preparation methods and fungicides on the management of major Hot pepper diseases and to evaluate economic feasibility of hot pepper disease management.

2. Materials and Method

2.1. Description of the Field Experimental Site

The field experiment was conducted at Dhaye sub site (Buno Bedele Zone, Dabo Hana district) and Tolicheka sub site (Ilu Aba Bor Zone, Bure district) during 2023 and 2024 main cropping season. The main crops produced in the area were Hot pepper, Maize, Tef and Sorghum.

2.2. Seed and Seedling Preparation

Before seedbed preparation, Hot pepper seed (Marekofana) was collected from Ilu Aba Bor Zone (Bure) Farmers and Merchants. After collecting the seeds, Seed was treated with fungicides (Apron star). Seedlings were raised on 3 seedbeds (Furrow, Raised and Flat) and 3 seed beds as a check with 1.5 m width and 3m length. The spaces between beds was 50 cm and sown at a depth of 0.5 cm in 6 rows with inter-row spacing of 15 cm in each bed. Grass mulch was applied on each bed and removed after the seedlings emerged. The beds were weeded as necessary. Hot pepper seedlings were transplanted after seed emergence of five weeks.

2.3. Experimental Material and Treatments

A total of 6 treatments were laid out in a factorial arrangement in randomized complete block design (RCBD) with three replications. A combination of three planting seedbed preparation types when the seeds were sown (Raised seedbed, Furrow seedbed and Flat seedbed) with Apron Star was used as seed treatment and including control (not treated with fungicide) and after the seedlings were transplanted (Ridge seedbed, Furrow seedbed and Flat seedbed) with Mancozeb 80WP used as Hot pepper different growth stages treatment and including control (not treated with fungicide) [24]. Mancozeb fungicide was applied by seedling dip solution method before and after the seedlings transplanted. The treated seedlings were transplanted immediately when the seedlings were ready to transplanting. Each Hot pepper seedlings were transplanted at 70 cm spacing between rows and 30cm between plants as recommended by [22]. The spacing between plots and blocks were 1m and 1.5 m, respectively. The plot was 1.5m width with 4.2m length. It was 6 rows, 5 plants per row and 30 plants per plot. The two surface drain practices raised bed and furrow bed was constructed by hand and flatbed was prepared with oxen drawn local implement. All recommended agronomic practices were also applied in the field.

Treatments when the seeds were sown

1) Furrow seedbed +Apron star (Seed treatment)
2) Only furrow seedbed (untreated seed)
3) Flat seedbed +Apron star (Seed treatment)
4) Only Flat seedbed (untreated seed)
5) Raised seedbed + Apron star (Seed treatment)
6) Only Raised seedbed (untreated seed)

Treatments after the seedlings were transplanted

1) Furrow seedbed + Mancozeb 80WP (after transplanted with interval of two weeks)
2) Only furrow seedbed (unsprayed)
3) Flat seedbed + Mancozeb 80WP (after transplanted with interval of two weeks)
4) Only Flat seedbed (unsprayed)
5) Ridge seedbed+ Mancozeb 80WP (after transplanted with interval of two weeks)
6) Only Ridge seedbed (unsprayed)

2.4. Data Collected

2.4.1. Disease Data

Disease incidence was recorded from assessment of 4 rows of each plot. It was recorded every 7 days intervals from starting of first appearance of the disease symptoms. The pathological, yield and yield component data was collected during the field experiment from four central rows of each experimental unit.

$$\text{Disease incidence} = \frac{\text{Infected plants}}{\textit{Total assessed plants}} * 100$$

2.4.2. Agronomic Data

Effect of fungicides (Apron Star and Mancozeb 80 WP) and Seedbed preparations on some agronomic characteristics; on height of plant, number of fruit per plant, Number of branch per plant and Dry fruit yield were recorded.

Days to 50% emergence: Days from planting to the emergence of 50% plants per row was recorded.

Days to 50% flowering: Days to flowering was recorded for each row when 50% of the plants in a plot flowered.

Days to 90% maturity: Days to 90% maturity of the crop was recorded when 90% of the pod reached physiological maturity.

Plant height (cm): It was recorded as among treatments in affecting height of plant at planting and height of plant at fruiting.

Number of pod per plant: Number of pod per plant was counted on five randomly taken plants means was recorded as number of pod/plant.

Number of branches per plant: Number of branches per plant was counted on five randomly taken plants means was recorded as number of branches/plant.

Pod length (cm): It was recorded as among treatments in affecting length of pod at length of plant at fruiting.

Yield (Qt/ha): It was recorded from each treatment and converted to yield (quintal per hectare).

2.5. Data Analysis

The analysis of variance (ANOVA) was performed for the disease parameters (incidence/severity) and yields parameters using GenStat software (GenStat 18th edition). Least significant difference (LSD) values were used to separate treatment means (P<0.05) among the treatments. Follow analysis using the standard procedure [12].

3. Result and Discussion

3.1. Effects of Seed Treatments, Fungicides and Seedbed Preparation Methods on Seed-Borne Fungi and Growth of Hot Pepper

In Buno Bedele and Ilu Aba Bor zones, Days to 50% emergence, Days to 50% flowering, Days to 90% physiological maturity, Plant height, number of branch per plant, number of fruit per plant, fruit length and dry fruit yield were significantly differed in response to seed treating with Apron Star compared to control (Tables 1 & 2). The longest days of Days to 50% emergence, Days to 50% flowering and Days to 90% physiological maturity were recorded from untreated seed plot at flat seedbed type at both locations. The shortest days of Days to 50% emergence, Days to 50% flowering and Days to 90% physiological maturity were obtained from seed treated plot with Apron Star fungicide at raised seedbed type at both locations (Tables 1 & 2). Chemical seed treatment consists of the application of pesticides (fungicides, insecticides, bactericides, nematicides and rodenticides) to control pests and seed borne diseases or to stimulate the germination or plant growth [1].

The effect of seed treatment, different seed bed types and fungicide applications methods were affected the performance of Hot pepper. Seed bed types had significant effect on Days to 50% emergence, Days to 50% flowering, Days to 90% physiological maturity, plant height, Number of fruits per plants, Fruit Length and Dry Fruit Yields of Hot pepper. The flat seedbed produced shorter plants and low yields while there was significant increase in the growth and yield characteristics of hot pepper plant in the ridge seedbed (Tables 1 and 2). This may be attributed to the deeper ploughing obtained on raised bed that allowed for proper intake of nutrient by the pepper plant. The highest plant height (57.4cm) was obtained from seed treated plot with Apron Star fungicide and sprayed plot with Mancozeb 80 WP at ridge seedbed type, whereas the lowest plant height (40.8cm) was recorded under untreated seed plot and unsprayed plot at furrow seedbed type. The maximum number of branches per plant (16.47), number of fruit per plant (54.13), fruit length (15.7cm) and dry fruit yield (35.6 qt/ha) were obtained from seed treated plot with Apron Star fungicide and sprayed plot with Mancozeb 80 WP at ridge seedbed type, whereas the minimum branches per plant (9.5), number of fruit per plant (21.53) and fruit length (8.67cm) were obtained under untreated seed plot and unsprayed plot at furrow seedbed type (Tables 1 and 2). Accordingly, the lowest dry fruit yield (10.4 qt/ha) was obtained under untreated seed plot and unsprayed plot at flat seedbed type. In the present study; Apron Star fungicide significantly reduced seed borne fungal pathogens of Hot pepper diseases, simultaneously increased the germination percentage and enhanced the growth characters of hot pepper seedlings. Correspondingly, previous studies have demonstrated that such treatments effectively suppress seed-borne fungal infections, boost germination rates, and improve the growth performance of vegetable seedlings [14-16]. Furthermore, the application of systemic fungicides offers targeted protection against soil-borne pathogens, safeguarding vulnerable seedlings during and after emergence [3].

Table 1. *Effect of fungicides and seedbed types on Hot pepper Agronomic parameters in Bure district.*

Treatments	DE	DF	DM	PH (cm)	NBPP	NFPP	FL (cm)	DFY (Qtl/ha)
Furrow bed+ Apron star and Mancozeb	8.00b	58.40b	95.67b	47.0d	12.80c	38.13c	11.00c	20.7cb
Untreated furrow bed	8.67a	60.80a	104.00a	40.8e	9.50e	21.53e	8.67d	11.1d
Flatbed + Apron star and Mancozeb	7.33c	56.87c	90.67cd	53.27b	15.00b	48.60b	13.40b	26.7b
Untreated Flat bed	8.00b	59.30ba	102.33a	42.2e	10.57de	27.20e	8.93d	10.4d
Raised bed+ Apron star and Mancozeb	7.00c	56.37c	87.00d	57.40a	16.47a	54.13a	15.70a	35.6a
Untreated Raised bed	8.00b	58.77b	94.00cb	50.13c	11.73dc	35.27c	11.00c	12.6cd
Grand mean	7.833	58.42	95.61	48.5	12.68	37.5	11.45	19.5
LSD (0.05)	0.58	1.51	3.7	2.34	1.2	3.07	1.47	8.8
CV (%)	4.04	1.42	2.12	2.7	5.2	4.51	7.04	24.9

DE-Days to 50% emergence DF- Days to 50% flowering DM- Days to 90% physiological maturity PH-Plant height.
NBPP-Number of branch per plant NFPP-Number of fruit per plant FL-Fruit length DFY-Dry fruit yield.

Table 2. *Effect of fungicides and seedbed types on Hot pepper Agronomic parameters in Dabo Hana district.*

Treatments	DE	DF	DM	PH (cm)	NBPP	NFPP	FL (cm)	DFY (Qtl/ha)
Furrow bed+ Apron star and Mancozeb	8.00b	57.5c	100.3c	47.13cb	13.73c	32.20c	11.10c	15.3c
Untreated furrow bed	9.00a	60.10a	105.7a	37.33d	10.80d	25.60e	8.40e	4.6e
Flatbed + Apron star and Mancozeb	7.70b	56.50d	96.70d	49.33b	17.50b	39.80b	14.00b	25.8b
Untreated Flat bed	8.70a	59.5ba	103.0b	40.70d	12.5dc	27.4ed	9.80d	12.1dc
Raised bed+ Apron star and Mancozeb	7.00c	55.60e	87.33e	54.90a	20.53a	49.30a	15.40a	31.4a
Untreated Raised bed	8.00b	58.93b	99.33c	44.50c	14.30c	29.20d	10.73c	9.7d
Grand mean	8.06	58.02	98.72	45.63	14.9	33.9	11.6	16.5
LSD (0.05)	0.54	0.68	2.43	3.53	2.60	2.71	0.75	4.9
CV (%)	3.70	0.64	1.4	4.3	9.5	4.4	3.6	16.5

DE-Days to 50% emergence DF- Days to 50% flowering DM- Days to 90% physiological maturity PH-Plant height.
NBPP-Number of branch per plant NFPP-Number of fruit per plant FL-Fruit length DFY-Dry fruit yield.

3.2. Effects of Seed Treatments, Fungicides and Seedbed Preparation Methods on Seed Borne Fungi and Diseases of Hot Pepper

The plots showed significantly (P ≤ 0.05) different levels severity of Damping off of Hot pepper disease starting from the first date of disease assessment after Days to Days of 50% emergence. The maximum mean severity was recorded on the untreated seed plot at flat, furrow and raised seedbed types, while minimum mean severity of damping off was recorded on the plot seed treated with Apron Star fungicide at raised, flat and furrow seedbed types at both Bure and Dabo Hana districts (Table 3). Result of this experiment was similar with the results recorded by [26, 27], who reported minimum pre and post emergence damping off, which was on parameter with metalaxyl treatment. Saha *et al.* [28, 35], reported that thiram recorded lowest disease incidence. Sharma and Sain [31], Thakur and Tripathi [34] reported that T. harzianum and T. viride effectively reduced the pre and post emergence damping off.

The applied fungicides were significantly affect severity of hot pepper diseases when compared with unsprayed check (Table 3). The plots showed significantly (P ≤ 0.05) different levels severity of Cercospora leaf spot of Hot pepper disease starting from the first date of disease assessment (95DAT). The maximum mean severity of Cercospora leaf spot, Bacterial leaf spot, Fusarium wilting, Blossom end rot and Anthracnose were recorded on the unsprayed plots with Mancozeb 80WP at flat and furrow seedbed types, while the lowest mean severity were recorded on the plot sprayed with Mancozeb 80WP at ridge seedbed type at Bure and Dabo Hana districts (Table 3).

Table 3. *Effect of fungicides and seedbed types on Hot pepper diseases parameters in Bure and Dabo Hana districts.*

Treatments	Bure district						Dabo Hana district					
	CLS	BLS	FW	Damp	BER	Anth	CLS	BLS	FW	Damp	BER	Anth
Furrow bed + Apron star and Mancozeb	25.4c	14.5c	10.7c	9.4b	12.8cb	7.1c	7.2d	27.2b	8.7c	6.6c	9.0b	5.8b
Untreated and Unsprayed furrow bed	53.3a	35.0ba	28.7b	32.0a	25.4a	16.6b	31.0a	68.3a	48.3a	25.8a	35.0a	22.0a
Flatbed + Apron star and Mancozeb	23.4c	16.8c	10.0c	5.8b	10.3cd	6.0c	4.4ed	29.4b	7.7c	5.8c	6.2b	3.4b
Untreated and Unsprayed Flat bed	56.0a	42.0a	43.3a	26.6a	27.7a	29.0a	21.6c	63.9a	56.0a	22.0ba	30.2a	27.6a
Raised bed + Apron star and Mancozeb	13.4d	10.8c	5.3c	2.8b	5.3d	2.8c	2.2e	26.0b	4.0c	2.4c	5.0b	3.4b
Untreated and Unsprayed Raised bed	43.0b	30.0b	26.0b	31.0a	17.8b	21.1b	26.0b	57.8a	35.3b	19.0b	32.0a	20.0a
Grand mean	35.8	24.9	20.7	17.9	16.5	13.8	15.4	45.4	26.7	13.6	19.6	13.7
LSD (0.05)	9.3	7.2	11.5	8.2	6.7	4.9	4.1	15.0	11.5	4.5	6.4	7.6
CV (%)	14.3	15.9	30.5	25.1	22.3	19.8	14.6	18.2	23.7	18.2	17.9	30.7

CLS-Cercospora leaf spot BLS-Bacterial leaf spot FW-Fusarium wilting BER-Blossom end rot Anth- Anthracnose.
LSD-List significance difference.

3.3. Economic Analysis/Production Cost Analysis

Different diseases management needs different cost of production. Economic analysis results showed that highest marginal rate of return (20881.1) was obtained from treatment Raised/ridge seedbed + Apron star and Mancozeb, while the lowest MRR (9428.3) from Untreated furrow seedbed diseases management practices (Table 4).

Table 4. *Disease fungicide on economic analysis of Hot pepper.*

Treatments	Ave yield (kg ha^{-1})	Adj yield (kg ha^{-1})	TVC	Gross return	Net Benefit	MRR (%)
Furrow bed+ Apron star and Mancozeb	1800	1620	60480	1800000	1739520	0

Treatments	Ave yield (kg ha^{-1})	Adj yield (kg ha^{-1})	TVC	Gross return	Net Benefit	MRR (%)
Untreated furrow bed	790	711	49880	790000	740120	9428.3
Flatbed + Apron star and Mancozeb	2620	2358	60480	2620000	2559520	17164.2
Untreated Flat bed	1130	1017	49880	1126000	1076120	13994.3
Raised bed+ Apron star and Mancozeb	3350	3015	60480	3350000	3289520	20881.1
Untreated Raised bed	1110	999	45000	44955000	1065000	14370.3

4. Conclusion and Recommendations

Seed treatment followed by seedling treatment and foliar spraying of fungicide Mancozeb 80 WP can be applied to manage the devastating Hot pepper disease. Similarly, Sowing of Hot pepper on raised and Ridge seed beds were superior to sowing on flat bed and others on the vegetative parameters to manage the devastating Hot pepper disease at seedbed (Raised seedbed) and after transplanted (Ridge seedbed). The maximum reduction of Hot pepper diseases severity observed in raised seedbed by seed treatment (Damping-off and Fusarium wilting diseases) and observed in Ridge seedbed by foliar spraying of fungicide Mancozeb 80WP (Cercospora leaf spot, Blossom end rot, Bacterial leaf spot, Fusarium wilting, Blossom end rot and Anthracnose diseases). Therefore, on the basis of present investigation it recommended that seed treatment with Apron Star followed by seedling treatment and foliar spraying of fungicide Mancozeb 80 WP at recommended rate (after transplanted with interval of two weeks) and sowing of hot pepper on raised seedbed and transplanted on Ridge seedbed can be applied to manage the devastating Hot pepper diseases.

Abbreviations

RCBD	Randomized Complete Block Design
ANOVA	Analysis of Variance
LSD	Least Significant Difference
DAT	Days After Transplanted
MRR	Marginal Rate of Returns
TVC	Total Variable Costs

Author Contributions

Takele Kusa: Conceptualization, Data curation, Formal Analysis, Methodology, Project administration, Software, Supervision, Writing – original draft, Writing – review & editing

Alemayehu Abdeta: Conceptualization, Formal Analysis, Methodology, Writing – review & editing

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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