American Journal of Plant Biology
2024, Vol. 9, No. 4, pp. 100-105
https://doi.org/10.11648/j.ajpb.20240904.11

Research Article

Influence of Plant Density and Fungicides on Downy Mildew (*Peronospora Destructor*) and Bulb Yield of Onion in Ethiopia

Adina Getinet*, Desalegn Yalew, Muluadam Berhan

Ethiopian Institute of Agricultural Research, Fogera National Rice Research and Training Center, Bahir Dar, Ethiopia

Abstract

Onion is a popular vegetable crop, which has been produced for its daily uses and economic benefits. Downey mildew caused by the fungus *Peronospora destructor* is among the most important yield-reducing factor in onion production. The effect of three different levels of plant population and fungicide frequency with two different fungicides was studied on downy mildew severity and yield of onion. Nineteen treatment of this Experiment included two fungicides mancozeb + metalaxyl and copper hydrox-ide, three different spraying interval with (10 days, 15 days and 21 days) and three level of plant population (0.71, 0.95 and 1.2 million plants/ha). The experiment was laid out in a randomized block design with three replications for two year at Fogera and for one year at Dera districts of South Gondar zone Ethiopia. Data on disease severity, bulb yield, bulb number and bulb size were recorded during the time of harvest. The price of bulb yield was assessed from the local market and the total price of the yield obtained from each treatment was computed on hectare basis. Input costs like seed, fungicides and labor were converted into hectare basis according to their frequencies used. Fungicides cost was estimated based on the price of the local market. Cost of the labor was in Birr per man-days; cost of spray and spray equipment to spray per hectare were also calculated. Based on the obtained data from the above mentioned parameters economic analysis was performed. The lowest disease severity was recorded in treatment were lowest level of plant population (0.71 million plant/hectare) spraying with fungicide mancozeb + metalaxyl within 15days interval. In this treatment bulb yield and bulb weight were the highest. The economic evaluation showed that the highest net benefit with acceptable marginal rate of return was obtained from T3 (0.71million plants/ha spraying with fungicide mancozeb + metalaxyl within 15days interval).

Keywords

Audpc, Onion, Downy Mildew, Fungicide, Plant Density

1. Introduction

Onion (Allium cepa L.) is one of the most useful and essential spices of vegetable crops grown in many countries of the world, including Ethiopia. However, Productivity of the crop is below the world and African averages due to pests, diseases and low level of improved agricultural technology [1]. Among the most important onion diseases, Purple blotch and downy mildew have been reported in Ethiopia [2, 3]. Downy mildew of onion, caused by the fungus Peronospora

*Corresponding author: adinagetinet@gmail.com (Adina Getinet)

Received: 29 August 2024; **Accepted:** 19 September 2024; **Published:** 10 October 2024

destructor Berk, is worldwide in occurrence and causes devastating economic losses to the crop [4-6]. Yield reductions of onion bulbs due to downy mildew outbreaks may range from 30% up to 70% when the environment is conducive for the disease [7-10]. The disease attacks the plants at all stages of growth and all parts of the plant may be invaded [11].

A number of chemicals have been evaluated by different researcher to control the disease. Among the fungicides Ridomil is the most effective in reducing the disease severity and enhancing yield [12]. However, frequent application of fungicide is costly and ineffective due to the high price and inappropriate use of fungicides. Significant influence of variable fertilizer levels and plant density on downy mildew have been reported [13, 14]. Thus reducing fungicide frequency by integrating host management practices could decrease the risk to human health and increase the economic benefit for farmers. The objective of this study was to evaluate the effect of plant density and reduced fungicide application frequency for management of downy mildew and yield of onion.

2. Materials and Methods

Nineteen treatment of this Experiment included two fungicides mancozeb + metalaxyl and copper hydroxide, three different spraying interval with (10 days, 15 days and 21 days) and three level of plant population (0.71, 0.95 and 1.2 million plants/ha). The experiment was laid out in a randomized block design with three replications for two year at Fogera and for one year at Dera districts of South Gondar zone Ethiopia. The seeds of onion were sown in seedling bed. The 45 day old seedlings were uprooted from the seed bed and were planted in field. After first appearance of downy mildew data on its severity (1-9 scale) were recorded [15] and converted to Area under disease progress curve (AUDPC) [16]. Other data on bulb yield, bulb number and bulb size were recorded during the time of harvest.

The price of bulb yield was assessed from the local market and the total price of the yield obtained from each treatment was computed on hectare basis. Input costs like seed, fungicides and labor were converted into hectare basis according to their frequencies used. Fungicides cost was estimated based on the price of the local market. Cost of the labor was in Birr per man-days; cost of spray and spray equipment to spray per hectare were also calculated.

Based on the obtained data from the above mentioned parameters economic analysis was performed according to the procedure [17]. The dominance analysis procedure as detailed in the economics training manual by CIMMYT was used to select potentially profitable treatments from the range that was tested and serve to eliminate some of the treatments from further consideration and thereby simplify the analysis [17]. The dominant or dominated treatments were ranked from lowest to highest costs that vary (Table 2). A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary [18].

3. Result and Discussion

3.1. Effects of Plant Density and Fungicide on Area Under Disease Progress Curve (AUDPC)

Significant difference were observed in AUDPC for different treatments during two year at both locations (Tables 1 and 3). The lowest AUDPC (717.5-755) were recorded on T3, T4, T5 and T6, at Fogera during 2020 year. At Dera, lowest AUDPC (320-472.5) were recorded on T1, T2, T3, T5, T6, T10, T11, T12 and T13 during 2020 year. The lowest AUDPC was also recorded in T5, T6, T12 and T13 at Fogera in 2021 (Table 3). These treatments did not differ significantly from each other with respect to mean AUDPC value reduction; however, all these treatments significantly reduced mean AUDPC value as compared to the highest AUDPC value in other treatment (Tables 1 and 3). Thus minimum plant population (0.71 million plants/ha) with reduced fungicide frequency (with15 day interval) effectively reduced mean AUDPC values. Similar results were also reported by [19] who indicated that the lowest downy mildew and purple blotch percentage in onion plants was obtained from the lowest plant density (30 plants/m^2) in 2014/15 and 2015/16 seasons. This can be attributed to the increased plants per meter in dense stands, which are known to increase the moisture between plants at high plant density leading to high percentage in downy mildew disease.

3.2. Effects of Downy Mildew on Onion Bulb Yield and Average Bulb Weight

The two year data (2020-2021) showed significant differences among different treatments indicating the effect of plant population, fungicides and fungicide intervals on onion bulb yield and average bulb weight at both locations (Fogera and Dera) (Tables 1 and 3). During 2020, the highest bulb yield (236.11-250q/ha) and highest bulb weight (57.58-64.1g) were observed in T3, T4, T5 and T6 at Fogera (Table 1). Bulb yield (186.11-216.67q/ha) and bulb weight (39.1-45.81g) were also the highest in T3, T4, T5 and T6 at Dera during 2020 year (Table 3). These treatments did not differ significantly from each other with respect to bulb yield increment; however, all these treatments significantly increased bulb yield as compared to the lowest bulb yield in other treatments (Tables 1 and 3). Thus, reduced fungicide frequency (with 15 days interval) with minimum plant density (0.71 million plants/ha) effectively reduced downy mildew diseases severity and increased bulb yield. However, Bulb yield (152.08q/ha) and bulb weight (48.75g) were the highest in T1 (0.7 million/ha sprayed with mancozeb + metalaxyl fungicide in 21 days

interval) at Fogera during 2021 year (Table 1). It might be due to the low disease pressure occurred during the experimental period.

Table 1. *Effect of Plant density and fungicides on Downy mildew severity and yield of onion at Fogera during 2020 and 2021 cropping season.*

		2020	Year		2021	year	
Tr.no	**Treatments**	**AUDPC**	**Y (q/ha)**	**BW (g)**	**AUDPC**	**Y (q/ha)**	**BW**
1	P2F1I3	842.5	200	55.14	448.73	152.083	48.7533
2	P2F2I3	877.5	219.45	58.19	405.40	95.8333	31.8833
3	P2F1I2	730	244.45	57.58	406.60	139.583	46.31
4	P2F2I2	755	236.11	58.25	366.67	129.167	40.08
5	P2F1I1	717.5	250	64.1	346.67	127.083	41.13
6	P2F2I1	755	250	57.97	396.40	122.917	36.06
7	P1-F0	1700	140.74	29.59	454.79	120.833	35.39
8	P1F1I3	1007.5	131.48	37.44	420.77	124.307	32.9467
9	P1F2I3	1137.5	162.97	34.08	360.93	151.853	42.0267
10	P1F1I2	732.5	174.08	41.63	354.09	143.517	43.8967
11	P1F2I2	707.5	157.41	34.21	386.28	110.187	31.6733
12	P1F1I1	717.5	170.37	37.94	353.29	147.22	40.4167
13	P1F2I1	717.5	148.15	32.87	303.99	130.093	49.4467
14	P3F1I3	1412.5	190.74	27.82	475.53	130.953	20.54
15	P3F2I3	1625	164.82	25.56	449.05	171.42	27.86
16	P3F1I2	1465	170.37	25.32	480.87	190.477	28.2333
17	P3F2I2	1337.5	170.37	26.62	463.35	190.48	34.0167
18	P3F1I1	1365	177.78	22.95	463.92	154.76	25.66
19	P3F2I1	1350	201.85	28.94	443.20	180.95	32.7233
	CV (%)	22.62	13.35	14.43	9.82	18.35	16.24
	LSD	392.68	32.07	9.49	66.51	43.3	9.73

Table 2. *Partial budget analysis of plant density and fungicides effect on Downy mildew of onion at Fogera and Dera in 2020 and 2021 cropping season.*

		Fogera				Dera	
			2020		2021	2020	
Treatments		**TVC**	**NB**	**MRR (%)**	**NB**	**NB**	**MRR (%)**
1	P2F1I3	151948.3	217491.7		124161.7	118051.70	
2	P2F2I3	153508.3	252501.7	2244.231	21741.7	156487.70	2463.85
3	P2F1I2	154308.3	297501.7	5625	99301.7	235697.70	9901.25
4	P2F2I2	156258.3	282489.7D		78991.7	178739.7D	

		Fogera				Dera	
			2020		2021	2020	
Treatments		TVC	NB	MRR (%)	NB	NB	MRR (%)
5	P2F1I1	159028.3	307491.7	211.6525	74441.7	205975.7D	
6	P2F2I1	161758.3	307491.7D		64991.7	203245.7D	
7	P1-F0	188761.1	64570.9D		28738.9	57910.9D	
8	P1F1I3	198201.1	47902.9D		27910.9	45140.9D	
9	P1F2I3	199761.1	104584.9D		76324.9	30242.9D	
10	P1F1I2	200561.1	124582.9D		60128.9	79446.9D	
11	P1F2I2	202511.1	94576.9D		-1425.1	67488.9D	
12	P1F1I1	205281.1	117904.9D		64434.9	74726.9D	
13	P1F2I1	208011.1	77908.9D		31656.9	85316.9D	
14	P3F1I3	245395.9	107376.1D		-7319.9	91276.1D	
15	P3F2I3	246955.9	60720.1D		64350.1	-283.9D	
16	P3F1I2	247755.9	70710.1D		97462.1	78908.1D	
17	P3F2I2	249705.9	70710.1D		95908.1	43622.1D	
18	P3F1I1	252475.9	84048.1D		30812.1	64198.1D	
19	P3F2I1	255205.9	127374.1D		76004.1	34792.1D	

TVC: total variable cost; NB: net benefit; MRR: marginal rate of return; D: dominated treatment (MRR less than 100%)
D: Dominated treatment (MRR less than 100%)

3.3. Economic Analysis of Fungicides and Application Methods Effects on Pepper Wilt

Economic analysis results showed that highest net benefit with acceptable marginal rate of return were obtained from treatment five and three at Fogera and Dera, respectively, during 2020 year (Table 2). According to the manual for economic analysis, The identification of a recommendation is based on the minimum acceptable marginal rate of return, and the treatment with the highest net benefit together with an acceptable MRR becomes the tentative recommendation [17]. In this study, 100% was considered as minimum acceptable rate of return for farmers' recommendation. It is important to note that the acceptable minimum rate of return for farmers' recommendation is 50 to 100% (CIMMYT, 1988). Accordingly, the study revealed that Highest net benefit with acceptable marginal rate of return were obtained T5 (0.71million plants/ha spraying with fungicide mancozeb + metalaxyl within 10 days interval) and T3 (0.71million plants/ha spraying with fungicide mancozeb + metalaxyl within 15days interval) is effective treatment at Fogera and Dera, respectively, during 2020. Highest net benefit was obtained in T1 which had the lowest variable cost at Fogera during 2021 year (Table 2).

Table 3. *Effect of Plant density and fungicides on Downy mildew severity and yield of onion Dera during 2020 cropping season.*

	Treatments	AUDPC	Yield	BW
1	P2F1I3	410	150	39.1933
2	P2F2I3	472.5	172.22	40.88
3	P2F1I2	472.5	216.67	41.11
4	P2F2I2	555	186.11	39.1033
5	P2F1I1	320	202.78	41.45
6	P2F2I1	357.5	202.78	45.81
7	P1-F0	1137.5	137.04	35.08
8	P1F1I3	567.5	135.19	31.0733
9	P1F2I3	512.5	127.78	36.61
10	P1F1I2	407.5	155.56	44.52
11	P1F2I2	410	150	39.04
12	P1F1I1	345	155.56	39.97

	Treatments	AUDPC	Yield	BW
13	P1F2I1	347.5	162.96	36.9967
14	P3F1I3	885	187.04	25.8933
15	P3F2I3	795	137.04	22.8267
16	P3F1I2	842.5	181.48	22
17	P3F2I2	1015	162.96	25.16
18	P3F1I1	782.5	175.93	25.5767
19	P3F2I1	672.5	161.11	24.42
	CV (%)	9.82	18.35	16.24
	LSD	66.51	43.3	9.73

However, the highest net benefit was obtained in T1 (0.71million plants/ha spraying with fungicide mancozeb + metalaxyl within 21 days interval) that had lower costs that vary and all other treatments had dominated at Fogera during 2021 year. A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary [18]. So, marginal rate of return could not be calculated at Fogera during 2021 year. This indicates that, the value of the increase in yield is not enough to compensate for the increase in costs. It might be due to the low disease pressure occurred during the experimental period and the plant population difference of the treatment. Hence, growers would be better off using lowest level of plant population with minimum fungicide frequency when lowest diseases pressure occurred.

4. Conclusion and Recommendation

From the obtained results and from the economic point of view it can be concluded that lowest level of plant population (0.7 million/ha) sprayed with mancozeb + metalaxyl fungicide in 15 days interval was more economical for the management of onion downy mildew and increases bulb yields. Further, cost effective and feasible integrated management options need to be developed for onion downy mildew in the country.

Abbreviations

AUDPC	Area under Disease Progress Curve
BW	Bulb Weight
D	Dominated Treatment
I1	Fungicide Sprays Interval One (10 Days Interval)
I2	Fungicide Sprays Interval Two (10 Days Interval)
I3	Fungicide Sprays Interval Three (21 Days Interval)
MRR	Marginal Rate of Return
NB	Net Benefit
P1	Plant Population One (0.71 Million Plants/Ha)
P2	Plant Population Two (0.95 Million Plants/Ha)
P3	Plant Population Three (1.2 Million Plants/Ha)
TVC	Total Variable Cost
Y	Yield

Acknowledgments

The authors would like to thank the Ethiopian Institute of Agricultural Research (EIAR) for the financial and logistic support.

Author Contributions

Adina Getinet: Conceptualization, Project administration, Writing – original draft

Desalegn Yalew: Supervision, Writing – review & editing

Muluadam Berhan: Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Muluneh BE, C Mosissa, OF Bikila. Major Onion (Allium cepa L.) Production Challenges in Ethiopia: A Review. Food Science and Quality Management, 86: 1-6.

[2] Bewuketu Haile, Tsegaye Babege and Awalom Hailu. 2016. Diseases and Insect Pests of Onion (Allium cepa L.) in Masha District of Sheka Zone, South-West Ethiopia. Academia Journal of Agricultural Research 4(10): 629-632.

[3] Adina G, D Yalew, M Berhan. 2021. Survey on Major Diseases of Vegetable and Tuber Crops in South Gondar Zone, Ethiopia. In: Birhanu et al., (ed.). Results of Plant Protection Research. Proceedings of the Completed Plant Protection Research Activities. p. 106-111.

[4] Cook, H. T. (1932). Downy mildew disease of onion. *NY Agric. Exp. Station. Ithaca, New York. Mem*, *143*, 1-40.

[5] Viranyi, F. 1974. Downy mildew of onion. Novenyvdlem. 10: 205-209.

[6] Yadav, P. M., Rakholiya, K. B. and Pawar, D. M. 2013. Evaluation of bioagents for management of the onion purple blotch and bulb yield loss assessment under field conditions. The Bioscan, 8 (4), 1295-1298.

[7] Van Doorn, A. M. 1959. Onderzoekingen over het optreden en de bestrijding van valsemeeldauw (Peronospora destructor) bijuien. TijdschrivenPlantenziekten, 65, 193–255.

[8] Maude, R. B. 1990. Leaf diseases of onions. In: "Onion and Allied Crops" H. D. Rabinowitch & J. L. Brewster (Ed.), pp. 173–212. Boca Raton: CRC.

[9] Raziq, F., I. Alam, Naz, I. and Khan, H. 2008. Evaluation of fungicides for controlling downy mildew of onion under field conditions. Sarhad J. Agric. 24(1), 85- 92.

[10] Pablo, H. Gonzalez and Colnago, P. 2011. Quantitative studies on downy mildew (Peronospora destructor Berk. Casp.) afecting onion seed production in southern Uruguay. Eur. J. Plant Pathol. 129, 303– 314.

[11] Butler JE, SD Jones. 1955. Plant Pathol. Macmillan and Co., New York. 693 pp. Cook, H. T. 1932. Downy mildew disease of onion. N.Y. Agric. Exp. Station. Ithaca, New York. Mem. 143: 1-40.

[12] Fazli R, A Ishtiaq, N Ishrat, K Hakim. 2008. Evaluation of Fungicides for Controlling Downy Mildew Of Onion Under Field Conditions. Sarhad Journal of Agriculture, 24 (1): 85-9.

[13] Yemane K, B Derbew, A Fetien. 2013. Effect of intra-row spacing on yield and quality of some onion varieties (Allium cepa L.) at Aksum, Northern Ethiopia. African Journal of Plant Science, 7(12): 613-622.

[14] Geisseler D, SO Roberto, J Diaz. 2022. Nitrogen nutrition and fertilization of onions (Allium cepaL.)- A literature review. Scientia Horticulturae, 291: 110591.

[15] Mohibullah. 1992. Studies on major diseases of bulb vegetables (onion and garlic) in NWFP. Final Tech. Rep. Agric. Res. Instt. Tarnab. 130 pp.

[16] Shaner G, RE Finney. 1997. The effect of nitrogen fertilization on the expression of slow mildewing resistance in wheat. Phytopathology, 67: 1051-1056.

[17] CIMMYT (International Maize and Wheat Improvement Center). 1988. From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely revised edition. Mexico, D.F. 84 p.

[18] Stephen K, M Nicky. 2007. In service training on partial budgeting techniques. Mount Makulu, Lusaka, Zambia.

[19] Aboukhadrah SH, AWAH El-Alsayed, L Sobhy, W Abdelmasieh. 2017. Response of onion yield and quality to different planting date, methods and density. Egyptian Journal of Agronomy, 39(2): 203-219.