Plant Pathology & Quarantine 10(1): 111–119 (2020) ISSN 2229-2217
www.ppqjournal.org **Article**

Doi 10.5943/ppq/10/1/13

Development of integrated disease management program against Anthracnose-Twister (*Colletotrichum gloeosporioides-Gibberella moniliformis*) disease of onion (*Allium cepa*)

Alberto RT[1] and Perez PM[2]

[1]Department of Crop Protection, College of Agriculture, Central Luzon State University, Science City of Muñoz Nueva Ecija, Philippines
[2]Institute of Graduate Studies, Department of Crop Protection, College of Agriculture, Central Luzon State University, Science City of Muñoz Nueva Ecija, Philippines

Alberto RT, Perez PM 2020 – Development of integrated disease management program against Anthracnose-Twister (*Colletotrichum gloeosporioides-Gibberella moniliformis*) disease of onion (*Allium cepa*). Plant Pathology & Quarantine 10(1), 111–119, Doi 10.5943/PPQ/10/1/13

Abstract

Anthracnose-Twister disease caused by *Colletotrichum gloeosporioides* and *Gibberella moniliformis* has always been the major problem of onion growers every onion season due to absence of efficient and cost effective management system, thus, this study was conceptualized by integrating all the available management approaches to put the disease at bay. The results showed that management program T3 (Benomyl-Propineb-Difenoconazole~Propiconazole (DP)-Difenoconazole-Carbendazim-Mancozeb-*Trichoderma* sp.) had the lowest % disease incidence and severity, where ideal size of the marketable bulbs, highest number and heaviest weight of the marketable bulbs were also obtained. It was also found out to be the most cost effective management program and had the highest net income. On the otherhand, highest % mortality was observed in T4 (Carbendazim---Mancozeb---Difenoconazole---*Trichoderma* sp.---Benomyl---Propineb---DP) and T9 (Untreated Control). It was also in this plots together with T8 (Farmer's Practice) where the highest level of % incidence and % severity, lowest and lightest weight of the marketable bulbs were obtained. Furthermore, late transplanting date as well as using 15x15cm spacing between hills and rows and 5-day irrigation interval contributed against the occurrence of anthracnose-twister disease. The weather factors prevailing in the area were found to have an influence in the occurrence and progress of the disease in all the treated plots as well as in the control plots (T9) as it shows strong relationship between low temperature and small amount of rainfall which promotes low levels of incidence and severity. Moreover, results showed that application of protectant fungicide during the early part of the season followed by systemic fungicide application can bring down the disease incidence and severity as adequate protection to the plants were provided.

Key words – Anthracnose – Twister – Disease – Integrated – Disease Management – (IDM) Management Programs

Introduction

Anthracnose-Twister disease of onion caused by *Colletotrichum gloeosporioides* and *Gibberella moniliformis* remains destructive in most onion fields every cropping season. The

Submitted 20 June 2020, Accepted 9 October 2020, Published 22 October 2020
Corresponding Authors: Ronaldo T. Alberto – e-mail – travert2157@gmail.com,
Princess M. Perez – email – przprncss@gmail.com

disease complex causes 80% to 100% yield loss which could result to low supply of onion in the market resulting to high price (Alberto & Aquino 2010). Therefore, quick response and immediate actions are always crucial in addressing this disease because it can affect the entire onion industry as well as leaving a devastating mark in every farmer's lives. However, as reported by Alberto & Aquino (2010) there is still no effective management yet developed against the disease because the *Gibberella moniliformis* which is one of the causal organisms is a facultative endophyte which is hard to control even by fungicide applications. Hence, a single management is not enough and obviously cannot handle nor defeat the two pathogens. Although a lot of studies and experiments were conducted in trying to find a management approach that would put the disease at bay, yet still unsuccessful, thus integration of different disease management approaches should be formulated against the two pathogens to generate a series of plan and action that will result into a strong program against the disease. Thus, this study was conducted to; (a) develop an integrated disease management program for the anthracnose-twister disease of onion; (b) evaluate the effectiveness of different combinations of approaches that result into an effective management program; (c) determine the prevailing environmental conditions in the area that contribute to the occurrence of the disease and (d) determine which among the management program was the most cost effective that can be recommended to the farmers.

Materials & Methods

Transplanting

The 50-day old onion seedlings were transplanted in a raised bed (~5cm high) with the length of ~3m and ~2m wide. The ~30cm distance was provided between experimental plots. Prior to transplanting, the seedlings were dipped first in the different assigned treatments which were also used and sprayed 10 days after transplanting (Table 1). Management programs applied to the onion plants used the manufacturer's recommended rates of six (6) commercial fungicides and one (1) biological agent (Table 2) which had different spraying schedules (Table 1). The experimental plots were arranged in Randomized Complete Block Design (RCBD) with five blocks or replications.

Gathered Data

Meteorological and other environmental factors contributory to the incidence and severity of the anthracnose-twister disease of onion were also determined and correlated with each other. Weather parameters such as relative humidity, minimum and maximum temperature (°C) and rainfall (mm) were collected. Regular monitoring and recording of observations were carried out starting from seed sowing up to harvesting period. Assessment of the disease was carried out from the transplanting period up to the application of different Integrated Disease Management (IDM) programs. Percent disease incidence and severity was recorded on a weekly basis and calculated using the formula below and scored using the 0-9 scale as described by Alberto (2014). Moreover, data such as percent mortality of the transplanted onion plants, yield per plot, marketable and non-marketable yield, size and weight of the marketable bulbs were also recorded. The data were analyzed using the IBM SPSS V.25. Tukey's Honest Significant Difference (HSD) was used to compare the treatment means.

$$\text{Disease Incidence (\%)} = \frac{\text{Number of plants infected}}{\text{Total number of plants}} \times 100$$

$$\text{Disease Severity (\%)} = \frac{\text{Total number of infected leaves classified by grade}}{\text{Total number of leaves examined/plot} \times 9} \times 100$$

Table 1 Schedule of management programs used in the field experiment.

Treatment	Application						
	10 DAT*	**17 DAT**	**24 DAT**	**31 DAT**	**38 DAT**	**45 DAT**	**52 DAT**
1	T**	T	T	T	T	T	T
2	M**	D	T	DP	P	C	B
3	B**	P	DP	D	C	M	T
4	C**	M	D	T	B	P	DP
5	D**	B	P	C	M	DP	T
6	DP**	C	M	B	D	T	P
7	P**	DP	C	M	T	B	D
8	M**	--	--	--	--	--	--
9	--	--	--	--	--	--	--

* DAT-Days After Transplanting
** T-*Trichoderma* sp., M-Mancozeb, B-Benomyl, C-Carbendazim, D-Difenoconazole, DP-Difenoconazole-Propiconazole, P-Propineb

Table 2 Commercial fungicides and biological agent used in the field experiment.

Trade name	Active ingredient	Recommended rate	Manufacturer
TrichoPlus	*Trichoderma* sp.	250g/16L	Ramon Magsaysay Center for Agricultural Resources and Environment Studies (RM-CARES), CLSU
Antracol	Propineb (700g/kg)	50-65g/16L	Bayer
Armure 300 EC	Difenoconazole (150g/kg) Propiconazole (150g/kg)	15-20ml/16L	Syngenta Phil. Inc
Ben-on-Time	Benomyl (500g/kg)	10-20g/16L	Fulon Chemical Industrial Company
Dithane M-45	Mancozeb (800g/kg)	30-60g/16L	Dow AgroSciences
Score 250 EC	Difenoconazole (250g/L)	10-20ml/16L	Syngenta Phil. Inc
Sundazim 50 WP	Carbendazim (500g/kg)	10-20g/16L	Marthdave Company

Results & Discussion

% Disease Incidence

The different management programs tested showed significant effects on the incidence and severity of the disease as compared to the control (with no intervention at all). Among the management programs, T3 (Benomyl-Propineb-Difenoconazole~Propiconazole(DP)-Difenoconazole-Carbendazim-Mancozeb-*Trichoderma* sp.) seemed to perform well as it exhibited the lowest % incidence of the disease, followed by T5

(Difenoconazole-Benomyl-Propineb-Carbendazim-Mancozeb-DP-*Trichoderma* sp.) and T4 (Carbendazim-Mancozeb-Difenoconazole-*Trichoderma* sp.-Benomyl-Propineb-DP). Highest % incidence was observed in T8 (Mancozeb) and T1 (*Trichoderma* sp.) (Fig. 1).

% Disease Severity

The severity levels in onion plants treated with different management programs were also significantly lower than the control plants most specifically in T3 and then followed by T5 and T4. Among the different management programs T8 had the highest severity level followed by T1 (Fig. 2). Overall, disease severity was not that damaging to the onion plants.

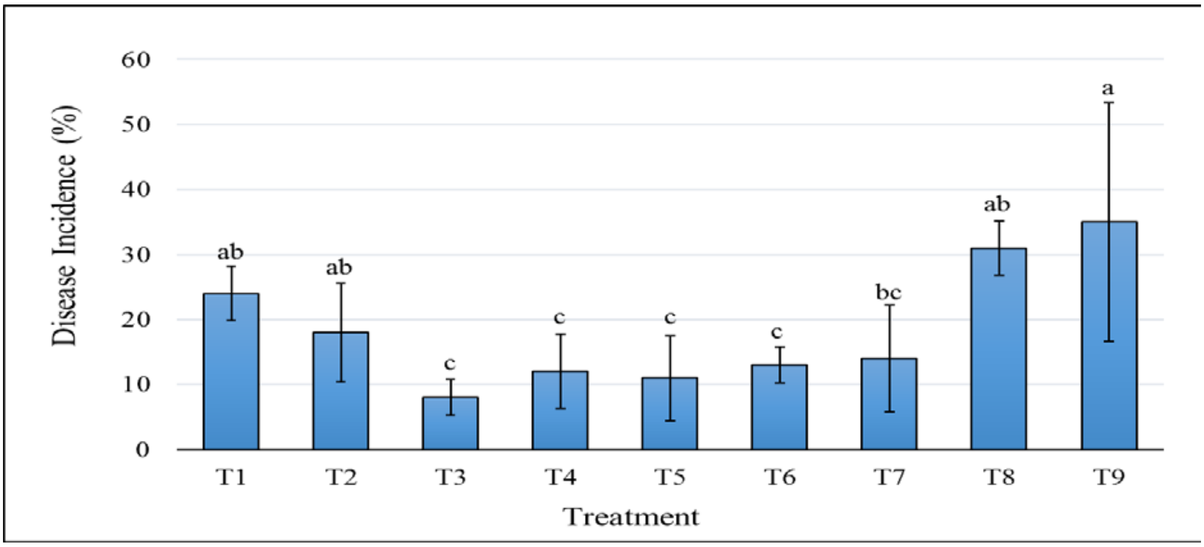

Fig. 1 – Disease incidence (%) of the onion plants at Olivete, Bongabon Nueva Ecija (Dry Season, 2019)

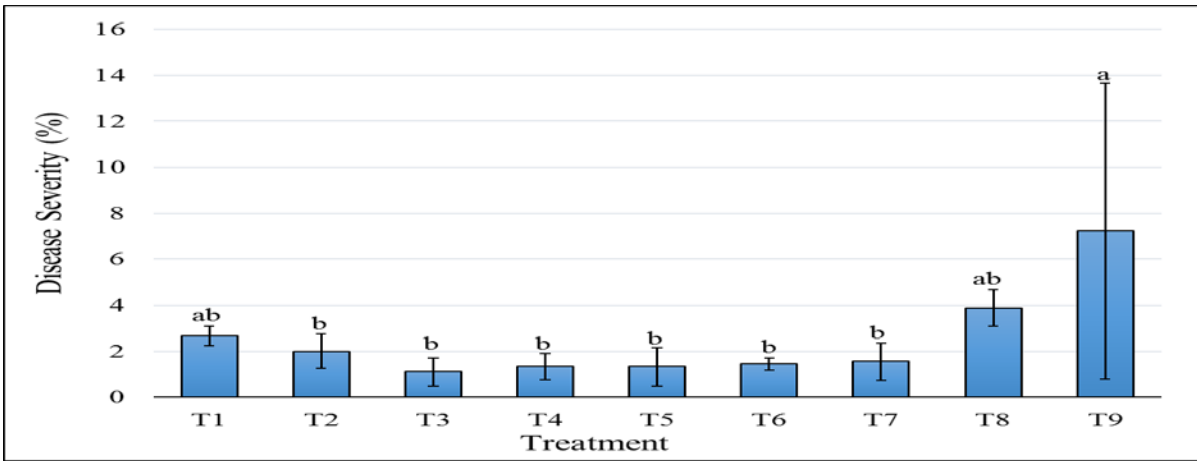

Fig. 2 – Disease severity (%) in the onion plants at Olivete, Bongabon Nueva Ecija (Dry Season, 2019)

Percent Mortality of Transplanted Onion Plants

The highest percentage of onion plant mortality was recorded in the T9 (control plots) followed by T4 (Carbendazim-Mancozeb-Difenoconazole-*Trichoderma* sp.-Benomyl-Propineb-Difenoconazole~Propiconazole (DP)) and T1 (*Trichoderma* sp.) whereby, yellowing of the leaves and bulb rotting were commonly observed (Fig. 9). On the other hand, T6 (DP-Carbendazim-Mancozeb-Benomyl-Difenoconazole-*Trichoderma* sp.-Propineb) had the lowest percentage of mortality, though statistically it was not significantly different among the other treatments (Fig. 3).

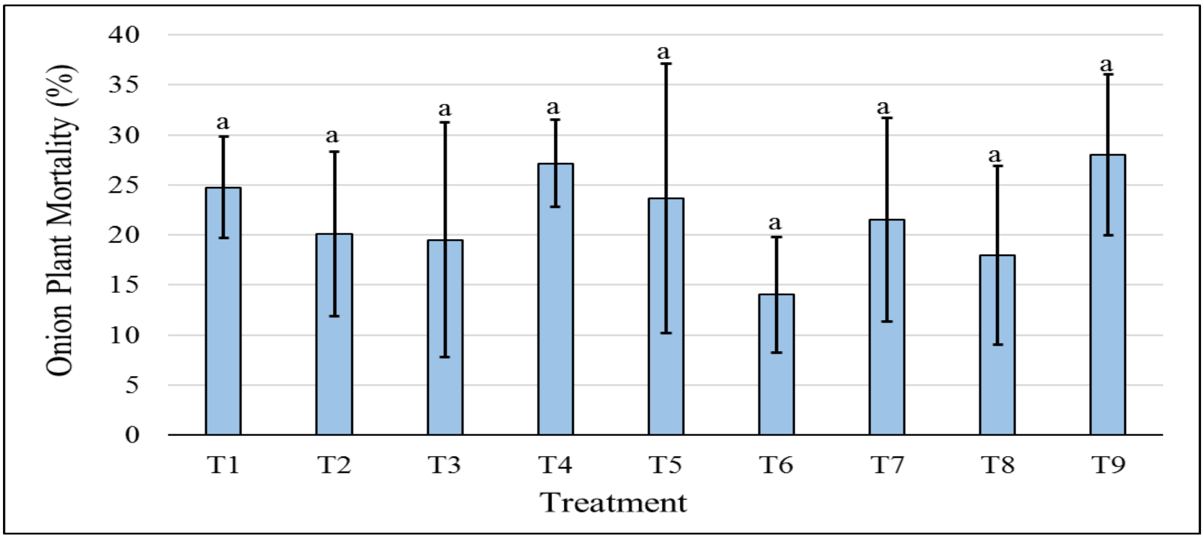

Fig. 3 – Percent mortality of onion plants under field experiment at Olivete, Bongabon Nueva Ecija (Dry Season, 2019)

Yield (kg)

T3 (Benomyl-Propineb-DP-Difenoconazole-Carbendazim-Mancozeb-*Trichoderma* sp.) had the highest number of marketable bulbs and the lowest number was recorded in the T9 (control plots). The high percentage of marketable bulbs were observed in the treated onion plants whereas, high non-marketable bulbs (%) were obtained in the control plots (T9) (Fig. 4).

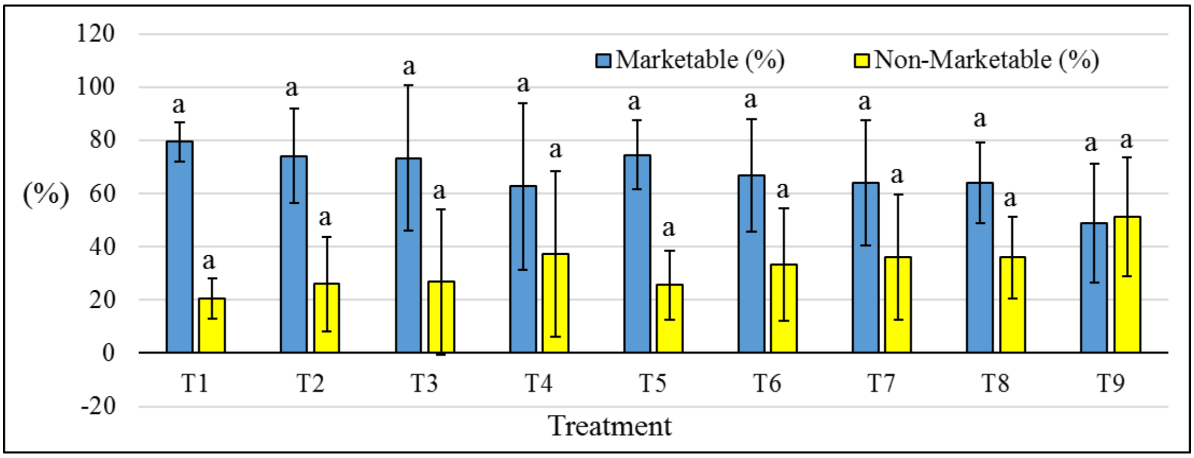

Fig. 4 – Marketable (%) and non-marketable bulbs (%) in the field experiment at Olivete, Bon Gabon Nueva Ecija (Dry Season, 2019

Bulb Diameter (mm)

Based on the results, the acceptable diameter of marketable bulbs reached 46.27 mm which was recorded in the T3 (Benomyl-Propineb-DP-Difenoconazole-Carbendazim-Mancozeb-*Trichoderma* sp.) and considered the most ideal size that fits with the market demand (Fig. 13). It was significantly accepted among other treatments particularly in the T1 (45.22mm), T2 (44.46mm), T4 (42.92mm), T5 (44.89mm), T6 (43.78mm) and T7 (42.87mm) (Fig. 5).

Weight of Onion Bulbs (kg)

Based on the projected weight of the yield it showed that on the average, onion plants under T3 (Benomyl-Propineb-DP-Difenoconazole-Carbendazim-Mancozeb-*Trichoderma* sp.) had the heaviest weight and in T9 (control plots) where the lightest weight was observed (Fig. 6). Though, it did not statistically differ from the other treatment means.

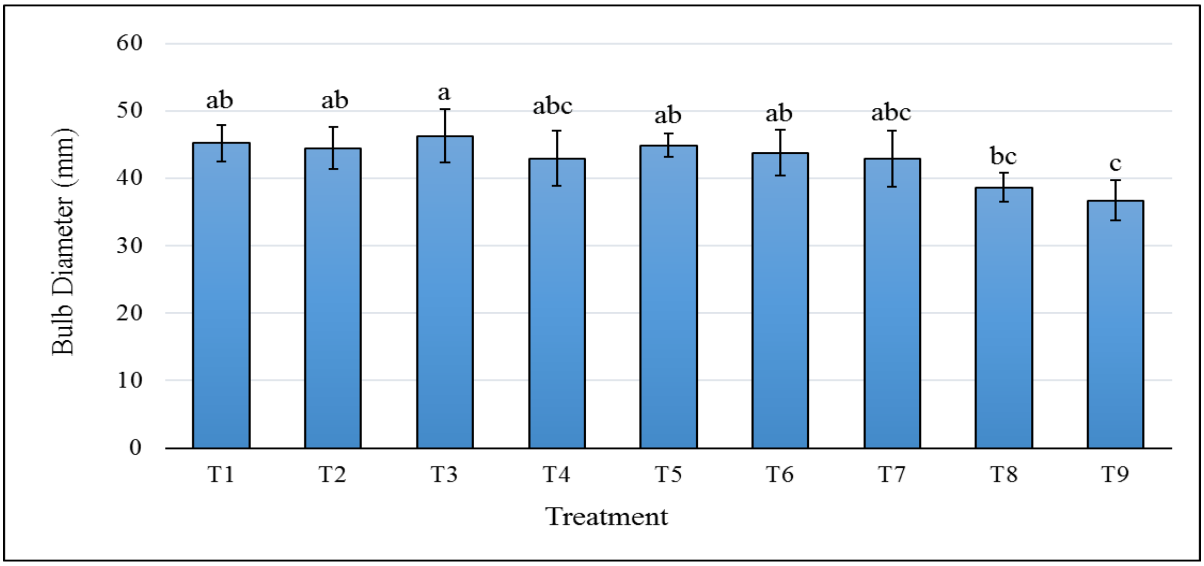

Fig. 5 – Diameter (mm) of marketable onion bulbs in field experiment at Olivete, Bongabon Nueva Ecija (Dry Season, 2019)

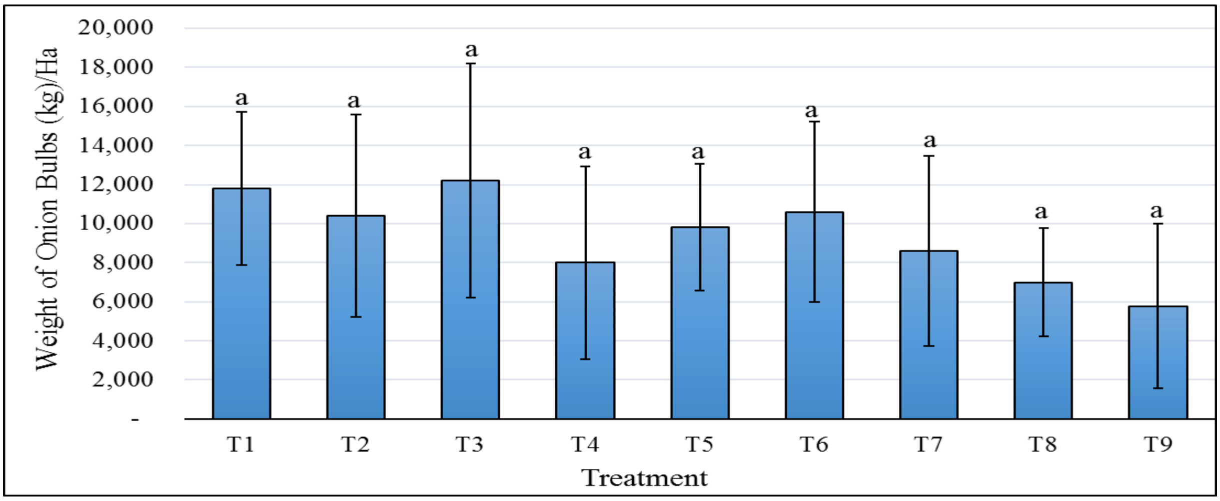

Fig. 6 – Weight of onion bulbs (kg)/ha in field experiment at Olivete, Bongabon Nueva Ecija (Dry Season, 2019)

A delay in the disease development was observed in the treated onion plants with late transplanting date as one of the reasons for the delay. The weather parameters crucial for the development of the disease during that time were quite favorable for the development of the disease but management interventions were already carried out, as shown by the low levels of incidence and severity. Based on the results, it was also important to take note and consider the transplanting date as the fundamental part of cultural management. It showed that late transplanting date promoted disease escape and prevented further disease development inspite of the presence of favorable weather factors such as temperature, relative humidity and heavy rainfall which affected the development of the disease. To develop an effective disease management program, the compatibility of potential bio-agents with fungicides is essential. Combinations of fungicides and compatible bio-agents in an Integrated Disease Management (IDM) strategy protects the seeds and seedlings from soil borne and seed borne inoculum (Dubey & Patil 2001). Integration of compatible bio agents with fungicides may enhance the effectiveness of disease control and provide better management of soil borne diseases (Papavizas & Lewis 1981). Silimela & Korsten (2001) have reported also that the efficiency of the biological control agent could further be improved when it was applied with the recommended fungicide and used at a lower concentration.

Meteorological Factors Involved in the Anthracnose-Twister Disease Development

Weather parameters such as temperature (°C), relative humidity and rainfall were collected from NASA (https://power.larc.nasa.gov//). Based on the observations, during the plant recovery period until the growing period, the prevailing meteorological factors were ideal for the growth and development of the onion plants and not for the development of the anthracnose-twister disease as shown by low temperature and low relative humidity. The anthracnose-twister pathogens were actually favored by high temperature (27-29°C) and high relative humidity (80-95%) for their growth and development.

Correlation and Regression Analysis

The weather parameters such as maximum and minimum temperature (°C), relative humidity (%) and rainfall (mm) correlated positively to the occurrence of the disease incidence and severity. Based on the correlation coefficient (r), it showed a weak to substantial relationship among the control plots (T9) from Week 8-Week 11 (Tables 4, 6) showing that without management interventions, disease would further develop by those different weather parameters.

The small amount of rainfall and low temperature (°C) that prevailed during the experiment together with the management approaches applied in the different treatments caused the delay in the occurrence and development of the disease most especially in the management programs T1-T8. Based on the value of correlation coefficient (r), it established a weak to strong relationship between the weather parameters and the disease occurrence and progress which indicated that low levels of severity and incidence were correlated and dependent on the small amount of rainfall and low temperature (Tables 5, 7).

Summary, Conclusion and Recommendation

Integration of different disease management approaches like cultural, biological and chemical was done in the study. Two commercial protectant fungicides, namely: Mancozeb and Propineb and four systemic (Benomyl, Carbendazim, Difenoconazole and Difenoconazole-Propiconazole) were used and the *Trichoderma* sp. was also used as the biological agent. The six commercial fungicides and one biological agent were assigned alternately into different spraying schedules.

According to CLARRDEC (2007) these are chemical management approach to be applied in onion plants. Application of protectant fungicides {Captan, Mancozeb (Dithane) or Benomyl (Benlate)} one week after transplanting or one week after emergence for direct seeded onion. Repeat application at 7–14 days interval depending on the severity of the disease. Or use systemic foliar fungicides {e.g., Armure (Mancozeb, Difenoconazole/Propiconazole), Score (Difeconazole)} two weeks after transplanting. Repeat application at 7–14 days interval depending on the severity of the disease.

Eleven weeks after transplanting, incidence of the disease became very evident in the control plots (T9). It was also recorded that the most severe symptoms of twister were observed in the T9 as well as with the highest percentage of mortality. The lowest yield and highest number of non-marketable bulbs were also observed in the control plots.

On the other hand, onion plants under the T3 (Benomyl-Propineb-Difenoconazole~Propiconazole (DP)-Difenoconazole-Carbendazim-Mancozeb-*Trichoderma* sp.) showed the lowest percentage of disease incidence and severity, it had also the highest number and heaviest weight of the marketable bulbs. Lowest number of non-marketable bulbs was recorded in onion plants under T1 (*Trichoderma* sp.) program. The most ideal size of the onion bulbs was obtained in the harvest of T3. While, the lowest percentage of mortality was recorded in the T6 (DP-Carbendazim-Mancozeb-Benomyl-Difenoconazole-*Trichoderma* sp.-Propineb).

The study showed that late transplanting date and spacing of 15x15cm between hills and rows showed a positive effect against the occurrence of anthracnose-twister disease. A five-day interval of irrigation in the area also contributed to delayed disease development.

Weather parameters such as maximum and minimum temperature (°C), relative humidity (%) and rainfall (mm) were positively correlated with the occurrence of disease incidence and severity, though a delay in the development of the disease was observed in the different management programs (T1-T8).

The T3 program had the highest net income among other management programs namely the T1, T2, T4, T5, T6 and T7 which also had a positive net income; which was very cost efficient as compared to T8 and T9.

Since this field experiment was only conducted for one cropping season, two or more field trials must be conducted to further validate and confirm the effectiveness of the different management programs.

Table 4 Correlation coefficient (r) of disease incidence with weather parameters in the control plots (T9) at Olivete, Bongabon Nueva Ecija (Dry Season, 2019).

Weather Parameter	R Value		
	Week 8	Week 9	Week 10
Maximum Temperature (°C)	0.32	0.22	0.26
Minimum Temperature (°C)	0.03	0.41	0.63
Relative Humidity (%)	0.42	0.34	0.23
Rainfall (mm)	0.18	0.48	0.38

Table 5 Correlation coefficient (r) of disease incidence with weather parameters in different management programs (T1-T9) on Week 11 at Olivete, Bongabon Nueva Ecija (Dry Season, 2019).

Weather Parameter	R Value								
	T1	T2	T3	T4	T5	T6	T7	T8	T9
Maximum Temperature (°C)	0.43	0.42	0.88	0.71	0.46	0.40	0.49	0.51	0.21
Minimum Temperature (°C)	0.44	0.75	0.79	0.66	0.52	0.70	0.80	0.75	0.33
Relative Humidity (%)	0.53	0.56	0.90	0.87	0.57	0.55	0.66	0.68	0.23
Rainfall (mm)	0.45	0.40	0.75	0.69	0.61	0.32	0.58	0.45	0.15

Table 6 Correlation coefficient (r) of disease severity with weather parameters in the control plots (T9) at Olivete, Bongabon Nueva Ecija (Dry Season, 2019).

Weather Parameter	R Value		
	Week 8	Week 9	Week 10
Maximum Temperature (°C)	0.23	0.50	0.39
Minimum Temperature (°C)	0.47	0.13	0.88
Relative Humidity (%)	0.77	0.02	0.41
Rainfall (mm)	0.43	0.46	0.50

Table 7 Correlation coefficient (r) of the disease severity with weather parameters of the different management programs (T1-T9) on Week 11 at Olivete, Bongabon Nueva Ecija (Dry Season, 2019).

Weather Parameter	**R Value**								
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**
Maximum Temperature (°C)	0.51	0.66	0.44	0.56	0.30	0.17	0.56	0.57	0.66
Minimum Temperature (°C)	0.76	0.79	0.58	0.62	0.60	0.27	0.76	0.77	0.64
Relative Humidity (%)	0.66	0.79	0.65	0.69	0.50	0.36	0.75	0.73	0.82
Rainfall (mm)	0.50	0.55	0.34	0.57	0.23	0.08	0.63	0.53	0.67

Acknowledgement

The author would like to acknowledge the Department of Science and Technology-Accelerated Science and Technology Human Resource Development Program (DOST-ASTHRDP) for supporting and funding this study.

References

Alberto RT. 2014 – Pathological response and biochemical changes in *Allium cepa* L. (bulb onions) infected with anthracnose-twister disease. Plant Pathology & Quarantine, 4(1), 23–31.
Doi: 10.5943/ppq/4/1/4

Alberto RT, Aquino VM. 2010 – Characterization of *Colletotrichum gloeosporioides* (Penzig) Penzig and Sacc. (Anthracnose) and *Gibberella moniliformis* Wineland (Twister) infecting onions in the Philippines. Asia Life Sciences, 19(1) 1–36.

CLARRDEC. 2007 – (Central Luzon Agriculture, Resources Research, Development Consortium) Major diseases of onion: A field guide. Los Baños, Laguna: PCARRDDOST, CLARRDEC-CLSU, 18p. – (CLARRDEC Farm Primer No. 02/2007).

Dubey SC, Patil B. 2001 – Determination of tolerance in *Thanetophorus cucumeris*, *Trichoderma viride*, *Gliocladium virens* and *Rhizobium* sp. to fungicides. Indian Phytopathol 54, 98–101.

Papavizas GC, Lewis JA. 1981 – Introduction and augmentation of microbial antagonists for the control of soil-borne plant pathogens. In: Biological control in crop production, Papavizas, G.C. (Ed.). Allanheld and Qsmun, Totowa, New Jersey, pp. 305–322.

Silimela M, Korsten L. 2001 – Alternative methods for preventing pre and post-harvest diseases and sunburn on mango fruits. S.A. Mango Growers Assoc. Yearbook 21, 39–43.