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Determination of Economic Threshold Level (ETL) of Tobacco Mosaic and Leaf Curl Viruses

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Abstract

Experiments were conducted for the determination of economic threshold of Tobacco Mosaic and Leaf Curl viruses of tobacco. Infection of tobacco plants occurred naturally in the field. Mean values of yield were obtained after curing of tobacco leaves which varied significantly with incidence of disease. Yield loss assessment of tobacco caused by Tobacco Mosaic Virus and Tobacco Leaf Curl Virus was considered first. Grade index values of tobacco that influence market value and support price of flue-cured tobacco were also considered. Economic threshold values were determined from economic analysis and regression analysis and those were found to be at 4.5% and 4% disease incidence in NC 95 and K326 for Tobacco mosaic Virus and 4% and 4.5% for Tobacco Leaf Curl Virus respectively.

Keywords: Tobacco; Economic Threshold Level; TMV; TLCV; Yield Loss.

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1. Introduction

Tobacco (*NIcotiana tabacum)* belonging to the family Solanaceae, is one of the leading cash-crops of the world. Cultivation of this stimulant crop and its industry has developed to one of the most important enterprises. Economy of many countries would not have reached to its current level, but for tobacco [17]. In Bangladesh, tobacco is the third most important cash crop and it plays an important role for the economic growth of the country. Although the total annual consumption of tobacco and its products has increased considerably in the recent years, the production of the crop has remained almost static here at 8.6 crores pounds for long time. The average yield of tobacco in the country is only 0.864 ton per hectare, which is one of the lowest in the world [11].

Tobacco, like other crop plants, is vulnerable to various diseases. More than one hundred different diseases are known to occur on this crop [55]. Under favorable conditions, some of these diseases may outbreak in epiphytotic for and can either cause total failure of the crop or affect its yield and quality causing substantial losses to the economy of many countries [13]. According to rough estimate, the world annual loss due to tobacco diseases is in excess of 5.7 hundred million dollars [05].

Tobacco mosaic and leaf curl viruses attack the crop and cause complete loss of the yield (quality and quantity) [40]. Valleau and Johnson [52] were among the first investigators to attempt to characterize the effects of TMV on tobacco yield and value. In 1927, they reported as much as 60% reduction in crop value caused by early mosaic infection. McMurtrey (1929)[32] conducted similar studies on Maryland tobacco and noted an average yield reduction of 30-35% and more than a 50% reduction in gross value. He also reported a relationship between time of infection with respect to plant growth and development and the subsequent severity of effects. Chaplin (1978) [08] reported yield losses of 20% in yield and 24% in value when plants were inoculated at transplanting.

To control the diseases, unplanned and indiscriminate use of pesticides is blamed for side effects and also economic loss [50]. Concerted efforts are, therefore, being made to develop rational basis for application of pesticides keeping in view the ecological soundness and profitability of control because of high cost of chemical insecticides and problems associated with them [47]. The aim of the modern disease management program is to maintain or suppress disease infection level below an economically and ecologically tolerable level ;[23]. To achieve this aim, the development of realistic criteria to justify the control action of a disease is very crucial and essential. In this regard, a guiding principle is that a control measure is justified only when the expected incremental return would exceed the incremental costs of control. This is expressed in terms of economic threshold level (ETL) of a disease on a crop [10]. It has become necessary to determine economic threshold level for Tobacco Mosaic Virus and Tobacco Leaf Curl Virus. ETL is a dynamic parameter, varying with a number of factors i.e. variety, geographical area and changes with change in (1) the cost of artificial control measures (2) monetary value of harvested product (3) the environmental factors i.e. tolerance of the plant and feeding of the insect [33]. Besides, ETL for TMV and Leaf Curl viruses for tobacco in Bangladesh has not been determined yet. It is reported that TMV and Leaf Curl viruses cause 11% plant damage every year only in the field of BAT (British American Tobacco), the largest processing and marketing company in Bangladesh (www.bat.com). It is well known that virus infected plant yielded lower grade tobacco [27]. To minimize this loss, ETL of TMV and Leaf Curl viruses is to be determined to reduce the amount of low-grade tobacco yield and environmental hazardous chemical pesticides. Keeping in view the above facts, the present research work is undertaken to establish correlation among the viruses' infection and yield losses in order to determine ETL for Tobacco Mosaic and Tobacco Leaf Curl viruses for Tobacco at the farmer's level in Bangladesh. In view of such information, the present experiments were undertaken to meet the following objectives: 1)To determine the relation between the intensity of viruses and yield of tobacco. 2)To quantify differences in yield, quality, and value among cultivars under conditions of TMV versus no TMV and Leaf Curl versus no Leaf Curl. 3)To determine Economic Threshold Level (ETL) for Tobacco Mosaic and Leaf Curl.

2. Materials and Methods

2.1. Experimental Site

The experiment was conducted at the farm of the British American Tobacco Bangladesh (BATB) located at Kushtia (Photo 1-2). The soil of the farm belongs to the agro-ecological zone, High Ganges River Flood-Plain. The texture of the soil of the experimental area is silt-loam [51].

2.2. Experimental Period

The experiment was conducted in one tobacco growing season (Photo 3) the winter season, from December-2010 to March -2011.

2.3. Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) with 7(seven) replications. The individual plot size was 49m^2 and 56m^2 for tobacco varieties NC 95 and K 326 respectively.

2.4. Varieties of tobacco used

Two varieties were used in the experiment. They were –

1) **NC-95:** The variety NC 95's Origin is in the Republic of Panama. It was released in 1966. It is very popular and still most widely grown. Its strong root system tended to give it better support. It is resistant to the root knot nematode species *M. incognita* [22].

2) **K-326:** K 326 was released by Novartis Seeds, Inc. in 1982. It was developed from a cross of two breeding lines that were derived from crosses between Coker 139 and Coker 319 and McNair 30 and NC 95. The variety has low resistance to black shank and Granville wilt, and has resistance to root-knot nematodes, and is susceptible to mosaic. The yield is much higher than NC 2326 or NC 95; and its quality as indicated by dollars/cwt and quality index is much higher than NC 2326 or NC 95. K 326 is known for its high quality and curability. K 326 has a very low level of weather fleck [35].

2.5. Diseases studied

Two diseases of tobacco were studied in the experiment. These were -

1. Tobacco Mosaic Disease (TMV)

2. Tobacco Leaf Curl Disease (TLCV)

1. **Tobacco mosaic virus** (TMV)

Figure 1: Tobacco leaves showing mosaic symptoms

2. **Tobacco Leaf Curl virus (TLCV)**

Figure 2: Tobacco leaves showing leaf curl symptoms.

2.6. Data collection

Data collection was done on the following aspects –

i. Number of plants infected per plot
ii. Number of leaves infected per plant
iii. Weight of infected leaves
iv. Grade (Quality) of processed tobacco as per virus intensity

Numbers of leaves per plant were assessed weekly throughout the season. Twenty plants in each row were selected randomly and marked three weeks after transplanting [28].

2.7. Identification of diseases and measurement of their prevalence

The Tobacco Mosaic (TMV) and Leaf Curl (TLCV) diseases were identified based on field symptoms. Prevalence of diseases was measured by calculating disease incidence .The following formula was used in this connection [46].

$$\text{Disease incidence (DI)} = \frac{\text{Number of infected plants}}{\text{Total number of plants inspected}} \times 100$$

2.8. Collection of flue cured tobacco grades

After final harvest, all priming of all plots were cured, weighed, and graded. A 0-99 tobacco grade index that group's federal tobacco grades according to equivalent value [54] was used to estimate the quality of each harvest or priming. This index estimates quality by measuring three characteristics of flue-cured tobacco leaves (leaf type, body, and color) that affect their market value. Flue-cured tobacco quality, however, includes other characteristics not reflected in the grade index. Average market prices for all flue-cured tobacco grades were obtained from BATB (British American Tobacco Bangladesh Co. Ltd). The value for each harvest of each plot was calculated by multiplying the priming weight by the average market price of the priming grade. Yields and values were each summed and grade index values averaged over all harvests for each plot to obtain the total yield, total value, and average grade index of each plot.

3. Results

3.1. Incidence of tobacco mosaic virus and yield of tobacco leaves

3.1.1. Tobacco variety NC 95

In variety NC 95 data were recorded at 0, 3, 5, 6.1, 7.5, 8.1, 9 and 13 percent disease incidence level. Disease infection occurred naturally in the field. Yield was variable at different TMV incidence level. Yield reduction was the lowest at 0.00% level and highest at 13.00% level. Yield at 0.00% TMV incidence was 13.07 kg/49m^2 0r 2667.34 kg/ha.

This was considered as potential yield (PY). Yields for different levels of TMV infection were significantly different. Yields at 0.00 and 3.0% TMV were statistically similar but significantly different from the rest yields. Yields at 5 to 8.8% TMV were statistically higher than that at 10-13%TMV. The lowest yield was obtained at 13% TMV. Yield kg/ha and corresponding yield reduction and loss in monetary terms followed the same trend as described for disease incidence and kg/49m^2 (Table 1).

Table 1: Incidence of TMV and comparison of mean values of yield of tobacco leaves in NC 95

SL	Disease	Yield	Yield	Yield	Yield	Yield reduction
1	0.00a	13.07a	0.00a	2667.34a	0.00	0.00
2	3.00b	12.40a	6.73b	2530.61b	136.71	12376.00
3	5.00c	11.14b	17.32c	2273.46c	393.85	35840.35
4	6.10d	10.38b	25.91d	2118.36d	438.77	39928.07
5	7.50e	10.13b	29.02e	2067.34e	489.79	44570.89
6	8.10f	9.34bc	39.93f	1906.12f	565.30	51442.30
7	9.00g	9.10c	43.62g	1857.14g	699.99	63699.09
8	13.00h	8.60d	51.19h	1673.46h	879.58	80041.78
LSD	0.619	0.516	3.037	3.296		
CV%	5.47	7.91	12.13	0.06		

* Price of Tobacco leaves @ Tk 91/Kg

3.1.2. Tobacco variety K326

In variety **K326** data were recorded at 0, 3.6, 6.5, 7.1, 8.7, 11.4 and 12.97 percent disease incidence level. Disease infection occurred naturally in the field. Yield was recorded at different incidence level of Tobacco mosaic disease incidence. Yield reduction was the lowest at 0.00% level and highest at 12.97% level. Yield at 0.00% TMV incidence was 17.40 kg/56m^2 0r 3107.14 kg/ha. This was considered as potential yield (PY). Yields for different levels of TMV infection were significantly different. Yields at 0.00 and 3.6% TMV were statistically similar but significantly different from the rest yields. Yields at 6.5 to 7.1 and also at 8.7% TMV were statistically higher than that 11.4-12.97 % TMV. The lowest yield was obtained at 12.97% TMV. Yield kg/ha and corresponding yield reduction and loss in monetary terms followed the same trend as described for disease incidence and yield kg/56m^2 (Table 2).

Table 2: Incidence of TMV and comparison of mean values of yield of tobacco leaves in K326

SL.	Disease	Yield	Yield	Yield	Yield	Yield reduction
1	0.00a	17.40a	0.00a	3107.14a	0.00	0.00
2	3.60b	17.01a	2.08b	3025.00b	82.11	7472.01
3	6.50c	14.32b	17.28c	2557.12c	549.99	50049.09
4	7.10d	14.10bc	18.55d	2517.83d	589.28	53624.48
5	8.70e	13.73c	20.63e	2451.76e	655.35	59636.85
6	11.40f	13.01d	24.79f	2323.19f	783.92	71336.72
7	12.97g	12.87d	25.60g	2298.19g	808.92	73611.72
LSD	0.66	1.63	0.89	4.78		
CV%	5.25	6.46	3.27	0.10		

* Price of Tobacco leaves @ Tk 91/Kg

3.2. Incidence of Tobacco Leaf Curl Virus and yield of tobacco leaves

3.2.1. Tobacco variety NC 95

In variety NC 95 data were recorded at 0, 4.1, 5.27, 6.31, 7.76, 10.50 and 12.27 percent disease incidence level. Disease infection occurred naturally in the field. Yield was variable at different TLCV incidence level. Yield reduction was the lowest at 0.00% level and highest at 12.27% level. Yield at 0.00% TLCV incidence was 13.07 kg/49m^2 0r 2667.34 kg/ha. This was considered as potential yield (PY). Yields for different levels of TLCV infection were significantly different. Yields at 0.00 and 4.1% TLCV were statistically similar but significantly different from the rest yields. Yields at 5.27% TLCV were statistically higher than that at 6.31-12.27% TLCV incidence. The lowest yield was obtained at 12.27% TMV. Yield kg/ha and corresponding yield reduction and loss in monetary terms followed the same trend as described for disease incidence and yield kg/49m^2 (Table 3).

Table 3: Incidence of Tobacco Leaf Curl disease and comparison of mean values of yield of tobacco leaves in NC-95

Plot no.	Disease	Average	Yield	Yield	Yield	Yield reduction
1	0.00a	13.07a	0.00a	2667.34a	0.00	0.00
2	4.1b	12.30a	6.20b	2510.20b	157.14	14299.74
3	5.27bc	11.83b	10.48c	2271.42c	395.89	36025.99
4	6.31c	10.83bc	20.68d	2087.75d	518.34	47168.94
5	7.76d	9.90cd	32.02e	1918.36e	732.64	66670.24
6	10.5e	9.63cd	35.72f	1883.67f	783.66	71313.06
7	12.27f	9.31d	40.38g	1797.00g	869.38	79113.58
LSD	1.24	1.25	0.86	4.21		
CV%	10.86	4.61	3.62	0.08		

* Price of Tobacco leaves @ Tk 91/Kg

3.2.2. Tobacco variety K326

In variety K326 data were recorded at 0, 4.0, 6.1, 7.2, 8.1, 9, and 11.20 percent disease incidence level. Disease infection occurred naturally in the field.

Yield was recorded at incidence level of tobacco leaf curl virus (TLCV) disease incidence. Yield reduction was the lowest at 0.00% level and highest at 11.20% level. Yield at 0.00% TLCV incidence was 15.80 kg/56m^2 0r 2821.40 kg/ha.

This was considered as potential yield (PY). Yields for different levels of TLCV infection were significantly different.

Yields at 0.00 and 4% TLCV were statistically similar but significantly different from the rest yields. Yields at 6.1 to 7.2 % TLCV were statistically higher than that at 8.1-11.20 % TLCV.

The lowest yield was obtained at 11.20% TLCV. Yield kg/ha and corresponding yield reduction and loss in monetary terms followed the same trend as described for disease incidence and kg/56m^2 (table 4).

Table 4: Incidence of Tobacco Leaf Curl disease and comparison of mean values of yield of tobacco leaves in K326

SL	Disease	Yield	Yield	Yield	Yield reduction	Yield reduction
1	0.00a	15.80a	0.00a	2821.40a	0.00	0.00
2	4.00b	15.30a	5.06b	2678.57b	142.83	12997.53
3	6.10c	14.40b	8.86c	2571.40c	250.00c	22750.00
4	7.20d	13.9b	12.02d	2482.12d	339.28	30874.48
5	8.10e	13.20c	16.45e	2357.12e	464.28	42249.48
6	9.00f	13.01cd	17.65e	2323.19f	498.21	45337.11
7	11.20g	12.50d	20.88f	2232.12g	589.28	53624.48
LSD	0.39	0.66	1.12	5.41		
CV%	3.33	2.70	5.58	0.12		

* Price of Tobacco leaves @ Tk 91/Kg

3.3. Comparison of varietal reaction to virus diseases for yield

3.3.1. Comparison of varietal reaction to Tobacco Mosaic Disease

Potential yield of flue-cured tobacco for TMV disease for variety NC95 was 2667.34kg/ha and for variety K326 it was 3107.14 kg/ha. Potential yield difference was 16.48%. Yield of flue cured tobacco leaves decreased with increase in disease incidence. Yield difference was the highest at 12.97% disease incidence level and it was the lowest i.e. 1857.14kg/ha in NC95 and 2299.19kg/ha in K326 (Table 5).

Table 5: Comparison of the mean values of yield between NC95 and K326 for TMV

Disease	**Disease incidence (%)**	**Yield (Kg/ha)**		
		NC95	**K326**	
Tobacco Mosaic Disease	0.00a	2667.34a	3107.14a	16.48
	3.00b	2530.61b	3014.10b	19.50
	5.00c	2273.46c	2543.22c	12.30
	6.10d	2118.36d	2502.73d	18.61
	7.50e	2067.34e	2401.76e	18.59
	9.00f	1906.12f	2323.39f	22.94
	12.97g	1857.14g	2299.19g	23.74
	LSD	3.296	4.781	
	CV%	0.06	0.10	

3.3.2. Comparison of varietal reaction to Tobacco Leaf Curl Disease

Potential yield of flue-cured tobacco for TLCV disease in variety NC95 was 2667.34akg/ha and for variety K326 it was 2821.40 kg/ha. Yield difference was 5.77%. Yield of flue cured tobacco leaves decreased with increase in disease incidence. Yield difference was the highest at 11.20% disease incidence level and it was the lowest i.e. 1797.00kg/ha in NC 95 and 2242.12 kg/ha in K326.

Table 6: Comparison of the mean values of yield between NC95 and K326 for Tobacco Leaf Curl Virus.

Disease	Disease	Yield (kg/ha)		Yield difference (%)
		NC95	**K326**	
Tobacco Leaf Curl Disease	0.00a	2667.34a	2821.40a	5.77
	4.1b	2510.20b	2679.37b	6.70
	5.27c	2271.42c	2591.10c	13.63
	6.31d	2087.75d	2470.16d	18.79
	7.76e	1918.36e	2357.13e	23.39
	10.5f	1883.67f	2315.29f	23.44
	11.20g	1797.00g	2242.12g	24.21
	LSD	4.211	5.409	
	CV%	0.08	0.12	

3.4. Grades of tobacco affected by Tobacco Mosaic and Tobacco Leaf Curl diseases

Determination of tobacco grades is a very difficult task. But for grade deviation basically we considered disease incidence. Flue-cured tobacco quality, however, includes other characteristics not reflected in the grade index.

3.4.1. Grades of tobacco affected by Tobacco Mosaic and Tobacco Leaf Curl diseases in variety NC95

In variety NC95 tobacco grades decreased with the increase in disease incidence. At 0% disease incidence level highest grade of tobacco was obtained. Disease incidence up to 5% did not affect the grades of flue-cured tobacco. At 7% incidence grades for TMV remained between 1 and 2 and for TLCV 2 and 3. At 10% incidence tobacco grades deteriorated up to 4 for both diseases while at 12% incidence grades went down to 6. More than 12% disease incidence grades of flue-cured tobacco were considered as the lowest one (Table 7).

Table 7: Decrease of tobacco grades with the increase of disease incidence var. NC95

	Grades	
Disease Incidence (%)	**Tobacco Mosaic Virus**	**Tobacco Leaf Curl Virus**
0	1	1
5	1	1
7	1,2	2,3
10	2,3,4	3,4
12	4,5,6	4,5,6
>12	7,8	6,7,8

3.4.2. Grades of tobacco affected by Tobacco Mosaic and Tobacco Leaf Curl diseases in variety K326

In variety K326 tobacco grades decreased with the increase in disease incidence. At 0% disease incidence level highest grade of tobacco was obtained. Disease incidence up to 7% for TMV and 5% for TLCV did not affect the grades of flue-cured tobacco. At 7% incidence grades for TLCV remained between 2 and 3. At 10% incidence tobacco grades deteriorated up to 4 for both diseases while at 12% incidence grades went down to 6. More than 12% disease incidence grades of flue-cured tobacco were considered as the lowest one (Table 8).

Table 8: Decrease of tobacco grades with the increase of disease incidence var. K326

	Grades	
Disease Incidence (%)	**Tobacco Mosaic Virus**	**Tobacco Leaf Curl Virus**
0	1	1
5	1	1
7	1	2,3
10	2,3,4	3,4
12	4,5,6	4,5,6
>12	7,8	6,7,8

3.5. Determination of Economic Threshold Level for tobacco mosaic virus

3.5.1. Tobacco variety NC 95

Yield reduction increased with the increase of tobacco mosaic disease in tobacco plant. Now at 0% and 3% level of disease incidence, yield reduction was insignificant comparing with the yield of disease-free plant. Yield reduction was significant at 5% level of disease incidence. So ETL lies at the disease incidence level where percent yield reduction will be significant. In order to calculate the exact disease incidence level at which yield reduction will be significant the correlation of percent disease incidence (X) with the yield reduction (Y) was calculated. There was a strong positive correlation and linear relationship between those two variables (Fig. 1).

The regression equations derived were as follows:

$Y = 4.431X - 1.921$, ($R^2 = 0.943$) Where,

X = Disease incidence level

Y = yield reduction

From the above equations the ETL of Tobacco Mosaic Virus was determined as 4.5% disease incidence level in tobacco variety NC 95.

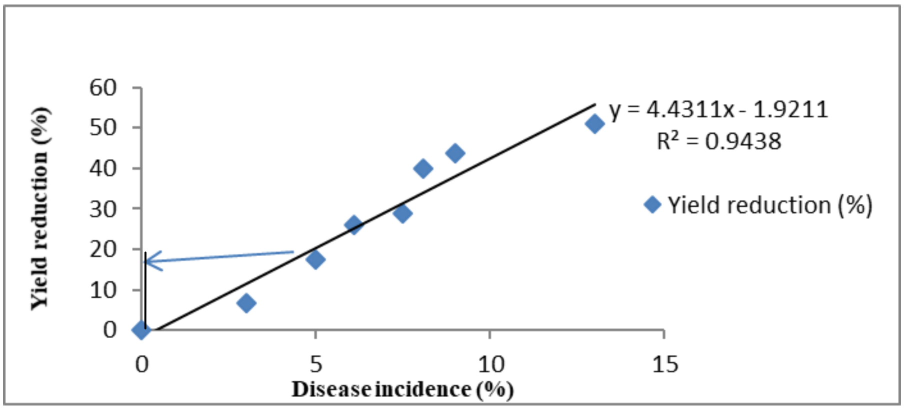

Figure 3: Disease incidence (%) and yield reduction (%) for TMV in NC-95

3.3.2. Tobacco variety K326

Yield reduction increased with the increase of tobacco mosaic disease in tobacco plant. Now at 0% and 3% level of disease incidence, yield reduction was insignificant comparing with the yield of disease free plant. Yield reduction was significant at 5% level of disease incidence. So ETL lies at the disease incidence level where percent yield reduction will be significant. In order to calculate the exact disease incidence level at which yield reduction will be significant the correlation of percent disease incidence (X) with the yield reduction (Y) was calculated. There was a strong positive correlation and linear relationship between those two variables (Fig. 2).

The regression equations derived were as follows:

$Y = 2.646x - 1.889$, ($R^2 = 0.933$) Where,

X = Disease incidence level

Y = yield reduction

From the above equations the ETL of Tobacco Mosaic Virus was determined as 4% disease incidence level in tobacco variety K326.

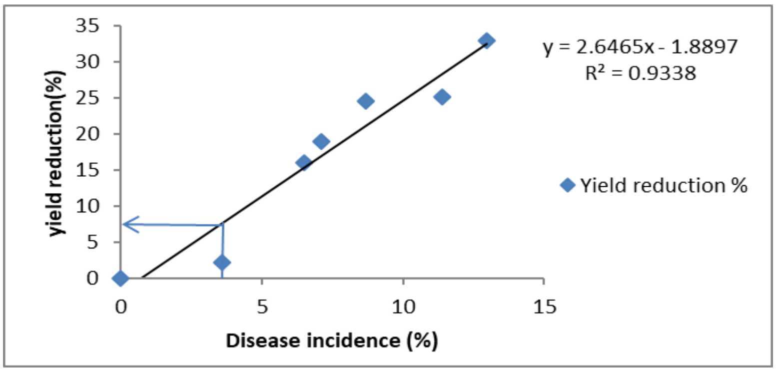

Figure 4: Disease incidence (%) and yield reduction (%) for TMV in K-326

3.4. Determination of Economic Threshold Level for Tobacco Leaf Curl Virus

3.4.1. Tobacco variety NC 95

Yield reduction increased with the increase of tobacco leaf curl disease in tobacco plant. Now at 0% and 4%, level of disease incidence yield reduction was insignificant comparing with the yield of disease free plant. Yield reduction was significant at 5% level of disease incidence. So ETL lies at the disease incidence level where percent yield reduction will be significant. In order to calculate the exact disease incidence level at which yield reduction would be significant the correlation of percent disease incidence (X) with the yield reduction (Y) was calculated. There was a strong positive correlation and linear relationship between those two variables (Fig. 3). The regression equations derived were as follows:

$Y = 3.684x - 3.537$ ($R^2 = 0.917$) Where,

X = disease incidence level

Y = yield reduction

From the above equations the ETL of Tobacco Leaf Curl Virus was determined as 4% disease incidence level in tobacco variety NC 95

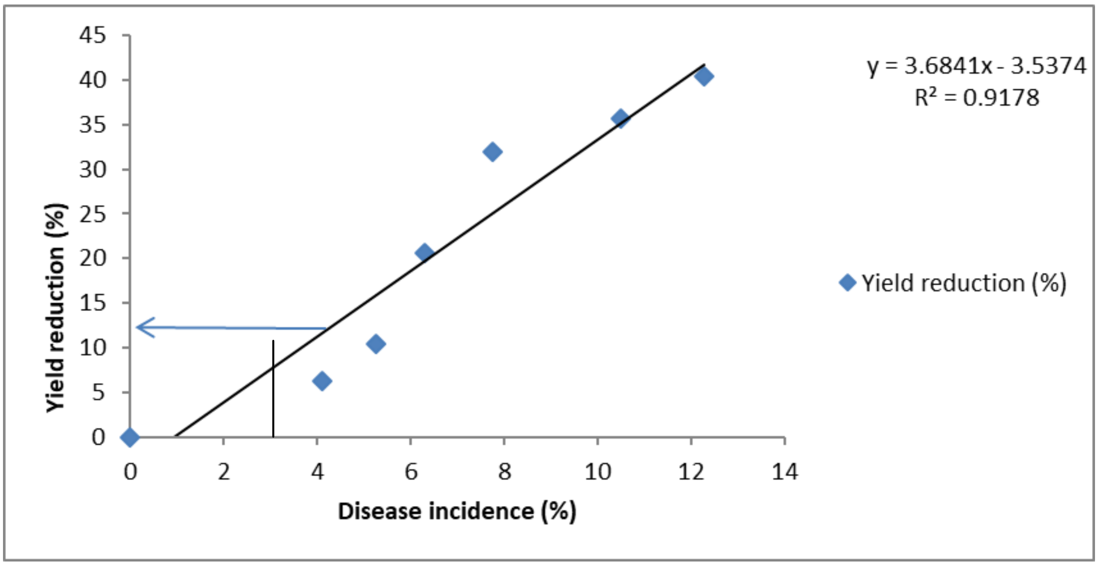

Figure 5: Disease incidence (%) and yield reduction (%) for Tobacco Leaf Curl Virus in NC-95

3.4.2. Tobacco variety K326

Yield reduction increased with the increase of tobacco leaf curl disease in tobacco plant. Now at 0% and 4% level of disease incidence, yield reduction was insignificant comparing with the yield of disease free plant. Yield reduction was significant at 5% level of disease incidence. So ETL lies at the disease incidence level where percent yield reduction will be significant. In order to calculate the exact disease incidence level at which yield reduction will be significant the correlation of percent disease incidence (X) with the yield reduction (Y) was calculated. There was a strong positive correlation and linear relationship between those two variables (Fig. 4).

The regression equations derived were as follows:

$Y = 2.568x - 3.294$, ($R^2 = 0.928$) Where,

X = disease incidence level

Y = yield reduction

From the above equations the ETL of Tobacco Leaf Curl Virus was determined as 4.5% disease incidence level in tobacco variety K326.

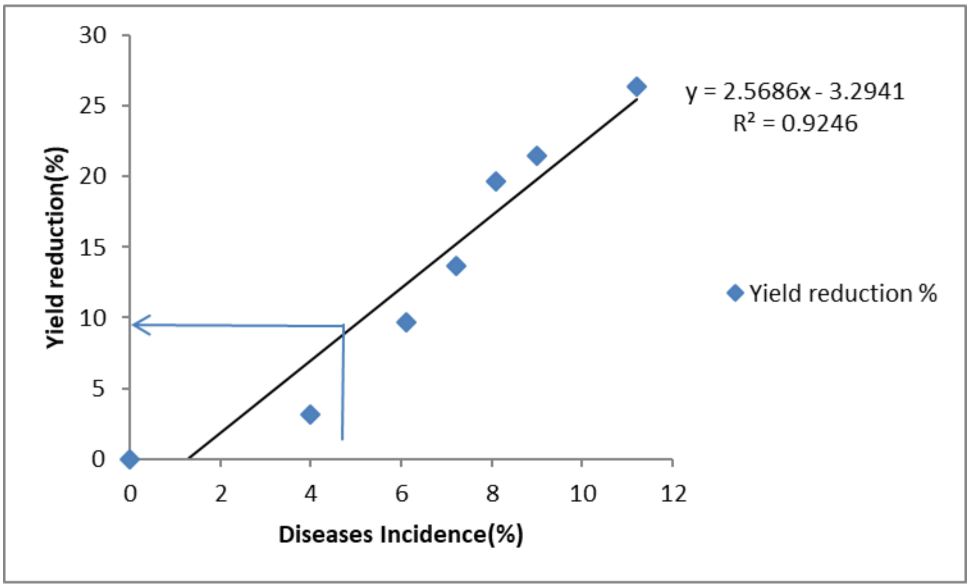

Figure 6: Disease incidence (%) and yield reduction (%) for Tobacco Leaf Curl Virus in K-326

4. Discussion

Disease management tactics are often evaluated by direct comparison of a single level of disease with one or more disease-control treatments. Such tests cannot adequately describe the relationship between the range of disease levels and yield losses. Growers may encounter the ensuing crop losses resulting from these different levels. Because treatment costs are seldom considered, test results are not analyzed to account for the various costs involved. These test designs can identify disease control measures that are consistently beneficial under standard conditions but could overlook disease management options that show desirable results in some situations but not in others.

Our approach was similar to that used by Norton [36] for defining an economic threshold to control the potato cyst nematode by using dichloropropanedichloropropene and Afzal and his colleagues [01] for the evaluation and demonstration of economic threshold level (ETL) for chemical control of rice stem borers. In our study, losses in yield and value caused by TMV and TLCV were quantified over a range of disease incidences and these losses were characterized as damage functions. We compared these functions with possible yield and value losses associated with TMV and TLCV resistance to formulate an econometric trade-off model. The model was further generalized for wider application by using percent reductions to describe loss rather than actual yield and value numbers as the dependent variables similar to Johnson and Main [29] and Nainar and Pappiah [34].

Econometric trade-off models identify disease thresholds that could help growers decide when and where to use control measures [41]. Another use of such models is to estimate the cost of making the wrong pest and disease management decisions, i.e. how much income or yield may be lost if some suboptimal control measure is chosen. This cost is simply the difference in yield or income between the tactic employed and an optimal tactic. Such costs are relatively easy to calculate [21]. Regression models were developed to describe percent differences (losses) in yield and value caused by TMV and TLCV rather than yield and value because one of the objectives of this research was to develop a method to expand flue-cured tobacco disease incidence sample-survey results into estimates of an economic threshold level and establishment of an economic model [25;35]. On an individual field basis, an estimate of yield may be preferable to a prediction of percent loss, but the focus of this project was on the determination of economic threshold level basis of crop production losses due to diseases rather than crop of production itself. The damage caused by TMV and TLCV also resulted in the deterioration of flue-cured tobacco grades. Highest quality grades were obtained up to 5% disease incidence and more than 12% decrease yielded the lowest grades. But the loss in leaf quality caused by TMV and TLCV may not be attributed to the tobacco grades that influence market value and determine the support price of the flue-cured tobacco. Losses in cured leaf quality were found to result from increases in the variability of stalk positions, maturity, curing factors (i.e. temperature, curing period etc.), quality ratings and colors (21). Increases in the variability of these components of tobacco grades were observed in TMV and TLCV infected tobacco leaves. Further research on the effects of various environmental and cultural factors on tobacco mosaic and Tobacco Leaf Curl will be necessary to predict the incidence of this disease in an objective and quantitative manner. Data would have to be collected from a large set of fields over at least 3 years, preferably more. Given such probabilities of incidence based on pattern and extent of pathogen spread, soil type, soil moisture, winter air temperatures, crop rotation, alternate hosts, tillage practices and tobacco cultivar, an evaluation of TLCV and TMV-directed sanitation practices could be attempted. This knowledge would greatly increase the usefulness and test the validity of the crop loss assessment model(s) and economic threshold level(s) for TLCV and TMV in flue-cured tobacco.

5. Summary and Conclusion

5.1. Summary

The experiment was conducted in the field of British American Tobacco (BAT), Kushtia, Bangladesh during the period of December- 2010 to March -2011 to determine the economic threshold level of tobacco mosaic and leaf curl viruses of two varieties namely NC 95 and K 326. The experiment was laid out in a randomized complete block design with 7(seven) replications. Assessment of tobacco mosaic virus and leaf curl incidence was made at different growth stages of tobacco plants. Regression models were developed to describe percent differences (losses) in yield and value. The intercepts for yield loss equation did not equal zero. The regressions would have been manipulated so that the intercepts would equal zero but we decided that such an approach would not improve the accuracy or usefulness of the models in predicting loss. The exact disease incidence at which yield reduction was significant was calculated from the regression model. The economic threshold level of Tobacco Mosaic Virus was found 4.5% for NC95, 4% for K326 and of Tobacco leaf Curl Virus 4% for NC95, 4.5% for K326. The results of this study indicate that losses in flue-cured tobacco yield, quality and value caused by TMV and Leaf Curl Virus are not as large as had been generally believed but are still important enough to require careful management. To ensure a crucial, appropriate and essential disease management of tobacco, economic threshold level is required.

5.2. Conclusion

It can be concluded that the economic threshold level for the control of tobacco mosaic virus in varieties NC95 and K326 are 4.5% and 4% and Tobacco Leaf curl virus in NC95 and K326 are 4% and 4.5% disease incidence respectively. It is the best time for the application of control measures as it fits best according to existing economic and environmental condition.

6. Recommendations

The present study will contribute to the development of management tactics to reduce low-grade tobacco production as well as environmental hazardous pesticide use. It will also check unnecessary use of pesticides that reduce the high-grade tobacco production cost. This finding also attests to the need for further researches to be done in this area. Expansion of scope may be applied to future researches by delving into the conditions that help or degrade the condition of tobacco grades and production. And since control of TMV and TLCV diseases and reducing pesticides use being an indispensable factor on tobacco production, human and environment health there needs to be more research focusing on varietal resistance of viral diseases (TMV and TLCV) and the various biotic and abiotic variables within the discourse.

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