The Pharma Innovation Journal 2021; 10(4): 453-457

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(4): 453-457

www.thepharmajournal.com
Received: 28-01-2021
Accepted: 21-03-2021

Bipul Kumar Mandal
Krishi Vigyan Kendra, Madhepura, Bihar Agricultural University, Sabour, Bihar, India

RP Sharma
Krishi Vigyan Kendra, Madhepura, Bihar Agricultural University, Sabour, Bihar, India

Rahul Kumar Verma
Krishi Vigyan Kendra, Madhepura, Bihar Agricultural University, Sabour, Bihar, India

Corresponding Author:
Bipul Kumar Mandal
Krishi Vigyan Kendra, Madhepura, Bihar Agricultural University, Sabour, Bihar, India

To access the efficacy of bio-regulator against tomato leaf curl virus under dry farming condition of South Bihar

Bipul Kumar Mandal, RP Sharma and Rahul Kumar Verma

Abstract
The experiment to access the efficacy of bio-regulator on tomato productivity against leaf curl virus disease under dry farming condition of South Bihar was conducted on ten farmers field of Aurangabad district of Bihar with a tomato cultivar "Kashi Vishesh" during the month of october- march in winter season for the two year *i. e*. 2014-15 and 2015-16. There were three bio-regulators viz., Salicylic Acid @ 100 ppm, Para chloro phenoxy Acetic Acid @ 50 ppm and Virtex @ 3000 ppm were evaluated against the leaf curl disease of tomato. Agro-chemical were applied individually on 40 DAT and 60 DAT and data were collected on different parameter such as percent disease incidence, Days to 50 % flowering, Fruit length, Marketable fruit yield and B:C ratio. It was found that all the treatment significantly reduce disease incidence (12.65– 43.50 %) and increased marketable yield over control (30.81-65.00 %). Virtex @ 3000 ppm treated plot found most effective (12.65 %) disease incidence with 70.91 per cent disease reduction over farmers practice and maximum fruit yield obtained (338.5 q/ha) against farmer practice whereas the least protection was obtained from SA (100 ppm) treated plot. The 3000 ppm Concentration of Virtex resulted not only the lowest disease incidence but also increase the tomato yield and hence economic benefit in tomato production is increased. The present study revealed that the selected bio-regulator could be used for successful management of Leaf Curl Virus Disease in tomato.

Keywords: bio-regulator, tomato leaf curl virus, dry farming condition

Introduction
Tomato is one of the most important commercial vegetable crop widely grown in open field as well as under protected cultivation in tropical and temperate regions. In India, tomato ranks third in vegetable crops after potato and sweet potato and first among the processed vegetable. (Rewal *et al*., 2019) [22] and it was cultivated in 786 thousand hectare with production of 19377 thousand million tonnes with productivity of 24.4 MT per hectare during the year 2017-18 (Anon 2018) [5]. It is the most important protective food having high nutritive value, source of valuable vitamins (Anon 2017) [4] and medicinal properties (Wageningen 2005) [28]. The national productivity of tomato is lower than global average and the main reason of low yield or production loss is due to its susceptibility to various pests and diseases. Besides, fungal, bacterial and physiological disease it is also affected by several viral disease. Among all major constraints of tomato production, tomato leaf curl virus (TLCV) is one of the major causal agents responsible for the maximum yield loss (Kamal *et al*., 2015) [13] and it is considered that tomato leaf curl is a very destructive viral disease that can infect the plant at any growth stage Ruiz *et al*. (2017) [24]. The devastating effect of tomato leaf curl virus is common all over the world (Hanssen *et al*., 2010) [8]. The crop growth and yield is reduced up to 93.3% when the crop is infected at any early stage (Loannou, 1992) [17]. In recent times due to climate vulnerability the tropical and subtropical have become a prone zone of TLCV throughout the year. (Alegbejo and Banwo 2006, Kumar *et al*., 2012) [3, 15]
The disease is characterized by imitation of small vein thickening type symptom of younger leaves, upward leaf curling, puckering and yellow margin of the leaves, reduced leaf size and plant emerge with stunted growth. Tomato fruits are symptomless, although they are sometime smaller than usual; if infection occur at an early growth stage, flower abortion can result in total yield loss. The incidence and severity of this disease is related to many factors such as environmental condition, virus source, vector population, host reaction and the time of infection etc. (Verma *et al.*, 1989) [26]. As the viruses are transmitted by vector (white fly) hence the possible management practices of TLCV will be the use of insecticide and plant bio-regulators. For this regular application of systemic chemicals are advised and

the use of insecticide to control vector because several adverse effect i.e residual toxicity, pollution in the environment and high cost (Kumar *et al*., 2011) [16]. As claimed the use of pesticide contaminates the food stuff thus, instead of supporting health, these will become a great health hazard (Jaga and Dharnam, 2003, Akland *et al*., 2000) [10, 1] thus warrant a suitable safer remedial measure for plant containing leaf curl disease menace in tomato.

Therefore, it has become a necessity to adopt ecofriendly approach for better crop health and yield. In recent years, a wide range of naturally occurring phenolic compound and hormone based plant bio –regulator have been demonstrated to be used for inducing resistance to a number of biotic and abiotic stress and enhancing yield of different crops under field condition (Sarwar *et al*., 2011) [25]. Among these, salicylic acid (SA) is known for its ability to establish as a plant morphogenetic regulator including as a flower inducing factor and inducing plant resistance towards pathogen disease resistance (Negi & Prasad, 2001; Malviya, 2008, Hadi and Balali 2010) [20, 18, 7]. Whereas PCPA (Parachloro Phenoxy Acitic Acid) is a synthetic amino acid having stimulatory effect on plant growth, flowering and fruiting, yield and quality of fruits (Jagdish *et al*., 2002) [11].

In addition, Kurex, a herbal based formulation developed by Agriplex pvt. Ltd., Bangalore believed to act an elicitor, stimulating plant to resist virus infections and prevent the proliferation of virus.

Therefore, considering the above facts the present studies were undertaken to investigate the effect along with the performance evaluation of agro chemicals like SA, PCPA and herbal based formulation Kurex for the effective and sustainable ecofriendly management of leaf curl disease of tomato.

Materials and Method

The experiment to assess the efficacy of bio-regulator against tomato leaf curl virus under dry farming condition of South Bihar was conducted on ten farmer's field of Aurangabad district of Bihar with a tomato Cv. Kashi Vishesh during 2014-15 and 2015-16. The district experiences the extreme average temperature of 7-8 ^{0}C in winter and 40.5 ^{0}C in summer. The present work was performed during the month of Oct.-March in winter season. The monthly weather data viz, maximum temperature (MAXT), minimum temperature (MINT), rainfall (RF), maximum relative humidity of crop period i.e. 6 months were collected from Krishi Vigyan Kendra, Aurangabad and depicted in table no.4 (A) & 4(B).

Seedlings were produced in the seed bed. Seeds (10gm) were sown in 3 m^2 bed in each farmer's plot. Healthy seedlings were maintained by controlling insect vector through covering the nursery bed by white agro-net. Seedlings having 25-30 days old were transplanted in all main plots with 60 cm row to row and 50 cm plant to plant spacing. The farmer's field were well prepared into a good tilth by ploughing followed by laddering. The healthy seedlings with uniform growth and height were selected for transplanting. The treatments were randomly design in the experimental plots. All the recommended cultural practices were followed during the conduction of the experiment. There were three bio-regulators viz. Salicylic acid (100 ppm), Paracholorophenoxy acetic acid (50 ppm) and Virtex (3000 ppm) which were sprayed individually on 40 D AT and 60 D AT and data were collected on different parameter such as percent incidence in TLCV, days to 50% flowering, average fruit weight, fruit length, marketable fruit yield and B:C ratio.

Leaf curl infected plants were recorded on the basis of symptoms. Plants with typically symptoms of leaf curl disease were considered as infected. Percent disease incidence of disease rating of leaf curl were recorded from individual plots at fort nightly interval. Number of healthy and leaf curl infected plants per plots were recorded. Percent disease incidence was calculated by following formulae suggested by Nene (1972) [19].

$$Percentage\ incidence = \frac{Number\ of\ infected\ plants\ per\ plots}{Total\ number\ of\ plants\ per\ plots} \times 100$$

The disease rating of individual plants were recorded using a slightly modified visual scale of 0-7 (Alegbejo 1995 and Alegbaejo and Banwo, 2006) [2].

Where,

0-No visible disease symptoms.

1-Top leaves curled only,

3-Top leaves curled and slightly stunting of plant or all leaves curled without stunting,

5-All leaves curled and slightly stunting of plants, and

7-Severe curling of leaves, stunting of plants and proliferation of auxiliary branches.

The disease rating was recorded for each plant of every plot by adopting the above rating scale.

Monthly weather or meteorological data viz. maximum temperature (MAXT), minimum temperature (MINT), rainfall (RF), maximum relative humidity of crop period i.e. six months were collected from Krishi Vigyan Kendra, Aurangabad.

Results & Discussion

The efficacy of bio-regulator namely Salicylic acid, Parachlorophenoxy acetic acid and Kurex (vertex SPS) spray were tested @100 ppm, 50 ppm and 3000 ppm, respectively for the management of leaf curl disease in tomato. The results revealed that the ultimate mean plant height of tomato at flowering was higher in control (85.10 cm) in comparison to salicylic acid and PCPA treated plots followed by kurex 3000 ppm (84.50 cm). Similarly, parameter like days to 50% flowering was also maximum (42.06) in untreated plots (control) whereas other bio regulator treated plots of salicylic acid (36.54), PCPA (38.03) and vertex SPS (38.35) were lower in comparison to control where no bio-regulator were sprayed. All together there was 5.52 days advancement in days to 50% flowering observed in salicylic acid treated plants (Table 1). The same Table obviously indicated that during both the year of experimentation the spray of Salicylic acid significantly took minimum days to 50% flowering in comparison to other bio-regulator spray and control. The results are in accordance with the findings of to Negi & Prasad (2001) [20].

The results of field experiment presented in Table 2 indicated that each of the bio-regulator were significantly effective in minimizing the leaf curl tomato disease compared to control. The highest per cent of incidence in tomato leaf curl virus was observed in case of untreated plots whereas a significant

reduction in the disease incidence was observed in all the bio regulator treated plots. However, kurex 3000 ppm was found effective in minimizing the disease incidence of TLCV (12.65%) followed by PCPA @50 ppm (24.75%) while salicylic acid was least effective compared to other bio regulator treated plots. The per cent mean efficacy of disease control was ranged between 12.65 to 30.55 %. Similarly, among the individual treatments mean reduction in tomato leaf curl virus percent was observed remarkably highest (71.87%) in vertex 3000 ppm treated plots. Among the different treatments tested, it was also observed that all the bio regulator were found significantly effective in suppression of tomato leaf curl virus in both the year of the conducted trial over the farmer practices. The experimental findings makes it evident that during the first year of experimentation (2014-15), percentage reduction in tomato leaf curl virus was higher in all the bio regulator spread plots than the following year (2015-16). During the year 2014-15, the mean maximum and minimum temperature and rainfall during the crop growth period was lower than the following year which might be helpful in suppressing the incidence of TLCV as the vegetative and reproductive processes including tomato leaf curl virus in tomato are strongly modified by temperature alone or in conjunction with other environmental factor (Abdalla and Verkerk, 1968 and Rodrigo and Marcello, 2019) [6, 23].

Yield is the most promising character which was estimated during the experiment. Data in respect of yield attributes and yield dispread in mean summary Table 1 & 2 revealed that among all the individual treatment tested kurex (Vertex SPS) with 3000 ppm foliar spray recorded the maximum total average yield per hectare (285.45 q/ha), which was significantly superior when compared to control (Table 3) and it was followed by PCPA 50 ppm and salicylic acid 100 ppm foliar spray treated plants. The results of PCPA spray 50 ppm are in close conformity with finding of Jagdish *et al*. (2002) [11]. From the collected data it was also clearly evident that the same treatment (kurex, 3000 ppm) recorded the maximum fruit length (5.19 cm), fruit weight (80.50 gm), fruit yield per plant 3.2 kg and emerged as the best treatment among all. The highest total yield per hectare of tomato achieved by spraying of vertex SPS@3000 ppm mainly due to lower incidence of leaf curl virus and gaining of higher yield attributes viz, average fruit weight and fruit yield per plant which in turn enhanced the yield (39.76%). Like percentage reduction in disease incidence, fruit yield expressed in kilogram per plant as well as quintal per hectare were also noticed higher during the first year of experimentation in comparison to the 2nd year (2015-16) while the trends showed their consistency in results during both the year which was almost similar as the percentage reduction in TLCV is directly correlated with the yield per plant and their was strong interaction between these two.

The estimated economic benefit of different bio-regulator application is presented in Table 3. The results indicated that, the application of 3000 ppm concentration of vertex SPS two spray have yielded maximum gross return (171270.50 Rs/ha) with B:C ratio 2.90 which lower than PCPA owing to higher price of chemical (Kurex), while the minimum gross return (123090 Rs/ha) with 2.49 B:C ratio was calculated under T1 (Farmers Practice – No use of bio-regulator). The experiment requires the mean fixed cost of Rs 49415/ha and the variation of total input cost were only due to bio-regulator applications.

Table 1: Effect of bio-regulator on growth & flowering parameters against TLCV under dry Farming situation of South Bihar.

Treatment	Plant height (cm)			Days to 50% flowering			Fruit length (cm)			Fruit wt (g)		
	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean
Farmer's Practice (Untreated control)	78.85	91.36	85.10	46.80	37.32	42.06	4.40	3.80	4.10	35.30	29.70	32.50
Salicylic acid @100 ppm	78.37	86.32	82.35	40.98	32.10	36.54	4.65	3.80	4.25	57.55	45.44	51.50
Para chloro phenoxy acetic acid (PCPA) @ 50ppm	76.96	80.90	78.93	41.00	35.05	38.03	4.90	4.19	4.54	81.70	64.30	73.00
Kurex (vertex SPS)@ 3000ppm	83.50	85.50	84.50	42.30	34.40	38.35	5.55	4.86	5.19	86.50	74.50	80.50
CD	0.121	0.362	0.24	0.232	0.182	0.21	0.04	0.03	0.49	1.988	1.675	1.83
Sem (+ -)	0.041	0.124	0.08	0.08	0.062	0.07	0.01	0.01	0.17	0.681	0.574	0.63

Table 2: Effect of bio-regulator on disease per cent and yield parameters against TLCV under dry Farming situation of South Bihar.

Treatment	Incidence in TLCV (%)			Reduction in TLCV (%)			Fruit yield/plant (kg)			Yield (q/ha)		
	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean
Farmer's Practice (Untreated control)	36.80	50.20	43.50	0.00	0.00	0.00	1.93	1.57	1.75	225.10	185.20	205.15
Salicylic acid @100 ppm	24.30	36.80	30.55	33.96	26.69	30.33	2.68	1.52	2.10	258.00	219.00	238.50
Para chloro phenoxy acetic acid (PCPA) @ 50ppm	19.70	29.79	24.75	46.46	40.65	43.56	3.05	2.25	2.65	275.70	261.00	268.35
Kurex (vertex SPS)@ 3000ppm	8.10	17.19	12.65	77.98	65.75	71.87	3.85	2.55	3.20	300.30	270.60	285.45
CD	0.999	1.158	1.08	-	-	-	0.068	0.043	0.06	2.659	3.319	2.99
Sem (+ -)	0.342	0.397	0.37	-	-	-	0.023	0.015	0.02	0.911	1.138	1.02

Table 3: Effect of bio-regulator on economic parameters against TLCV under dry farming situation of South Bihar.

Treatment	Increase in yield (%)			Cost of cultivation (Rs.)			Gross return (Rs.)			B : C ratio		
	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean	2014-15	2015-16	Mean
Farmer's Practice (Untreated control)	-	-	-	49015.00	49815.00	49415.00	135060.00	111120.00	123090	2.75	2.23	2.49
Salicylic acid @100 ppm	14.61	18.25	16.43	50790.00	51700.00	51245.00	154800.00	131400.00	143100	3.04	2.54	2.79
Para chloro phenoxy acetic acid (PCPA) @ 50ppm	22.47	40.92	31.70	52660.00	53650.00	53155.00	165420.00	156600.00	161010	3.14	2.91	3.02
Kurex (vertex SPS)@ 3000ppm	33.40	46.11	39.76	58000.00	58450.00	58225.00	180180.00	162360.00	171270	3.10	2.7	2.9

Table 4 (A): Mean monthly Rainfall, Temp., and Relative Humidity of the district during 2014-15

Month	Rainfall (mm)	Temp. (ºC)		Relative Humidity (%)	
		Max.	Min.	Max.	Min.
Apr-14	0	39.29	21.89	57.5	14.13
May-14	29.76	38.6	25.46	59.39	23.29
Jun-14	34.5	37.68	27.21	75.9	32.8
Jul-14	258.23	32.7	26.08	89.26	59.65
Aug-14	95.48	32.21	26.17	90.74	63.48
Sep-14	96.3	32.77	25.45	99.63	69.87
Oct-14	54.56	29.73	20.91	96.77	63.71
Nov-14	0	28.92	13.87	97	16.96
Dec-14	0.75	22.25	8.95	99.11	40.36
Jan-15	9.3	20.38	10.42	99.87	61.87
Feb-15	0	26.93	13.38	99	42.93
Mar-15	0	30.46	16.65	92.84	36.29
Total	578.88	371.92	236.44	1057.01	525.34

Table 4 (B): Mean monthly Rainfall, Temp., and Relative Humidity of the district during 2014-15

Month	Rainfall (mm)	Temp. (ºC)		Relative Humidity (%)	
		Max.	Min.	Max.	Min.
Apr-15	0	37.12	21.74	85.17	24.13
May-15	0	40.56	25.85	73.39	17.94
Jun-15	1.75	36.97	27.22	77.1	37.83
Jul-15	64.1	33.18	27.47	96.4	67
Aug-15	99.5	33.23	26.87	99.25	61.74
Sep-15	0	32.87	25.77	98.55	63.15
Oct-15	0	30.2	21.65	95.47	60.37
Nov-15	0	27.92	18.46	90.56	58.57
Dec-15	0	25.58	17.45	85.47	50.59
Jan-16	15.2	23.37	13.86	92.87	60.36
Feb-16	0	26.47	15.15	83.46	53.76
Mar-16	15.6	33.54	20.47	80.93	49.48
Total	196.15	381.01	261.96	1058.62	604.92

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