The Andhra Agric. J 60(4):849-855, 2013

Effect of Systemic Acquired Resistance Elicitors on Yellow Mosaic Disease and Growth of Blackgram

K Basavaraj, J Krishna Prasadji, M Adinarayana, P Anil Kumar and G Ramachandra Rao
Department of Plant Pathology, Agricultural College, Bapatla 522 101, Andhra Pradesh

ABSTRACT

Field experiment was conducted with mungbean yellow mosaic susceptible variety LBG 623 during *kharif* and *rabi* 2011-12 with a view to alleviating the effects of whitefly borne geminivirus, Mungbean Yellow Mosaic Virus (MYMV) in blackgram through foliar application of salicylic acid (SA) 3mM, triacontanol (tria) 10 ppm and certain mineral nutrients like potassium as KNO_3 (0.5%), magnesium as $MgSO_4$ (0.5%) and manganese as $MnSO_4$ (0.2%) either alone successively or alternated with each other. The treatments tria followed by KNO_3 and tria-KNO_3 were found more effective in reducing the MYMV incidence and intensity with a consequent increase in growth and yield. The application of SA and mineral nutrients either alone or in alternation with tria and SA also reduced the disease compared with unsprayed check. Acetamiprid spray in combination with yellow sticky trap in the present investigation was not found to be effective.

Key words : Mineral nutrients blackgram, *Mungbean yellow mosaic virus* (*MYMV*), Salicylic acid, Triacontanol.

Blackgram or urdbean is a major pulse crop of Andhra Pradesh with a special significance as it fits well in rice – pulse cropping system as a relay crop particularly in Krishna – Godavari and North Coastal zones. *Mungbean yellow mosaic virus* (*MYMV*) is a serious constraint in the cultivation of blackgram in recent years. Attempts made mostly focussing on the vector, *Bemisia tabaci* management, were reasonably successful over a considerable period (Ganapathy and Karuppiah, 2004). However, in recent years management of *MYMV* through vector control was ineffective for unknown reasons.

Alleviation of the effects of infection with a view to limiting the losses could be an alternative strategy for managing virus disease. Exogenous application of systemic acquired resistance (SAR) elicitor like salicylic acid was shown to attenuate the effects of virus infection in plants (Radwan *et al.,* 2008). Triacontanol, an aliphatic alcohol, could be an ideal molecule with twin activities of promoting plant growth by increasing chlorophyll and inducing defence enzyme, peroxidase (Henry and Gordon, 1980) for limiting virus infection. Beneficial effects of micronutrients in reducing disease in virus infected plants were demonstrated in some crops (Bobade *et al.,* 2009; Jalaluddin *et al.,* 2006).

The use of SAR elicitors and novel molecules has not been contemplated in the management of yellow mosaic in pulses. Hence, the present investigation was carried out with the objective to evaluate SAR elicitor: salicylic acid, triacontanol and mineral nutrients as foliar sprays for their efficacy in alleviating the effects of *MYMV* infection in blackgram

MATERIAL AND METHODS

The present investigation was conducted at the Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, during *kharif* and *rabi* 2011-12. The experiment was laid out in a randomized block design with three replications and fourteen treatments *viz*., SA 3 mM (T_1), tria 10 ppm (T_2), KNO_3 0.5 % (T_3), $MgSO_4$ 0.5 % (T_4), $MnSO_4$ 0.2 % (T_5), SA 3mM followed by tria 10 ppm (T_6), SA 3 mM-KNO_3 0.5 % (T_7), SA 3 mM-$MgSO_4$ 0.5 % (T_8), SA 3 mM-$MnSO_4$ 0.2 % (T_9), tria 10 ppm-KNO_3 0.5 % (T_{10}), tria 10 ppm-$MgSO_4$ 0.5 % (T_{11}), tria 10 ppm-$MnSO_4$ 0.2 % (T_{12}), acetamiprid 0.2 g/l + yellow sticky trap (T_{13}), and untreated check (T_{14}). The treatments were imposed from 15 days after sowing, at one week interval for four times. Treatments T_6 to T_{12} were applied with the first mentioned chemical as first and third sprays and alternated with the second

chemical as second and fourth sprays. SA was initially dissolved in a small quantity of sodium hydroxide (0.1%) solution and the final spray fluid was made up with water to the desired concentration of 3 mM.

Recommended agronomic practices were followed during crop period, Nitrogen @ 20 kg and phosphorus @ 50 kg/ha were applied as basal dose before sowing.

MYMV incidence was scored by counting the total number of plants infected in each treatment plot and per cent disease incidence was calculated.

MYMV severity at weekly intervals was recorded from 10 randomly marked plants from each microplot and disease was scored from the first appearance till harvest of crop following the modified scale of All India Coordinated Research Project on MULLaRP (Alice and Nadarajan, 2007). The severity was calculated by the following formula

$$\text{Percent Disease Index (PDI)} = \frac{\text{Sum of all numerical ratings}}{\text{Number of observations} \times \text{maximum disease grade}} \times 100$$

Observations on growth and yield contributing parameters like root length, shoot length, number of primary branches/plant, number of pods/plant, number of seeds/pod, seed yield, 100 seed weight and total plant dry matter were made on five randomly selected plants from each plot at harvesting stage.

RESULTS AND DISCUSSION

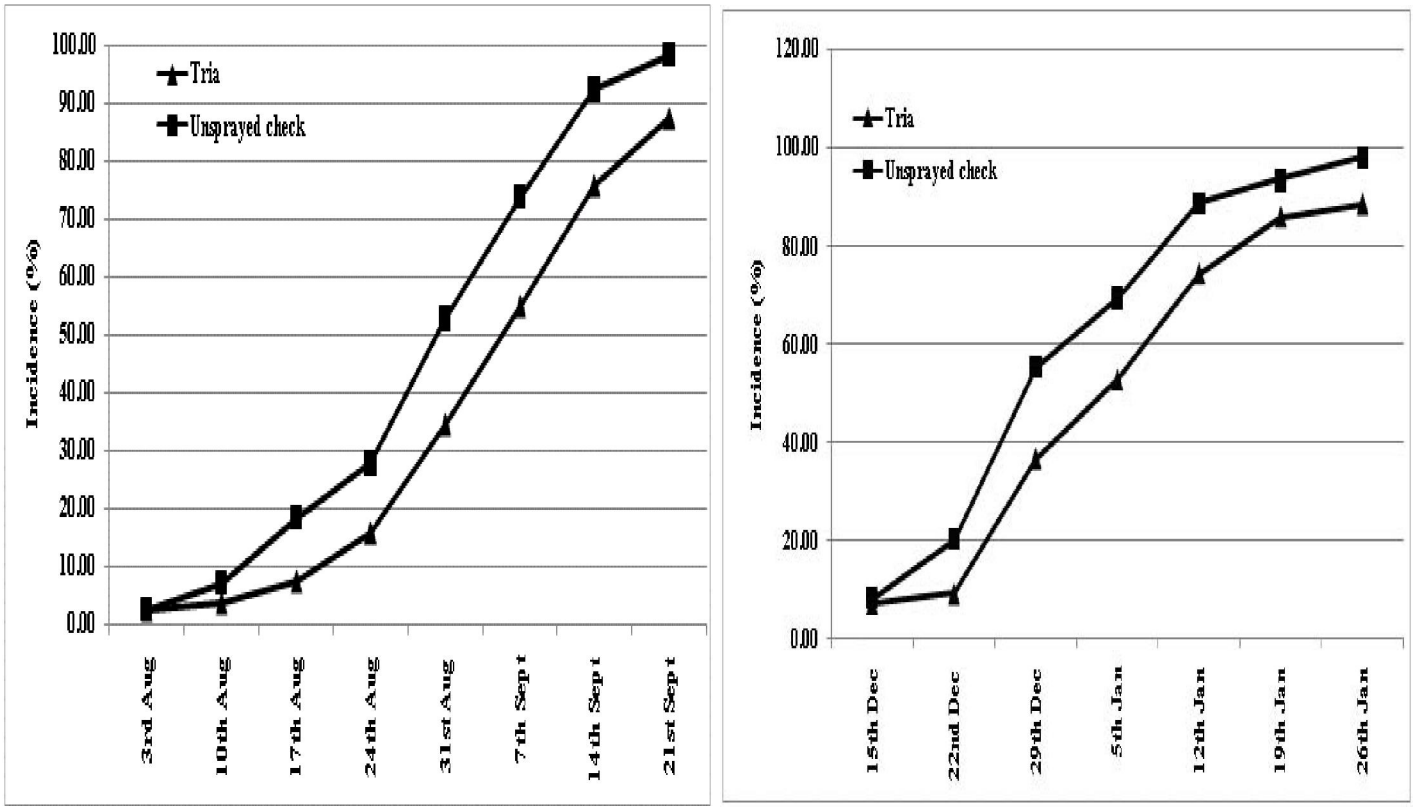
MYMV Incidence and severity

SA, tria and mineral nutrients sprayed successively or alternated with each other decreased *MYMV* incidence in blackgram in both *kharif* and *rabi* seasons. However, the incidence was significantly lower in tria, KNO_3 and tria-KNO_3 treated plots in both the seasons. While it was also significantly lower in SA, $MgSO_4$, $MnSO_4$, SA-tria, tria-$MgSO_4$ and tria-$MnSO_4$ sprayed plants in *kharif* , none of the other treatment was found to significantly reduce disease incidence in *rabi* (Table 1).

Table 1. Effect of salicylic acid, triacontanol and mineral nutrients on MYMV incidence and severity of blackgram during *kharif* and *rabi* 2011-12

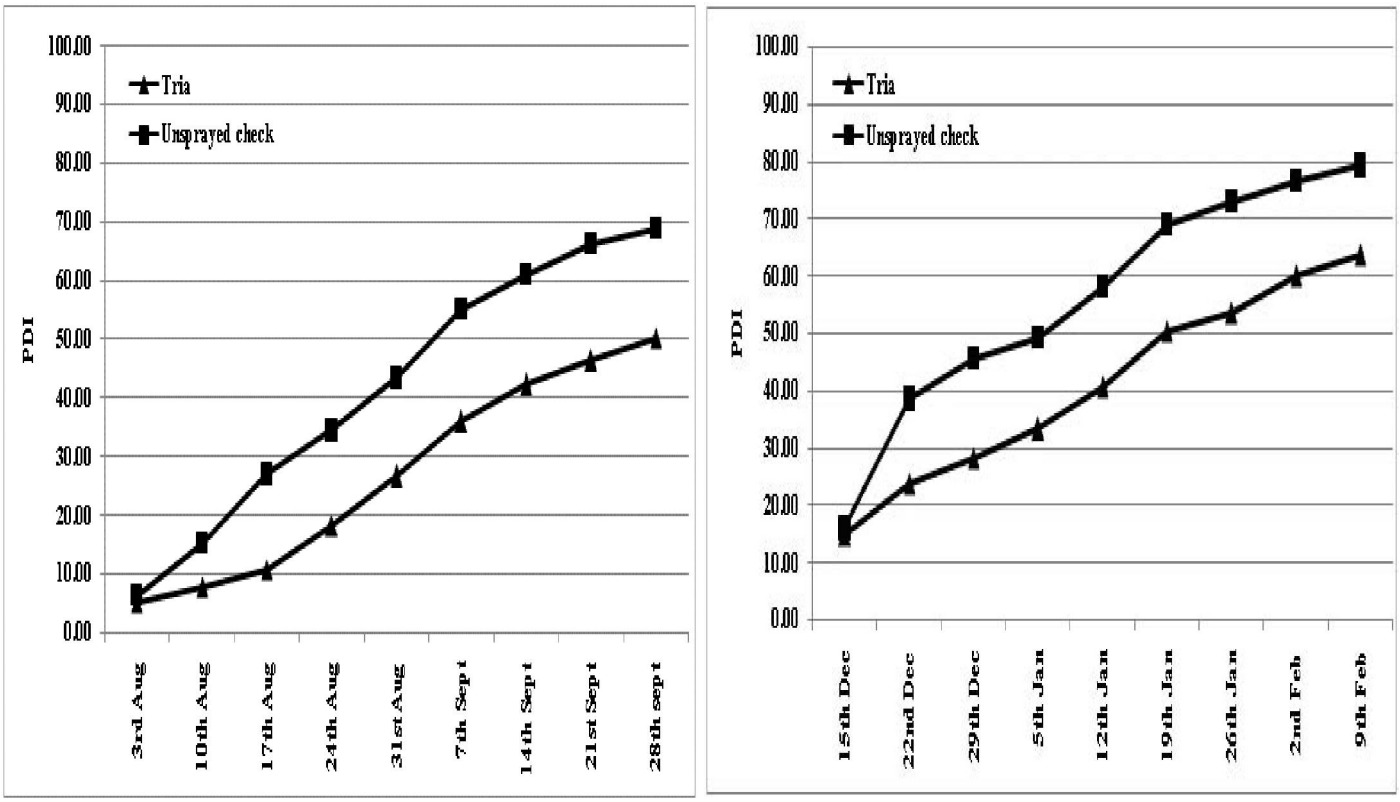
Treat. No.	Treatment	MYMV Incidence (%)		MYMV Severity (PDI)	
		Kharif	*Rabi*	*Kharif*	*Rabi*
1	Salicylic acid (SA)	93.67 (75.51)*	96.92 (80.15)	63.70 (52.96)	72.22 (58.22)
2	Triacontanol (Tria)	87.42 (69.24)	88.50 (70.18)	50.37 (45.21)	63.70 (52.95)
3	KNO_3	88.17 (69.88)	93.08 (74.78)	54.81 (47.95)	68.14 (55.65)
4	$MgSO_4$	92.67 (74.38)	97.33 (81.07)	59.62 (50.60)	72.59 (58.49)
5	$MnSO_4$	93.33 (75.48)	95.17 (77.31)	57.77 (49.67)	72.96 (58.68)
6	SA-tria	93.00 (74.95)	97.50 (81.46)	62.59 (52.32)	73.70 (59.16)
7	SA-KNO_3	96.33 (79.14)	96.50 (79.37)	61.85 (51.88)	73.70 (59.16)
8	SA-$MgSO_4$	95.17 (77.49)	94.83 (77.25)	62.96 (52.54)	73.70 (59.15)
9	SA-$MnSO_4$	94.92 (77.25)	95.17 (77.73)	66.66 (54.77)	74.81 (59.97)
10	Tria-KNO_3	89.42 (71.12)	92.50 (74.18)	52.96 (46.71)	68.51 (55.88)
11	Tria-$MgSO_4$	90.83 (72.52)	94.92 (77.34)	57.03 (49.04)	69.25 (56.45)
12	Tria-$MnSO_4$	92.92 (74.60)	95.75 (78.29)	55.92 (48.43)	71.47 (57.73)
13	Acetamiprid	95.08 (78.40)	96.08 (78.79)	61.11 (51.44)	74.07 (59.40)
14	Unsprayed check	98.25 (82.84)	98.08 (82.29)	68.88 (56.11)	79.25 (62.99)
CD ($P \leq 0.05$)		5.64	5.56	4.64	4.34
CV (%)		4.47	4.25	5.45	4.44

* Figures in parentheses are arc sine transformed values



Kharif 2011-12 *Rabi* 2011-12

Fig 1. *MYMV* incidence in best treatment (tria) and unsprayed check



Kharif 2011-12 *Rabi* 2011-12

Fig 2. *MYMV* severity in best treatment (tria) and unsprayed check

SA, tria and mineral nutrients sprayed either alone or alternated with each other also had a decreasing effect on *MYMV* severity. Treatments tria, KNO_3, $MgSO_4$, tria-KNO_3, tria-$MgSO_4$ and tria-$MnSO_4$ caused significant reduction in PDI in both the seasons than unsprayed check. While treatments $MnSO_4$ and acetamiprid in *kharif* and SA in *rabi* also significantly reduced PDI (Table 1). Over all tria, tria-KNO_3 and KNO_3 and tria alternated with mineral nutrients were found effective in reducing the disease severity.

Onset of *MYMV* incidence was observed early and about 50% incidence was recorded by the seventh week after sowing in *kharif* crop and fifth week after sowing in *rabi* crop in unsprayed plants. Occurrence of 50% incidence was delayed up to nine weeks after sowing in *kharif* and six weeks after sowing in *rabi* in the best treatment of tria (Fig. 1). The dynamics of manifestation of virus infection *i.e.*, severity, could also be a factor in the ultimate effect on growth and yield of infected plants. Increase in PDI was rapid in the initial weeks in unsprayed plants (Fig. 2) while it gained momentum only in later weeks in the plants that received the best treatments; tria and tria-KNO_3. The PDI increase with age was moderate in other treatments except acetamiprid in which it was closer to that observed in unsprayed check. The slower disease manifestation in initial weeks after the start of spray applications of treatments could be because of sustained SAR levels while after the final spray, with lapse in time the SAR levels could have fallen and hence, disease manifestation could have been faster in later weeks. Gorlach *et al*. (1996) reported similar phenomenon of higher SAR levels immediately after SA application that have fallen with lapse of time in wheat against powdery mildew.

Harmful effects of infection and growth inhibition by *Bean Yellow Mosaic virus* in faba bean (Radwan *et al*., 2008) and *Zucchini Yellow Mosaic Virus* in *Cucurbita pepo* (Radwan *et al*., 2006) were shown to be reduced by spraying SA. Reduction in okra yellow vein mosaic virus infection was found to be induced by barium chloride, acetyl salicylic acid and SA (Pun *et al*., 2000). Mayers *et al.* (2005) recorded a lowered *Cucumber Mosaic Virus* (*CMV*) infection in squash and *Arabidopsis thaliana* with SA application. Systemic acquired resistance inducing molecules like acibenzolar-S-methyl, disodium hydrogen phosphate and alum were found to suppress *MYMV* and increase yield in blackgram (Venkatesan *et al.,* 2010).

Table 2. Effect of salicylic acid, triacontanol and mineral nutrients on growth characters in *MYMV* infected blackgram during *kharif* and *rabi* 2011-12

Treat. No.	Treatment	Root length (cm)		Shoot length (cm)		No. of primary branches/plant	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
1	Salicylic acid (SA)	14.9	10.3	51.3	17.6	2.8	2.7
2	Triacontanol (Tria)	18.2	13.3	57.1	24.0	3.8	3.3
3	KNO_3	15.7	11.8	53.8	21.6	3.4	2.9
4	$MgSO_4$	14.5	9.8	52.2	19.3	2.9	2.6
5	$MnSO_4$	14.7	10.6	51.6	18.6	2.9	2.7
6	SA-tria	13.7	10.0	48.7	17.7	3.1	2.9
7	SA-KNO_3	13.5	9.7	50.2	18.8	2.8	2.7
8	SA-$MgSO_4$	14.1	10.0	51.2	20.0	3.2	2.7
9	SA-$MnSO_4$	14.8	10.5	49.9	19.8	3.1	2.8
10	Tria-KNO_3	16.9	11.9	54.6	22.5	3.6	3.1
11	Tria-$MgSO_4$	15.1	11.1	52.0	20.3	3.4	2.9
12	Tria-$MnSO_4$	15.0	10.6	52.4	20.1	3.3	2.8
13	Acetamiprid	13.9	9.2	48.9	17.4	3.0	2.6
14	Unsprayed check	12.8	8.6	45.0	15.7	2.6	2.4
CD ($P \leq 0.05$)		2.4	1.4	4.3	2.8	0.5	0.3
CV (%)		9.8	7.7	5.0	8.6	9.3	6.4

Mineral nutrients were also found to reduce viral infection in plants. Soil application of potassium and phosphorus @ 40 kg/ha was shown considerably reduced *MYMV* incidence (Sekhar and Hari-Chand, 2001). Potassium application was found to widen potassium/nitrogen ratio that resulted in thickened outer walls of epidermis (Perrenoud, 1990) which might have acted as a tough barrier for the viruliferous whitefly to inoculate the plants. Secondly, potassium could have played an important role in the synthesis of defence enzymes (Marschner 1995) that led to a decreased disease incidence and severity. Diminished *Tabacco Mosaic Virus* multiplication in tobacco was reported with manganese application (Welkie and Pound, 1958). Bobade *et al.* (2009) reported that soil and spray application of magnesium sulphate, manganese sulphate, zinc sulphate and ferrous sulphate reduced *Geminivirus* infection in frenchbean.

Although beneficial effects of tria and its mechanism of action were reported (Jin and Hong, 1988 and Naeem *et al*., 2012), its efficacy in reducing the effects of virus infection in plants has not been reported. Reduction in *MYMV* incidence and severity with tria either alone or in alternation with SA and mineral nutrients was found in this study. It is probable that tria and its second messenger 9- -1(+)-adenosine (Ries, 1991) could have played a signal like role in the activation of resistance responses in treated plants and thus could have contributed to lesser severity in infected plants.

Growth and yield parameters

SA, tria and mineral nutrients had an ameliorative effect on growth and yield of blackgram in spite of *MYMV* infection. All the treatments increased root and shoot lengths, and number of primary branches with a significant increase in tria, tria-KNO_3 and KNO_3 sprayed plots in both *kharif* and *rabi* seasons. All other treatments in *kharif* and acetamiprid and $MgSO_4$ and SA-KNO_3 in *rabi* though increased root length were not significantly effective. With the exception of SA, SA-tria and acetamiprid the rest of the treatments significantly increased shoot length. All treatments caused increase in primary branches number which however, was not significant in SA,

Table 3. Effect of salicylic acid, triacontanol and mineral nutrients on yield characters in MYMV infected blackgram during *kharif* and *rabi* 2011-12.

Treat. No.	Treatment	No. of pods/plant		No. of seeds/pod		Seed yield (q/ha)	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
1	Salicylic acid (SA)	13.6	8.3	5.6	5.2	10.15	5.63
2	Triacontanol (Tria)	15.3	12.8	6.4	6.1	11.46	8.26
3	KNO_3	14.8	9.3	5.7	5.6	11.11	6.95
4	$MgSO_4$	14.2	8.4	5.6	5.5	10.34	6.18
5	$MnSO_4$	13.4	8.4	5.5	5.4	9.58	6.02
6	SA-tria	13.2	8.4	5.6	5.5	9.86	6.32
7	SA-KNO_3	14.5	9.6	5.4	5.3	10.44	6.93
8	SA-$MgSO_4$	13.1	8.7	5.3	5.3	8.79	6.21
9	SA-$MnSO_4$	13.5	8.5	5.7	5.6	10.26	6.40
10	Tria-KNO_3	15.1	10.9	6.3	6.0	11.32	7.86
11	Tria-$MgSO_4$	14.2	10.2	6.2	5.9	10.93	7.54
12	Tria-$MnSO_4$	14.3	10.2	6.0	6.0	10.38	7.21
13	Acetamiprid	12.1	7.9	5.1	4.9	7.60	5.18
14	Unsprayed check	11.4	7.7	4.8	4.7	7.12	4.57
CD ($P \leq 0.05$)		2.1	1.8	0.5	0.4	2.06	1.35
CV (%)		9.2	11.7	5.0	4.6	12.36	12.29

$MgSO_4$, $MnSO_4$, SA- KNO_3, SA-$MnSO_4$ and acetamiprid in *kharif*, and SA, $MgSO_4$, SA- KNO_3, SA-$MgSO_4$ and acetamiprid in *rabi* (Table 2).

Tria, tria-KNO_3, tria-$MgSO_4$, tria-$MnSO_4$ and SA-KNO_3 application significantly increased pod number in both *kharif* and *rabi* while the increase was also significant in KNO_3 and $MgSO_4$ treated plants in *kharif*. All the treatments except SA-$MgSO_4$ and acetamiprid in *kharif* and acetamiprid in *rabi* have significantly increased seed number/pod with the highest in tria treated followed by tria-KNO_3 treated plants. Consequently significantly higher yield was obtained with all the treatments except SA-$MgSO_4$ and acetamiprid in *kharif* and SA and acetamiprid in *rabi*. The highest yield was recorded in tria followed by tria-KNO_3 sprayed plots (Table 3).

Nene (1972), Dhingra and Chenulu (1985) and Yadav and Brar (2010) reported that early infection leads to greater damage. Delayed progress in incidence and severity with reference to crop age and an actual reduction in severity due to tria and other treatments in comparison to unsprayed check were observed in this study which might have contributed to better growth and yield than in unsprayed check besides the natural growth promoting property as reported by Jeyakumar *et al*. (2008).

Higher *MYMV* incidence and severity were shown to cause greater reduction in growth and yield characters like number of pods, seeds per pod, and seed yield (Haq *et al*., 1992; Chand and Verma, 1983). In the present investigation also drastic reduction in vegetative and yield characters in relation to *MYMV* severity was observed. Root and shoot lengths were longer in treated plants particularly with tria than in unsprayed check that could be attributed to general beneficial effects and alleviation of the ill effects of virus infection such as indole acetic acid (IAA) degradation in stressed plants. Tria, which produced the longest roots in both healthy and diseased plants, was shown to decrease IAA degradation and hence promote root and shoot growth (Henry and Gordon, 1980). The increase in growth and yield might be due to their beneficial effects on plant metabolism coupled with their effect on disease reduction.

LITERATURE CITED

Alice D and Nadarajan N 2007 Pulses: Screening techniques and assessment for disease resistance. *All India Coordinated Research Project on MULLaRP*- Tamil Nadu Agricultural University. Kasturi Graphics and Printers, Coimbatore. 24.

Bobade A, Chaurasiya A and Katare S 2009 Study on testing the role of micronutrients on chlorotic mottle (geminivirus) disease development in Frenchbean (*Phaseolus vulgaris* L). *International Journal of Plant Protection*, 2: 12-14.

Chand P and Verma J P 1983 Effect of yellow mosaic on growth components and yield of mungbean and urdbean. *Haryana Agricultural University Journal of Research*, 13: 98-102.

Dhingra K L and Chenulu V V 1985 Effect of yellow mosaic on yield and nodulation of soybean. *Indian Phytopathology,* 38: 248-251.

Ganapathy T and Karuppiah R 2004 Evaluation of new insecticides for the management of whitefly (*Bemisia tabaci* Genn.), mungbean yellow mosaic virus (MYMV) and urdbean leaf crinkle virus (ULCV) diseases in mungbean (*Vigna radiata* (L) Wilezek). *Indian Journal of Plant Protection*, 32: 35-38.

Gorlach J, Volrath S, Bieter K G, Henry G and Beckhove U 1996 Benzothiadiazole, a novel class of inducers of systemic acquired resistance, activates gene expression and disease resistance in wheat. *Plant Cell*, 8: 629-643.

Haq M A, Ilyas M B and Iftikhar K 1992 Growth responses of urdbean cultivars to yellow mosaic virus infection. *Pakistan Journal of Agriculture Science*, 29: 275- 279.

Henry E G and Gordon C J 1980 The effect of triacontanol on peroxidase, IAA, and plant growth in *Pisum sativum* var. Alaska and Little Marvel. *Journal of Experimental Botany*, 1: 1297-1303.

Jalaluddin M, Khalil M I and Kashem M A 2006 Management of yellow mosaic of summer mungbean with boron, molybdenum, rogueing and insecticide. *Bangladesh Journal of Plant Pathology*, 22: 17-20.

Jeyakumar P, Velu G, Rajendran C and Amutha R 2008 Varied responses of blackgram (*Vigna mungo*) to certain foliar applied chemicals and plant growth regulators. *Legume Research*, 31: 110-113.

Jin C D and Hong Y N 1988 The effect of triacontanol on chloroplast development of radish cotyledons. *Korean Biochemistry Journal*, 21: 68-76.

Marschner H 1995 *Mineral Nutrition of Higher Plants*. 2nd edition, Academic press, London. 889.

Mayers C N, Lee K C, Moore C A, Wong S M and Carr J P 2005 Salicylic acid induced resistance to cucumber mosaic virus in squash and *Arabidopsis thaliana*: Contrasting mechanism of induction and antiviral action. *Molecular Plant-Microbe Interactions*, 18: 428-434.

Naeem M, Massoor M, Khan A and Mouniddin 2012 Triacontanol: a potent plant growth regulator in agriculture. *Journal of Interactions*, 7: 129-42.

Nene Y L 1972 A survey of the viral diseases of pulse crops in Uttar Pradesh. *First Annual Report. FG-IN-358,* Uttar Pradesh Agricultural University. 1-25.

Perrenoud S 1990 *Potassium and Plant Health*. IPI Research topics no. 3. 2nd revised edition. International Potash Institute, Basel, Switzerland.

Pun K B, Doraiswamy S and Jeyarajan R 2000 Screening of virus inhibitory chemicals and neem products against okra yellow vein mosaic virus. *Indian Phytopathology,* 53: 95-96.

Radwan D E M, Fayez KA, Mahmoud S Y, Hamad A and Lu GuoQuan 2006 Salicylic acid alleviates growth inhibition and oxidative stress caused by zucchini yellow mosaic virus infection in *Cucurbita pepo* leaves. *Physiological and Molecular Plant Pathology*, 69: 172-181.

Radwan D E M, Lu GuoQuan, Fayez K A and Mahmoud S Y 2008 Protective action of salicylic acid against bean yellow mosaic virus infection in *Vicia faba* leaves. *Journal of Plant Physiology*, 165: 845-857.

Ries S 1991 Triacontanol and its second messenger 9-β -1 (+) - adenosine as plant growth substances. *Plant Physiology*, 95: 986-989.

Sekhar N R and Hari-Chand 2001 Effect of host nutrition on mungbean yellow mosaic virus, anthracnose, root rot and leaf crinkle of mungbean (*Vigna radiata* (L) Wilkzek). *Indian Journal of Plant Protection*, 29: 88-91.

Venkatesan S, Radjacommare R, Nakkeeran, S and Chandrasekhara A 2010 Effect of biocontrol agent, plant extracts and safe chemicals in suppression of mungbean yellow mosaic virus (*MYMV*) in blackgram (*Vigna mungo*). *Archieves of Phytopathology and Plant Protection*, 43: 59-72.

Welkie G W and Pound G S 1958 Manganese nutrition of *Nicotiana tabacum* L. in relation to multiplication of tobacco mosaic virus. *Virology*, 5: 92-109.

Yadav M S and Brar K S 2010 Assessment of yield loss due to mungbean yellow mosaic India virus and evaluation of mungbean genotypes for resistance in South-West Punjab. *Indian Phytopathology.* 63: 318-320.

(Received on 08.08.2012 and revised on 11.02.2013)