Integration of organic and inorganic amendments with native bioagents for bio-intensive management of vascular bacterial wilt on eggplant (Solanum melongena)

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ABSTRACT: The potential of biocontrol consortium and organic/inorganic soil amendments as the major component of bio-intensive management strategy of Ralstonia solanacearum induced vascular bacterial wilt on eggplant (Solanum melongena L.) in New Alluvial region of West Bengal was studied. The in vitro antagonistic potential of native rhizospheric fluorescent pseudomonads (PF) revealed that PF-3, followed by PF-2 produced highest inhibition zone 5.19 mm and 4.26 mm, respectively. Further, only PF-2 was able to inhibit all the R. solanacearum isolates. Among different organic amendments tested, green manuring with dhaingha leaf (25 q/ha) and application of neem cake (500 kg/ha) one month before transplanting were the most effective treatments in terms of disease reduction by 42.3% and 41.57%, respectively, over the control. Among different inorganic amendments, application of bleaching powder (20 kg/ha) followed by lime (500 kg/ha), one month before transplanting, were most effective treatments in terms of disease reduction up to 44.91% and 28.04%, respectively over the control. The integration module constituting green manuring with dhaingha leaf (25 q/ha) + bleaching (20 kg/ha) + lime (500 kg/ha) + consortium of fluorescent pseudomonads (PF-2 and PF-3) (seedling treatment and soil spot application) was the best performer among seven different modules, both in terms of disease reduction (72.25%), enhancing yield (11.8 t/ha) over the control. The present investigation indicated that exploitation of biodiversity with organic and inorganic amendment towards assistance for preferential adaptation of native biological consortia is indeed able to suppress this versatile complex pathogen.

Key words: Native biological consortium, organic and inorganic amendment, Ralstonia solanacearum, vascular bacterial wilt

Ralstonia solanacearum (Smith, 1896; Yabuuchi et al., 1996) is considered to be one of the most important plant pathogenic bacteria as it causes great economic losses by means of vascular bacterial wilt disease worldwide (Hayward, 1991). At the same time sound disease management option is still a mess due to wide range of adventage of the pathogen towards edapho-climatic condition (Shekhawat et al., 1978), high degree of variability and genetic diversity (Fegan and Prior, 2005), long-term survival ability and unique survival strategy under adverse conditions (Grey and Steek, 2001), wide host range (Hayward, 1964) and some specific cultural practices adopted by growers in West Bengal, India (Ghosh, 2005). Thus, site-specific, appropriate and bio-intensive strategies for management is needed to be explored against the dreaded disease.

Bio-intensive management strategy has been evolved that stands on the exploitation of planned biodiversity with every possible assistance for preferential adaptation over altered biodiversity in the changing ecological niche. These assistance either in terms of manipulation of soil properties and/or reactions by means of organic/inorganic soil amendment or by using novel plant ‘variety’ having unique rhizosphere exudates that promote the native biological consortia and demote the pathogen as-and-when required basis. Obviously, bio-intensive management could be employed site-specifically relatively in small-scale farm where all the ecological aspects are more or less homogeneous.

Several workers attempted to manage the disease using organic and inorganic soil amendment separately or in combination with other components. For instance, bleaching powder at the rate of 25 kg/ha or urea at the rate 428 kg/ha and lime 5000 kg/ha (Dhital et al., 1997); nitrogen 200 kg/ha and CaO 5000 kg/ha (Michel and Mew, 1998); phosphoric acid (H3PO4) (Norman et al., 2006); urea, fly ash and bleaching powder singly or in combination (Kanjilal et al., 2000); poultry or other livestock manure (Hayward and Hartman, 1994); combined application of urea + ground garlic leaves (Abd-El-Ghafar and Abd-El-Sayed, 2002). Cruciferous residues have been used as bio-fumigating agent by Olivier et al. (2006). Ghosh and Mandal (2009) found that well-decomposed cowdung at land preparation, seed piece tuber treatment with Carbandazim + streptocycline, stable bleaching powder (1%) drenching along with protective banding with well-decomposed cowdung, oilcake, SSP and MOP (20:5:3:1) were the best treatments in terms of their response to yield, disease management and higher return per rupee investment.

The roots of most plants have a relationship with certain beneficial bacteria (e.g. fluorescent Pseudomonads, hereinafter Pf) of nutritive and spatial
competence in the rhizosphere (Jagadeesh et al., 2001). Vanitha et al. (2009) suggested that seed treatment with antagonistic Pseudomonas fluorescens significantly reduced disease incidence as well as improve the quality of seed germination and seedling vigour. Wydra and Semrau (2005), and Nguyen and Ranamukhaarachchi (2010) reported reduction of vascular bacterial wilt and yield increase were associated with biocontrol agents like Bacillus spp., fluorescent Pseudomonads, Enterobacter cloacae, Pichia guillermondii and Candida ethanolica. Chakraborty and Kalita (2012) used indigenous strain of Pseudomonas fluorescens as potential biocontrol agent against bacterial wilt of brinjal. They also showed that bacterial wilt incidences were the lowest when cell suspension of P. fluorescens applied by root and soil treatment. Murthy et al. (2013) effectively used Trichoderma asperellum to enhance induced resistance against R. solanacearum.

Unfortunately, most of the microbial product available in the market are single-culture microbial inoculants and have not proven to be effective under field conditions. Higa (1991) pointed out that there is a greater likelihood of controlling the soil microflora by introducing mixed, compatible cultures rather than single pure cultures. Sarma and Anandaraj (1998) suggested the consortium approach for disease management in plantation and spice crops. Kumar et al. (2002) showed that R. solanacearum population was the least in treatments where antagonists (P. fluorescens and B. cereus) were combined with VAM (Glomus mosseae). Rosyidah et al. (2014) reported the potential of Pseudomonas fluorescens in combination with Streptomyces sp. and Trichoderma viride + Streptomyces sp. regarding induction of resistance towards R. solanacearum on potato.

The hypothesis of the present investigation is that application of inorganic soil amendment and/or soil disinfectant such as stable bleaching powder suppresses the competitive microbiota in soil (Dhital et al., 1997; Kanjilal et al., 2000). Application of organic amendment, on the other hand, increased microbial diversity in soil and simultaneously preferentially suppress the plant pathogenic soil microbes with low competitive saprophytic ability or at least delay the disease onset (Irikiin et al., 2006). The organic amendment also deposits sufficient amount of organic matter that could be used as source of energy by soil microbiota.

The native biological antagonists do have the ecological benefits in a given soil towards adaptation irrespective of nature and magnitude of competition with the native microbiota. Now application of inorganic amendment and/or soil disinfectant suppresses the existing microbial activity in soil, followed by application of organic amendment that promote the planned biodiversity and this altered soil ecosystem can be exploited for preferential adaptation of biological antagonists. Therefore, an experiment was conducted to study the potential of biocontrol consortium and organic/inorganic soil amendments as major component of bio-intensive management strategy of R. solanacearum induced vascular bacterial wilt on eggplant (Solanum melongena L.) in New Alluvial region of West Bengal.

MATERIALS AND METHODS

Isolation and maintenance of R. solanacearum isolates

The samples of infected plants of eggplants with R. solanacearum were collected from different locations in West Bengal. The infected plant parts were cut into small pieces, surface sterilized with appropriate surface sterilizing reagent, followed by three times washing in sterile distilled water (SDW) and dipped in SDW containing culture tubes to allow oozing. All operations were carried out within Laminar airflow chamber. After 15-20 min, ooze in sterile water were streaked on R. solanacearum semi-selective medium (modified SMSA, Englebrecht, 1994) supplemented with 0.005% 1,3,5 triphenyl tetrazolium chloride (TZC), following quadric streaking method. Inoculated Petri-plates were then allowed to incubate at 30±1°C. The R. solanacearum produces fluidal colony with pink centre and whitish periphery 48 h after incubation. Pure culture was isolated from such colonies on SMSA medium without TZC. Pure cultures were maintained in sterile distilled water under room temperature for further investigation. The pathogen was identified through PCR with the primer pair 759F/760R and protocol described by Opina et al. (1997) followed by 2% agarose gel electrophoresis.

Isolation and maintenance of native fluorescent pseudomonads

Thoroughly mixed composite rhizosphere soil collected from various fields and 10 g sample soil from well-mixed composite soil samples were taken and suspended in 90 ml of SDW and volume was made up to 100 ml using SDW to prepare 10¹ dilution and kept as stock. Serial dilution was made up to 10⁶ dilution. One ml of each dilution was poured into empty sterile Petri-plates. The cool molten King’s B (KB) medium were then poured into each Petri-plates and rotated clockwise and anti-clockwise to mix the suspension with the media and kept for solidification. After the media become solidified, the Petri-plates were then wrapped with sterile polythene packet and incubated into the BOD incubator at 28±1°C for 48 h under inverted condition. Yellow-green fluorescent colonies were isolated and streaked on to the KB slants for purification. After 48 h of incubation, the slants were tested for fluorescent pigment using UV light and fluorescent pigment positive isolates were then kept at 4°C for future use.

In-vitro screening of native fluorescent pseudomonads against R. solanacearum isolates

The screening of antagonistic potentiality of Pf was conducted on general nutrient agar media by dual culture and spot inoculation method. Twenty-four hours of actively growing cultures of seven isolates of R.
solanae areum belongs to Race 1 Biovar III, or Race 1, Biovar IIIA were suspended in sterile water and OD values were adjusted to 0.5 at 625 nm. One millilitre aliquot of each suspension were poured into sterile Petri-plates and cool molten nutrient agar were poured into the Petri-plates and mixed with bacterial suspension by rotating the plates both clock- and anti-clockwise direction and kept undisturbed to solidify. The Pf isolates of 48 h age was then spot inoculated on solidified Petri-plates and allowed to incubate at 28±1oC for 2-3 days. After incubation, plates were examined for inhibition zone created around the spot inoculated Pf isolates. In all the cases, positive control with Kanamycin 30µg/5mm disc and negative control with SDW were used as reference.

The experiment was laid out in a completely randomized design.

Field experiments

The field experiments were conducted at farmers’ fields near Kalyani, Nadia, West Bengal. The experiment was laid out in simple RBD with four, three and three replications for organic, inorganic soil amendment and experiment with integrated modules, respectively. In each case, organic and inorganic amendments were applied to the field one month before transplanting and mixed thoroughly with the soil. Standard cultural practices were followed and recommended basal dose of nutrients were applied during land preparation in all the field experiments. Potential Pf isolate or consortium of Pf isolates were applied as seedling root dipping in a solution of Pf @ 5 ml (0.3OD at 600nm)/l or the consortium of Pfs @ 5 ml each (0.3OD at 600nm)/l for 60-90 min. Soil (spot) application was also done before transplanting with a mixture of 1000 ml of (0.3OD at 600nm) Pf suspension (prepared in KB broth) and 20 kg of well-rotten cow dung.

The mixture was prepared seven days before transplanting. Thirty days old local eggplant cv. Jhuri (clustered short fruiting type, highly susceptible to bacterial wilt disease) seedlings were transplanted in each plot. Field efficacy of treatments was studied on the basis of disease severity and yield. Disease severity was assessed 30, 45, 60, 75, 90, 105 and 120 days after transplanting (DAT). Disease severity in terms of percent disease index (PDI) (McKinney, 1923) was calculated from disease rating for individual plants in a 0-4 scale based on visual observation of foliage wilt (0 = no symptom, 1 = 1-2 leaf wilting, 2 = one-third of plant wilting, 3 = two-thirds of plant wilted and 4 = total plant wilted or dead) (Winstead and Kelman, 1952). The PDI was calculated using the formula PDI = [("R × T) /(S × N)] × 100. Where R = rating and T = number of plants in each rating; S = highest rating; N= total number of plants observed (McKinney index, McKinney, 1923).

Statistical analysis

The data obtained from the investigation were statistically analyzed using ANOVA and F test under Completely Randomized Design for in vitro experiments and in randomized block design for field experiments and the distinctness of the effect sizes was determined on the basis of Duncan’s multiple range test (DMRT) and value of critical deference (CD at p<0.05 or p<0.01) (Cochran and Cox, 1950; Panse and Sukhatme, 1961).

RESULTS AND DISCUSSION

The antagonistic potential of nine Pf isolated from rhizosphere of different crops was studied in vitro against seven eggplant isolates of R. solanae areum by dual culture method (Table 1). The results depicted that inhibition zone (mm) by all the Pf isolates were significantly lower than the positive control (Kanamycin 30µg.5mm-1 disc). However, mean antagonistic activity of PF-3 (inhibition zone 5.19 mm) was highest, followed by PF-2 (4.26 mm) and PT-1 (4.14 mm) irrespective of R. solanae areum isolates (Table 1). But PF-2 was able...
showed that green manuring with dhaincha was best. However, yield performance of these two treatments by 42% and 41%, respectively, over the control (Table 3).

The performance of green manure, oilcakes and vermicompost were superior to FYM. This finding was in contradiction with Islam and Toyota (2004), who observed that long-term (14 year) organically maintained soil using FYM showed high suppressive effect on VBW severity as well as pathogen survival in FYM soil. Satoh and Toyota (2004) also suggested that repeated application of organic manure, which increase the C:N ratio at higher level, is necessary to achieve VBW suppressive soil. However, condition of the present investigation does not seem to be identical with these two works as the application of FYM has been done in the plot only for three years. To obtain disease suppressive soil using FYM need long-term application of FYM in soil to achieve the working condition of Islam and Toyota (2004).

The present findings corroborate with Cardoso et al. (2006) who observed that decomposing fresh green organic matter (green manuring with dhaincha leaf in the present study) increase the soil microbial activity, thereby, challenging the pathogenic population of soil by increasing the competition under the same ecological niche. They also pointed out that decomposed organic matter did not increase biological activity in soil as compared to decaying fresh organic matter. The present findings with vermicompost, a highly decomposed organic matter, corroborate with the findings of Cardoso et al. (2006) in terms of disease suppression. Incorporation of organic amendment, into soil might increase the antibiotic producing actinomycete population in the soil and thereby, confers suppression of the pathogenic population of R. solanacearum.

Among different inorganic amendments, application of bleaching powder at 20 kg/ha, followed by bleaching powder at 15 kg/ha, lime at 5 q/ha and gypsum at 3 q/ha, one month before transplanting, was the most effective treatment both in terms of disease reduction and yield performance (Table 3).

Gypsum could add both exchangeable calcium and sulphur in soil solution and it is also known that decrease in S increased susceptibility to diseases due to decreased accumulation of glucosinolates in plants (Dubuis et al., 2005). However, in the present study cumulative PDI showed no significant difference with lime to inhibit all the R. solanacearum isolates irrespective of biovars and none others were able to do so. Considering the predominant race and biovar situation of R. solanacearum in New Alluvial Zone of Nadia district in West Bengal, PF-2 can then be potentially used following extensive experimentation to prove its efficacy under field condition, method of inoculation as well as mass multiplication and storage environment standardization for the purpose of commercial use. The PF-7, PF-8, PF-11, PF-13 and PF-14 were potentially less effective against different R. solanacearum isolates than PF-3, PF-2, PT-1 and PB-3 (Table 1).

The antagonistic effect of different Pf isolates varied significantly against different R. solanacearum isolates of eggplant. The antagonistic potentiality of Pf isolates was the highest against R. solanacearum isolates of BBN, BNN and BFN. Thus, present study indicated that consortium of Pfs should be applied at the field level for obtaining sustainable management against R. solanacearum. Thus, it is clear from the results that high degree of variability exist among different eggplant R. solanacearum isolates in terms of susceptibility towards different native Pf isolates from the New Alluvial Zone of West Bengal.

The green manuring with dhaincha (Sesbania speciosa) one month before transplanting and application of neem cake one month before transplanting were most effective treatment and significantly reduced wilt severity by 42% and 41%, respectively, over the control (Table 2). However, yield performance of these two treatments showed that green manuring with dhaincha was best treatment in terms of yield (11.33 t/ha), followed by neem cake application (10.85 t/ha). Significant enhancement of yield and reduction of vascular bacterial wilt incidence was recorded during the active production period in all the organic amended plots as compared to the control. Under treated condition specifically in case of green manuring treatment with dhaincha the first disease incidence was observed in a later growth stage (during 75 DAT), i.e. beyond the active production stages of eggplant. Clearly, number of disease-free plants during active production period is more important than the terminal severity that affects the yield.

The antagonistic potentiality of Pf isolates was the highest against R. solanacearum isolates of BBN, BNN and BFN. Thus, present study indicated that consortium of Pfs should be applied at the field level for obtaining sustainable management against R. solanacearum. Thus, it is clear from the results that high degree of variability exist among different eggplant R. solanacearum isolates in terms of susceptibility towards different native Pf isolates from the New Alluvial Zone of West Bengal.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (t/ha)</th>
<th>Cumulative PDI</th>
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</thead>
<tbody>
<tr>
<td>T1 Control</td>
<td>3.1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>61.74&lt;sup&gt;1&lt;/sup&gt;(51.79)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>T2 FYM 100 q/ha</td>
<td>9.47&lt;sup&gt;1&lt;/sup&gt;</td>
<td>49.80 (44.88)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>T3 Green Manuring (dhaincha)(25 q/ha)</td>
<td>11.33&lt;sup&gt;1&lt;/sup&gt;</td>
<td>35.62 (36.64)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>T4 Neem Cake 5 q/ha</td>
<td>10.85&lt;sup&gt;1&lt;/sup&gt;</td>
<td>36.07 (36.91)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>T5 Mustard Cake 10 q/ha</td>
<td>10.47&lt;sup&gt;1&lt;/sup&gt;</td>
<td>41.74 (40.25)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>T6 Vermi-compost 25 q/ha</td>
<td>10.05&lt;sup&gt;1&lt;/sup&gt;</td>
<td>45.55 (42.45)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE(m)±</td>
<td>0.12</td>
<td>1.59</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.39</td>
<td>4.91</td>
</tr>
</tbody>
</table>

<sup>1</sup> Figure in parentheses are angular transformed values

All the data shown in the table are the arithmetic mean of four replications and data bearing the same letters are not significantly different in 5% probability level of significance based on DMRT.

[PDI = Percent disease index; FYM = farmyard manure]
Table 3. Effect of different inorganic soil amendment on yield and VBW severity

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield (t/ha)</th>
<th>Cumulative PDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt; Control (only with basal fertilizer dose)</td>
<td>2.91&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62.91 (52.49)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt; Bleaching powder 0.15 q/ha</td>
<td>9.27&lt;sup&gt;b&lt;/sup&gt;</td>
<td>42.25 (40.54)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt; Bleaching powder 0.2 q/ha</td>
<td>10.22&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.65 (36.00)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt; Gypsum 1.5 q/ha</td>
<td>8.42&lt;sup&gt;d&lt;/sup&gt;</td>
<td>47.45 (43.53)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T&lt;sub&gt;5&lt;/sub&gt; Gypsum 3 q/ha</td>
<td>8.33&lt;sup&gt;e&lt;/sup&gt;</td>
<td>54.37 (47.51)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T&lt;sub&gt;6&lt;/sub&gt; Lime 3 q/ha</td>
<td>7.51&lt;sup&gt;f&lt;/sup&gt;</td>
<td>53.74 (47.15)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T&lt;sub&gt;7&lt;/sub&gt; Lime 5 q/ha</td>
<td>9.29&lt;sup&gt;g&lt;/sup&gt;</td>
<td>45.27 (42.21)&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE(m)±</td>
<td>0.30</td>
<td>0.99</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.91</td>
<td>3.05</td>
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</table>

All the figures shown in the table are average of three replications and data bearing same alphabets are not significantly different in 5% probability level based on DMRT. Figures in parentheses are angular transformed values.

Table 4. Effect of different combination of organic and inorganic soil amendments on yield and VBW severity

<table>
<thead>
<tr>
<th>Integrated module</th>
<th>Pooled yield (t/ha)</th>
<th>Pooled cumulative PDI</th>
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<td></td>
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<tr>
<td>Control (only with basal fertilizer dose)</td>
<td>3.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.2 (56.29)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Green manuring (dhaincha) + bleaching (0.2 q/ha)</td>
<td>12.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.4 (32.83)&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Green manuring (dhaincha) + lime (5 q/ha)</td>
<td>11.68&lt;sup&gt;c&lt;/sup&gt;</td>
<td>36.5 (37.17)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Green manuring (dhaincha) + bleaching (0.2 q/ha) + lime (5 q/ha)</td>
<td>12.74&lt;sup&gt;d&lt;/sup&gt;</td>
<td>24.7 (29.80)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Single fluorescent Pseudomonas (PF3) (seedling treatment + soil spot application)</td>
<td>9.35&lt;sup&gt;e&lt;/sup&gt;</td>
<td>42.4 (40.63)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Consortium of fluorescent Pseudomonads (PF-2 &amp; PF-3) (seedling treatment + soil spot application)</td>
<td>10.70&lt;sup&gt;f&lt;/sup&gt;</td>
<td>32.1 (34.51)&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Green manuring (dhaincha) + bleaching (0.2 q/ha) + lime (5 q/ha) + consortium of fluorescent Pseudomonads (PF-2 &amp; PF-3), (seedling treatment + soil spot application)</td>
<td>14.33&lt;sup&gt;g&lt;/sup&gt;</td>
<td>19.2 (25.99)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE(m)±</td>
<td>0.41</td>
<td>1.12</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>1.29</td>
<td>3.46</td>
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</table>

All the data shown in the table are two year pooled average of three replications and data bearing same letters are not significantly different in 5% probability level based on DMRT. Figures in parentheses are angular transformed values.

Fig. 1. Growth stage-wise disease incidence (%) under control and integrated module 7 corresponding to table 4, (DAT = days after transplanting)

application and gypsum application. Again it is also evidenced from the study that higher amount (300 kg/ha) of gypsum was more efficient in disease reduction than lower amount (150 kg/ha) so as in the case of lime application. This clearly indicated that sulphur has least effect on disease suppression in the present situation, which may be due to impaired sulphur uptake capacity of cv. Jhuri and needs further investigation. The present findings indicated that calcium might be related to expression of tolerance to vascular bacterial wilt of eggplant and this finding was in accordance with the findings of Yamazaki et al. (2000).
The above mentioned primary findings lead to formulate the third experiment with different combinations of organic and inorganic amendments, and biological consortia to formulate the holistic approach for bio-intensive management of vascular bacterial wilt of eggplant.

The integrated module-7: green manuring with dhaincha leaf (25g/ha) + bleaching (20 kg/ha) + lime (5 q/ha) + consortium of fluorescent pseudomonads (PF-2 & PF-3), was the best performer among seven different integrated module, both in terms of reduction in disease severity and enhancement of yield (Table 4) and temporal variation of disease incidence (Fig. 1). PF-3 alone did not perform well in terms of both disease reduction and yield. However, a consortium of PF-2 and PF-3 was effective. Thus, present finding indicated that a biological consortium with multiple modes of action is of utmost need to suppress the pathogens since there is little spatial segregation in cropping systems.

Some microorganisms are unable to establish themselves in certain environments, probably because of suboptimal conditions for growth and weak competitive saprophytic ability (Shekhawat and Chakrabarti, 1993). The efficacy of integrated module 7 (Table 4) was very effective in terms of yield and disease reduction as it provides better environment for the adaptation by means of decreased competition through application of bleaching and lime one month before transplanting and better growth environment through the application of dhaincha leaves as green manure.

Thus, it can be concluded that application of bleaching at the rate 20 kg/ha, lime at the rate of 5 q/ha and green manuring with dhaincha leaves one month before transplanting, along with seedling root treatment and soil spot application of consortium of native antagonists could be used as a sound bio-intensive management package against vascular bacterial wilt on eggplant.

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REFERENCE


