Assessment of the Performance of Different Options of Integrated Management of Late Blight Disease on Yield of Potato in West Bengal

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ABSTRACT

Potato (Solanum tuberosum L.), an important cash crop of India, is prone to many diseases and amongst these, late blight [c.o. Phytophthora infestans *(Mont) de-Bary] is one of the highly destructive diseases and a major constraint in the profitable cultivation of potato. After realizing the significance of controlling the devastating disease for the sustainability in potato production and thus ensuring more profitability, the present investigation has been conducted with an objective to assess the performance of different options of integrated management on yield of potato c.v.* 'Kufri Jyoti' *through reducing the disease incidence under West Bengal Condition. The present study was carried out by Howrah KVK during* rabi *season for consecutive three years (2009-10, 2010-11 and 2011-12) as On-Farm Trial mode at seven farmers fields of an adopted village of Howrah district in West Bengal. In each trial, there were four treatments including one control i.e. farmers' practice. The study concludes that the best integrated management option to combat late blight disease is application of recommended doses of fertilizers (N,* P_2O_5 *and* K_2O *in the form of Urea, SSP and MOP), seed treatment with* Trichoderma viridae *@ 4 g/ kg of seed tuber, application of boron (0.2%) at 30 DAP, application of Mancozeb 75% WP @ 2.5 g/ l of water at 30 and 60 DAP as well as application of either mixed formulation of Cymoxanil and Mancozeb (8%+64%) 72% WP @ 3 g/ l of water or sole application of Dimethomorph 50 WP @ 1 g/ l of water at 45 and 75 DAP of potato. The results of economic analysis reveal that highest net return as well as benefit cost ratio was also highest in Cymoxanil and Mancozeb based treatments followed by Dimethomorph based treatments.*

Key words: *Efficacy; IDM; Late blight; Potato, Yield; Economics;*

Potato (*Solanum tuberosum* L.) is an important cash crop of India determining the livelihood of number of farmers of the country. India is the third largest producer of potato in the world (*Kalloo et al, 2005*). Potato can play an important role in supplying vegetable throughout the year and can solve the problems related to nutritional security to a great extent for the lower income group. West Bengal ranked second in terms of area (386.61 million ha), production (11,591.3 million tonnes) and productivity (30.8 tonnes/ ha) of potato nationally (*Anon., 2014*). Hooghly, Bardhaman, Howrah, Paschim Medinipur and Bankura are leading potato producing districts of the state. However, there is enough scope to enhance the productivity of the crop. Potato is input intensive and prone to many diseases and amongst these, late blight [c.o. *Phytophthora infestans* (Mont) de-Bary] is one of the highly destructive diseases (*Chycoski and Punja, 1996*) and a major constraint in the profitable cultivation of potato worldwide and the state like West Bengal is not an exception. The incidence and severity of the disease is generally high in crop receiving imbalanced nutrition and devoid of disease control measure. Today, late blight is a recurring feature in plains of West Bengal. The farmers face havoc loss due to severe infestation of this disease which results drastic reduction of production. The disease occurs in mild to moderate form in every year but sometimes it appears in epidemic form resulting

total crop failure. The pathogen produces water soaked lesions with chlorotic borders that are small at first but expand rapidly under humid conditions, blighting the entire plant in only a few days with subsequent rotting of the developing tubers resulting in heavy yield losses under favourable conditions each year (*Flier et al., 2001*). The losses caused by late blight are reported to range between 25 to 85 per cent in terms of yield (*Kumar et al. 2003*). Through PRA, Howrah Krishi Vigyan Kendra (KVK) came to know that late blight is an increasing concern to the potato growers of the district and farmers generally applied chemical fertilizers and fungicides injudiciously and indiscriminately even in unscientific combinations. Though there are several effective fungicides (*Singh et al., 2003*) available in the market to manage this disease, but due to lacking of the proper knowledge about the mode of action and proper spray schedule of different fungicides many of the farmers were fail to manage this disease when it appears in epiphytotic form. As the pathogen has been reported to develop resistance to metalaxyl based fungicides in some places (*Gisi and Cohen, 1996*), new molecules with different mode of action need to be identified and used along with compatible bio-control agents to minimize the use of pesticides (*Roy et al., 1991*). On the other hand, in potato, boron deficiency has been reported very frequently more particularly in soils of acidic in nature in almost all the potato growing areas of the district. Boron has been reported to increase the number of tubers and size of tubers or both (*Sharma, 1998*) and adequate micronutrient nutrition should be viewed as an essential component of any integrated crop protection programme because by virtue of small amounts needed and their long residual value. After realizing the significance of controlling the devastating disease for the sustainability in potato production and thus ensuring more profitability, it has been necessary to study the performance of different integrated management options based on the efficacy and availability of bio-control agents (*Basu, 2009*) as well as recommended relatively newer fungicides (*Anon., 2009*) for enhancing the yield of potato through reducing the incidence of late blight disease. Keeping all these views in mind the present investigation has been conducted.

METHODOLOGY

The present study was carried out by Howrah KVK under the guidance of Bidhan Chandra Krishi Viswavidyaya as well as ICAR (Zone-II) during *rabi* season for consecutive three years (2009-10, 2010-11and 2011-12) as an On-Farm Trial at seven farmers fields of an adopted village *i.e.* Jhingra of Jagatballavpur block of Howrah district in West Bengal. The farmers, who grow potato in every year and suffer due to late blight problem, have been chosen for the experiment. The area under each trial is 0.13 ha (*i.e.* 1 bigha). In each trial, there were four treatments. The treatments considered are presented in Table 1 where T_1 *i.e.* the farmers' normal practice to control late blight disease has been followed as control. Each farmer's field was treated as one replication. The seed tubers of potato

Table 1. Treatment details (Integrated Disease Management options) of the experiment

Treatments	Details of Integrated Disease Management (IDM) options
T_1 (Farmers' Practice)	No seed treatment, imbalanced fertilization, no application of micronutrient, using of 200:125:125 N, P_2O_5 K_2O in the form of Urea, SSP and MOP along with minimum four times application of Mancozeb 75% WP @ 2.5 g / l of water and different other doses singly or in combination with other pesticides having non-compliance with recommended spraying schedule
T_2	Recommended dose of fertilizers (N, P_2O_5 and K_2O in the form of Urea, SSP and MOP) + Seed treatment with *Trichoderma viridae* @ 4 g/ kg of seed tuber + Application of Boron (0.2%) at 30 days after planting (DAP) + Application of Mancozeb 75% WP @ 2.5 g/ l of water at 30 and 60 DAP + Application of Metalaxyl and Mancozeb (8%+64%) 72% WP @ 2.5 g/ l of water at 45 and 75 DAP
T_3	Recommended dose of fertilizers (N, P_2O_5 and K_2O in the form of Urea, SSP and MOP) + Seed treatment with *T. viridae* @ 4 g/ kg of seed tuber + Application of Boron (0.2%) at 30 DAP + Application of Mancozeb 75% WP @ 2.5 g/ l of water at 30 and 60 DAP + Application of Cymoxanil and Mancozeb (8%+64%) 72% WP @ 3 g/ l of water at 45 and 75 DAP
T_4	Recommended dose of fertilizers (N, P_2O_5 and K_2O in the form of Urea, SSP and MOP) + Seed treatment with *T. viridae* @ 4 g/ kg of seed tuber + Application of Boron (0.2%) at 30 DAP + Application of Mancozeb 75% WP @ 2.5 g/ l of water at 30 and 60 DAP + Application of Dimethomorph 50 WP @ 1 g/ l of water at 45 and 75 DAP

var. '*Kufri Jyoti*' were sown in the second week of November in all the years of experimentation (2009, 2010 and 2011). The experiment was conducted in a Randomized Block Design with 7 replications (= 7 farmers) and 4 treatments with recommended agronomic practices.

The plot size of each treatment was 5 m x 5 m and spacing was maintained 60cm × 20cm each for row to row and plant to plant. The field was fertilized with recommended doses of fertilizers i.e. nitrogen, phosphorus and potassium @ 200-150-150 kg/ha in the form of Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP), respectively except the control plots where the farmers' practice has been followed (NPK @ 300-250-250 kg/ha). The mode of fertilizer application was half of Urea + full of SSP + half of MOP were given as basal dose, one fourth of Urea + one fourth of MOP were applied during first earthing up at 21 DAP and rest amount of fertilizers was applied during second earthing up at 10 days after first top dressing as recommended practice, however, the farmers applied half of Urea + full of SSP + three-fourth of MOP as basal and half of Urea + one-fourth of MOP during first earthing up at 21 DAP. All the cultural operations were provided in time and plant protection measures except those for late blight were also adopted properly. The harvesting of the crop commenced from last week of February and continued till 1st week of March. The experimental plots had been changed every year consciously to avoid residual effect of nutrients. An area of $1\times1m^2$ was randomly marked at 10 different places in each plot for recording the total number of diseased and healthy plants at 80 days after planting of the crop *i.e.* 5 days after last fungicidal treatment. The disease incidence was measured using the following formula (after *Debnath and Nath, 2009*):

$$PDI = \frac{\text{No. of plants infected}}{\text{Total no. of plants observed}} \times 100$$

PDI = Per cent disease incidence

An average of the ten assessments in the plots represented the average disease incidence of the plot. The data on percent disease incidence was converted into angular transformed value and statistically analyzed as per method suggested by *Panse and Sukhatme (2000)*. Accordingly, the observations on tuber yield of potato and other ancillary character i.e. dry weight of each tuber were also recorded and analyzed statistically as well. The tuber production per plot was converted to quintal per ha by simple arithmetic calculation. Afterwards, the economics of the experiment has been computed.

RESULTS AND DISCUSSION

Efficacy of different integrated management options against late blight of potato: The analyzed data as presented in Table 2 reveals that T_3 and T_4 differed significantly from T_2 and T_1 in respect of percent disease incidence (PDI) in all the three years of experimentation, though T_3 and T_4 have been reported to be statistically at par. The lowest PDI has been recorded in case of T_3 (1.4%, 2.4% and 2.8% during 2009-10, 2010-11 and 2011-12, respectively) followed by T_4 (1.6%, 3.2% and 4.2% during 2009-10, 2010-11 and 2011-12, respectively) and T_2 (6.3%, 8.2% and 9.8% during 2009-10, 2010-11 and 2011-12, respectively) while, the highest PDI has been obtained in farmers' practice *i.e.* T_1 in all the

Table 2. Performance of different options of IDM to combat late blight of potato

Treatments	Disease incidence (%)				Dry weight/ tuber (g)				Yield (q/ha)			
	I Year	II Year	III Year	Mean	I Year	II Year	III Year	Mean	I Year	II Year	III Year	Mean
T_1 (Farmers' Practice)	15.8 *(23.39)	18.4 (25.37)	23.6 (29.09)	19.27	21.5	19.3	18.6	19.80	324.2	297.5	286.8	302.83
T_2	6.3 (14.54)	8.2 (16.68)	9.8 (18.23)	8.10	27.8	25.6	22.8	25.40	378.3	352.6	337.6	356.17
T_3	1.4 (6.83)	2.4 (8.97)	2.8 (9.56)	2.20	34.4	33.7	29.6	32.57	428.1	411.5	397.8	412.47
T_4	1.6 (7.33)	3.2 (10.37)	4.2 (11.87)	3.00	32.6	31.8	28.2	30.87	406.3	391.8	372.4	390.17
SEm±	0.63	0.47	0.61	-	1.02	0.99	1.14	-	1.37	1.45	1.70	-
CD(P=0.05)	1.86	1.41	1.80	-	3.02	2.93	3.38	-	4.08	4.31	5.05	-

* Figures in the parentheses are angular transformed values.

Table 3. Economic analysis of different treatments to assess the performance of different options of IDM to combat late blight of potato

Treatments	Net Return (Rs/ ha)				B:C Ratio			
	I Year	II Year	III Year	Mean	I Year	II Year	III Year	Mean
T_1 (Farmers' Practice)	21,450.00	21,875.00	36,760.00	26,695.00	1.28	1.27	1.40	1.32
T_2	36,990.00	40,310.00	56,320.00	44,540.00	1.48	1.49	1.59	1.52
T_3	51,200.00	60,075.00	81,810.00	64,361.67	1.66	1.72	1.84	1.74
T_4	44,950.00	53,650.00	70,880.00	56,493.33	1.58	1.64	1.73	1.65

years (15.8%, 18.4% and 23.6% during 2009-10, 2010-11 and 2011-12, respectively). The similar trend has been observed in case of an ancillary character of yield *i.e.* tuber weight. Here also, in all the experimental years, T_3 and T_4 differed significantly from T_2 and T_1 as well as statistically parity between T_3 and T_4. The highest tuber weight has been recorded in case of T_3 (34.4 g, 33.7 g and 29.6 g during 2009-10, 2010-11 and 2011-12, respectively) followed by T_4 (32.6 g, 31.8 g and 28.2 g during 2009-10, 2010-11 and 2011-12, respectively) and T_2 (27.8 g, 25.6 g and 22.8 g during 2009-10, 2010-11 and 2011-12, respectively) while, the highest PDI has been obtained in farmers' practice i.e. T_1 in all the years (21.5 g, 19.3 g and 18.6 g during 2009-10, 2010-11 and 2011-12, respectively). However, the analyzed data reveals that different integrated management options against late blight of potato differed significantly among themselves in respect of tuber yields in all the three years of experimentation. Significantly highest tuber yield has been recorded in case of T_3 (428.1 q/ ha, 411.5 q/ ha and 397.8 q/ ha during 2009-10, 2010-11 and 2011-12, respectively) followed by T_4 (406.3 q/ ha, 391.8 q/ ha and 372.4 q/ ha during 2009-10, 2010-11 and 2011-12, respectively) and T_2 (378.3 q/ ha, 352.6 q/ ha and 337.6 q/ ha during 2009-10, 2010-11 and 2011-12, respectively). The lowest yield has been obtained in farmers' practice *i.e.* T_1 in all the years (324.2 q/ ha, 297.5 q/ ha and 286.8 q/ ha during 2009-10, 2010-11 and 2011-12, respectively). Considering all the results it can definitely be said that all the integrated management options (T_2, T_3 and T_4) aiming to minimize potato late blight have been proved better than the farmer's own practice. The better efficacy of relatively newer fungicides like dimethomorph, mixed formulation of metalaxyl + mancozeb, cymoxanil + mancozeb to combat late blight disease had been reported earlier (*Thind et al., 2009*) though they experimented on another popular variety of potato i.e. '*Kufri Chandramukhi'*. However, mixed formulation of metalaxyl + mancozeb showed relatively less effectiveness here which may be due to developing resistance by the causal pathogen against metalaxyl based fungicides. *Gisi and Cohen (1996)* already reported about this. Besides, seed treatment (with bio-control agent like *Trichoderma viridae*) and application of boron played significant role not only in reducing the disease incidence but also in increasing number and size of potato tubers. Seed treatment with *T. viridae* and application of boron had been reported to be beneficial earlier (*Basu, 2009; Sharma, 1998*).

Economic analysis: For calculating gross return and cost of cultivation, the inputs and outputs prices of the produces prevailed during the investigation in all the years had been taken into consideration and afterwards from these two parameters net return as well as benefit cost ratio had been computed.

Table 3 showed that, highest net return has been achieved from T_3 (Rs. 51,200.00/ ha in 2009-10, Rs. 60,075.00/ ha in 2010-11, Rs. 81,810.00/ ha in 2011-12 with an average of Rs. 64,361.67/ ha of the three years) along with benefit cost ratio (1.66 in 2009-10, 1.72 in 2010-11, 1.84 in 2011-12 with an average of 1.74 of the three years) followed by T_4 (average net return Rs. 56,493.33/ ha and average benefit cost ratio of 1.65). The average benefit cost ratio of T_1 has been recorded as 1.32, while the average net return calculated is Rs. 26,695.00/ ha. These results clearly suggest that T_3 is the most profitable options than rest of the treatments followed by T_4.

CONCLUSION

From the investigation it can be concluded that the best integrated management option to enhance the tuber yield of potato through reducing incidence of late blight disease is T_3 *i.e.* application of recommended doses of fertilizers (N, P_2O_5 and K_2O in the form of Urea, SSP

and MOP), seed treatment with *Trichoderma viridae* @ 4 g/ kg of seed tuber, application of boron (0.2%) at 30 DAP, application of Mancozeb 75% WP @ 2.5 g/ l of water at 30 and 60 DAP as well as application of Cymoxanil and Mancozeb (8%+64%) 72% WP @ 3 g/ l of water at 45 and 75 DAP of potato, however, Dimethomorph 50 WP also, may be applied @ 1 g/ l of water at 45 and 75 DAP instead of Cymoxanil and Mancozeb where the mixed formulation of Cymoxanil and Mancozeb is unavailable in the market.

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