Management of Black Scurf (*Rhizoctonia solani*) of Potato through Organic Approaches

Vikee M. Patel, Narendra Singh

**ABSTRACT**

Black scurf (*Rhizoctonia solani*) disease of potato is becoming prominent in many potato growing districts of Gujarat state which reduce quality and market value of the produce, resulting in economic losses. The field experiment was conducted during the season of 2014-15 in naturally infested field with scurf pathogen at Potato Research Station, S.D. Agricultural University, Deesa (Gujarat) with the objective to find out suitable management strategies for black scurf through organic approaches (bio-agents and organic amendments). Among different bio-agents (*Trichoderma viride*, *T. harzianum*, *Pseudomonas fluorescens* and *Bacillus subtilis*) tested against black scurf, the tuber treatment with 2 per cent boric acid spray along with tuber treatment with *T. viride* @ 10 g/kg seed before sowing recorded the lowest disease incidence (15.33 %) and index (0.38) with highest total tuber yield (324.68 q/ha) with maximum income `2,57,414/ha. When price computed with healthy and diseased tuber yield among treatments, the maximum income variation was (`92,986/ha) recorded by the same treatment followed by the tuber treatment with 3 % boric acid spray before sowing (`68,440/ha). In case of various organic amendments tested, soil application of mustard cake @ 10 q/ha registered minimum disease incidence (37.33 %) and disease index (0.66) as compared to rest of the organic treatment with highest total tuber yield (`327.20 q/ha) with maximum income `2,65,010/ha. When price computed with healthy and diseased tuber yield among treatments, the maximum income variation was (`1,12,990/ha) recorded by the same treatment followed by the neem cake @ 10 q/ha (`56,660/ha). These organic treatments can provide an effective and economical management of black scurf of potato for cultivators.

**Key words:** Bio-agents, Black scurf, Management, Organic amendments, Potato, *Rhizoctonia solani*.

**INTRODUCTION**

Potato (*Solanum tuberosum* L.) is world’s third most important crop after rice and wheat and occupies an important place in the diet of many countries in the world. In India potato is largely consumed as vegetables while in most of the developed countries of the world it is considered as staple food.

India is an important potato producing country in the world. It ranks third in potato area (1.90 million/ha) after China and Russia and second in production (45 million tones) after China with average yield of 22.9 t/ha (Pandey *et al.* 2014). Food Agriculture Organization identified potato as a ‘Food of Future’ as it has potential of fighting hunger and poverty in very large part of the world. In this context year 2008-09 was celebrated as “International Potato Year” throughout the world. Gujarat is the fifth largest potato producing state in India after Uttar Pradesh, West Bengal, Bihar and Madhya Pradesh (Anonymous, NHB 2014).

Gujarat also has the distinction of attaining the first rank for potato productivity in the country. The area under potato cultivation in Gujarat state was 71,500 hectares with total production of 17,89,200 million tones with an average yield of 25.02 t/ha during 2012-13 (Anonymous, 2014).

The crop suffers from large number of soil and tuber borne diseases such as black scurf (*Rhizoctonia solani* Kuhn), common scab (*Streptomyces scabies* Thaxter),, powdery scab (*Spongospora subterranean* Walker), dry rot (*Fusarium* spp.), Sclerotium wilt (*Sclerotium rolfsii* Sacc), Verticillium wilt (*Verticillium alboatrum* Reink and Berth) and sclerotia stem rot (*Sclerotinia sclerotiorum* Lsib). Among these diseases, black scurf caused by *Rhizoctonia solani* Kuhn (*Thanatephorus cucumeris* (Frank) Donk.) is a serious disease of potato worldwide. It is distributed in India in different regions at different levels of severity and is a major disease problem in fields where potato is cultivated year after year in the same field (Khurana, *et al.*, 1998; Arora 2012). Although, the disease does not affect the yield quantitatively but it deteriorates the quality and acceptability of tubers for seed, consumers, industries and ultimately the market price. Black scurf is responsible for economical losses and significant reduction in potato quality especially...
for export-oriented potato (Daami-Remadi et al. 2008). Since, last few years, the disease has covered most of potato growing areas of Gujarat state due to continuous cultivation of potato year after year in the same piece of land by the growers with planting of black scurf infected tubers. Hence, it is now posing a serious threat for successful potato cultivation in the state. Indiscriminate use of pesticides (chemicals) for controlling diseases has done great harm to the human beings, animals, vegetation and environment as a whole. Increasing awareness among the consumers has drawn the attention of the farmers to shift to eco-friendly, non hazardous chemicals, bio-control agents and botanicals. Bio-formulations as well as bioactive products of plant origin being less persistent in environment, safe to mammals as well as non-target organisms, have therefore become the focus of attention these days. Organic amendments also play an important role as environment friendly and sustainable alternative approach to protect plants against soil borne pathogens. Soil amendments, using composted agricultural wastes fortified with bio-control agents could be acceptable approaches in this regard. The use of organic agricultural wastes in this respect can be an advantageous both in soil fertility, recycling of agricultural residues and could provide a powerful tool for management of plant diseases. In the present study efforts have been made to manage this disease with eco-friendly products viz; bio-formulations (Trichoderma viride, T. harzianum, Pseudomonas fluorescens and Bacillus subtilis strain B5), safer chemical with boric acid and organic amendments (cakes and manures) which are less expensive, non-hazardous and more eco friendly for potato production.

MATERIALS AND METHODS

Evaluation of bio-agents against black scurf disease of potato

The trial was conducted during rabi season of the year 2014-2015 in naturally infested field with scurf pathogen at Potato Research Station, S.D. Agricultural University, Deesa (Gujarat). Nine treatments in which four bio-agents (Trichoderma viride, T. harzianum, Bacillus subtilis and Pseudomonas fluorescens alone and /or their combinations) and one safer chemical (boric acid) were evaluated in this experiment (Table 1). The experiment was conducted using black scurf infested seed potatoes (40-60 gm) of cv. Kufri Khayti having 100 per cent disease incidence (I), with average disease index (DI) 1.0 -2.0. For application of T. viride, T. harzianum, P. fluorescens and B. subtilis, the formulations were applied evenly over the whole seed tubers whose surface was made wet with water and tubers rolled to cover them with the bio-agents evenly. The treatments were applied immediately before planting of the seed tubers in field. Bio formulation T. viride, T. harzianum, P. fluorescens and B. subtilis contained 1 × 107, 1 × 102, 1 × 108 and 1 × 108 c.f.u./g, respectively. The seed tubers after the treatments were planted at 50 x 20 cm2 spacing in 2.5 x 2.0 m2 plots (5 rows with 10 tubers each). Each treatment was replicated three times in a randomized block design. Planting was done in the third week of November. All other recommended practices required for cultivation of the crop were followed. After 30 days of planting, per cent plant emergence was recorded. The crop was harvested ninety days after planting (DAP). The observations pertaining to per cent disease incidence and disease index were recorded on one hundred as well as fifty tubers each respectively, selected at random from each plot of replications. Observations on per cent disease incidence and disease index (DI) were calculated by using the formula described by Somani (1986). Disease was measured on a scale of 0-5 where 0 = healthy; 1 = up to 10; 2 = >10 to 25; 3 = >25 to 50; 4 = >50 to 75 and 5 = > 75 per cent tuber surface affected by scurf. Disease index (DI) was calculated by using formula described by Jeswani and Sharma (1990) as: Disease index = (Number of tubers x their disease intensity grade)/total number of tubers x 100/ max. disease score. Observations on yield of healthy and diseased tubers as well as total tuber yield (q/ha) were recorded separately from different treatments and analyzed statistically. Income variation in healthy and diseased tubers yield of potato were also recorded.

Bio formulations have been received from Central Potato Research Station, Modal Town Jalandhar, (Punjab) and Central Potato Research Institute Campus, Modipuram, Meerut (Uttar Pradesh) for the conduct of experiment.

Evaluation of organic amendments against black scurf disease of potato

For this study, seven organic amendments among which four organic manures and three organic cakes were tested (Table 3). Cv. Kufri Khayti was used for the same purpose. The trial was conducted during rabi season of the year 2014-15 in naturally infested field with scurf pathogen at Potato Research Station, S. D. Agricultural University, Deesa, (Gujarat). The treatments were applied just before planting of the seed tubers in field. The seed tubers were planted at 50 x 20 cm2 spacing in 2.5 x 2.0 m2 plots (5 rows with 10 tubers each). Each treatment was replicated three times in a randomized block design. Planting was done in the third week of November. All other recommended practices required for cultivation of the crop were followed. After 30 days of planting, per cent plant emergence was recorded. The crop was harvested ninety days after planting (DAP). The observations pertaining to per cent disease incidence, disease index (DI), yield of healthy and diseased tubers and total tuber yield (q/ha) were recorded separately from different treatments and analyzed statistically. Income variation in healthy and diseased tubers yield of potato were also recorded.

RESULTS AND DISCUSSION

Evaluation of bio-agents on black scurf of potato

The data presented in Table 1 showed that per cent plant emergence was non-significant among treatments. It indicates that there is no any effect of the disease or treatments on germination. All the treatments were
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Table 1: Evaluation of bio-agents on black scurf disease of potato.

| Treatment details | Germination percentage* | Per cent disease incidence* | Disease index* | Healthy Tuber yield (q/ha) | Diseased Tuber yield (q/ha) | Total Tuber yield (q/ha) |
|-------------------|-------------------------|----------------------------|---------------|---------------------------|---------------------------|------------------------|
| T<sub>1</sub>: Control | 75.65** (93.33)** | 51.43** (60.66)** | 3.04 | 105.40 | 208.00 | 313.40 |
| T<sub>1</sub>: Tuber treatment with *Trichoderma viride* @ 10 g/kg seed | 80.46 (96.67) | 43.16 (46.33) | 1.48 | 124.60 | 184.60 | 309.20 |
| T<sub>2</sub>: Tuber treatment with *Trichoderma harzianum* @ 10 g/kg seed | 78.06 (95.00) | 43.93 (47.66) | 2.07 | 121.40 | 193.00 | 314.40 |
| T<sub>3</sub>: Tuber treatment with *Bacillus subtilis* @ 5 g/kg seed | 82.74 (97.31) | 46.98 (53.00) | 2.66 | 114.80 | 198.20 | 313.00 |
| T<sub>4</sub>: Tuber treatment with *Pseudomonas fluorescens* @ 5 g/kg seed | 76.16 (93.33) | 47.94 (54.66) | 2.84 | 113.60 | 200.50 | 314.10 |
| T<sub>5</sub>: Tuber treatment with T<sub>1</sub> + T<sub>4</sub> | 78.06 (95.00) | 37.74 (37.00) | 0.95 | 138.00 | 170.40 | 308.40 |
| T<sub>6</sub>: Tuber treatment with T<sub>4</sub> | 79.09 (95.83) | 39.69 (40.33) | 1.31 | 133.20 | 176.60 | 309.80 |
| T<sub>7</sub>: Tuber treatment with 3 % boric acid spray before sowing | 80.46 (96.67) | 24.44 (16.66) | 0.45 | 158.20 | 163.20 | 321.40 |
| T<sub>8</sub>: Tuber treatment with 2 % boric acid spray followed by tuber treatment with *T. viride* @ 10 g/kg seed before sowing | 84.11 (98.15) | 23.42 (15.33) | 0.38 | 175.20 | 149.48 | 324.68 |
| SE.m. ± | 2.14 | 0.85 | 0.08 | 3.88 | 3.99 | 5.94 |
| CD at 5 % | NS | 2.56 | 0.25 | 11.62 | 11.96 | NS |
| CV % | 4.67 | 3.71 | 8.64 | 5.10 | 3.78 | 3.27 |

*Average of three replications, **Arc sin transformed values, ***Original values.

significantly superior to reduce per cent disease incidence and disease index. Treatment T<sub>3</sub> i.e., tuber treatment with 2 per cent boric acid spray followed by tuber treatment with *T. viride* @ 10 g/kg seed before sowing recorded the least disease incidence (15.33 %) and index (0.38). However, tuber treatment with 3 per cent boric acid spray before sowing found at par with treatment T<sub>2</sub> to reduce the disease incidence (16.66 %) and disease index (0.45). Treatment T<sub>4</sub> i.e., tuber treatment with *Trichoderma viride* @ 10 g/kg seed + *Bacillus subtilis* @ 5 g/kg seed stood third best treatment with lower disease incidence (37.00 %) and disease index (0.95). So far as total tuber yield is concerned, all the treatments were found non-significant (Table 1). Although, tuber treatment with 2 per cent boric acid spray followed by *T. viride* @ 10g/kg seed before sowing gave highest tuber yield (324.68 q/ha). When healthy and diseased tuber’s yield computed, the results of diseased tuber yield and healthy tuber yield showed significant difference. Maximum healthy tuber yield (175.20 q/ha) and minimum diseased tuber yield (149.48 q/ha) were recorded in treatment T<sub>3</sub> i.e., tuber treatment with 2 per cent boric acid spray with bio - agent *T. viride* @ 10 g/kg seed before planting. The maximum income of total tuber yield was 92,986/ha followed by the treatment T<sub>4</sub> i.e., tuber treatment with 3 per cent boric acid spray before sowing (68,440/ha). The results of the field trial indicated that an integrated treatment of boric acid and *T. viride* might have produced a synergistic effect and gave better results than the use of other treatments. Since boric acid at 3 per cent also provided sufficient control of black scurf, the dosage can safely be reduced from 3 to 2 per cent. The efficacy of boric acid alone and/or in combination with *T. viride* against black scurf of potato has been reported by earlier workers also (Khanna and Sharma, 1996; Singh et al., 1998; Arora, 1999; Hazarika et al., 1999; Bari et al., 2000; Tsror et al., 2001 and Arora, 2005). The seed tuber treatment with 1.5 per cent boric acid followed by an application of *T. viride* formulation containing 1×10<sup>7</sup> cfu/g at 4.5 g/kg at planting reduced the disease to the level achieved with 3 per cent boric acid spray (Arora, 2008). Somani and Arora (2010) reported that black scurf disease (*Rhizoctonia solani*) of potato could significantly be reduced by treating the seed tubers with *Trichoderma viride*, *Bacillus cereus* strain B4 and *Bacillus subtilis* strain B5 alone or in different combinations. Singh and Chaudhari, (2012) reported that seed tuber treatment (spray) with 2 per cent boric acid before storage followed by *T. viride* @ 8g/kg tuber treatment at planting registered the minimum black scurf incidence (6.42%) and index (0.17). Bio-agents causing considerable morphological deformations of the fungal hyphae such as vacuolation, protoplast leakage and mycelia crack to the *R.
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**Table 2:** Income variation in healthy and diseased tubers yield of potato.

| Treatment details | Healthy tuber yield (q/ha) | Income of healthy tuber (750/q) | Diseased tuber yield (q/ha) | Income of diseased tuber (750/q) | Income of total tuber yield (750/q) | Income variation in healthy and diseased tuber yield (750/q) |
|------------------|-----------------------------|---------------------------------|-----------------------------|---------------------------------|-----------------------------------|-------------------------------------------------------------|
| **T<sub>1</sub>: Control** | 105.40                      | 1,05,400                         | 208.00                      | 1,14,400                        | 2,19,800                          | -9,000                                                       |
| **T<sub>2</sub>: Tuber treatment with *Trichoderma viride* @ 10 g/kg seed | 124.60                      | 1,24,600                         | 184.60                      | 1,01,530                        | 2,26,130                          | 23,070                                                       |
| **T<sub>3</sub>: Tuber treatment with *Trichoderma harzianum* @ 10 g/kg seed | 121.40                      | 1,21,400                         | 193.00                      | 1,06,150                        | 2,27,550                          | 15,250                                                       |
| **T<sub>4</sub>: Tuber treatment with Bacillus subtilis @ 5 g/kg seed** | 114.80                      | 1,14,800                         | 198.20                      | 1,09,010                        | 2,23,810                          | 5,790                                                        |
| **T<sub>5</sub>: Tuber treatment with *Pseudomonas fluorescens* @ 5 g/kg seed** | 113.60                      | 1,13,600                         | 200.50                      | 1,10,275                        | 2,23,875                          | 3,325                                                        |
| **T<sub>6</sub>: Tuber treatment with *T. viride* @ 10 g/kg seed before sowing** | 138.00                      | 1,38,000                         | 170.40                      | 93,720                          | 2,31,720                          | 44,280                                                       |
| **T<sub>7</sub>: Tuber treatment with *T. viride* @ 10 g/kg seed before sowing** | 133.20                      | 1,33,200                         | 176.60                      | 97,130                          | 2,30,330                          | 36,070                                                       |
| **T<sub>8</sub>: Tuber treatment with 3 % boric acid spray before sowing** | 158.20                      | 1,58,200                         | 163.20                      | 89,760                          | 2,47,960                          | 68,440                                                       |
| **T<sub>9</sub>: Tuber treatment with 2 % boric acid spray followed by tuber treatment with *T. viride* @ 10 g/kg seed before sowing** | 175.20                      | 1,75,200                         | 149.48                      | 82,214                          | 2,57,414                          | 92,986                                                       |

Price of healthy tubers `1000/q and diseased tubers `550/q.

**Table 3:** Evaluation of organic amendments on black scurf disease of potato.

| Treatment details | Germination percentage* | Per cent disease incidence* | Disease index* | Tuber yield (q/ha) |
|------------------|-------------------------|----------------------------|----------------|------------------|
| **T<sub>1</sub>: Control** | 78.06**                 | 56.47**                    | 3.24           | 113.00           |
| **T<sub>2</sub>: Vermicompost @ 10 q/ha** | (95.00) ***            | (69.00) ***                 |                | 209.20           |
| **T<sub>3</sub>: Farm Yard Manure (FYM) @ 10 q/ha** | 80.46 (96.66)        | 45.84 (51.00)               | 1.48           | 128.40           |
| **T<sub>4</sub>: Poultry manure @ 10 q/ha** | 79.43 (95.83)         | 42.40 (45.00)               | 0.97           | 131.40           |
| **T<sub>5</sub>: Neem cake @ 10 q/ha** | 76.69 (94.16)         | 49.49 (57.33)               | 1.76           | 123.80           |
| **T<sub>6</sub>: Mustard cake @ 10 q/ha** | 75.65 (93.33)         | 40.28 (41.33)               | 0.71           | 150.60           |
| **T<sub>7</sub>: Castor cake @ 10 q/ha** | 80.46 (96.66)         | 37.93 (37.33)               | 0.66           | 189.00           |
| **T<sub>8</sub>: Goat manure @ 10 q/ha** | 75.65 (93.33)         | 52.23 (62.00)               | 2.52           | 116.80           |
| **T<sub>9</sub>: Control** | 78.06 (95.00)         | 54.22 (65.33)               | 2.90           | 114.40           |

SE.m. ± 1.74 0.90 0.15 4.06 3.11 4.68
CD at 5% NS 2.72 0.47 12.30 9.43 NS
CV % 3.86 3.28 14.92 5.17 2.94 2.54

*Average of three replications, **Arc sin transformed values, ***Original values.

The results presented in Table 3 revealed that per cent plant emergence was non- significant among treatments. It indicates that there is no any effect of the disease or different amendments on germination. All the organic amendments were significantly effective in reducing black scurf incidence as well as index. Treatment **T<sub>5</sub>, i.e., soil application of mustard cake @ 10 q/ha** recorded minimum disease incidence (37.33%) with disease index (0.66). However, treatment **T<sub>6</sub>, i.e., soil application of neem cake @ 10 q/ha** at par with treatment **T<sub>5</sub>** to reduce the disease incidence (41.33 %) and disease index(0.71). The healthy and diseased tubers yield found differing might be due to enhancement of antagonistic activities supported by the organic amendments in varying degrees. Maximum healthy tuber yield (189.00 q/ha) and minimum diseased tuber yield (138.20 q/ha) were found in treatment **T<sub>6</sub>, i.e., soil application of mustard cake @ 10 q/ha**. But the total tuber yield is concerned, all the treatments were found non-significant (Table 3). It is clear indicative that total tuber yield is anyway not influenced by the disease. The maximum income of total tuber yield was `2,65,010/q ha obtained in treatment **T<sub>5</sub>** (Table 4). When price computed with healthy and diseased tubers yield among treatments, the maximum income variation was recorded by the

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Table 4: Income variation in healthy and diseased tubers yield of potato.

| Treatment details | Healthy tuber yield (q/ha) | Income of healthy tuber (\`/ha) | Diseased tuber yield (q/ha) | Income of diseased tuber (\`/ha) | Income of total tuber yield (\`/ha) | Income variation in healthy and diseased tuber (\`/ha) |
|-------------------|-----------------------------|---------------------------------|-----------------------------|-----------------------------------|-----------------------------------|---------------------------------------------|
| T₁ : Control      | 113.00                      | 1,13,000                        | 209.20                      | 1,15,060                          | 2,28,060                          | -2,060                                      |
| T₂ : Vermicompost @ 10 q/ha | 128.40                      | 1,28,400                        | 190.20                      | 1,04,610                          | 2,33,010                          | 23,790                                      |
| T₃ : Farm Yard Manure (FYM) @ 10 q/ha | 131.40                      | 1,31,400                        | 180.80                      | 99,440                            | 2,30,840                          | 31,960                                      |
| T₄ : Poultry manure @ 10 q/ha | 123.80                      | 1,23,800                        | 194.60                      | 1,07,030                          | 2,30,830                          | 16,770                                      |
| T₅ : Neem cake @ 10 q/ha | 150.60                      | 1,50,600                        | 170.80                      | 93,940                            | 2,44,540                          | 56,660                                      |
| T₆ : Mustard cake @ 10 q/ha | 189.00                      | 1,89,000                        | 138.20                      | 76,010                            | 2,06,010                          | 11,290                                      |
| T₇ : Castor cake @ 10 q/ha | 116.80                      | 1,16,800                        | 205.60                      | 1,13,080                          | 2,21,430                          | 3,720                                       |
| T₈ : Goat manure @ 10 q/ha | 114.40                      | 1,14,400                        | 194.60                      | 1,07,030                          | 2,21,430                          | 7,370                                       |

Price of healthy tubers \`1000/q and diseased tubers \`550/q.

 treatment T₅ i.e. soil application of mustard cake @ 10 q/ha (\`1,12,990/ha) followed by the treatment T₁, i.e., neem cake @ 10 q/ha (\`56,660/ha). Davies et al. (2002) reported that chitin, cabbage, vetch and rye amendments reduced the severity of black scurf, while seaweed and manure increased its severity. Dey et al. (2004) evaluated effectiveness of soil amendments as potential to suppress soil borne diseases. Among them, sawdust amendment (3 t/ha) and Terraclor (20 kg/ha) performed better in reducing black scurf disease of potato and increasing tuber yield.

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