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# Yield Loss Assessment Due to Alternaria Blight and its Management in Linseed

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**Abstract:** Field experiments were conducted during 2010-11 and 2011-12 to assess the yield losses due to Alternaria blight disease caused by *Alternaria lini* and *A. linicola* in recently released cultivars and their management with the integration of *Trichoderma viride*, fungicides and plant extract. Disease severity on leaves varied from 41.07 % (Parvati) to 65.01% (Chambal) while bud damage per cent ranged between 23.56% (Shekhar) to 46.12% (T-397), respectively in different cultivars. Maximum yield loss of 58.44% was recorded in cultivar Neelum followed by Parvati (55.56%), Meera (55.56%) and Chambal (51.72%), respectively while minimum loss was recorded in Kiran (19.99%) and Jeevan (22.22%). Minimum mean disease severity (19.47%) with maximum disease control (69.74%) was recorded with the treatment: seed treatment (ST) with vitavax power (2 g $kg^{-1}$ seed) + 2 foliar sprays (FS) of *Saaf* (a mixture of carbendazim+mancozeb) 0.2% followed by ST with *Trichoderma viride* (4g $kg^{-1}$ seed) + 2 FS of *Saaf* (0.2%). Minimum bud damage (13.75%) with maximum control (60.94%) was recorded with treatment of ST with vitavax power+2 FS of propiconazole (0.2%). Maximum mean seed yield (1440 kg $ha^{-1}$) with maximum net return (Rs. 15352/ha) and benefit cost ratio (1:11.04) was obtained with treatment ST with vitavax power + 2 FS of Neem leaf extract followed by treatment ST with vitavax power+2 FS of *Saaf* (1378 kg $ha^{-1}$).

**Key words:** *Linum usitatissimum*, *Alternaria lini* and *linicola, Trichoderma viride, Neem* leaf extract, fungicide

## INTRODUCTION

Linseed (*Linum usitatissimum* L.) is a multipurpose crop and is grown in India mainly for oil, whereas in western countries, it is grown especially for fibre. There are different varieties of linseed meant for both purposes. This crop has many industrial and medicinal values in addition to its direct food value. It is one of the most important oilseed crops of temperate and subtropical region of the world. India ranks second in area (437 lac hectares) and fourth in production (1.68 lac tonnes) after Canada, China and U.S.A. with average productivity of 449 kg $ha^{-1}$ (Srivastava, 2010) which was found less than average productivity of Asia (575 kg $ha^{-1}$) and world (867 kg $ha^{-1}$) (Anonymous, 2010). Besides, deferent causes of low productivity in this crop, diseases play a vital role in lowering in yield. Alternaria blight caused by *Alternaria lini* Dey and *A. linicola* Grooves and Skolko, is a major biotic stress limiting crop yield in hot and humid environment (Singh and Singh 2004a, 2005). Only few resistance genotypes are available at national lable against this diseases. (Singh *et al*., 2006, Singh *et al*., 2009). Extensive studies on different aspect of this disease have been taken time to time by earlier workers (Singh and Singh 2004a, 2005, 2007; Singh *et al*., 2009). Since the disease attacks both the assimilative and reproductive parts of the plants, therefore, resulting in high yield loss (Chauhan and Srivastava, 1975; Singh *et al*., 2003a). Yield losses due to this disease in recently released cultivars are not known and no effort has been made to integrate the plant product, biocontrol agents with fungicides for the effective management of this disease. Hence, the present study was undertaken to assess the yield losses due to blight in linseed cultivars caused by *Alternaria lini* and *A. linicola* and its management by integrated application of bioagent, plant product and fungicides.

## MATERIALS AND METHODS

Field experiments were conducted at University Experiment Station at Kumarganj (26°47'N, 82°12'E, 113 m above sea level), Faizabad, Uttar Pradesh following recommended practices during 2010-11 and 2011-12 crop season. Experiment for yield loss assessment was conducted under split-plot design in three replications by using 16 cultivars (varieties) namely, Type-397 (T-397), Neela, Jeevan, Parvati, Garima, Meera, Chambal, Sweta,

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Nagarkot, Shekhar, Surabhi, Sheela, Rashmi, Padmini, Kiran and Neelum. The plot size was 3×2 m and seeds were sown in first week of November during testing years under protected and unprotected conditions. Half of the seeds of each cultivar were treated with Topsin M at 2 g $kg^{-1}$ seed separately before sowing. The treated seeds were sown only in protected plots. In unprotected plots untreated seeds of each cultivar were sown. The required amount of spray fungicide (mancozeb 0.25%) was dissolved in small amount of water, the volume was made up to desired level and sprayed in protected plots using high volume Knap-Sack sprayer of 10 L capacity. Three sprays were given in protected plots starting from first appearance of disease and subsequently at 15 days intervals. The unprotected plots were sprayed with water only. The disease severity on leaves of protected and unprotected plots were recorded after last spray by using 0-5 scale (Conn *et al*., 1990) and per cent disease severity (PDI) was calculated using formula, PDI = [Sum of numerical rating/total number of observations taken x maximum disease score] x 100. Per cent bud damage and seed yield (kg $ha^{-1}$) were also recorded. Avoidable yield loss (AYL) due to disease using 1000 seed weight (Test weight) and yield data was calculated as: AYL = [(Yp-Yu)/Yp]×100, where Yp = Yield under protected and Yu = Yield under unprotected condition.

Another experiment was conducted to evaluate the performance of *Tricoderma viride* (4g $kg^{-1}$ seed) and Vitavax power (2 g $kg^{-1}$ seed) as seed dresser alone and in combination with two foliar sprays of Neem leaf extract (NLE) (5% w/v), mancozeb (0.25%), propiconazole (0.2%) and *Saaf* (mixture of carbendazim + mancozeb) (0.2%) for the management of Alternaria blight of linseed and compare these with recommended practice (seed treatment with thiram 3 g $kg^{-1}$ seed + 2 foliar sprays of mamcozeb 0.25% for comparative economics. *Tricoderma viride* ND strain (4 g $kg^{-1}$ seed) was mixed with seed and soaked with small amount of water, so that biocontrol agent gets adhered to the surface of seed. The *Tricoderma* coated seeds was incubated for 24 h at 25°C to facilitate the germination of spores. The incubated seeds were dried under shade for 2 to 3 h before sowing. Vitavax power (2 g $kg^{-1}$ seed) was also mixed with seed before sowing. Aqueous *Neem* leaf extract (5% w/v) was prepared by mixing 50 g leaves with one liter sterile water in warring blender. Extracts was filtered through double layered muslin cloth. Two foliar sprays were given, first after 30 days of sowing as prophylactic and second at disease initiation. Trial was planted in randomized block design having twelve treatments with three replications. The experimental field was fertilized with 60 kg N, 40 kg P and 20 kg K per hectare and sowing was done in first week of November during both the years. The crop was irrigated twice first at 35 days after sowing and second at capsule formation. Disease severity as per cent disease intensity on leaves, per cent bud damage, 1000 seed weight (g) and seed yield (kg $ha^{-1}$) in each treatment were recorded. Per cent disease control (PDC) was recorded as per formula: PDC = (DC-DT/DC)×100, where DC = Disease in control (untreated) plot, DT= Disease in treated plot.

Market price of linseed was considered for calculation of economics based on average of two years (2010-11 and 2011-12). For spraying one hectare area 3 man days were considered for fungicide spray, 6 man days for *Neem* leaf extract and half man days for seed treatment. Charges of labour, sprayer and seed dressing drum were taken into account to compute incremental net benefit-cost ratio. Additional net return and benefit cost ratio were calculated using seed yield for individual treatments following formula given below:

$$B:C\,ratio=\frac{\text{Additional not return from protection}}{\text{Cost of protection}}$$

## RESULTS AND DISCUSSION

**Yield loss assessment:** A perusal of the Table 1 indicate that disease severity (PDI) on leaves varied from 41.07 (Parvati) to 65.01% (Chambal), while bud damage (%) ranged from 23.56% (Shekhar) to 46.12% (T-397), respectively in different cultivars under unprotected (natural) condition. Maximum disease severity on leaves was noted in cultivar Chambal followed by Neela and T-397 while maximum bud damage was recorded in cultivar T-397 followed by Neela and Chambal, respectively but these were at par. Other cultivars showed more or less similar reactions to the disease on leaves while minimum bud damage was recorded in Padmini (19.45%) followed by Shekhar (23.56%), Nagarkot (23.67%) and Sheela (24.71%), respectively. Later were also found at par among themselves. Significantly less disease severity on leaves and buds were recorded in protected plots in comparison to unprotected condition irrespective of cultivars. Per cent disease control on leaves and buds varied from 22.90 to 57.39% and 32.17 to 65.24%, respectively. Per cent disease control indicates the susceptibility of the cultivars. Maximum disease control was recorded in susceptible cultivars (T-397, Neela, Chambal) while in tolerant cultivars (Sheela, Shekhar, Jeevan, Padmini and Kiran) disease control was less.

Losses in the test weight (1000 seed weight) were avoided from 0.98 to 7.15% in different cultivars due to protection. Maximum avoidable loss in test weight was recorded in Chambal (7.15%) followed by Kiran (5.19%)

Table 1: Alternaria blight severity on leaves and capsules under protected and unprotected conditions in different varieties (Pooled data of 2010-11 and 2011-12)

| | Severity on leaves (PDI) | | | | Severity on capsules (% Bud damage) | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | UP | P | Mean | % Control | UP | P | Mean | % Control |
| T-397 | 62.64 (52.32) | 26.55 (31.01) | 44.59 (41.66) | 57.61 | 46.12 (42.85) | 16.03 (23.45) | 31.87 (33.15) | 65.24 |
| Neela | 63.99 (53.12) | 24.02 (29.33) | 44.01 (41.23) | 62.46 | 45.11 (42.19) | 17.39 (24.48) | 31.25 (33.34) | 61.45 |
| Jeevan | 45.09 (42.18) | 26.55 (31.01) | 35.82 (36.59) | 41.12 | 23.97 (29.28) | 15.85 (23.85) | 19.91 (26.31) | 33.87 |
| Parvati | 41.07 (39.85) | 22.55 (28.34) | 31.81 (34.10) | 45.09 | 29.83 (33.09) | 16.43 (23.91) | 23.13 (28.50) | 44.92 |
| Garima | 48.94 (44.39) | 27.39 (31.49) | 38.17 (37.94) | 44.03 | 30.57 (33.55) | 18.95 (25.78) | 24.76 (29.66) | 38.01 |
| Meera | 44.42 (41.78) | 27.38 (31.55) | 35.90 (36.67) | 38.36 | 36.71 (37.28) | 14.55 (22.39) | 25.63 (29.83) | 60.36 |
| Chambal | 65.01 (53.73) | 29.87 (33.13) | 47.44 (43.43) | 54.05 | 41.01 (39.82) | 15.47 (23.09) | 28.24 (31.46) | 62.28 |
| Sweta | 43.02 (40.98) | 28.14 (32.04) | 35.58 (36.51) | 34.59 | 24.81 (29.84) | 13.20 (21.26) | 19.00 (25.55) | 46.79 |
| Nagarkot | 46.80 (43.17) | 28.40 (32.19) | 37.60 (37.68) | 39.32 | 23.67 (29.07) | 15.00 (22.70) | 19.34 (25.88) | 36.62 |
| Shekhar | 52.70 (46.55) | 31.95 (34.42) | 42.33 (40.48) | 39.37 | 23.56 (28.93) | 13.26 (21.26) | 18.41 (25.09) | 44.82 |
| Surabhi | 42.00 (40.38) | 32.38 (34.67) | 37.19 (37.53) | 22.90 | 26.95 (31.27) | 16.15 (23.66) | 21.55 (27.47) | 40.07 |
| Sheela | 43.38 (41.19) | 25.04 (29.99) | 34.21 (35.59) | 42.27 | 24.71 (29.71) | 16.76 (24.07) | 20.74 (26.93) | 32.17 |
| Rashmi | 44.72 (41.89) | 27.91 (31.88) | 36.32 (36.92) | 37.58 | 26.87 (31.16) | 14.79 (22.57) | 20.83 (26.86) | 44.95 |
| Padmini | 44.72 (40.80) | 28.19 (32.06) | 35.48 (36.43) | 34.01 | 19.45 (26.06) | 12.04 (19.96) | 15.74 (23.01) | 38.09 |
| Kiran | 47.74 (43.70) | 30.09 (33.27) | 38.92 (38.48) | 38.97 | 25.25 (30.15) | 16.33 (23.81) | 20.79 (26.78) | 35.32 |
| Neelum | 41.69 (40.90) | 25.52 (30.33) | 33.61 (35.27) | 38.78 | 30.44 (33.47) | 18.14 (25.19) | 24.29 (29.33) | 40.41 |
| Mean | 48.49 (44.18) | 27.62 (31.66) | | | 29.95 (32.98) | 16.25 (23.62) | | |

Table 2: Test weight, seed yield under protected and unprotected condition and available yield loss in different cultivars of linseed due to Alternaria blight (Pooled data of 2010-11 and 2011-12)

| | Test weight (g) | | | | Yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | UP | P | Mean | % AYL | UP | P | Mean | % AYL |
| T-397 | 5.83 | 5.89 | 5.86 | 1.01 | 800.00 | 1428.57 | 1247.62 | 43.99 |
| Neela | 5.45 | 5.73 | 5.59 | 4.88 | 723.81 | 1104.76 | 914.28 | 34.48 |
| Jeevan | 6.41 | 6.67 | 6.54 | 3.89 | 1066.67 | 1371.43 | 1219.05 | 22.22 |
| Parvati | 8.02 | 8.36 | 8.19 | 4.06 | 609.52 | 1371.43 | 990.48 | 55.56 |
| Garima | 7.51 | 7.76 | 7.64 | 3.22 | 609.52 | 1180.95 | 895.24 | 48.38 |
| Meera | 7.48 | 7.85 | 7.67 | 4.71 | 609.52 | 1371.43 | 990.48 | 55.56 |
| Chambal | 6.88 | 7.41 | 7.15 | 7.15 | 800.00 | 1657.14 | 1228.57 | 51.72 |
| Sweta | 7.78 | 8.11 | 7.25 | 4.06 | 819.05 | 1216.19 | 1017.62 | 32.65 |
| Nagarkot | 6.12 | 6.40 | 6.26 | 4.37 | 895.24 | 1390.47 | 1142.85 | 35.61 |
| Shekhar | 8.03 | 8.11 | 8.07 | 0.98 | 1142.86 | 1771.43 | 1457.15 | 35.48 |
| Surabhi | 5.33 | 5.44 | 5.38 | 2.02 | 609.52 | 1180.95 | 895.24 | 48.38 |
| Sheela | 7.00 | 7.31 | 7.15 | 4.24 | 990.48 | 1466.66 | 1228.57 | 32.47 |
| Rashmi | 7.33 | 7.54 | 7.43 | 2.78 | 723.81 | 1104.76 | 914.28 | 34.48 |
| Padmini | 7.92 | 8.09 | 8.00 | 2.10 | 1104.76 | 1428.57 | 1266.67 | 22.67 |
| Kiran | 6.75 | 7.12 | 6.93 | 5.19 | 990.48 | 1238.09 | 1114.28 | 19.99 |
| Neelum | 9.09 | 9.53 | 9.31 | 4.61 | 609.52 | 1466.67 | 1038.09 | 58.44 |
| Mean | 7.06 | 7.33 | - | - | 819.05 | 1359.34 | - | - |
| | SEm± | CD at 5% | | | SEm± | CD at 5% | | |
| Protection | 0.01 | 0.06 | | | 38.09 | 133.33 | | |
| Variety | 0.07 | 0.19 | | | 57.14 | 171.42 | | |
| Variety x Protection | 0.12 | 0.33 | | | 95.23 | 285.71 | | |

AYL: Avoidable yield loss

and Neela (4.88%) while minimum in Shekhar (0.98%) followed by T-397 (1.01%) and Surabhi (2.02%), respectively. Protection significantly increased seed yield (kg ha$^{-1}$) as compared to unprotected condition in each cultivar. Maximum seed yield (1771.43 kg ha$^{-1}$) was recorded in Shekhar under protected condition and minimum (609.52 kg ha$^{-1}$) in Parvati, Garima, Meera, Surabhi and Neelum under unprotected condition. Yield losses in different cultivars ranged between 19.99% to 58.44%. Maximum yield loss was recorded in Neelum (58.44%) followed by Parvati (55.56%), Meera (55.56%) and Chambal (51.72%) while minimum loss was recorded in cultivar Kiran (19.99%) followed by Jeevan (22.22%), Padmini (22.67%) and Sheela (32.47%), respectively (Table 2). Chauhan and Srivastava (1975) recorded 16.10 to 58.47% blight intensity with 16.10 to 58.47% yield loss in cultivar 'Heera' and reported losses in yield were approximately equal to percentage of incidence of disease. The present findings support this view. Singh *et al.* (2003b) assessed the losses in yield due to disease in 6 genotypes of linseed including cultivars Neelum, Garima and Chambal and recorded 18.2 to 35.80% losses. Several workers have also reported losses in yield due to *Alternaria* species in different crops (Kolte, 1982;

Suhag *et al*., 1983). Cultivars Kiran, Jeevan, Padmini, Sheela and Shekhar showed tolerant reaction to the disease with less loss in yield, hence can be recommended for successful cultivation in blight prone areas.

**Integrated management:** The effort has been made to integrate plant product and bioagent as ecofriendly component along with fungicides for effective management of this disease in linseed. Perusal of the Table 3 indicates all the treatments significantly reduced the severity of disease on leaves as compared to untreated check. Minimum mean disease severity (19.47%) with maximum disease control (69.74%) was recorded with treatment $T_8$ i.e. seed treatment (ST) with vitavax power (2g $kg^{-1}$ seed) + 2 foliar sprays (FS) of *Saaf* (a mixture of carbendazim + mancozeb) (0.2%) followed by treatment $T_6$ (ST with *Trichoderma viride* 4 g $kg^{-1}$ seed + 2 FS of *Saaf* 0.2%) and $T_9$ (ST with Vitavax power 2 g $kg^{-1}$ seed + 2FS of Propiconazole 0.2%), respectively. The former was significantly superior to other treatments during first year but was at par during second year while latter were at par among themselves and were also at par with treatments $T_4$, $T_7$, $T_{10}$ and $T_{11}$. All the treatments also significantly reduced the bud damage as compared to untreated check except $T_1$ and $T_2$ (ST only either with vitavax power or *T. viride*). Minimum bud damage (13.75%) with maximum control (60.94%) was recorded with treatment $T_9$ (ST with vitavax power+2 FS of propiconazole), $T_8$ (ST with vitavax power+2FS of *Saaf*) $T_6$ (ST with *T. viride*+2FS of *Saaf*), respectively but all these treatments were at par. Maximum average disease severity of 64.34% and bud damage of 35.20% was recorded, respectively in control (untreated) plots.

Percent yield increase on mean basis ranged between 7.97% to 49.74%. Maximum mean seed yield of 1440 kg $ha^{-1}$ was recorded with treatment $T_7$ (ST with vitavax power+2 FS of NLE) followed by $T_8$ (ST with vitavax power+2 FS of *Saaf*) and $T_9$ (ST with vitavax power + 2 FS of propiconazole) but all were at par. Most of the treatments were found at par among themselves in respect of enhanced yield during both the years of testing (Table 4). As regard the test weight no significant difference was recorded among different treatments, while treatment $T_1$ (ST with *T. viride*) and $T_{11}$ (recommended practices) had significantly higher test weight than check during 2010-11. During 2011-12 all the treatments significantly increase the test weight over check. Maximum net return of Rs. 15352/ha with benefit cost ratio of 11.04 was recorded with treatment $T_7$ (ST with vitavax power+2 FS of NLE 5% w/v) followed by $T_3$ (ST with *T. viride* +2 FS of NLE) and $T_8$ (ST with vitavax power+2 FS of *Saff*) (Table 5).

Among seed dressers vitavax power (2 g $kg^{-1}$ seed) was found significantly superior over *T. viride* (4 g $kg^{-1}$ seed) in reducing disease severity on leaves. Effectiveness of vitavax was also recorded in seed born diseases of wheat earlier (Srivastava *et al*., 1997; Srivastava and Yadav, 2006; Sharma *et al*., 2007a, b). Foliar sprays of *Saaf* (mixture of carbendazim + mancozeb) were found most effective in combination with vitavax power as seed dresser followed by propiconazole and recommended practice (ST with thrim 3g $kg^{-1}$ seed + 2 FS of mancozeb 0.25%). Thus, the study has been able to identify *Saaf*, a combination fungicide, for the management of Alternaria blight of linseed more effectively and cheaply than mancozeb, the best option available for the purpose so far (Singh and Singh 2004a, b) Carbendazim the other constituent of *Saaf* is also known to manage the Alternaria blight of linseed to some extent (Singh *et al*., 2001; Khan *et al*., 2004). Combination of carbendazim and mancozeb appears to have synergistic effect in managing the disease as noted in case of leaf

Table 3: Effect of treatments on blight severity and bud damage in linseed

| | Disease severity on leaves (PDI) | | | | Bud damage (%) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | 2010-11 | 2011-12 | Mean | Control (%) | 2010-11 | 2011-12 | Mean | Control (%) |
| $T_1$ | 59.92 (46.10) | 48.75 (44.28) | 54.34 (45.19) | 15.54 | 35.78 (36.70) | 23.75 (29.14) | 29.77 (32.92) | 14.86 |
| $T_2$ | 43.67 (41.36) | 43.96 (41.53) | 43.82 (41.45) | 31.89 | 34.44 (35.90) | 23.93 (29.26) | 29.19 (32.58) | 17.07 |
| $T_3$ | 31.25 (33.96) | 33.80 (35.53) | 32.53 (34.75) | 49.44 | 25.14 (30.90) | 17.00 (24.30) | 21.07 (27.60) | 40.14 |
| $T_4$ | 25.33 (30.14) | 32.25 (34.59) | 28.79 (32.37) | 55.25 | 15.63 (23.18) | 14.50 (22.21) | 15.07 (22.70) | 57.19 |
| $T_5$ | 30.33 (33.42) | 27.23 (31.44) | 28.78 (32.28) | 55.26 | 30.87 (33.75) | 25.20 (30.12) | 28.04 (31.94) | 20.34 |
| $T_6$ | 22.08 (28.00) | 25.22 (30.14) | 23.65 (29.07) | 63.24 | 20.78 (27.08) | 13.67 (21.63) | 17.23 (24.36) | 51.05 |
| $T_7$ | 26.50 (30.96) | 30.57 (34.54) | 28.54 (32.75) | 55.64 | 18.89 (25.75) | 18.20 (25.23) | 18.55 (25.49) | 47.30 |
| $T_8$ | 16.58 (23.98) | 22.35 (28.18) | 19.47 (26.08) | 69.74 | 19.90 (26.27) | 11.25 (19.59) | 15.58 (22.93) | 55.74 |
| $T_9$ | 22.50 (28.30) | 27.15 (31.40) | 24.83 (29.85) | 61.41 | 13.63 (21.61) | 13.87 (21.80) | 13.75 (21.71) | 60.94 |
| $T_{10}$ | 25.52 (30.27) | 25.18 (30.04) | 25.35 (30.16) | 60.60 | 23.90 (29.22) | 17.80 (24.38) | 20.85 (----) | 40.77 |
| $T_{11}$ | 26.92 (31.20) | 26.50 (30.94) | 26.71 (31.07) | 58.49 | 24.90 (29.44) | 19.80 (25.90) | 22.35 (27.67) | 36.51 |
| $T_{12}$ | 62.92 (52.50) | 65.75 (54.22) | 64.34 (53.36) | - | 39.98 (38.96) | 30.42 (33.42) | 35.20 (36.19) | - |
| SEm± | 1.21 | 1.22 | | | 1.61 | 1.41 | | |
| CD at 5% | 3.58 | 4.92 | | | 4.75 | 5.67 | | |
| CV% | 6.10 | 5.87 | | | 9.20 | 9.70 | | |

Table 4: Effect of treatments on test weight (1000 seed weight) and seed yield of linseed

| | Test weight (g) | | | | Seed yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | 2010-11 | 2011-12 | Mean | Control (%) | 2010-11 | 2011-12 | Mean | Control (%) |
| $T_1$ | 7.99 | 7.97 | 7.98 | 10.38 | 870 | 1206.67 | 1038.34 | 7.97 |
| $T_2$ | 7.67 | 7.88 | 7.76 | 7.78 | 970 | 1200.00 | 1085.00 | 12.82 |
| $T_3$ | 7.66 | 7.92 | 7.79 | 8.19 | 1130 | 1353.33 | 1241.67 | 29.12 |
| $T_4$ | 7.61 | 7.87 | 7.74 | 7.50 | 1220 | 1343.33 | 1281.67 | 33.28 |
| $T_5$ | 7.46 | 7.82 | 7.64 | 6.11 | 1000 | 1496.67 | 1248.34 | 29.81 |
| $T_6$ | 7.65 | 7.87 | 7.76 | 7.78 | 1080 | 1533.33 | 1306.67 | 35.88 |
| $T_7$ | 7.65 | 7.84 | 7.75 | 7.64 | 1380 | 1500.00 | 1440.00 | 49.74 |
| $T_8$ | 7.71 | 8.12 | 7.92 | 10.00 | 1170 | 1586.67 | 1378.34 | 43.33 |
| $T_9$ | 7.46 | 7.94 | 7.70 | 6.94 | 1260 | 1403.33 | 1331.67 | 38.47 |
| $T_{10}$ | 7.59 | 7.80 | 7.70 | 6.94 | 1120 | 1470.00 | 1295.00 | 34.66 |
| $T_{11}$ | 7.69 | 7.79 | 7.74 | 7.50 | 1090 | 1300.00 | 1195.00 | 24.26 |
| $T_{12}$ | 7.19 | 7.22 | 7.20 | - | 770 | 153.33 | 961.67 | - |
| SEm± | 0.163 | 0.045 | | | 77.00 | 80.16 | | |
| CD at 5% | 0.482 | 0.133 | | | 227.00 | 245.75 | | |
| CV% | 3.72 | 1.00 | | | 12.26 | 10.75 | | |

$T_1$: Seed treatment (ST) with *Trichoderma viride* (Tv) (4g kg$^{-1}$ seed), $T_2$: ST with Vitavax power (Vp) (2g kg$^{-1}$ seed), $T_3$: ST Tv + Foliar sprays (FS) of *Neem* leaf extract (NLE) (5% W/V), $T_4$: ST Tv + FS of propiconazole (0.20%), $T_5$: ST Tv + FS of mancozeb (0.25%), $T_6$: ST Tv + FS of *Saaf* (0.20%), $T_7$: ST Vp + FS of NLE (5% W/V), $T_8$: ST Vp + FS of *Saaf* (0.20% ), $T_9$: ST Vp + FS of propiconazole (0.20%), $T_{10}$ = ST Vp + FS of mancozeb (0.25%), $T_{11}$: Recommended practice (ST with thiram 3g kg$^{-1}$ seed) + FS of mancozeb (0.25%), $T_{12}$: Untreated (check)

Table 5: Economics of treatments for the management of Alternaria blight of linseed (Pooled data of 2010 and 2011-12)

| Treatments | Doses | Yield (kg ha$^{-1}$) | Additional yield over check (kg ha$^{-1}$) | Additional income (Rs./ha) | Cost of protection (Rs./ha) | Net return (Rs./ha) | Benefit cost ratio |
|---|---|---|---|---|---|---|---|
| $T_1$= ST with *T. viride* | 4g kg$^{-1}$ seed | 1038.34 | 76.67 | 2683 | 80 | 2603 | 32.54 |
| $T_2$= ST with vitavax power | 2g kg$^{-1}$ seed | 1085.00 | 123.33 | 4317 | 130 | 4187 | 32.21 |
| $T_3$= ST with *T. viride* + FS of NLE | 5% w/v | 1241.67 | 280.00 | 9800 | 1340 | 8460 | 6.31 |
| $T_4$= ST with *T. viride* + FS of propiconazole | 0.20 % | 1281.67 | 320.00 | 11200 | 5530 | 5620 | 1.01 |
| $T_5$= ST with *T. viride* + FS of mancozeb | 0.25% | 1248.34 | 286.67 | 10033 | 2590 | 7443 | 2.87 |
| $T_6$= ST with *T. viride* + FS of *Saaf* | 0.20 % | 1306.67 | 345.00 | 12075 | 2540 | 9135 | 3.11 |
| $T_7$= ST with vitavax power+ FS of NLE | 5% w/v | 1440.00 | 478.33 | 16742 | 1390 | 15352 | 11.04 |
| $T_8$= ST with vitavax power+ FS of *Saaf* | 0.20 % | 1378.34 | 416.67 | 14583 | 2990 | 11593 | 3.88 |
| $T_9$= ST with vitavax power+FS of propiconazole | 0.20 % | 1331.67 | 370.00 | 12950 | 5630 | 7320 | 1.30 |
| $T_{10}$= ST with vitavax power+ FS of mancozeb | 0.25% | 1295.00 | 333.33 | 11667 | 2640 | 9027 | 3.42 |
| $T_{11}$= ST with thiram+ FS of mancozeb | 0.25% | 1195.00 | 233.33 | 8167 | 2585 | 5582 | 2.16 |
| $T_{12}$= Untreated (Check) | - | 961.67 | - | - | - | - | - |

ST: Seed treatment; FS: Foliar spray; NLE: Neem leaf extracts, cost of protection: Efficacy of sprayer, 1 ha/day, rent for sprayer, Rs. 30/day; rent for seed dressing drum, Rs. 5/ha; labour charges, Rs. 100/day; cost of fungicides, mancozeb, Rs. 370/kg; propiconazole, Rs. 1210/kg; *Saaf*, Rs. 550/kg; vitavax power, Rs. 1410/kg; thriam, Rs. 195/kg; *Trichoderma viride*, Rs. 200/kg; Sale price of linseed, Rs. 3500/toune

spot of groundnut (Singh *et al*., 2004). Concurrent with present findings Singh *et al*. (2009) have also reported fungicide *Companion* (a mixture of carbendazim and mancozeb) as most effective and economical for management of this disease in linseed in comparison to mancozeb alone. Propiconazole too, manage this disease efficaciously but less economically. This fungicide is new for linseed, have been reported effective in managing leaf blight disease elsewhere (Biswas and Singh, 2005; Kumar *et al*., 2009).

*Neem* leaf extracts (NLE) (5% w/v) sprays were also found significantly effective in controlling the disease severity and enhancing the seed yield with maximum net return. Effectiveness of NLE and other *Neem* products were reported against *Alternaria* species causing leaf blight in different crops *in vitro* condition (Babu *et al*., 2001; Pandey *et al*., 2002; Singh *et al*., 2003a). In present findings seed treatment with vitvax power followed by 2 foliar sprays of *Neem* leaf extracts provided highest yield than other treatments. This may be due to synergic effect of fungicides and botanicals and can be recommended for the economic and eco-friendly management of Alternaria blight in linseed.

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