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Effect of fungicides and Biocontrol agents on seed germination, seedling vigour index and seed mycoflora of safflower

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Abstract
The present investigation was undertaken with the main objective to effect of fungicides and biocontrol agents on seed germination, seedling vigour index and seed mycoflora of safflower were conducted at Department of Plant Pathology, College of Agriculture, Rajendranagar, Hyderabad. Effect of fungicides and biocontrol agents on seed germination, seedling vigour index and seed mycoflora was evaluated on two popular verities of safflower *viz.*, Nira and ISF-764 by standard blotter method and paper towel method. Seed treatment with captan (0.25%) was found superior followed by seed treatment with *Trichoderma harzianum* (1%), in all the two popular varieties tested in the testes parameters.

Keywords: Safflower, seed germination, seedling vigour index, seed mycoflora, captan, *Trichoderma harzianum*

Introduction
Safflower (*Carthamus tinctorius* L.) is one of the major *Rabi* oilseed crop cultivated in the Deccan Plateau region of India. Safflower has been grown in India since ancient times not only for the orange red dye extracted from its glittering florets but also for its seed oil. The dye is largely used for colouring purposes in food and textile industry. Safflower oil is rich in polyunsaturated fatty acids (linoleic acid 78%), which play an important role in reducing blood cholesterol level and is considered as a healthy cooking medium. The oil also contains a high amount of Vitamin E which reduces respiratory problems, helps blood circulation and strengthens the immune system. The oil is used mainly for cooking, illuminating purpose and also soap manufacture. It possesses good dyeing properties and it is used in paints, dyeing, coating and rubber industries. Safflower oil is also used in lubricating oils, gasolines and diesel fuels. Safflower seed cake is a rich source of protein (25-30%). Seed hull is useful to manufacture cellulose, furfural, insulation and abrasives *etc*. Hull is a good source of fuel with calorific value of 4565 k cal/kg. Safflower is used as a green vegetable in India Safflower producing states are Maharashtra, Karnataka, Telangana, Andhra Pradesh, Odisha, Madhya Pradesh. In Telangana, the crop is grown in an area of 1000 ha and with a production and productivity of 605 kg ha^{-1} respectively.

Despite the rapid spread of the crop, a disheartening trend is that the productivity has reduced in recent years. In India, safflower production and productivity was 44 MT and 843 kg/ha during 2019-2020 (INDIASTAT, 2019-20). The productivity level is low in India compared to USA and Mexico (1500 to 2000 kg/ha) (Damodaram and Hegde, 1999) [3]. This is due to several biotic and a biotic constraints due to which the full potential of the crop is far from being explored. Among the several biotic limiting factors for successful safflower production, susceptibility to diseases is one of the major constraints.

Several diseases are known to cause yield loss in safflower and many of these diseases are seed-borne *viz.*, Alternaria leaf blight (*Alternaria carthami*), Rust (*Puccinia carthami*) and Fusarium wilt (*Fusarium oxysporum* f. sp. *carthami*). Wilt of safflower caused by *Fusarium oxysporum* f. sp. *carthami* Klisiewicz and Houston, 1963 [7] (*Foc*) has been assumed to increased economic importance in recent years with high incidence of the disease being reported in India than the other areas under the crop in the world.

In safflower most of the seed borne diseases has shown variable trends over the years with huge loss in total production necessitating the importance of healthy and viable seed, which is free from fungal infection. To increase the production of safflower qualitatively and

quantitatively, farmer requires healthy quality seeds with high germination per cent and purity. Hence, it is imperative that the seeds must be tested before they are sown in the field. Another adverse effect of seed borne pathogen is that they contaminate the areas which were disease free previously. So, it necessitates the eradication of seed borne inoculum through various seed treatments and through the enforcement of proper domestic and international quarantine acts and procedures. Seed treatment is the oldest practice in plant protection and now, this is an attractive delivery system for either fungal or bacterial bio protectants. Seed treatment with bio protectents provides economical and relatively non polluting delivery systems for protective materials compared to other field application systems. Bio protectants applied to seeds may not only protect seeds but also may colonize and protect roots and increase the plant growth. However, biological agents have tended to be somewhat less effective and more variable than chemical seed treatments. However, information on effect of fungicides and biocontrol agents on seed germination, seedling vigour index and seed mycoflora of safflower. Keeping this in view, the present investigation was taken up.

Material and Methods

Safflower seeds were collected from different areas of Telangana and Andhra Pradesh. Standard blotter method was used to evaluate seed quality. Both untreated seeds and seeds treated with fungicides (Mancozeb, Carbendazim, Captan) and bio control agents (*Trichoderma harzianum*, *Pseudomonas fluorescens*) were placed in Petri plates with three layers of moistened blotters using sterile distilled water (10 seeds/ plate). For each variety ISTA techniques (Anon, 1976) were used to study the mycoflora, where 40 untreated and 40 treated seeds per variety were used for the blotters test. The Petri plates were incubated at 25°± 2 ^{0}C under 12 h of alternating cycle of light and darkness for 7days. Seeds from each sample were examined for the percentage of mycoflora per 30 seeds under binocular microscope on the seventh day.

Germination percentage for all the varieties using paper towel method (ISTA, 1996) [6] was carried out. Three replications of 100 seeds by random pick were placed on the paper towel, which were kept in a beaker containing water for two weeks and also by Petri plate method where ten seeds per Petri plate were kept. Shoot length and root length were recorded for each seed in each sample. Seedling vigour index was calculated by multiplying the per cent of germination with the sum of root and shoot length that is expressed in centimetres (Abdul Baki and Anderson 1973) [1].

Results and Discussion

Effect of Fungicides and Biocontrol Agents on Seed Germination, Seedling Vigour Index and Seed Mycoflora of Safflower (Nira)

1. Standard Blotter Paper Method

In standard blotter paper method the fungicides and bio control agents were evaluated for their efficacy against the seed mycoflora, seedling vigour index and germination of safflower cv. Nira was studied under *in vitro* conditions and results indicated that all the seed treatments were significantly superior in reducing the seed mycoflora and improving seed germination and seedling vigour index when compared to control. The results of experiments presented in Table 1 and Fig 1 showed that the per cent germination, seedling vigour index and per cent seed mycoflora of safflower seeds.

The results showed that the per cent germination of safflower seeds in all the treatments ranged from 78.50 to 88.50 per cent and significantly higher as against 71.00 per cent in the control. Among all the individual treatments, T_3 (seed treatment with captan recorded maximum (88.5%) germination followed by treatment T_4 (seed treatment with *T. harzianum*, 86.5%), T_1 (seed treatment with Mancozeb, 81.8%), T_2 (seed treatment with Carbendazim, 80.0%) and T_5 (seed treatment with *P. fluorescens*, 78.5%). In all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments.

The results indicated that the seedling vigour index of safflower seeds in all the treatments ranged from 351.5 to 458.0 and significantly higher as against 294.7 in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded maximum (458.0) seedling vigour index followed by T_4 (seed treatment with *T. harzianum*, 437.0), T_1 (seed treatment with Mancozeb, 404.5), T_2 (seed treatment with carbendazim, 364.0) and T_5 (seed treatment with *P. fluorescens*, 351.5) respectively. Among all the treatments T_3 (seed treatment with captan) was significantly superior over all other treatments but T_4 (seed treatment with *T. harzianum*) was statistically on par. The treatments T_2 and T_5 were statistically on par.

The results showed that the per cent seed mycoflora of safflower seeds in all the treatments (11.0 to 17.25%) was significantly superior as against 88.0 per cent in the control. Among all the individual treatments, T_3 (seed treatment with captan) recorded minimum (11.0%) seed mycoflora followed by T_4 (seed treatment with *T. harzianum*), T_1 (Seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 13.25, 14.50, 16.75 and17.25 per cent respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments but T_4 (seed treatment with *T. harzianum*) was statistically on par T_3. The treatments T_4 and T_1, T_1 and T_2, T_2 and T_5 were statistically on par.

2. Paper Towel Method

In paper towel method the fungicides and bio control agents were evaluated for their efficacy against the seed mycoflora, seedling vigour index and germination of safflower cv. Nira was studied under *in vitro* conditions and results indicated that all the seed treatments were significantly superior in reducing the seed mycoflora and improving seed germination and seedling vigour index when compared to control.

The results of experiments presented in Table 1 and Fig 2 showed that the per cent germination, seedling vigour index and per cent seed mycoflora of safflower seeds. The results showed that the per cent germination of safflower seeds in all the treatments (79.25 to 87.5%) was significantly higher as against 70.50 per cent in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded maximum 87.50 per cent germination followed by T_4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 87.00, 84.50, 82.25 and 79.25 per cent respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments but T_4 (seed treatment with *T. harzianum*) was statistically on par with each other. The treatments T_2 and T_5 were also statistically on par.

The results showed that the seedling vigour index of safflower seeds in all the treatments (957.40 to 1326.35) was significantly higher as against 770.40 in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded maximum (1326.35) seedling vigour index followed by T_4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 1264.35, 1138.13, 1031.78 and 957.40 respectively. Among all the treatments T_3 (seed treatment with captan) was significantly superior over all other treatments.

The results showed that the per cent seed mycoflora of safflower seeds in all the treatments (8.50 to 15.00%) was significantly superior as against 85.75 per cent in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded minimum (8.50%) seed mycoflora followed by T_4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 10.00, 12.75, 14.00 and 15.00 per cent respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments but T_4 (seed treatment with *T. harzianum*) was statistically on par T_3. The treatments T_2 and T_5 were statistically on par.

Effect of Fungicides and Biocontrol Agents on Seed Germination, Seedling Vigour Index and Seed Mycoflora of Safflower (ISF-764)

1. Standard Blotter Paper Method

In standard blotter paper method the fungicides and bio control agents were evaluated for their efficacy against the seed mycoflora, seedling vigour index and germination of safflower cv ISF-764 was studied under *in vitro* conditions and results indicated that all the seed treatments were significantly superior in reducing the seed mycoflora and improving seed germination and seedling vigour index when compared to control. The results of experiments presented in Table 2 and Fig 3 showed that the per cent germination, seedling vigour index and per cent seed mycoflora of safflower seeds.

The results showed that the per cent germination of safflower seeds in all the treatments (79.25 to 89.25%) was significantly higher as against 70.25 per cent in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded maximum 89.25 per cent germination followed by T_4 (seed treatment with *Trichoderma harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with carbendazim) and T_5 (seed treatment with *Pseudomonas fluorescens*) with 88.00, 82.75, 80.75 and 79.25 per cent respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments but T_4 (seed treatment with *Trichoderma harzianum*) was statistically on par.

The results showed that the seedling vigour index of safflower seeds in all the treatments (378.40 to 470.80) was significantly higher as against 314.25 in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded maximum (470.80) seedling vigour index followed by T_4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 450.93, 411.70, 403.73 and 378.40 respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments but T_4 (Seed treatment with *T. harzianum*) was statistically on par.

The results showed that the per cent seed mycoflora of safflower seeds in all the treatments (10.00 to 17.50%) was significantly superior as against 83.75 per cent in the control. Among all the individual treatments, T3 (seed treatment with Captan) recorded minimum (10.0%) seed mycoflora followed by T_4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 12.25, 13.25, 15.75 and 17.50 per cent respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments. The treatments T_4 and T_1, T_2 and T_5 were statistically on par.

2. Paper Towel Method

In paper towel method the fungicides and bio control agents were evaluated for their efficacy against the seed mycoflora, seedling vigour index and germination of safflower cv. ISF-764 was studied under *in vitro* conditions and results indicated that all the seed treatments were significantly superior in reducing the seed mycoflora and improving seed germination and seedling vigour index when compared to control. The results of experiments presented in Table 2 and Fig 4 showed that the per cent germination, seedling vigour index and per cent seed mycoflora of safflower seeds.

The results showed that the per cent germination of safflower seeds in all the treatments (81.25 to 88.25%) was significantly higher as against 73.5 per cent in the control. Among all the individual treatments, T_3 (Seed treatment with Captan) recorded maximum 88.25 per cent germination followed by T_4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 87.5, 85.75, 82.5 and 81.25 per cent respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments but T_4 (seed treatment with *T. harzianum*) was statistically on par, T_4 and T_1, T_2 and T_5 were statistically on par.

The results showed that the seedling vigour index of safflower seeds in all the treatments (996.78 to 1319.00) was significantly higher as against 786.08 in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded maximum (1319.00) seedling vigour index followed by T4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 1251.30, 1157.60, 1047.23 and 996.78 respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments.

The results showed that the per cent seed mycoflora of safflower seeds in all the treatments (10.75 to 16.50%) was significantly superior as against 82.00 per cent in the control. Among all the individual treatments, T_3 (seed treatment with Captan) recorded minimum (10.75%) seed mycoflora followed by T_4 (seed treatment with *T. harzianum*), T_1 (seed treatment with Mancozeb), T_2 (seed treatment with Carbendazim) and T_5 (seed treatment with *P. fluorescens*) with 11.25, 12.25, 13.25 and 16.5 per cent respectively. Among all the treatments T_3 (seed treatment with Captan) was significantly superior over all other treatments but T_4 (seed treatment with *T. harzianum*) was statistically on par T_3. The treatments T_4 and T_1, T_1 and T_2 were statistically on par.

Among all the treatments and methods across all the varieties tested, in control, fungi *viz.*, *Fusarium* spp., *Aspergillus flavus*, *Aspergillus niger*, *Chaetomium* spp., *Curularia* spp., *Alternaria* spp., *Rhizopus* spp. and *Macrophomina phaseolina* were observed. Seed treatment with captan could completely inhibit *Fusarium* spp., *Chaetomium* spp., *Curularia* spp. *Alternaria* spp. and *Macrophomina phaseolina;* Seed treatment with carbendazim could completely inhibit *Fusarium* spp., *Chaetomium* spp. and *Curvularia* spp. only; Seed treatment with mancozeb could completely inhibit *Chaetomium* spp., *Curularia* spp. and *Alternaria* spp*;* Seed treatment with *Pseudomonas fluorescens* could completely inhibit *Fusarium* spp., *Chaetomium* spp., and *Curularia* spp; Seed treatment with *Trichoderma harzianum* could completely inhibit *Fusarium* spp., *Chaetomium* spp., *Curularia* spp., *Alternaria* spp. and *Rhizopus* spp.

Among all the treatments tested, *Fusarium* spp. was completely inhibited by seed treatment with captan, carbendazim, *Pseudomonas fluorescens* and *Trichoderma harzianum*; *Chaetomium* spp. and *Curvularia* spp. were completely inhibited by all the seed treatments tested; *Alternaria* spp. was completely inhibited by seed treatment with Captan, Mancozeb and *Trichoderma harzianum*; *Rhizopus* spp. was completely inhibited by seed treatment with captan and *Trichoderma harzianum* and *Macrophomina phaseolina* was completely inhibited by seed treatment with captan only. Similar results of fungicides and bioagents completely inhibiting certain specific fungi was also reported by Srinivas (2016) [11].

The present findings are in confirmation with earlier findings of Raghuwanshi and Deokar (2002) [9] who reported that mycoflora associated with safflower seeds reduced seed germination, seedling vigour and other seed quality parameters.

Among the fungicides, captan followed by mancozeb were found effective in enhancing the seed quality and seed germination. Carbendazim as a seed treatment was found less effective over Captan and Mancozeb seed treatments, which might be attributed because of carbendazim belongs to benzimidazole group and these fungicides are not effective against dark coloured spores like *Alternaria*, *Helminthosporium etc.* similar results were reported by Singh *et al.* (2008) [10]. All the seed treatments involving Captan, Mancozeb, Carbendazim *T. harzianum* and *P. fluorescens*, were recorded less number of fungal colonies over untreated seeds. In case of bioagents, *T. harzianum* was found significantly effective over seed treatment with *Pseudomonas fluorescens*. It is interesting to note that the efficacy of seed treatment with *T. harzianum* was similar in all the cultivars tested confirming the effectiveness of the seed treatments in reducing the total fungal colonies and also enhanced the seed quality parameters. Keeping in view of the adverse effect of the fungicides on the agro-ecosystem, the use of potential bioagents can be exploited in the management of seed mycoflora of safflower. Hence farmers are advised to use *T. harzianum* @ 10 g/kg, to enhance seedling emergence, to safeguard against seed and seedling diseases and to reduce environmental pollution and the cost of pesticides there by reaping higher yields in safflower.

Similar findings were reported by Govindappa *et al*. (2011) [4], fungicides COC, Captan and Mancozeb were found extremely effective in reducing *Fusarium oxysporum* f. sp. *carthami* wilt. The seed treatments improved seed germination, seedling vigour and plant stand. Due to these treatments many of the seed-borne fungi failed to express in the normal way. Bioagents formulations *viz*., *Trichoderma harzianum*, *Bacillus subtilis* and *Pseudomonas fluorescens* reduced the wilt incidence both under greenhouse and field conditions, thereby enhancing the growth of the seedlings. These antagonists significantly reduced the population of *Fusarium oxysporum* f. sp. *carthami*, increased the seed germination and seedling vigour.

Fungicides acted possibly by inducing metabolic changes leading to development of toxic factors, resulting in the internal environment unfavorable for pathogens growth and activity, ultimately inducing the resistance and protection against infection. These results are confirmatory with the observations of Kumar and Dubey (2001) [8] in cowpea, blackgram, brinjal and sunflower, respectively. Pedgoanker and Mayee (1989) [13] have reported the effectiveness of Thiram, Cabendazim against safflower wilt pathogen *F. oxysporum* f. sp. *carthami*. All the fungicidal seed treatments increased germination, plant height which correlated with the findings of Pathak *et al*. (2001) [12]. Bioagents formulations gave significant results controlling the wilt disease, and also enhanced seed germination.

T. harzianum was more effective than *P. fluorescens* which minimized the wilt. Application of biocontrol agents as a seed treatment may induce the accumulation of lytic enzymes in safflower. The increased activities of PAL, lytic enzymes and accumulation of phenolics in safflower in response to seed treatment with *T. harzianum* and *P. fluorescens* might have also contributed to increase resistance against pathogen. Effect of these bioagents in plant disease management have been reported by Prasad and Rangeswaran (1999) [14]. But *B. subtilis* enhanced the plant height compared to *T. harzianum* and *P. fluorescens*.

Table 1: Effect of fungicides and biocontrol agents on seed germination, seedling vigour index and seed mycoflora in cv. Nira

Treatments	Standard blotter paper method			Paper towel method		
	Germination (%)	Seedling Vigour index	Seed mycoflora (%)	Germination (%)	Seedling Vigour index	Seed mycoflora (%)
T_1- seed treatment with Mancozeb @ 0.25%	81.80 (64.69)	404.50	14.50 (22.34)	84.50 (66.80)	1138.13	12.75 (20.87)
T_2 seed treatment with Carbendazim @ 0.1%	80.00 (63.41)	364.00	16.75 (24.13)	82.25 (65.07)	1031.78	14.00 (21.91)
T_3 seed treatment with Captan @ 0.25%	88.50 (70.17)	458.00	11.00 (19.32)	87.5 (69.29)	1326.35	8.50 (16.91)
T_4 seed treatment *Trichoderma harzianum* with @ 1.0%	86.50 (68.43)	437.00	13.25 (21.31)	87.00 (68.89)	1264.35	10.00 (18.42)
T_5 seed treatment with *Pseudomonas fluorescens* @ 1.0%	78.50 (62.35)	351.50	17.25 (24.51)	79.25 (62.91)	957.40	15.00 (22.77)

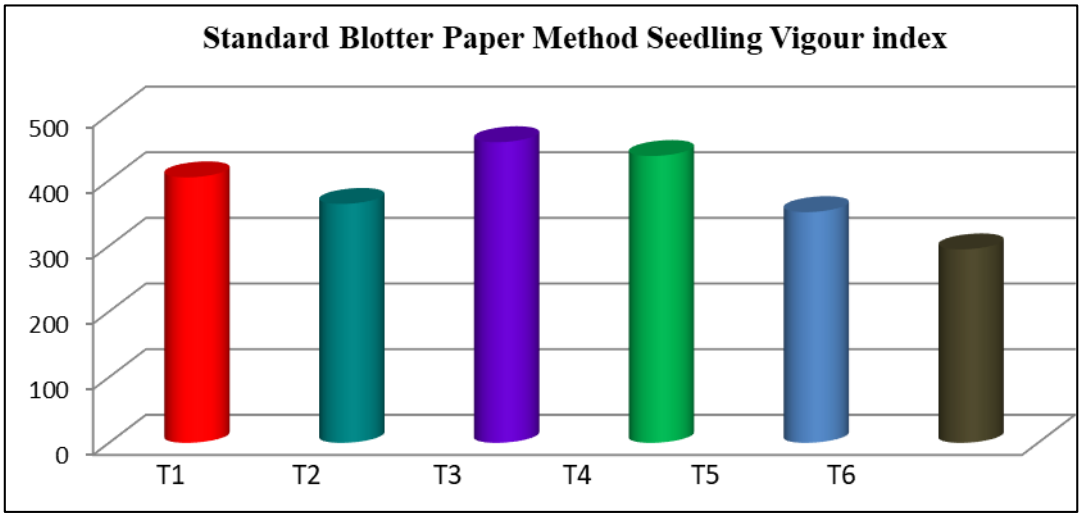
T_6 Control	71.00 (57.41)	294.75	88.00 (69.80)	70.50 (57.08)	770.40	85.75 (67.80)
S.E(m)±	0.54	7.91	0.85	0.68	15.29	0.66
C.D	1.60	23.68	2.55	2.05	45.77	1.99

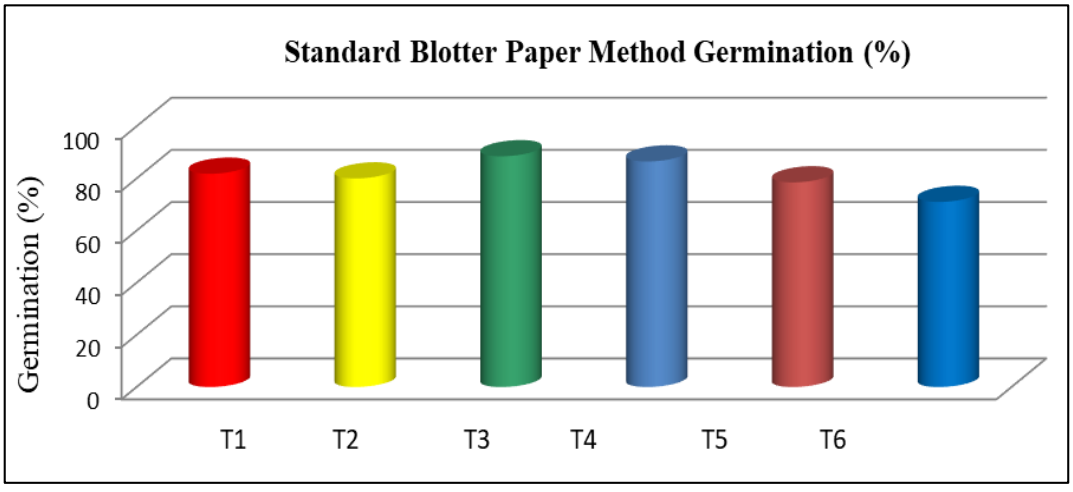
*Mean of four replication
** Figures in parenthesis are angular transformed values

Table 2: Effect of fungicides and biocontrol agents on seed germination, seedling vigour index and seed mycoflora in cv. ISF-764

Treatments	Standard blotter paper method			Paper towel method		
	Germination (%)	Seedling Vigour index	Seed mycoflora (%)	Germination (%)	Seedling Vigour index	Seed mycoflora (%)
T_1- seed treatment with Mancozeb @ 0.25%	82.75 (65.44)	411.70	13.25 (21.33)	85.75 (67.80)	1157.60	12.25 (20.44)
T_2 seed treatment with Carbendazim @ 0.1%	80.75 (63.96)	403.73	15.75 (23.36)	82.5 (65.27)	1047.23	13.25 (21.33)
T_3 seed treatment with Captan @ 0.25%	89.25 (70.85)	470.80	10.00 (18.40)	88.25 (69.97)	1319.00	10.75 (19.10)
T_4 seed treatment *Trichoderma harzianum* with @ 1.0%	88.00 (69.71)	450.93	12.25 (20.42)	87.5 (69.29)	1251.30	11.25 (19.57)
T_5 seed treatment with *Pseudomonas fluorescens* @ 1.0%	79.25 (62.88)	378.40	17.50 (24.71)	81.25 (64.34)	996.78	16.50 (23.95)
T_6 Control	70.25 (56.93)	314.25	83.75 (66.22)	73.5 (59.01)	786.08	82.00 (64.92)
S.E(m)±	0.38	6.93	0.63	0.70	10.51	0.71
C.D	1.13	21.07	1.88	2.11	31.47	2.14

*Mean of four replication
** Figures in parenthesis are angular transformed values





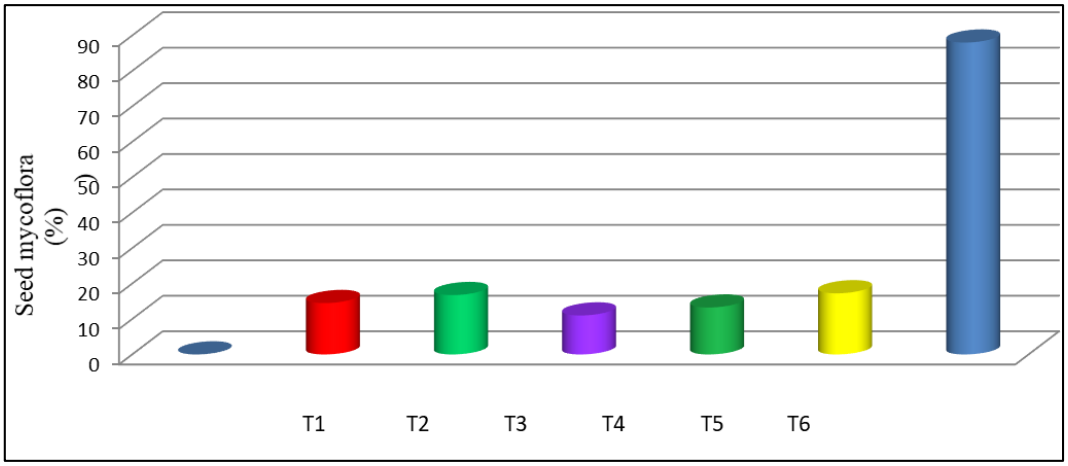
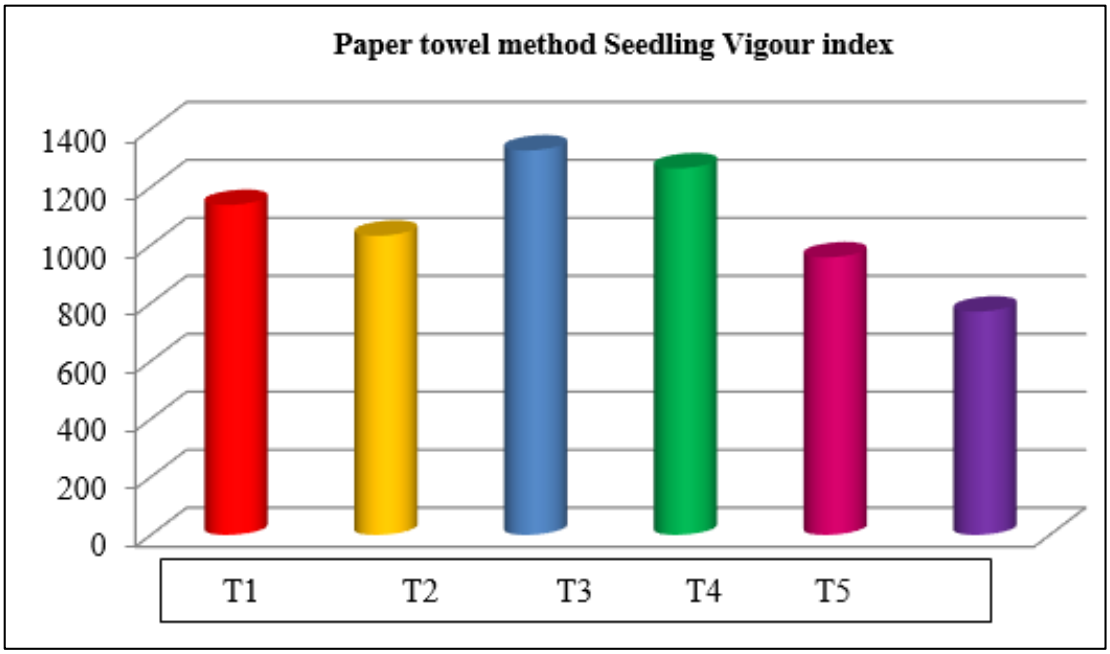
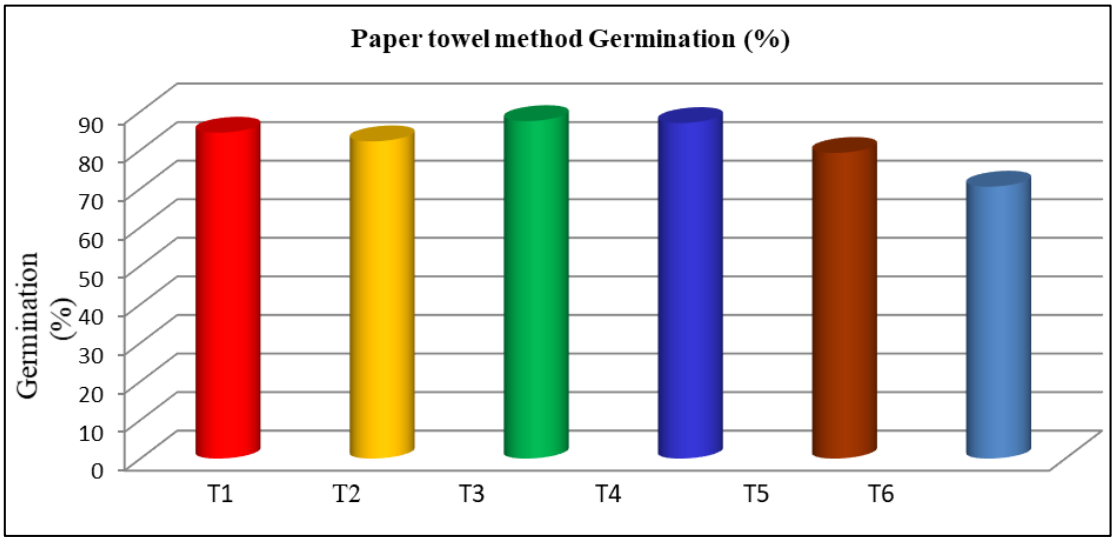


Fig 1: Effect of fungicides and bio-control agents on seed germination, seedling vigour index and seed mycoflora (cv. Nira) by standard blotter paper method T_1-Seed treatment with Mancozeb @ 0.25%, T_2 Seed treatment with Carbendazim @ 0.1% T_3 -Seed treatment with Captan @ 0.25%, T_4 -Seed treatment *Trichoderma harzianum* with @ 1.0%, T_5 -Seed treatment with *Pseudomonas fluorescens* @ 1.0%, T_6 Control





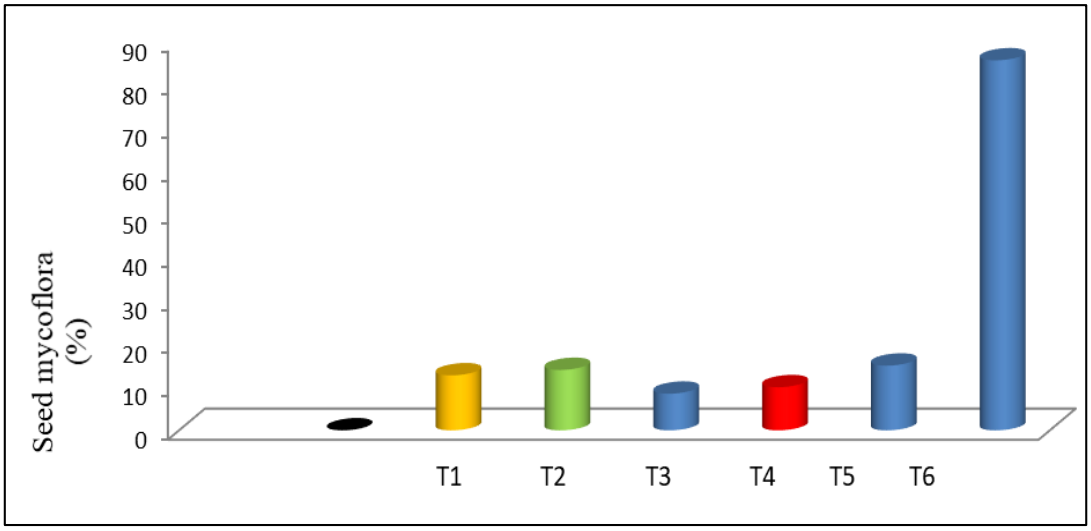
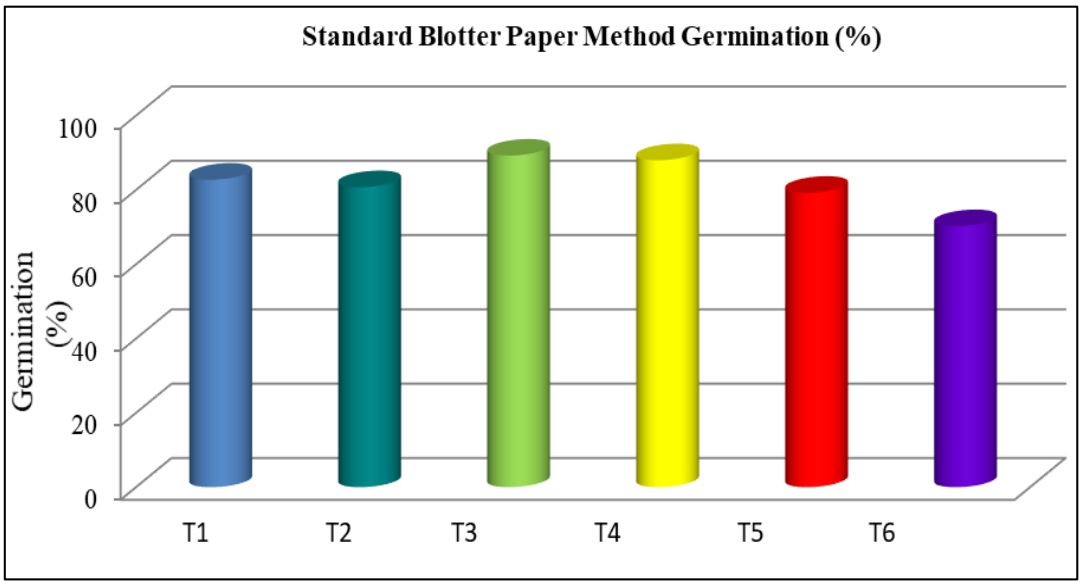
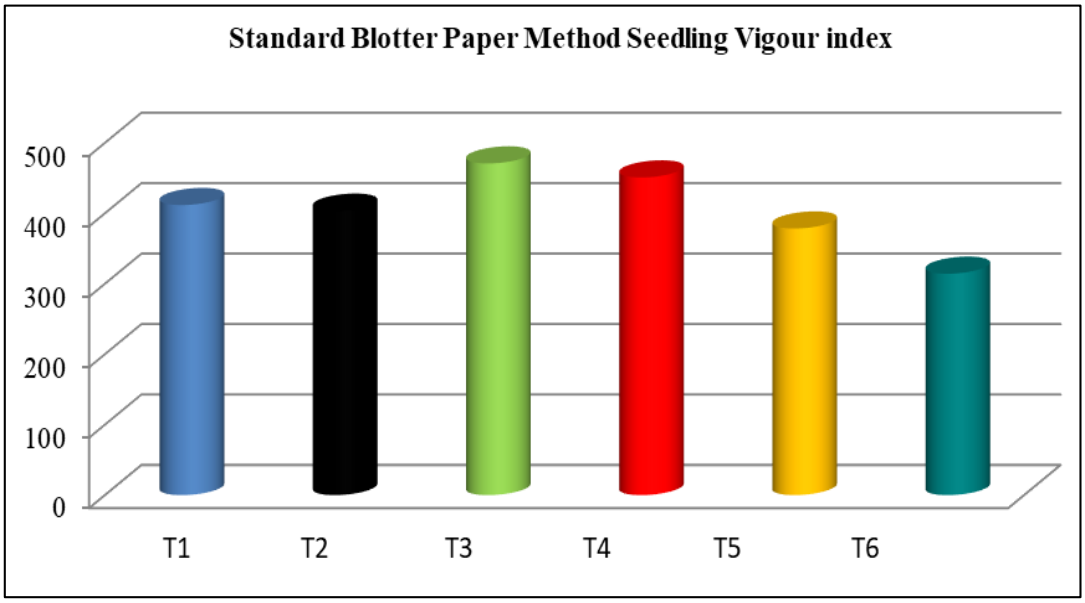


Fig 2: Effect of fungicides and bio-control agents on seed germination, seedling vigour index and seed mycoflora (cv. Nira) by Paper towel method T_1-Seed treatment with Mancozeb @ 0.25%, T_2 Seed treatment with Carbendazim @ 0.1% T_3 -Seed treatment with Captan @ 0.25%, T_4 -Seed treatment *Trichoderma harzianum* with @ 1.0%, T_5 -Seed treatment with *Pseudomonas fluorescens* @ 1.0%, T_6 Control





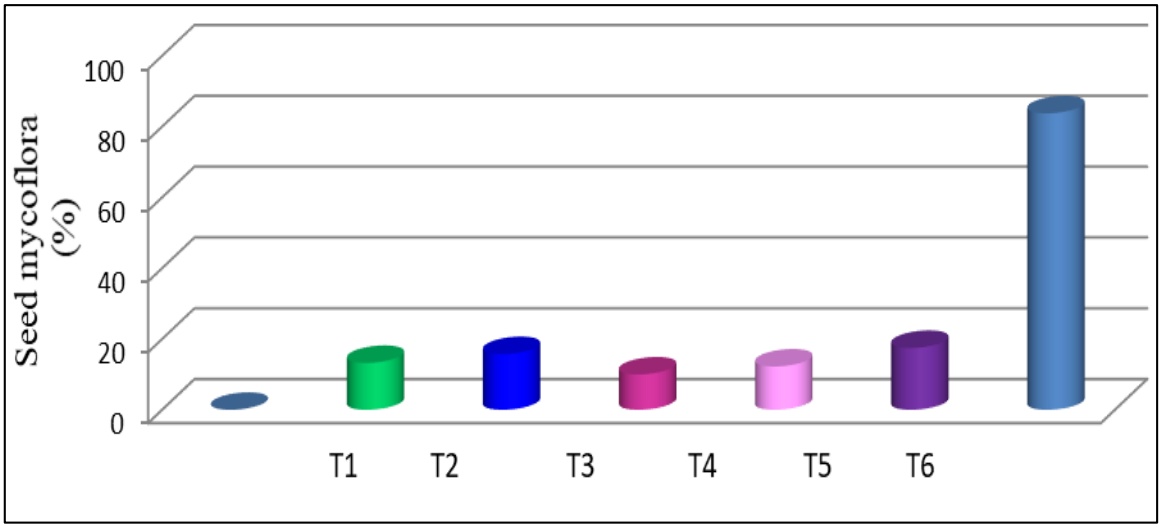
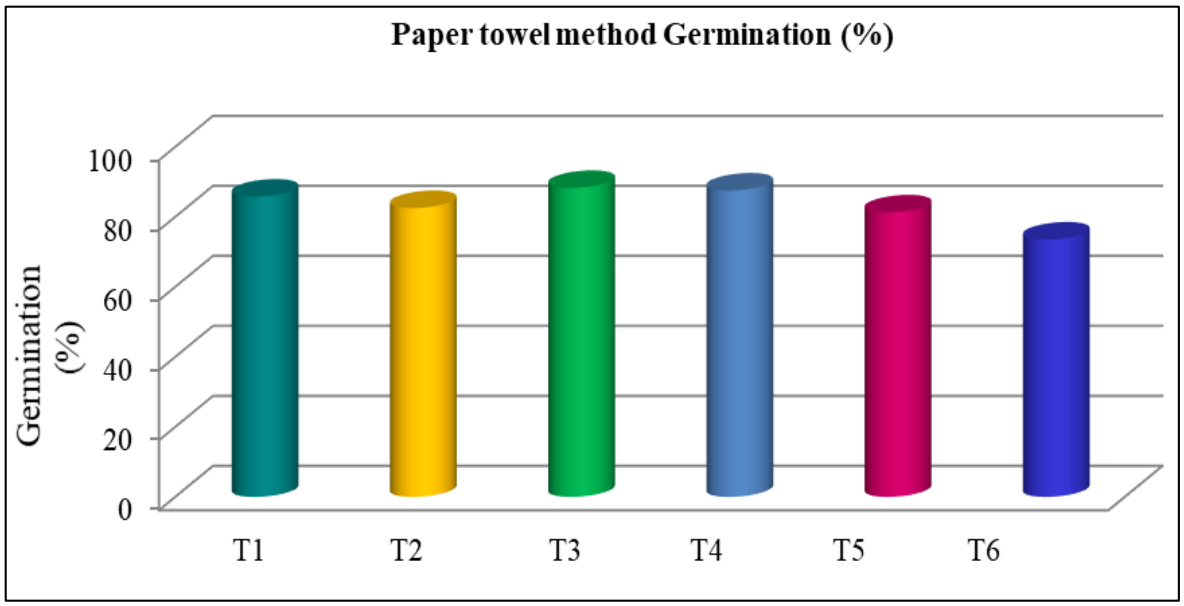
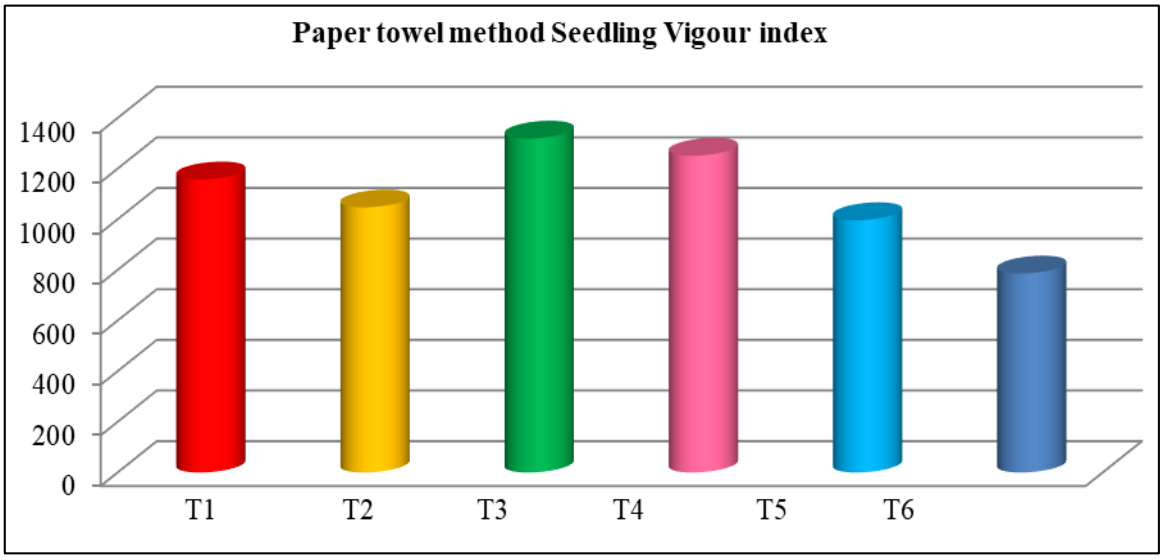


Fig 3: Effect of fungicides and bio-control agents on seed germination, seedling vigour index and seed mycoflora (cv. ISF-764) by standard blotter paper method T_1-Seed treatment with Mancozeb @ 0.25%, T_2 Seed treatment with Carbendazim @ 0.1% T_3 -Seed treatment with Captan @ 0.25%, T_4 -Seed treatment *Trichoderma harzianum* with @ 1.0%, T_5 -Seed treatment with *Pseudomonas fluorescens* @ 1.0%, T_6 Control





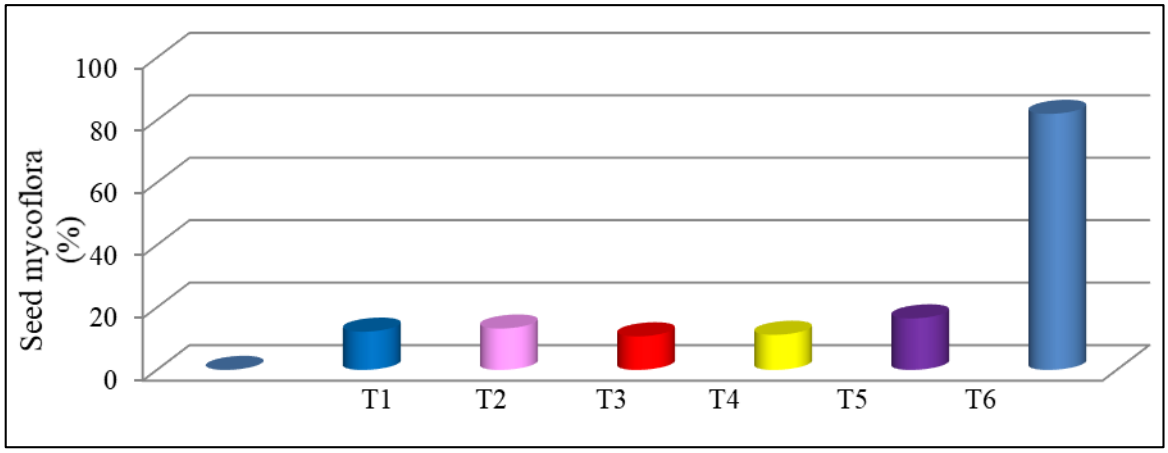


Fig 4: Effect of fungicides and bio-control agents on seed germination, seedling vigour index and seed mycoflora (cv. ISF -764) by paper towel method T_1-Seed treatment with Mancozeb @ 0.25%, T_2 Seed treatment with Carbendazim @ 0.1% T_3 -Seed treatment with Captan @ 0.25%, T_4 -Seed treatment *Trichoderma harzianum* with @ 1.0%, T_5 -Seed treatment with *Pseudomonas fluorescens* @ 1.0%, T_6 Control

Summary and Conclusions

The effect of fungicides and biocontrol agents on seed germination, seedling vigour index and seed mycoflora was evaluated on two popular varieties of safflower *viz.*, Nira and ISF-764 by standard blotter method and paper towel method. Seed treatment with Captan (0.25%) was found superior followed by seed treatment with *Trichoderma harzianum* (1%), in all the two popular varieties for all the parameters.

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