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Effect of effective fungicides and bioagents against *Fusarium oxysporum* f. sp. *udum* on seed germination and seedling vigour in cultivar ICP-2376 in pot culture

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Abstract
The fungicide and bioagents taken in the study could be able to reduce the mycoflora associated with seed and therby increase germination percentages, root and shoot length and ultimately seedling vigor index and also reduction in mortality per cent. Various fungicides and bioagents i.e. carbendazin 50% WP @ 0.1%, thiophanate methyl 70% WP @ 0.1%, carboxin 37.5% + thirum 37.5% WP @ 0.25%, carbendazim 12% + mancozeb 63% WP @ 0.25%, *T. asperellum*, *T. harzianum* and *T. hamatum* were tested against *Fusarium oxysporum* f. sp. *udum* in pot. The cultivar ICP-2376 was used for experiment. The maximum seed germination per cent was observed in carboxin 37.5% + thirum 37.5% WP @ 0.25% which recorded 96.90% germination, followed by carbendazim 12% + mancozeb 63% WP @ 0.25% which recorded 93.80% germination. The shoot and root length were ranged between 20.68 to 32.63 cm and 7.52 to 10.51 cm, respectively. The maximum seedling vigour index was observed in carboxin 37.5% + thiram 37.5% WP @ 0.25% which recorded 4180.2. The maximum pre-emergence and post-emergence mortality was observed in control (untreated) which recorded 46.86% and 4.41%, respectively. The maximum fresh and dry weight was observed in carboxin 37.5% + thiram 37.5% WP @ 0.25 which recorded 13.36 g and 4.97 g, respectively.

Keywords: Fungicides, bioagents, seed germination, seedling vigour, mycoflora

1. Introduction
India is the largest producer as well as the consumer of pulses. In India, pulses can be produced with a minimum use of resources and hence are less expensive and can be cultivated as intercrops and also as a mixed crop (Geetha, 2017) [4]. Pigeonpea (*Cajanus cajan* (L.) Millsp.) is a legume belonging to family of fabaceae. Other common names are "Red gram, Arhar, Tur, Congo pea, Gunga pea, Turvarica, Thogari or Ganduland No-eye pea" (Sheela, 2013) [13]. It is an important grains legume crop of rainfed agriculture in the tropics and subtropics compared with other grains legumes, pigeonpea ranks only sixth in area and production, but it is used in more diverse ways than other. Pigeonpea is a versatile crop grown primarily as a vegetable and a multi-use green crop (dhal) in India. Pigeonpea seed is composed of cotyledons (85%), embryo (1%) and seed coat (14%) (Faris and Singh, 1990) [3]. In India during 2017-18, pigeonpea was cultivated on an area of 4.43 M ha with a production of 4.25 million MT (Anonymous, 2018) [2]. In Maharashtra, pigeonpea is cultivated on an area of 12.29 Lakh/ha with the production of 10.59 Lakh/tones. Seed treatment for controlling plant diseases has been termed as the "pain less method" for farmers. In under developing country like India, it is all the more important since farmers cannot pay the heavy costs of spraying and dusting. Seed treatment with fungicide application can minimize disease and thus increase genetic potential and ultimately yield. Biological agents *viz. Trichoderma* sp., *Bacillus* sp. and *Pseudomonas* sp. manage wide range of seed borne fungi and there is no risk to produced resistance. Another, one source of potential new pesticides is natural products produced by plants. Plant extracts and essential oils show antifungal activity against a wide range of fungi (Abd-Alla *et al.*, 2001) [1].

2. Materials and Methods
The experiment conducted in CRD design with three replication and eight treatment including untreated control to evaluated the efficacy of effective fungicides and bioagents on seed germination and seedling vigour in pot, surface sterilized seeds of ICP-2376 were treated with fungicides and the seed were primed with bioagents. Treated seeds were sown in pot in sterilized soil. Germination was recorded on 7th day after sowing. Root and shoot length and total dry weight of seedlings were recorded 21 days after sowing in pot.

2.1. Treatment details

Table 1: Shoe the treatment details

Tr. No.	Treatments	Conc. (%)	Tr. No.	Treatments	Conc. (%)
T1	Carbendazim 50%WP	0.1	T5	*T. asperllum*	0.4
T2	Thiophanate methyl 70%WP	0.1	T6	*T. harzianum*	0.4
T3	Carboxin 37.5% + thiram37.5% 75WP	0.25	T7	*T. hamatum*	0.4
T4	Carbendazim 12% + mancozeb 63% 75WP	0.25	T8	Control (Untreated)	-

2.2. Mass multiplication of test pathogen

For this purpose the major seedborne pathogen *viz*. *Fusarium oxysporum* f. sp. *udum* isolated from pigeonpea seeds were used. The test pathogens *Fusarium oxysporum* f. sp. *udum* were mass multiplicated on maize grains. The seeds of maize were broken coarsely in mixture-cum grinder and separately soaked in distilled water (Three parts broken seeds+ one part distilled water) for one hour, then excess water was drained off and this presoaked broken seeds were filled in polypropylene bags, to which PVC pipe (1″) diameter was fitted and the mouth was ploughed with non-absorbent cotton. These bags were inoculated aseptically with mycelial disc of the test pathogen and incubated at room temperature for two weeks or until the maize grains completely covered with the growth of *Fusarium oxysporum* f. sp. *udum.*

2.3. Preparation of *Fusarium oxysporum* f. sp. *udum* sick soil

For this purpose, potting mixture of soil + sand + FYM (2:1:1) was fumigated by formaldehyde solution @5%, overnight and on next day the polythene sheet was removed to escape the fumes of formalin, for whole day. During evening, earthen pots were filled with this potting mixture, watered gently and inoculated with mass multiplied culture of the *Fusarium oxysporum* f. sp. *udum* these inoculated pots were incubated for two weeks to ramify the test pathogens in potting mixture.

3. Result and Discussion

In *in vitro* evaluation of various fungicides and bioagents, carbendazim 50% WP @ 0.1%, thiophanate methyl 70% WP @ 0.1%, carboxin 37.5% + thiram 37.5% WP @ 0.25%, carbendazim 12%+ mancozeb 63% WP @ 0.25%, *T. asperellum*, *T. harzianum* and *T. hamatum* were found most effective against *Fusarium oxysporum* f. sp. *udum*. Hence, such effective fungicides and bioagents were used in pot. The cultivar ICP-2376 was used for experiment. Germination was recorded on 7th day after sowing. Root, shoot length and fresh, dry weight of seedlings were recorded from 10 seedling of each treatment on 21st day after sowing in pot. The results revealed that, maximum seed germination per cent was observed in carboxin 37.5% + thiram 37.5% WP @ 0.25% which recorded 96.90% germination, followed by carbendazim 12% + mancozeb 63% WP @ 0.25% which recorded 93.80% germination, *T. hamatum* which recorded 92.26% germination, *T. harzianum* which recorded 91.33% germination, *T. asperellum* which recorded 90.43% germination, thiophanate methyl 70% WP @ 0.1% which recorded 90.31% germination, carbendazim 50% WP @ 0.1% which recorded 78.55% germination and least germination per cent was observed in control (untreated) which recorded 53.16% germination. The results indicated that, shoot and root lengths were ranged between 20.68 to 32.63 cm and 7.52 to 10.51 cm, respectively. The maximum seedling vigour index was observed in carboxin 37.5% + thiram 37.5% WP @ 0.25% which recorded 4180.2 followed by *T. hamatum* which recorded 3869.1, carbendazim 12% + mancozeb 63% WP @ 0.25% which recorded 3790.4, *T. harzianum* which recorded 3742.0, *T. asperelum* which recorded 3685.0, thiophanate methyl 70% WP @ 0.1% which recorded 3032.9, carbendazim 50% WP @ 0.1% which recorded 2340.0 and least seedling vigour index was observed in control (untreated) which recorded 1338.5.

The results revealed that, maximum pre-emergence and post-emergence mortality was observed in control (untreated) which recorded 46.86% and 4.41%, respectively, followed by carbendazim 50% WP @ 0.1% which recorded 21.48% and 2.81%, respectively, *T. asperellum* which recorded 9.55% and 1.07%, respectively, *T. harzianum* which recorded 6.65% and 1.80%, respectively, thiophanate methyl 70% WP @ 0.1% which recorded 6.65% and 1.80%, respectively, carbendazim 12% + mancozeb 63% WP @ 0.25% which recorded 6.13% and 1.96% respectively. *T. hamatum* which recorded 3.44 and 0.00, carboxin37.5% + thiram 37.5% WP @ 0.25% which recorded 3.10% and 0.00%, respectively.

The results indicated that, maximum fresh and dry weight was observed in carboxin 37.5% + thiram 37.5% WP @ 0.25% which recorded 13.36 g and 4.97 g respectively, followed by *T. hamatum* which recorded 12.26 g and 4.91 g respectively, carbendazim 12% + mancozeb 63% WP @ 0.25% which recorded 12.16 g and 4.28 g, respectively, *T. asperellum* which recorded 12.15 g and 4.21 g, respectively, *T. harzianum* which recorded 11.97 g and 4.02 g, respectively, thiophanate methyl 70% WP @ 0.1% which recorded 11.80 g and 3.96 g, respectively, carbendazim 50% WP @ 0.1% which recorded 10.92 g and 3.90 g, respectively and least was observed in control (untreated) which recorded 7.25 g and 3.11 g, respectively.

The above results clearly showed that, fungicides and bioagents taken in the study could be able to reduce the mycoflora associated with seeds and thereby increase germination percentage, root and shoot length, and ultimately seedling vigour index and also reduction in mortality per cent. The results also indicated that the fungicide carboxin 37.5% + thiram 37.5% WP @ 0.25% was found effective in management of *Fusarium oxysporum* f. sp. *udum*. Among bioagents *T. hamatum* found effective in management of *Fusarium oxysporum* f. sp. *udum* causing wilt in pigeonpea. The above findings are in agreement with the findings of other researchers. Paschal (1979) [12] reported captan, thiram and benomyl; Kannaiyan *et al.* (1980) [6]; Kumar and Srivastava (1985) [9], Agrosan GN, bavistin, difolatan, captan, vitavax and mancozeb; Lokesh and Hiremath (1988) [10] captan, brassicol and thiram; Solanke *et al.* (1990) [15], thiram + carbendazim and captan; Haware and Kannaiyan (1992) [5], benomyl + thiram; Sumitha and Gaikwad (1995) [16], bavistin, topsin M-70 and thiram; Krishna Murthy and Niranjana (2003) [8], captafal and bavistin; Khare and Kumar (2006) [7], thiram, vitavax and bavistin; Mallesh *et al.* (2008) [11], carbendazim and Singh *et al.* (2011) [14] found bavistin as effective fungicides for the reduction of mycoflora associated with pigeonpea seeds and increase seedling vigour index.

Table 2: Efficacy of effective fungicides and bioagents against *Fusarium oxysporum* f. sp. *udum* on seed germination and seedling vigour of ICP-2376 in pot

Sr. No.	Treatment	Plant growth parameters							
		Seed germination (%)	Shoot length (cm)	Root length (cm)	Seedling vigour	Mortality (%)		Fresh weight (g)	Dry weight (g)
						PESM	POESM		
T1	Carbendazim 50% WP @ 0.1%	78.55	20.68	9.11	2340.0	21.48	2.81	10.92	3.90
T2	Thiophanate methyl 70% WP @ 0.1%	90.31	22.63	9.86	3032.9	6.65	1.80	11.80	3.96
T3	Carboxin 37.5% + thiram 37.5% WP @ 0.25%	96.90	32.63	10.51	4180.2	3.10	0.00	13.36	4.97
T4	Carbendazim 12% + mancozeb 63% WP @ 0.25%	93.80	30.51	9.90	3790.4	6.13	1.96	12.16	4.28
T5	*T. asperellum*	90.43	31.35	9.40	3685.0	9.55	1.07	12.15	4.21
T6	*T. harzianum*	91.33	31.53	8.56	3742.0	6.65	1.80	11.97	4.02
T7	*T. hamatum*	92.26	32.55	7.52	3869.1	3.44	0.00	12.26	4.91
T8	Control (Untreated)	53.16	18.46	6.83	1338.5	46.86	4.41	7.25	3.11
SE±		0.78	0.82	0.59	147.7	0.71	0.56	0.50	0.68
CD (1%)		2.27	2.40	1.74	431.7	2.07	1.65	1.48	2.01

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