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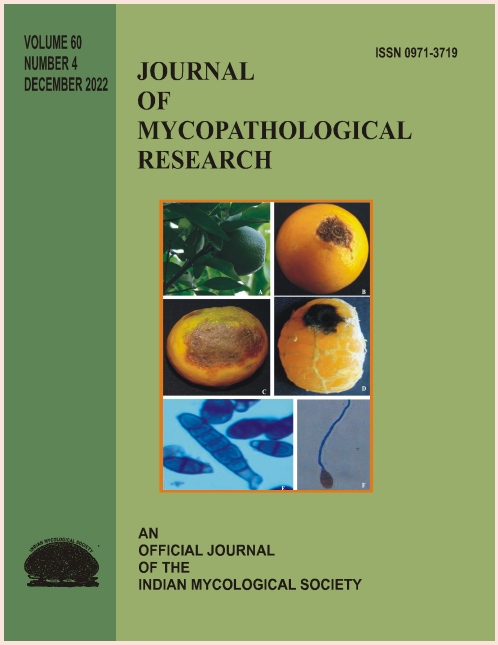

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Efficacy of plant origin pesticides and biological control agents against *Taphrina deformans* (Berk.) Tul.

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The leaf curl caused by *Taphrina deformans* (Berk.) Tul. is the most serious disease of peaches which counts for loss in quantitative and qualitative yield. Cool and humid climate favours the development of the disease. In affected orchards, it occurs every year and causes epidemics that frequently affect 60-90% of the shoots. The disease can be managed effectively with the timely sprays of fungicides however, efficacy of bioagents and plant origin pesticides needs to be explored. The present investigation was undertaken to evaluate different plant origin pesticides and biological control agents against *Taphrina deformans*. The results revealed maximum inhibition of blastospores germination in Neemazal (75.17%) followed by Nimbicide (73.76%). Maximum inhibition of ascospores germination was also observed in Neemazal (76.11%) and Nimbicide (71.11%) under in *in vitro* conditions. whereas, *P. fluorescens* at 0.1% was found effective at pink-bud stage while, *B. subtilis* at 0.1% was found effective at green-tip stage.

Key words: Ascospores, blastospores, bio agents, plant origin pesticides, *Taphrina deformans*

INTRODUCTION

Peach (*Prunus persica* L. Batsch.) is one of the most important stone fruit crops grown extensively in the temperate, sub-temperate and subtropical regions of the world. It is a favourite table fruit and rich source of protein, sugars, minerals, vitamins. In India, peach is grown on commercial scale in mid hills of Himachal Pradesh, Jammu & Kashmir, Uttrakhand, subtropical plains and to a limited scale in North Eastern states. The production of peach and nectarine per unit area is very low in India as compared to other countries like China, Italy, Spain and USA. The production of peach and nectarine per unit area is very low in India as compared to other countries like China, Italy, Spain and USA. Peach area cultivation in India during 2018-19 was 19,000 ha and annual production118,000 MT with productivity of 6.21 MT per hectare (Anonymous, 2019).

Cultivation area of peach in Himachal Pradesh in 2018-19 was 5042 ha and production 7292 tonnes with productivity of 1.44 kg/ha (Anonymous, 2019). Low average yield is due to different cultivation constraints including both biotic and abiotic factors. Among biotic factors, leaf curl caused by *Taphrina deformans* is the most serious disease of peaches which counts for loss in quantitative and qualitative yield. It affects peaches and nectarines in most regions of the world where these fruits are grown. Peach cultivation faces the threat of intensive development of leaf curl (Randal, 2016) caused by *Taphrina deformans* and it also infects apricot trees in Syria (Khalil *et al.* 2020), Japanese plums in South Korea (Oh *et al.* 2020).

Cool and humid climate favours the development of the disease.In affected orchards, it occurs every year and causes epidemics that frequently affect 60-90% of the shoots, however, infection on fruits are usually less severe (Rossi, 2006). The disease can be managed effectively with the timely sprays of fungicides however, efficacy of biological control agents and plant origin pesticides needs to be explored keeping in view the environmental concerns. The present investigation was undertaken to evaluate efficacy of different plant

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origin pesticides and biological control agents against peach leaf curl pathogen *Taphrina deformans*.

MATERIALS AND METHODS

In vitro efficacy of plant origin pesticides against peach leaf curl pathogen

The efficacy of five different plant origin pesticides(Neemazal, Mimbicide,Jeevamrit,Field formulation and cow urine) at 3 different concentrations (500, 1000 and 2000 ppm) was evaluated under *invitro* conditions for their effect on germination per cent of blastospores and ascospores as mentioned below.

Effect on germination of blastospores

A double strength fungicide solution was prepared for each fungicide by doubling the amount of fungicides except water. 5 µl drops of blastospore suspension (Kardam, 2018) (having ~7 x 10^8 spores per ml) mixed with 5 µl drops of double strength fungicide was placed in each cavity of cavity slides and placed on triangle glass rod and finally kept in petri dishes (90mm) containing blotting paper and thin layer of colon wool and moistened with sterilize distilled water. Petri dishes were covered and sealed with parafilm to maintain 100% relative humidity and were incubated in BOD incubator at most effective temperature (20±°C) for 12 h. For control, distilled water was used instead of fungicide solution. Five replications were maintained for each fungicide. After incubation period number of blastospore germinated were examined microscopically.Per cent germination of ascospores and blastospores were calculated as per the formula given below:

$$\text{Spore Germination (\%)} = \frac{\text{No. of spores germinated}}{\text{Total numbers of spores}} \times 100$$

Effect on germination of ascospores

To test the effect of fungicide on ascospores germination, diseased sample were collected from the experimental area. The infected leaves were squeezed with the help of absolute alcohol and sterile pestle and mortar. The samples were squeezed uniformly in 1.0 ml of distilled water. The squeezed sample then transferred to 100ml of sterilized distilled water to obtain a suspension of ascospores. A double strength fungicide solution was prepared for each fungicide by doubling the amount of fungicides except water. Five micro liter drops of ascospores suspension (having ~7 x 10^8 spores per ml) mixed with 5 µl drops of double strength fungicide was placed in each cavity of cavity slides and placed on triangle glass rod and finally kept in petri dishes (90 mm) containing blotting paper and thin layer of cotton wool and moistened with sterile distilled water. Petri dishes were covered and sealed with parafilm to maintain 100% relative humidity and were incubated in BOD incubator at most effective temperature (20±°C) for 12 h. For control, distilled water was used instead of fungicide solution. Five replications were maintained for each fungicide. After incubation period no of ascospores germinated were examined microscopically.

Management of the peach leaf curl by application of biological control agents at pink-bud and green-tip stages

Five different biological control agents at different concentration (Table 1) were sprayed at pink bud and green tip stages. Each biological control agent was tested on 3 plants (10 year old and 3-5m height) representing three replications of standard cultivars of peach *viz*. Glo haven at experimental farm of KVK, Kandaghat district Solan, Himachal Pradesh. Plants were scored according to per cent leaf infected at the time of full leaf stage of plants in last week of April, 2018 and to calculate the per cent disease severity, 0-5 score was given to each tree according to per cent leaves with visible sign of leaf curl (Ackerman, 1953), where 0- ; 1=Upto 20% of leaves exhibiting some symptoms; 2=21-40% of leaves with symptoms; 3=41-60%of leaves with symptoms; 4=61-80%of leaves with symptoms and 5= 81-100% of leaves with symptoms. Disease severity was calculated (Mckinney, 1923) using the following formula:

$$\text{Disease serverity (\%)} = \frac{\text{Sum of disease ratings}}{\text{Total No. of ratings x Maximum disease grade}} \times 100$$

RESULTS AND DISCUSSION

In vitro efficacy of plant origin pesticidesData on evaluation of five plant origin pesticides under in vitro condition (Table 2) revealed that maximum inhibition of blastospores germination was observed in Neemazal (75.17%) followed by

Table1 : Different biological control agents tested for their efficacy against peach leaf curl

Sr. No.	Biological control agent (cfu/ml)	Concentration (%)	Plant stage
1.	Trichovir (*Trichoderma viride*) (2×10^6cfu/ml)	0.1	Pink-bud, green tip
2.	Trichovir (*Trichoderma viride*) (2×10^6cfu/ml)	0.5	Pink-bud, green tip
3.	*Pseudomonas fluorescens* (2×10^6cfu/ml)	0.1	Pink-bud, green tip
4.	*Bacillus subtilis* (2×10^6cfu/ml)	0.1	Pink-bud, green tip
5.	*Trichoderma harzianum* (2×10^6cfu/ml)	0.1	Pink-bud, green tip
6.	Control		-------

Table 2: Effect of plant origin pesticides on per cent germination and inhibition of *T. deformans* blastospores under *in vitro* conditions

Plant origin pesticide	Concentration (ppm)	Germination (%)	Inhibition (%)
Neemazal	500	31.22 (33.95)	68.78
	1000	27.03 (31.31)	72.97
	2000	24.83 (29.87)	75.17
Nimbicide	500	33.22 (35.18)	66.78
	1000	30.86 (33.73)	69.14
	2000	26.24 (30.80)	73.76
Jeevaamrit	500	40 (39.21)	60
	1000	37.43 (37.70)	62.57
	2000	33.7 (35.47)	66.3
Field formulation	500	57.76 (49.44)	42.24
	1000	57.36 (49.21)	42.64
	2000	48.8 (44.29)	51.2
Cow urine	500	49.75 (44.84)	50.25
	1000	46.61 (43.04)	53.39
	2000	42.65 (40.76)	57.35
Control		66.12 (54.39)	33.88
$CD_{0.05}$	Plant origin pesticide = 0.45		
	Concentration = 0.32		
	Plant origin pesticides × Concentration = 0.77		

*Figures in the parentheses are arc sine transformed values

Nimbicide (73.76%). Jeevaamrit (66.3%) and Cow urine (57.35%) were next in efficacy. Field formulation was found least effective with minimum inhibition of blastospore germination (51.2%).

Further, data on efficacy of plant origin pesticideson per cent germination and inhibition of *T. deformans* ascospores under *in vitro* condition (Table 3) revealed that maximum inhibition of ascospores germination was observed in Neemazal (76.11%)

Table.3: Effect of plant origin pesticides on per cent germination and inhibition of *T. deformans* ascospores under *in vitro* conditions

Plant origin pesticide	Concentration (ppm)	Germination (%)	Inhibition (%)
Neemazal	500	30.92 (33.77)	69.08
	1000	27.73 (31.77)	72.27
	2000	23.89 (29.25)	76.11
Nimbicide	500	32.84 (34.95)	67.16
	1000	29.92 (33.15)	70.08
	2000	28.89 (32.5)	71.11
JeevaAmrit	500	39.28 (38.80)	60.72
	1000	37.28 (37.61)	62.72
	2000	32.48 (34.73)	67.52
Field formulation	500	57.22 (49.13)	42.78
	1000	51.07 (45.60)	48.93
	2000	48.81 (44.30)	51.19
Cow urine	500	49.7 (44.81)	50.3
	1000	45.1 (42.17)	54.9
	2000	42.32 (40.56)	57.68
Control		69.52 (56.47)	30.48
	Plant origin pesticides = 0.39		
$CD_{0.05}$	Concentration = 0.28		
	Plant origin Pesticides × Concentration = 0.67		

*Figures in the parentheses are arc sine transformed values

Table 4: Efficacy of biological control agents against peach leaf curl caused by *T. deformans* under field conditions

Fungicide	Concentration (%)	Disease severity (%)	
		Pink-bud stage	Green-tip stage
Trichoderma viride	0.1	4.06 (2.25)	4.13 (2.26)
Trichoderma viride	0.5	3.63 (2.15)	3.69 (2.16)
Pseudomonas fluorescens	0.1	2.44 (1.85)	2.69 (1.92)
Bacillus subtilis	0.1	2.75 (1.97)	2.38 (1.84)
Trichoderma harzianum	0.1	3.94 (2.22)	4.06 (2.25)
Control		7.44 (2.90)	7.56 (2.93)
$CD_{0.05}$		0.08	0.08

*Figures in the parentheses are square root transformation value

followed by Nimbicide (71.11%). Jeevaamrit (67.52%) and Cow urine (57.68%) were next in efficacy while, field formulation (51.19%) was found least effective. Efficacy of plant origin pesticides have not been studied against *T. deformans* so far hence, cannot be supported with any reference. But several other authors (Bhat and Shrivastava, 2003; Mishra *et al.* 2009; Govindaraju and Somasekhara, 2016) reported that Neemazal, a commercial formulation based on kernel extract of neem have been effective against a number of pathogenic fungi.

Efficacy of biological control agents under field conditions

Five different biological control agents at varying concentrations were used for the management of peach leaf curl disease at pink-bud stage and green-tip stage and per cent disease severity was observed for each biological control agents at these two stages (Table 4). *Trichoderma viride* at 0.1% concentration showed maximum disease severity of 4.06% and 4.13% at pink-bud stage and green-tip stage, respectively, while *Pseudomonas fluorescens* at 0.1% showed minimum disease severity of 2.44% at pink-bud stage and *Bacillus subtilis* at 0.1% showed minimum disease severity of 2.38% at green-tip stage. Thus, at earlier stage (pink-bud stage) *P. fluorescens* at 0.1% was found effective for the management of peach leaf curl while at later stage (green-tip stage) *B. subtilis* at 0.1% was effective for the management of peach leaf curl.

Efficacy of biological control agents have not been studied against peach leaf curl. However, Ganeshan and Kumar (2007) reported the use of *P. fluorescens* as a potential bio-pesticide for augmentative biological control of many disease of agriculture and horticulture importance.

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