

Original Research Article

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***In vitro* Compatibility between Botanicals and Pesticides against
Xanthomonas axonopodis pv. *punicae***

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The study reveals the possibility to use simultaneously botanicals and pesticide control products as efficient and environmental friendly for disease control, which could provide a decrease of the pesticide dose needed for plant protection. This experiment reports the *in vitro* compatibility of botanicals viz., *Garcinia indica* and *Prosopis juliflora* and pesticides viz., Streptocycline, 2-bromo-2-nitropropane-1,3-diol, Carbendazim, Difenconazole, Hexaconazole, Propiconazol, Chlorothalonil, Copper oxychloride, Mancozeb, Chlorpyrifos, Dichlorovas and Dimethoate. Results indicate that, among the pesticides, 2-bromo-2-nitropropane-1,3-diol (bronopol) in combination with *Prosopis juliflora* and *Garcinia indica* recorded highest average zone of inhibition of 32.11 and 31.11 mm. Followed by *Prosopis juliflora* @ 1:5+Streptocycline 500ppm (30.78 mm) and *Garcinia indica* @ 1:5+Streptocycline 500ppm (28.66 mm).

Introduction

Bacterial blight caused by *Xanthomonas axonopodis* pv. *punicae* is a major concern. Since then several workers have reported the occurrence of blight and resultant losses from different states of the country viz., Tamil Nadu (Rangaswami, 1962), Himachal Pradesh (Sohi *et al.*, 1964), Haryana (Kanwar, 1976), Karnataka (Chand and Kishun, 1991), Maharashtra (Kamble, 1990) and Punjab (Rani and Verma, 2001). Stem infection is also observed in severely infected orchards with girdling and cracking symptoms. Spots on fruits are variably dark brown in colour, irregular, slightly raised with oily appearance, which splits open with L or Y-shaped cracks

under severe stages of disease (Bora and Katak, 2014). Use of chemicals is not only the solution for management of any disease, while its use leads to pollution and hazard to the ecosystem.

Apart from the fact that pomegranate is largely exported to European and American markets, they have rigid grading standards *vice-versa.*, residual toxicity level for various pesticides, hence, the use of antibiotics/bactericides is discouraged. Thus, there is a need to develop alternative and eco-friendly measures for controlling the disease. Greater emphasis has been placed towards development of biological pesticides, which includes botanicals.

Materials and Methods

All the botanicals and their combinations were tested under laboratory condition by agar well diffusion method to know the compatibility between botanicals and pesticides. Compatibility of botanicals with different bactericides, fungicides and insecticides commonly used in pomegranate were tested under laboratory condition by agar well diffusion method (Table 1).

The compatibility of these botanicals was confirmed by Agar well diffusion method (Holder and Boyse, 1994). The culture of *X. axonopodis* pv. *punicae* was added to nutrient medium and poured in to the Petri plate and allowed solidify. The agar plates were punched aseptically with 6-mm sterilized cork borer to prepare wells. The wells were filled with 100 µl of botanical extracts. All plates were incubated (30°C) for 48h. After incubation, the diameters of any clear zones around the wells were measured in milli meter. Sterile water filled in agar well considered as negative control.

Results and Discussion

The results of the efficiency of *P. juliflora* in combination with different bactericides, contact and systemic fungicides and insecticides under *in vitro* were recorded and presented in Table 2. The pesticides were used in three different concentrations. Among the botanicals with bactericides, *P. juliflora* (1:5) with 2-bromo-2-nitropropane-1,3-diol (bronopol) found more efficient with the highest inhibition zones in diameter (28.67, 32.00 and 35.67 mm at 250, 500 and 750 ppm respectively). Streptocycline at 250, 500 and 750 ppm along with *P. juliflora* (1:5) recorded 27.67, 30.00 and 34.67 mm respectively. However 2-bromo-2-nitropropane-1,3-diol (bronopol) and Streptocycline alone recorded 24.67 and 22.00 mm at 250 ppm, 25.33 and

24.00 mm at 500 ppm and 28.67 and 26.67 mm at 750 ppm respectively.

In case of systemic fungicide tested all the four systemic fungicides compatible with *P. juliflora* at their three different concentrations tested. Among these propiconazole 25% EC at 0.5, 1 and 2 ml/lit along with *P. juliflora* (1:5) recorded highest inhibition zone of 24.00, 26.00 and 30.67 mm respectively. This treatment followed by *P. juliflora* + hexaconazole (21.33, 22.67 and 25.33 mm), *P. juliflora* (1:5) + difenconazole (20.33, 20.67 and 26.00 mm) and *P. juliflora* (1:5) + carbendazim (20.00, 22.67 and 25.00 mm at 1, 2 and 3 g/lit respectively). However the propiconazole 25% EC (11.33, 12.67 and 15.33 mm), hexaconazole 5 EC (9.67, 12.00 and 14.33 mm), difenconazole (10.67, 12.33 and 14.67 mm) with zone of inhibition in diameter at 0.5, 1 and 2 ml/lit respectively and carbendazim 50 WP also recorded no inhibition zone at their three concentrations.

In case of contact fungicides tested all the three fungicides compatible with *P. juliflora* (1:5) at their three different concentrations tested. Among them copper oxychloride 50 WP at 1, 2 and 3 g/lit along with *P. juliflora* (1:5) showed highest inhibition zone of 23.33, 24.00 and 26.00 mm respectively. Followed by *P. juliflora* (1:5) + mancozeb 75 WP (22.67, 24.00 and 25.33 mm), *P. juliflora* (1:5) + chlorothalonil 75 WP (22.00, 23.33 and 24.33 mm) at 1, 2 and 3 g/lit respectively. Whereas copper oxychloride 50 WP (14.67, 21.33 and 23.33 mm), mancozeb 75 WP (11.33, 15.67 and 24.00 mm) and chlorothalonil 75 WP (8.76, 14.00 and 17.67 mm) alone recorded zone of inhibition in diameter at 1, 2 and 3 g/lit respectively.

However, in case of insecticides, all three insecticides are compatible with *P. juliflora* (1:5) at their three different concentrations tested.

Table.1 Treatment used in compatibility of botanicals with commonly using pesticides in pomegranate

Treatment	Chemicals	Source/ manufacturers	Concentration		
			L	M	H
Bactericides					
T ₁	2-bromo-2-nitropropane-1,3-diol(bronopol)	Multiplex agricareP Ltd	250 ppm	500 ppm	750 ppm
T ₂	K-cyclin	-	250 ppm	500 ppm	750 ppm
T ₃	Streptomycin sulphate90%+Tetracycline hydrochloride+10%(Streptocyclin)	Hindustan Antibiotics Ltd, Pune	100 ppm	250 ppm	500 ppm
Fungicides					
T ₄	Carbendazim 50 WP (Bavistin)	BASF, West Germany	1g/lit	2g/lit	2.5g/lit
T ₅	Chlorothalonil 75 WP(Kavach)	SDS Biotech. KK	1.0g/lit	2.0g/lit	3.0g/lit
T ₆	Copper oxychloride 50 WP (Blitox)	Artee Graphite P Ltd., Delhi.	1g/lit	2.0g/lit	3g/lit
T ₇	Difenconazole 25 EC (Score)	Syngenta Crop Protection AG Monthey, Switzerland	0.5ml/lit	1ml/lit	2ml/lit
T ₈	Hexaconazole 5 EC (Contaf)	Rallis India Ltd.	0.5ml/lit	1ml/lit	1.5ml/lit
T ₉	Mancozeb75 WP (Indofil M-45)	Dow Agro Science, USA	1g/lit	2-3g/ml	4g/lit
T ₁₀	Propiconazole 25% EC (Tilt)	Syngenta Crop Protection AG., Monthey, Switzerland	0.5ml/lit	1ml/lit	2ml/lit
Insecticides					
T ₁₁	Chlorpyrifos 20% EC (Predator)	Dow Agro Sciences LLC, USA	1.5ml/lit	2ml/lit	2.5ml/lit
T ₁₂	Dichlorovas 76% EC (Nuvan)	Makhteshim Agan, Israel.	0.25%	0.5%	0.1%
T ₁₃	Dimethoate 30% EC (Rogor)	Agrimot SPA, Italy	0.5ml/lit	1m/lit	2ml/lit
T ₁₄	Imidachloprid 70% WG (Admire)	Bayer Crop Science, AG, Germany	0.15ml/lit	0.3ml/lit	0.45ml/lit
T ₁₅	Control	-	-	-	-

Table.2 Compatibility of *Prosopis juliflora* with pesticides against *Xanthomonas axonopodis* pv. *punicae* under *in vitro* condition

Treat ments	Treatment details	Zone of inhibition (mean diameter in mm)			
T₁	<i>Prosopisjuliflora</i> (1:5)	22.33 (4.83)			
Bactericides		L*	M*	H*	Average
T₂	<i>Prosopisjuliflora</i> + Streptocycline (L= 250 ppm, M=500ppm, H=750ppm)	27.67 (5.26)	30.00 (5.57)	34.67 (5.97)	30.78 (5.60)
T₃	<i>Prosopis juliflora</i> + 2-bromo-2-nitropropane-1,3-diol (L= 0.25 ppm, M=0.5 ppm, H=0.75 ppm)	28.67 (5.45)	32.00 (5.74)	35.67 (6.05)	32.11 (5.75)
T₄	Streptocycline (L= 250 ppm, M=500ppm, H=750ppm)	22.00 (4.79)	24.00 (5.01)	26.67 (5.26)	24.22 (5.17)
T₅	2-bromo-2-nitropropane-1,3-diol (L= 0.25 ppm, M=0.5 ppm, H=0.75 ppm)	24.67 (5.07)	25.33 (5.13)	28.67 (5.45)	26.20 (5.01)
Systemic fungicides					
T₆	<i>Prosopisjuliflora</i> + Carbendazim 50 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	20.00 (4.58)	22.67 (4.86)	25.00 (5.01)	22.55 (4.85)
T₇	<i>Prosopisjuliflora</i> + Difenconazole 25 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	20.33 (4.62)	20.67 (4.65)	26.00 (5.19)	22.33 (4.82)
T₈	<i>Prosopisjuliflora</i> + Hexaconozole 5 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	21.33 (4.72)	22.67 (4.86)	25.33 (5.13)	23.11 (4.91)
T₉	<i>Prosopisjuliflora</i> + Propiconazole 25EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	24.00 (4.89)	26.00 (5.20)	30.67 (5.63)	26.89 (5.27)
T₁₀	Carbendazim 50 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T₁₁	Difenconazole 25 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	10.67 (3.41)	12.33 (3.65)	14.67 (3.96)	12.55 (3.67)
T₁₂	Hexaconozole 5 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	9.67 (3.26)	12.00 (3.60)	14.33 (3.92)	12.00 (3.59)
T₁₃	Propiconazole 25% EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	11.33 (3.51)	12.67 (3.70)	15.33 (3.04)	13.11 (3.75)
Contact fungicides					
T₁₄	<i>Prosopisjuliflora</i> + Chlorothalonil 75WP (L= 1g/lit, M=2g/lit, H=3g/lit)	22.00 (4.79)	23.33 (4.93)	24.33 (4.93)	23.22 (5.01)
T₁₅	<i>Prosopisjuliflora</i> + Copper oxychloride 550 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	23.33 (4.93)	24.00 (4.89)	26.00 (5.12)	24.44 (5.04)
T₁₆	<i>Prosopisjuliflora</i> + Mancozeb75 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	22.67 (4.86)	24.00 (4.89)	25.33 (5.13)	24.00 (5.01)
T₁₇	Chlorothalonil 75WP (L= 1g/lit, M=2g/lit, H=3g/lit)	8.67 (3.11)	14.00 (3.87)	17.67 (4.32)	13.44 (3.77)
T₁₈	Copper oxychloride 550 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	14.67 (3.96)	21.33 (4.73)	23.33 (4.93)	19.77 (4.54)
T₁₉	Mancozeb75 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	11.33 (3.51)	15.67 (3.96)	24.00 (4.51)	17.00 (4.00)
Insecticides					
T₂₀	<i>Prosopisjuliflora</i> + Chlorpyrifos 20% EC (L= 1.5 ml/lit, M= 2ml/lit, H=3ml/lit)	22.00 (4.79)	22.33 (4.83)	26.67 (5.26)	23.66 (4.96)
T₂₁	<i>Prosopis juliflora</i> + Dichlorovas 76% EC (L= 0.25%, M= 0.5%, H=1.0%)	20.00 (4.58)	22.33 (4.83)	25.33 (5.13)	22.55 (4.85)
T₂₂	<i>Prosopisjuliflora</i> + Dimethoate 30% EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	22.67 (4.86)	23.67 (4.97)	26.67 (5.26)	23.89 (5.02)
T₂₃	Chlorpyrifos 20% EC (L= 1.5 ml/lit, M= 2ml/lit, H=3ml/lit)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T₂₄	Dichlorovas 76% EC (L= 0.25%, M= 0.5%, H=1.0%)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T₂₅	Dimethoate 30% EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T₂₆	Control	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
	Between treatments	Between dilutions		Interactions	
SEm±	0.04	0.01		0.07	
CD (0.01)	0.12	0.04		0.20	

*The results in the parentheses are square root transformed values

Note*: L= Lower concentration, M= Medium concentration, H=Higher concentration

Table.3 Compatibility of *Garcinia indica* with pesticides against *Xanthomonas axonopodis* pv. *punicae* under *in vitro* condition

Treatments	Treatment details	Zone of inhibition (mean diameter in mm)			
T ₁	<i>Garcinia indica</i> (1:5)	20.44 (4.52)			
Bactericides		L*	M*	H*	Average
T ₂	<i>Garcinia indica</i> +Streptocycline (L= 250 ppm, M=500ppm, H=750ppm)	25.33 (5.13)	28.00 (5.39)	32.67 (5.80)	28.66 (4.44)
T ₃	<i>Garcinia indica</i> +2-bromo-2-nitropropane-1,3-diol (L= 250 ppm, M=500ppm, H=750ppm)	27.33 (5.32)	32.00 (5.57)	34.00 (5.92)	31.11 (5.60)
T ₄	Streptocycline (L= 250 ppm, M=500ppm, H=750ppm)	22.00 (4.79)	24.00 (4.89)	26.67 (5.26)	24.22 (5.02)
T ₅	2-bromo-2-nitropropane-1,3-diol (L= 250 ppm, M=500ppm, H=750ppm)	24.67 (5.07)	25.33 (5.13)	28.67 (5.45)	26.22 (5.21)
Systemic fungicides					
T ₆	<i>Garcinia indica</i> + Carbendazim 50 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	17.00 (4.24)	20.00 (4.58)	21.00 (4.70)	19.33 (4.51)
T ₇	<i>Garcinia indica</i> + Difenconazole 25 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	18.00 (4.36)	20.33 (4.62)	22.67 (4.87)	20.33 (4.61)
T ₈	<i>Garcinia indica</i> + Hexaconazole 5 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	20.00 (4.58)	23.33 (4.93)	25.00 (5.10)	22.77 (4.87)
T ₉	<i>Garcinia indica</i> + Propiconazole 25 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	22.00 (4.79)	24.00 (4.89)	26.00 (5.20)	24.00 (5.00)
T ₁₀	Carbendazim 50 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T ₁₁	Difenconazole 25 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	10.67 (3.41)	12.33 (3.65)	13.33 (3.96)	12.11 (3.67)
T ₁₂	Hexaconazole 5 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	9.67 (3.26)	12.00 (3.60)	13.33 (3.92)	11.66 (3.60)
T ₁₃	Propiconazole 25 EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	11.33 (3.51)	12.67 (3.700)	13.67 (4.04)	12.55 (3.75)
Contact fungicides					
T ₁₄	<i>Garcinia indica</i> + Chlorothalonil 75WP (L= 1g/lit, M=2g/lit, H=3g/lit)	19.00 (4.73)	20.67 (5.07)	23.00 (5.30)	20.89 (5.03)
T ₁₅	<i>Garcinia indica</i> + Copper oxychloride 50% WP (L= 1g/lit, M=2g/lit, H=3g/lit)	21.33 (4.65)	24.67 (4.23)	27.00 (4.90)	24.33 (4.93)
T ₁₆	<i>Garcinia indica</i> + Mancozeb75 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	20.67 (4.47)	23.00 (4.65)	26.33 (4.90)	23.33 (4.67)
T ₁₇	Chlorothalonil 75WP (L= 1g/lit, M=2g/lit, H=3g/lit)	8.67 (3.11)	14.00 (3.87)	17.67 (4.32)	13.44 (3.77)
T ₁₈	Copper oxychloride50% WP (L= 1g/lit, M=2g/lit, H=3g/lit)	14.67 (3.96)	21.33 (4.73)	23.33 (4.93)	19.77 (4.54)
T ₁₉	Mancozeb75 WP (L= 1g/lit, M=2g/lit, H=3g/lit)	11.33 (3.51)	15.67 (3.96)	19.33 (4.51)	15.44 (4.00)
Insecticides					
T ₂₀	<i>Garcinia indica</i> + Chlorpyrifos 20% EC (L= 1.5 ml/lit, M= 2ml/lit, H=3ml/lit)	18.67 (4.43)	20.67 (4.65)	23.00 (4.90)	20.78 (4.66)
T ₂₁	<i>Garcinia indica</i> + Dichloroas 76% EC(L= 0.25%, M= 0.5%, H=1.0%)	17.67 (4.32)	20.00 (4.58)	21.33 (4.73)	19.66 (4.54)
T ₂₂	<i>Garcinia indica</i> + Dimethoate 30% EC(L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	19.67 (4.54)	21.33 (4.73)	24.67 (5.07)	21.89 (4.78)
T ₂₃	Chlorpyrifos 20% EC (L= 1.5 ml/lit, M= 2ml/lit, H=3ml/lit)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T ₂₄	Dichloroas 76% EC (L= 0.25%, M= 0.5%, H=1.0%)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T ₂₅	Dimethoate 30% EC (L= 0.5 ml/lit, M= 1ml/lit, H=2ml/lit)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
T ₂₆	Control	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)	0.00 (1.41)
	Between treatments	Between dilutions		Interaction	
SEM±	0.03	0.01		0.06	
CD (0.01)	0.10	0.03		0.18	

*The results in the parentheses are square root transformed values

Note*: L= Lower concentration, M= Medium concentration, H=Higher concentration.

Among them dimethoate 30% EC at 0.5, 1 and 2 ml/lit in combination with *P. juliflora* (1:5) showed highest inhibition zone of 22.67, 23.67 and 26.67 mm respectively. Followed by *P. juliflora* (1:5) + chlorpyrifos 20% EC with 22.00, 22.33 and 26.67 mm at 1.5, 2 and 3 ml/lit respectively and *P. juliflora* (1:5) + dichlorovas 76% EC (20.00, 22.33 and 25.33 mm at 0.25%, 0.5% and 1.0% respectively) and there was no inhibition of bacterial growth when insecticides tested alone at their three different concentrations.

Hulloli *et al.*, (1998) recorded neem products can act as synergistically with antibiotics (Streptocycline and kanamycin)/fungicides (ridomymancozeb) and reduced their hazardous effects. The MIC (minimal inhibitory concentration) of certain mixture was effective at lower concentrations than the MIC of individual chemicals indicating that neem formulations have synergistic activity when combined with antibiotics and fungicides. It is thus clear that addition of neem products to chemicals not only reduced their MIC but also eliminated the hazards of the development of the drug mutants.

Kumbhar *et al.*, (2001) evaluated the combined formulation of *Capsicum annuum* (green chilli), *Zingiber officinale* and *Allium sativum* with 5 per cent cyclohexane exhibited better potential than individual formulation and crude extracts against *A. niger*, *A. flavus* and *F. oxysporum* under *in vitro*.

The data in Table 3, recorded that the efficiency of *G. indica* (1:5) in combination with different bactericides, contact and systemic fungicides and insecticides in three different concentrations under *in vitro* on the growth of *X. axonopodis* pv. *punicae*. Among the pesticides tested, the bactericide 2-bromo-2-nitropropane-1,3-diol (bronopol) in combination with *G. indica* (1:5) showed maximum inhibition zone of 27.33, 32.00 and

34.00 mm in diameter at 250, 500 and 750 ppm concentration respectively. Streptocycline at 250, 500 and 750 ppm in combination with *G. indica* (1:5) recorded with 25.33, 28.00 and 32.67 mm respectively. However, 2-bromo-2-nitropropane-1,3-diol (bronopol) and Streptocycline alone recorded 24.67 and 22.00 mm at 250 ppm, 25.33 and 24.00 mm at 500 ppm and 28.67 and 26.67 mm at 750 ppm respectively.

In case of systemic fungicide tested along with *G. indica* (1:5) at their three different concentrations tested. Among them propiconazole 25% EC at 0.5, 1 and 2 ml/lit along with *G. indica* (1:5) showed highest inhibition zone of 22.00, 24.00 and 26.00 mm respectively. The next best treatments were, *G. indica* (1:5) + hexaconazole (20.00, 23.33 and 25.00 mm), *G. indica* (1:5) + difenconazole (18.00, 20.33 and 22.67 mm) and *G. indica* (1:5) + carbendazim (17.00, 20.00 and 21.00 mm) at 1, 2 and 3 g/lit respectively. However the propiconazole 25% EC (11.33, 12.67 and 15.33 mm), hexaconazole 5 EC (9.67, 12.00 and 14.33 mm), difenconazole (10.67, 12.33 and 14.67 mm) recorded zone of inhibition in diameter at 0.5, 1 and 2 ml/lit respectively. No inhibition zone at their three concentrations when tested alone. Whereas carbendazim 50wp alone recorded no inhibitory action. Results also revealed that all systemic fungicides are compatible with *G. indica* (1:5).

In case of contact fungicides all the three fungicides compatible with *G. indica* (1:5) at their three different concentrations tested. Among contact fungicides, copper oxychloride 50 WP at 1, 2 and 3 g/lit along with *G. indica* (1:5) showed highest inhibition zone of 21.33, 24.67 and 27.00 mm respectively. Followed by *G. indica* (1:5) + mancozeb 75 WP (20.67, 23.00 and 26.33 mm), *G. indica* (1:5) + chlorothalonil 75 WP

(19.00, 20.67 and 23.00 mm) at 1, 2 and 3 g/lit respectively. When the copper oxychloride 50 WP (14.67, 21.33 and 23.33 mm), mancozeb 75 WP (11.33, 15.67 and 24.00 mm) and chlorothalonil 75 WP (8.76, 14.00 and 17.67 mm) zone of inhibition in diameter at 1, 2 and 3 g/lit respectively, when they tested alone.

In case of insecticides all three are compatible with *G. indica* (1:5) at their three different concentrations tested. Among the insecticides dimethoate 30% EC at 0.5, 1 and 2 ml/lit in combination with *G. indica* (1:5) showed highest inhibition zone of 19.67, 21.33 and 24.67 mm respectively. Followed by *G. indica* (1:5) + chlorpyrifos 20% EC (18.67, 20.67 and 23.00 mm at 1.5, 2 and 3 ml/lit respectively) and *G. indica* (1:5) + dichlorovas 76% EC (17.67, 20.00 and 21.33 mm at 0.25%, 0.5% and 1.0% respectively) and there was no inhibition of bacterial growth when insecticides tested alone at their three different concentrations.

Meena *et al.*, (2017) reported efficacy of antibiotic, fungicide and botanical were examined individually as well as in combinations for two consecutive years. Combined application of tetracycline @ 250 ppm + copper hydroxide @1000 ppm along with garlic clove extract @ 20 per cent effectively suppressed the disease and recorded the minimum of 16.20 PDI with 76.72 per cent reduction over control than the individual treatments. Application of garlic cloves extract along with tetracycline @ 250 ppm and copper hydroxide @1000 ppm had synergistic effect on the suppression of the bacterial pathogen associated with pomegranate. Similar response were also recorded during 2014 with the foliar application of tetracycline + copper hydroxide + garlic cloves extract, which had a minimum of 13.40 PDI with 79.51 per cent disease reduction over control. It was comparatively

superior over the standard check namely, streptomycin + copper oxychloride. However, individual application of tetracycline @ 250 ppm or copper hydroxide @1000 ppm or, garlic cloves extract were least effective in the suppression of pomegranate bacterial blight. Therefore, it can be hypothesized that combine application of these chemicals with different mode of action have very good response in managing plant disease due to their synergistic effect. Besides, it also reduced the chance of multidrug resistance development within pathogen's population.

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