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RESEARCH ARTICLE

Field efficacy of *Nomuraea rileyi* (Farlow) Samson alone and in combination with insecticides against *Spodoptera litura* (Fabricius) infesting groundnut

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ABSTRACT

A field experiment was conducted to determine the efficacy of *Nomuraea rileyi* (Farlow) Samson alone and in combination with insecticides against *Spodoptera litura* (Fabricius) infesting groundnut at Junagadh Agricultural University campus, Junagadh during *Kharif* 2010. Considering the effectiveness and economics of different treatments, *N. rileyi* @ 1.25 kg/ha combined with spinosad 0.0045 per cent, *N. rileyi* @ 1.25 kg/ha + novaluron 0.004 per cent, *N. rileyi* @ 1.25 kg/ha + methomyl 0.025 per cent and *N. rileyi* @ 1.25 kg/ha + indoxacarb 0.0015 per cent were found as effective and economical as the recommended synthetic insecticides alone *viz.*, methomyl 0.05 per cent, novaluron 0.008 per cent, indoxacarb 0.003 per cent and spinosad 0.009 per cent, and can be recommended for eco-friendly management of *S. litura* in groundnut ecosystem, when they were applied twice first at 50 per cent flowering and second at 50 per cent pod formation.

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INTRODUCTION

Groundnut (*Arachis hypogaea* L.), an important oilseed-cum-grain legume crop is cultivated an area of 16863 hectare with production of 27168 million ton and productivity of 1611 kg/ha during 2011-2012 (Anonymous, 2012) Saurashtra region contributes 80.70 and 79.50 per cent of area and production of groundnut, respectively. In Saurashtra, Junagadh district ranks first with the area of 4125 hectares and 7350 ton of production (Anonymous, 2012). Hence, the region of Saurastra is considered being the groundnut bowl of the country. *Spodoptera litura* (Fabricius) is a serious pest of groundnut. The indiscriminate use of chemical pesticides has caused the environment pollution and insecticidal resistance. Hence, entomologists and environmentalists felt to develop viable alternate strategies which could be integrated into a workable system called integrated pest management. Among such eco-friendly approaches, entomopathogenic fungi form one of the most important components which are being employed to control noxious insect pests of pigeonpea ecosystem *viz.*, *S. litura*. Among several entomopathogenic fungi, *Nomuraea rileyi* (Farlow) Samson is an important natural mortality factor of many lepidopteran pests on variety of crop ecosystem. Looking to the importance of *N. rileyi* as microbial control agent, it is highly necessity to evaluate field efficacy of *Nomuraea rileyi* (Farlow) Samson against *S. litura* infesting groundnut.

MATERIAL AND METHODS

The field experiment on groundnut (var. GG -20) was conducted at College Farm, Junagadh Agricultural University, Junagadh, Gujarat during *Kharif*, 2010. The crop was grown at a spacing of 60 cm × 10 cm with three replications and total twelve treatments with control (Table 1) in Randomized Block Design. The spraying of treatments was done with the help of

Knapsack sprayer and obtained uniform coverage of insecticide in each plot. Two applications were carried out; first application at the appearance of the pest and second spray after 15 days of first spray. All the recommended practices were adopted for raising the crop. Observations on *S. litura* population were recorded from five randomly selected and tagged plants in each plot before spray and after 3, 5, 7 and 15 days of spraying. Corrected per cent mortality of pest in each treatment was calculated by using the modified formula as given by Henderson and Tilton (1955). The data thus obtained were transformed into Arcsin percentage and analyzed statistically. The yield of groundnut pod and fodder from each net plot was recorded separately and data were subjected to statistical analysis. Cost benefit ratio (CBR) was worked out to compare the economics of different treatments.

RESULTS AND DISCUSSION

The data on per cent mortality of reduction in *S. litura* larvae (Table 1) recorded after three, five, seven and fifteen days of first spray revealed that novaluron 0.008 per cent gave significantly highest reduction as it recorded 80.73, 85.54, 87.10 and 85.19 per cent mortality, respectively. However, it was statistically at par with the treatment of methomyl 0.05 per cent as it recorded 78.34, 80.67, 82.18, and 76.75 per cent mortality, respectively. Among the other treatments, *N. rileyi*

Table 1 : Percentage reduction of *Spodoptera* larvae in different treatments after first spray in groundnut during *Kharif* 2010

Sr. No.	Treatments	Per cent mortality of *S. litura* larvae				
		3 days	5 days	7 days	15 days	Mean
1.	*N. rileyi* @ 1.5 kg/ha	28.41 (22.63)	31.24 (26.90)	34.14 (31.50)	35.72 (34.08)	32.38 (28.78)
2.	*N. rileyi* @ 2.5 kg/ha	29.48 (24.21)	34.47 (32.03)	38.46 (38.68)	39.84 (41.03)	35.56 (33.99)
3.	*N. rileyi* @ 1.25 kg/ha + Methomyl 40 SP 0.025%	49.17 (57.25)	50.82 (60.09)	53.45 (64.54)	56.13 (68.94)	52.39 (62.71)
4.	*N. rileyi* @1.25 kg/ha + Novaluron 10 EC 0.004%	50.29 (59.19)	51.82 (61.80)	54.95 (67.02)	56.80 (70.01)	53.47 (64.51)
5.	*N. rileyi* @ 1.25 kg/ha + Indoxacarb 15 SC 0.0015%	48.62 (56.31)	50.31 (59.21)	52.60 (63.10)	55.51 (67.93)	51.76 (61.64)
6.	*N. rileyi* @ 1.25 kg/ha + Spinosad 45 SC 0.0045%	51.03 (60.45)	55.14 (67.33)	56.33 (69.27)	58.07 (72.02)	55.14 (67.27)
7.	Methomyl 40 SP 0.05%	62.26 (78.34)	63.92 (80.67)	65.03 (82.18)	61.17 (76.75)	63.10 (79.49)
8.	Novaluron 10 EC 0.008%	63.96 (80.73)	67.65 (85.54)	68.95 (87.10)	67.37 (85.19)	66.98 (84.64)
9.	Indoxacarb 15 SC 0.003%	55.08 (67.23)	57.07 (70.45)	58.11 (72.10)	56.04 (68.79)	56.58 (69.64)
10.	Spinosad 45 SC 0.009%	56.9 (70.18)	60.49 (75.74)	61.45 (77.15)	59.99 (74.99)	59.71 (74.52)
11.	Control (water spray)	6.79 (1.40)	6.5 (1.28)	6.3 (1.20)	4.94 (0.74)	6.13 (1.16)
S. Em. ±		2.74	2.80	2.68	2.70	
C.D. (P=0.05)		8.08	8.26	7.92	7.96	
C.V. %		10.40	10.08	9.30	9.32	

*Arcsine transformed value. Figures in the parentheses are retransformed values

Table 2 : Percentage reduction of *Spodoptera* larvae in different treatments after second spray in groundnut during *Kharif* 2010

Sr. No.	Treatments	Per cent mortality of S. *litura* larvae				
		3 days	5 days	7 days	15 days	Mean
1.	*N. rileyi* @1.5 kg/ha	26.35 (19.69)	29.86 (24.79)	33.07 (29.78)	34.75 (32.49)	31.01 (26.69)
2.	*N. rileyi* @2.5 kg/ha	28.52 (22.8)	33.83 (30.99)	37.20 (36.55)	39.02 (39.63)	34.64 (32.49)
3.	*N. rileyi* @ 1.25 kg/ha + Methomyl 40 SP 0.025%	48.24 (55.65)	49.81 (58.35)	52.37 (62.72)	54.67 (66.56)	51.27 (60.82)
4.	*N. rileyi* @ 1.25 kg/ha + Novaluron 10 EC 0.004%	49.39 (57.63)	51.79 (61.74)	53.83 (65.16)	55.64 (68.15)	52.66 (63.17)
5.	*N. rileyi* @ 1.25 kg/ha + Indoxacarb 15 SC 0.0015%	47.71 (54.73)	49.42 (57.68)	51.86 (61.85)	54.03 (65.50)	50.76 (59.94)
6.	*N. rileyi* @ 1.25 kg/ha + Spinosad 45 SC 0.0045%	49.66 (58.10)	53.39 (64.44)	55.31 (67.61)	57.16 (70.59)	53.88 (65.19)
7.	Methomyl 40 SP 0.05%	57.62 (71.32)	62.28 (78.36)	63.96 (80.73)	59.81 (74.71)	60.92 (76.28)
8.	Novaluron 10 EC 0.008%	62.98 (79.36)	66.33 (83.88)	67.65 (85.54)	65.73 (83.10)	65.67 (82.97)
9.	Indoxacarb 15 SC 0.003%	54.28 (65.92)	55.92 (68.6)	57.26 (70.74)	54.70 (66.60)	55.54 (67.97)
10.	Spinosad 45 SC 0.009%	55.76 (68.34)	59.34 (73.99)	60.33 (75.49)	58.48 (72.67)	58.48 (72.62)
11.	Control (water spray)	6.69 (1.36)	6.37 (1.23)	6.27 (1.19)	5.33 (0.86)	6.17 (1.16)
S. Em. ±		2.58	2.54	2.60	2.89	
C.D. (P=0.05)		7.61	7.48	7.66	8.54	
C.V. %		10.08	9.32	9.18	10.22	

*Arcsine transformed value. Figures in the parentheses are retransformed values

1.5 kg/ha (22.63, 26.90, 31.50 and 34.08 %) and *N. rileyi* 2.5 kg/ha (24.21, 32.03, 38.68, 41.03 %) gave lowest reduction. The remaining treatments, spinosad 0.009 per cent, indoxacarb 0.003 per cent, *N. rileyi* 1.25 kg/ha + spinosad 0.0045 per cent, *N. rileyi* 1.25 kg/ha + novaluron 0.004 per cent, *N. rileyi* 1.25 kg/ha + methomyl 0.025 per cent and *N. rileyi* 1.25 kg/ha + indoxacarb 0.0015 per cent remained next best treatments, which recorded 70.18, 67.23, 60.45, 59.19, 57.25 and 56.31 per cent pest reduction after three days, 75.74, 70.45, 67.33, 61.80, 60.09 and 59.21 per cent after five days, 77.15, 72.10, 69.27, 67.02, 64.54 and 63.10 per cent after seven days, 74.99, 72.02, 70.01, 68.94, 68.79 and 67.93 per cent after fifteen days, respectively. Almost similar trend in respect of different treatments was also observed, when observations were recorded at three, five, seven and fifteen days after second spray (Table 2).

It is evident from Table 3 that the highest pod and fodder yield of groundnut was obtained from the treatment of novaluron 0.008 per cent as it recorded 1400 and 2919 kg/ha, respectively. However it was statistically at par with methomyl 0.05 per cent which recorded 1360 and 2836 kg/ha. Lowest yield was obtained in untreated control plot (723 and 1510 kg/ha) and it was at par with water treated control (750 and 1545 kg/ha) and *N. rileyi* 1.5 kg/ha (880 and 1837 kg/ha). The remaining treatments, *N. rileyi* 1.25 kg/ha + novaluron 0.004 per cent, spinosad 0.009 per cent, *N. rileyi* 1.25 kg/ha + methomy l 0.025 per cent, *N. rileyi* 1.25 kg/ha + spinosad 0.0045 per cent, indoxacarb 0.003 per cent, *N. rileyi* 1.25 kg/ha + indoxacarb 0.0015 per cent and *N. rileyi* 2.5 kg/ha recorded moderately pod yield 1340, 1285, 1280, 1239, 1210, 1149 and 975 kg/ha, moderately fodder yield 2796, 2671, 2666, 2585, 2522, 2399 and 2035 kg/ha, respectively.

The economics of the various treatments indicated that the highest ICBR (1:9.73) was obtained in the treatment of *N. rileyi* 1.25 kg/ha + methomyl 0.025 per cent and it was followed by of methomyl 0.05 per cent(1:8.85), *N. rileyi* 1.25 kg/ha + novaluron 0.004 per cent(1:8.60), *N. rileyi* 1.25 kg/ha + spinosad 0.0045 per cent(1:8.41), spinosad 0.009 per cent (1:6.99), novaluron 0.008 per cent(1:6.71). The lower ICBR were obtained in *N. rileyi* 1.25 kg/ha + indoxacarb 0.0015 per cent (1:6.12) and *N. rileyi* 2.5 kg/ha(1:5.91), indoxacarb 0.003 per cent (1:5.02), *N. rileyi* 1.5 kg/ha (1:4.81) and showed second ranked treatments, whereas the lowest ICBR (1:1.37) was obtained in the treatment control (Table 3).

Looking to the efficacy, yield and economics of different treatments, novaluron 10 EC 0.008 per cent, indoxacarb 15 SC 0.003 per cent, spinosad 45 SC 0.009 per cent, methomyl 40 SP 0.05 per cent, *N. rileyi* @ 1.25 kg/ha + spinosad 45 SC 0.0045 per cent, *N. rileyi* @ 1.25 kg/ha + indoxacarb 15 SC 0.0015 per cent, *N. rileyi* @ 1.25 kg/ha + novaluron 10 EC 0.004 per cent and *N. rileyi* @ 1.25 kg/ha + methomyl 40 SP 0.025 per cent were found most effective and economical treatments against *S. litura* in groundnut. It was also evidenced with experimental support that *N. rileyi* 1.25 kg/ha combined with spinosad 45 SC 0.0045 per cent or indoxacarb 15 SC 0.0015 per cent or novaluron 10 EC 0.004 per cent or methomyl 40 SP 0.025 per cent was found as effective and economical as the

Table 3 : Economics of different treatments applied for the control of *S. litura* on groundnut

Sr. No.	Treatments	Total quantity of insecticides required for 2 sprays (lit or kg/ha)	Price of insecticides (Rs./lit or kg)	Cost of insecticides Rs./ha)	Cost of treatment (Rs./ha)	Yield (kg/ha)		Gross realization (Rs./ha)	Net realization (Rs./ha)	ICBR
						Pods	Fodder			
1.	*N. rileyi* @ 1.5 kg/ha	3	200	600	1320	880	1837	35594	6351	1:4.81
2.	*N. rileyi* @ 2.5 kg/ha	5	200	1000	1720	975	2035	39425	10182	1:5.91
3.	*N. rileyi* @ 1.25 kg/ha + Methomyl 40 SP 0.025%	2.5+0.875	200+1250	1594	2314	1280	2671	51755	22512	1:9.73
4.	*N. rileyi* @ 1.25 kg/ha + Novaluron 10 EC 0.004%	2.5+0.560	200+3000	2180	2900	1340	2796	54181	24939	1:8.60
5.	*N. rileyi* @ 1.25 kg/ha + Indoxacarb 15 SC 0.0015%	2.5+0.140	200+11410	2097	2817	1149	2399	46474	17231	1:6.12
6.	*N. rileyi* @ 1.25 kg/ha + Spinosad 45 SC 0.0045%	2.5+0.140	200+9000	1760	2480	1239	2585	50107	20864	1:8.41
7.	Methomyl 40 SP 0.05%	1.75	1250	2188	2908	1360	2836	54990	25748	1:8.85
8.	Novaluron 10 EC 0.008%	1.12	3000	3360	4080	1400	2919	56605	27363	1:6.71
9.	Indoxacarb 15 SC 0.003%	0.28	11410	3195	3915	1210	2522	48913	9670	1:5.02
10.	Spinosad 45 SC 0.009%	0.28	9000	2520	3240	1285	2666	51881	22638	1:6.99
11.	Control (water spray)	–	–	–	720	750	1545	30226	983	1:1.37
12.	Control (unsprayed)	–	–	–	–	723	1510	29243	–	–

* The labour charge has been calculated @ Rs. 360/ha/spray.

** Market value of groundnut pods has been calculated @ Rs. 30.00/kg and market value of groundnut fodder has been calculated @ Rs. 5/kg.

recommended synthetic insecticides (indoxacarb, novaluron, methomyl, spinosad) and can be recommended for eco-friendly management of *S. litura* in groundnut ecosystem. The *N. rileyi* alone showed its poor efficacy to suppress the pest in field that might be due to non-synchronization of the favourable abiotic factors, however, it exhibited a resultant synergism along with the synthetic insecticides particularly indoxacarb, novaluron, methomyl and spinosad. This *Nomuraea* bio-habit envisaged its amenability to infect the *S. litura* larvae those weakened by the particularly insecticides, and proved as an economic synergist of a specific *S. litura* chemo-ecology.

Effective control of *S. litura* was obtained with the treatment of novaluron 0.008 per cent as reported by Dhawan *et al.* (2007), whereas methomyl 0.05 per cent has been reported by Bapodra *et al.* (1986). According to Dharne *et al*. (2001), quinalphos 0.05 per cent, dichlorvos 0.05 per cent, methomyl 0.025 per cent and chlorpyriphos 0.04 per cent were significantly superior over the untreated control in reducing the damage of *S. litura* in groundnut. Stanley *et al*. (2006) reported that emamectin and spinosad were conformed very high per cent mortality. Prasad *et al.* (2007) reported that emamectin was the most toxic against the pest, followed by novaluron and indoxacarb. Srinivas and Ashwinder *et al*. (2007) reported that indoxacarb was the most toxic against *S. litura*, followed by thiodicarb, chlorpyrifos and spinosad. Manjula and Murthy (2005) reported that the combination *N. rileyi* + acephate were effective for the control of *S. litura*. The incubation period was shorter when *N. rileyi* was applied with insecticides than when applied alone. Thus, the present findings are in conformity with findings of earlier workers.

The study concluded that *N. rileyi* @ 1.25 kg/ha combined with methomyl 0.025 per cent or novaluron 0.004 per cent or spinosad 0.0045 per cent or indoxacarb 0.0015 per cent was found as effective and economical as the recommended synthetic insecticides alone *viz.*, methomy l 0.05 per cent, spinosad 0.009 per cent, novaluron 0.008 per cent and indoxacarb 0.003 per cent, and can be recommended for eco-friendly management of *S. litura* in groundnut ecosystem.

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