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Management of mealybug, *Phenacoccus solenopsis* Tinsley of cotton with insecticides and biorationals

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ABSTRACT: Efficacy of different insecticides and biorationals were evaluated against mealybugs on cotton under field conditions during 2010-2011 and 2011-2012 seasons. The results indicated that profenophos 50 EC @ 1500 ml/ha + soap water (1%) and buprofezin 25 SC @ 1000 ml/ha were effective in the management of mealybug on cotton. These 2 chemicals recorded least incidence of mealybugs after each spray. In general, profenophos at higher doses reduced mealybug incidence to the extent of 5.24 and 6.29 mealybugs/10 cm apical shoot after second spray during 2010-2011 and 2011-2012 seasons, respectively. Similarly Buprofezin 25 SC recorded lowest mealybug population of 0.56 and 3.45/10 cm apical shoot during 2010-2011 and 2011-2012 seasons, respectively. Maximum seed cotton yield 31.41 q/ha recorded in profenophos 50 EC @ 1500 ml/ha + soap water solution (1%) during 20010-2011 and profenophos 50 EC @ 2000 ml/ha recorded highest yield of 28.58 q/ha during 2011-2012.

Key words : Biorationals, cotton, management, *Phenacoccus solenopsis*

The development of transgenic cotton has resulted in an immensely increase in the seed cotton yield and reduction in the insecticidal sprays from 3.10 to 1.17 and from 12.20 sprays on non *Bt* to 5.75 sprays on *Bt* cotton in irrigated ecosystem at Raichur, Karnataka. Second generation *Bt* cotton has given solution to the bollworm complex to the larger extent but at the same time they are susceptible to most of the sucking pests. In the current decade, the trend of increased build up of various mealybug species in crop plants and in the wild is observed mainly due to certain abiotic change in climate and environment. Mealybug species *viz, Phenacoccus solenopsis* Tinsley, *Phenacoccus solani* Ferris and *Maconellicoccus hirsutus* (Green) have been recorded on cotton in India. Among them *P. solenopsis* is the major and wide spread in the country (Nagarare *et al.*, 2009). Severe economic damage to *G. hirsutum* was reported in 2007(Dharajyoti *et al.,* 2008; Dhawan, 2008) in 4 major cotton growing districts of Punjab, 2 districts of Haryana, and low to moderate damage in parts of Maharashtra, Tamil Nadu and Andhra Pradesh. Nearly 2000 acres of cotton destroyed by mealybug and over 100 acres of mealybug infested cotton was uprooted in Bhatinda and estimated loss ranged from US$ 400000 to 500000 in north India alone. In Karnataka mealybug appeared in isolated patches of cotton growing districts during 2006. Later it was found in the cotton growing districts of Raichur, Bellary, Gulbarga, Haveri, Dharwad and Belguam during 2007-2008. Mealybug incidence was more in the Tungabhadra project (TBP) and Upper Krishna project (UKP) areas which comprises major irrigated cotton growing areas (Hanchinal *et al.*, 2009). Management of this mealybug is difficult due to its wide host range, presence of waxy coating on the body and high reproductive potential. But the crawler stage is the most fragile and easily controllable stage in its life history. Recently some organophosphates, IGRs and bio pesticides have been recommended for

the control of mealybug (Suresh *et al.*, 2010).

MATERIALS AND METHODS

Field experiment was conducted during 2010-2011 and 2011-2012 seasons to evaluate the efficacy of insecticides and biorationals against *P. solenopsis* on *Bt* cotton NCS 145 (Bunny) at Main Agricultural Research Station, UAS, Raichur. The experiment was laid out in a randomized block design with 3 replications and 12 treatments during 2010-2011 and 3 replications and 13 treatments during 2011-2012. A plot size of 7.20 x 6.00 m and a spacing of 90 x 60 cm row to row and plant to plant were maintained. In each plot 80 plants were maintained and 5 plants were randomly selected and tagged for observation. In both the year, agronomic practices were followed as per the recommended package of practices.

In both the years 2 times treatments were imposed and 2 rounds of common sprays were taken to combat early sucking pests of cotton. Treatments were imposed when sufficient mealybug population was observed in the experimental block (90 days after sowing). Mealybugs were recorded on top apical shoot and presented as mealybugs/10 cm shoot length. Observations were recorded on one day before spray and 1, 3, 7 and 14 days after spray. Reduction in the mealybug population in different treatments was calculated and transferred to square root transformation for statistical analysis. Yield parameters like good opened bolls (GOB), bad opened bolls (BOB) and seed cotton yield were recorded/plot and converted to /ha. *Cryptoleamus* grubs were released after 90 days, when there was sufficient mealybug recorded on cotton.

RESULTS AND DISCUSSION

During 2010-2011,the pre treatment population of the mealybug ranged from 148.25 to 182.25/10 cm apical shoot. Difference in the mealybug population among the plots was not statistically significant on one day before the treatment (Table 1).

One day after spray lowest mealybug population of 46.12 mealybugs/10cm apical shoot was recorded in profenophos 50 EC @ 1500 ml/ha + soap water (1%) treatment which was significantly superior over rest of the treatments. This was followed by profenophos 50 EC @ 1500ml/ha alone which recorded 60.45 mealybugs/10cm apical shoot. Similar trend was observed on 3 days after treatment where profenophos 50 EC @ 1500 ml/ha + soap water (1%) was significantly superior over rest of the treatment. Profenophos 50 EC @ 1500 ml/ha + soap water (1%) was significantly effective and superior over rest of the treatment up to 7 days after spray which recorded lowest population of 14.12 mealybugs/10 apical shoot. Profenophos 50 EC @ 1500 ml/ha alone was the next best treatment which recorded 20.12 mealybugs/ 10cm apical shoot. Acephate 75 SP @ 2000 g/ha recorded 24.66 mealybugs /10 cm apical shoot which was *on par* with thiodicarb 75 WP@ 625g/ ha and these 2 treatments were significantly superior over control which recorded maximum of 135.36 mealybugs/10 cm apical shoot. At 7 7 days after spray,buprofezin 25 SC @ 1000 ml/ha recorded significantly lowest population of 21.24 mealybugs/10 cm apical shoot on 14 DAS. Population slightly increased in profenophos 50 EC @ 1500 ml/ha + soap water (1%) which recorded 26.21 mealybugs/10 cm apical shoot and was *on par* with thiodicarb @ 625g/ha and

Table 1. Efficacy of different insecticides/biorationals on mealybug population under irrigated ecosystem during 2010-2011 season

Treatments	Dosage (ml/ g/ha)	Population of mealybugs /10 cm apical shoot								
			First spray				Second spray			
		1 DBS	1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS
Thiodicarb 75WP	625 g	158.44	70.22	42.12	25.58	29.26	17.24	10.08	7.25	18.69
		-12.6	(8.40) ^{c}	(6.51) ^{bc}	(5.07) ^{c}	(5.43) ^{bc}	(4.15) ^{ab}	(3.10) ^{bc}	(2.76) ^{b}	(4.38) ^{cd}
Profenophos 50EC	1500 ml	162.44	60.45	35.36	20.12	34.32	19.34	6.25	4.22	8.22
		-12.76	(7.80) ^{b}	(5.97)^{b}	(4.49) ^{b}	(5.88) ^{c}	(4.40) ^{b}	(2.54) ^{b}	(2.07) ^{ab}	(2.92) ^{b}
Profenophos 50EC +	1500 ml	165.48	46.12	22.48	14.12	26.21	13.22	2.24	1.05	5.24
Soap water	(1%)	-12.88	(6.76) ^{a}	(4.58) ^{a}	(3.78) ^{a}	(5.15) ^{b}	(3.66) ^{a}	(1.62) ^{a}	(1.24) ^{a}	(2.40) ^{b}
Quinalphos 25EC	2000ml	172.58	94.48	65.44	36.36	42.22	30.82	18.08	14.12	26.58
		-13.15	(9.74) ^{d}	(8.11) ^{de}	(6.05) ^{de}	(6.52) ^{d}	(5.57) ^{c}	(4.25) ^{e}	(3.74) ^{cd}	(5.17) ^{ef}
Acephate 75SP	2000 g	182.25	106.65	57.64	24.66	30.44	20.24	16.34	11.32	16.54
		-13.52	(10.34) ^{e}	(7.60) ^{d}	(4.93) ^{c}	(5.50) ^{bc}	(4.43) ^{b}	(3.92) ^{de}	(2.99) ^{bc}	(3.95) ^{c}
Chlorpyriphos 20EC	2500ml	168.58	88.44	61.22	40.34	48.65	30.45	23.72	21.22	32.7
		-13	(9.42) ^{d}	(7.84) ^{de}	(6.37) ^{ef}	(6.99) ^{de}	(5.53) ^{c}	(4.87) ^{f}	(4.60) ^{de}	(5.73) ^{fg}
Buprofezin 25 SC	1000 ml	174.65	130.82	70.12	45.32	21.24	18.38	11.22	6.04	0.56
		-13.23	(11.45) ^{g}	(8.38) ^{e}	(6.72) ^{f}	(4.50) ^{a}	(4.13) ^{ab}	(3.38) ^{cd}	(2.45) ^{b}	(1.03) ^{a}
Neem oil	2000ml	168.44	125.45	45.22	32.14	54.68	46.24	24.13	15.63	22.24
		-13	(11.22) ^{gf}	(6.75) ^{c}	(5.69) ^{d}	(7.42) ^{ef}	(6.82) ^{d}	(4.93) ^{f}	(3.94) ^{d}	(4.73) ^{de}
Neemark1500 ppm	5000 ml	158.52	118.62	58.23	40.28	58.64	42.56	35.36	26.33	35.44
		-12.61	(10.91) ^{f}	(7.65) ^{d}	(6.36) ^{ef}	(7.67) ^{f}	(6.54) ^{d}	(5.95) ^{g}	(5.13) ^{ef}	(5.96) ^{g}
Cryptoleamus grubs	10/plant	174.63	125.48	94.46	67.24	52.22	48.34	56.48	62.44	48.42
		-13.23	(11.22) ^{gf}	(9.74) ^{f}	(8.23) ^{g}	(7.26) ^{ef}	(6.99) ^{d}	(7.55) ^{h}	(7.93) ^{g}	(6.99) ^{h}
Soap water	(1%)	168.44	122.54	88.45	64.22	88.48	51.22	36.25	30.56	46.48
		-13	(11.09) ^{gf}	(9.42) ^{f}	(8.03) ^{g}	(9.42) ^{g}	(7.17) ^{d}	(6.02) ^{g}	(5.52) ^{f}	(6.83) ^{h}
Control	—	148.25	154.44	152.52	135.36	124.25	98.22	120.22	134.58	112.45
		-12.19	(12.44) ^{h}	(12.36) ^{g}	(11.65) ^{h}	(11.16) ^{h}	(9.92) ^{e}	(10.98) ^{i}	(11.61) ^{h}	(10.62) ^{i}
SEm +		0.47	0.13	0.21	0.14	0.19	0.21	0.19	0.29	0.21
CD (p= 0.05)		NS	0.4	0.63	0.4	0.55	0.62	0.57	0.85	0.62

DBS – Day before spraying DAS – Days after spraying

In vertical columns means followed by similar letters are not different significantly (P = 0.05) by DMRT.

* Figures in the parentheses are " (x+1) values

acephate 75 SP@ 2000g/ha. All the above treatments were significantly superior over rest of the treatments and control where population was 124.25 mealybugs/10 cm apical shoot.

Similarly, one and 3 days after second spray, profenophos 50 EC @ 1500 ml/ha + soap water (1%) was found to be superior in reducing the mealybugs and recorded significantly lowest population of 13.22 and 2.24 mealybugs/10 cm apical shoot, respectively. Buprofezin 25 SC @ 1000 ml/ha was found to be effective at later days. It significantly reduced the mealybug to 0.56/10 cm apical shoot on 14th day after spray. Untreated control recorded highest population of 112.45 mealybugs/10 cm apical shoot (Table 1).

During 2011-2012, fish oil rosin soap and *Verticillium lecanii* were tested in addition to 2010-2011 treatments. Higher doses of Buprofezin @ 1500 ml/ha and Profenophos @ 2000 ml/ha were also tested because of their good efficacy in 2010-2011 season. Mealybug population was uniform in all the treatments and was non significant on one day before spray.

One day and 3 days after first spray, profenophos 50 EC @ 2000 ml/ha recorded lowest mealybugs of 55.34 and 26.98/10 cm apical shoot, respectively and was significantly superior over rest of the treatments. On 7 days after spray, profenophos 50 EC @ 2000 ml/ha recorded lowest mealybugs of 6.94/10 cm apical shoot and was significantly superior over rest of the

treatments. On 14 days after spray, lowest mealybug population of 20.58 was recorded in buprofezin 25 SC @ 1500 ml/ha which was *on par* with its lower dosage @ 1000 ml/ha and both the treatments were significantly superior over rest of the treatments.

Buprofezin 25 SC @ 1500 ml/ha proved to be superior on 14th day after spray which recorded minimum of 3.45 mealybugs/10 cm apical shoot and it was *on par* with its lower dosage which recorded 3.92 mealybugs/10cm apical shoot. These 2 treatments were significantly superior over rest of the treatments. Mealybug population increased in all the treatments on 14th day and it was maximum in *Verticillium lecanii* @ 2000g/ha which recorded 134.49 mealybugs/10 cm shoot length. However, mealybug population was significantly highest (146.19/10 cm apical shoot) in control. Similar trend was observed in the second spray, however Buprofezin 25 SC @ 1000 and 1500 ml/ha recorded lowest population of 3.92 and 3.45 mealybugs/10 cm shoot length, respectively and were significantly superior over rest of the treatments after 14 days of spray application (Table 2).

Profenophos 50 EC @ 1500 ml/ha + soap water (1%) recorded maximum good opened bolls (GOB) of 58.34/plant with significantly highest cotton yield of 31.41 q/ha. It was *on par* with

Table 2. Efficacy of different insecticides/biorationals on mealybug population under irrigated ecosystem during 2011-2012 season.

Treatments	Dosage (ml/ g/ha)	Population of mealybugs /10 cm apical shoot								
		First spray					Second spray			
		1 DBS	1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS
Thiodicarb 75WP	625 g	190.13	84.26	50.52	49.85	41.18	20.69^{c}	12.1	11.89	22.43
		-13.81	(9.20)^{c}	(7.81)^{c}	(7.09)^{h}	(6.45)^{c}	-4.59	(3.54)^{c}	(3.52)^{e}	(4.78)^{e}
Profenophos 50EC	1500 ml	194.93	72.54	42.43	14.14	35.11	17.81^{b}	7.5	5.06	9.86
		-13.97	(8.54)^{b}	(6.55)^{b}	(3.82)^{b}	(5.96)^{b}	-4.27	(2.81)^{b}	(2.35)^{b}	(3.20)^{c}
Profenophos 50EC	2000 ml	190.58	55.34	26.98	6.94	31.45	15.86^{a}	2.69	1.26	6.29
		-14.11	(7.47)^{a}	(5.23)^{a}	(2.72)^{a}	(5.65)^{b}	-4.03	(1.67)^{a}	(1.27)^{a}	(2.58)^{b}
Quinalphos 25EC	2000 ml	189.84	103.93	71.98	46.39	64.44	33.90^{e}	19.89	15.53	29.24
		-13.8	(10.22)^{d}	(8.51)^{h}	(6.84)^{g}	(8.05)^{e}	-5.86	(4.51)^{e}	(4.00)^{f}	(5.45)^{f}
Acephate 75SP	2000 g	191.36	111.98	50.54	43.92	51.96	21.25^{c}	10.87	8.7	17.37
		-13.86	(10.60)^{e}	(7.14)^{c}	(6.66)^{f}	(7.24)^{d}	-4.66	(3.36)^{c}	(3.03)^{d}	(4.22)^{d}
Chlorpyriphos 20EC	2500ml	193.87	84.24	54.26	40	55.95	20.22^{c}	12.34	14.4	37.61
		-13.91	(10.11)^{c}	(7.40)^{d}	(6.36)^{e}	(7.51)^{d}	-4.54	(3.57)^{c}	(3.86)^{f}	(6.17)^{g}
Buprofezin 25 SC	1000 ml	192.12	143.9	77.13	30.7	23.36	35.02^{e}	27.28	6.64	3.92
		-13.83	(12.08)^{h}	(8.81)^{i}	(5.58)^{d}	(4.88)^{a}	-5.96	(5.27)^{f}	(2.67)^{c}	(2.04)^{a}
Buprofezin 25 SC	1500 ml	192.02	126.76	67.95	25.89	20.58	23.21^{d}	17.16	5.85	3.45
		-13.88	(11.28)^{f}	(8.27)^{g}	(5.13)^{c}	(4.58)^{a}	-4.86	(4.20)^{d}	(2.51)^{bc}	(1.92)^{a}
Neem oil	2000ml	190.22	150.54	70.40^{g}	38.57	65.62	55.49^{g}	28.96	18.76	26.69
		-13.81	(12.29)^{i}	(8.42)^{h}	(6.25)^{e}	(8.13)^{e}	-7.48	(5.42)^{f}	(4.39)^{g}	(5.21)^{f}
Neemark1500 ppm	5000 ml	193.84	131.67	64.64	44.71	65.09	47.24^{f}	39.25	29.23	39.34
		-13.94	(11.50)^{g}	(8.07)^{f}	(6.72)^{fg}	(8.10)^{e}	-6.91	(6.30)^{g}	(5.45)^{h}	(6.31)^{g}
Fish oil rosin soap	3125 ml	198.84	83.24	55.53	39.36	65.56	35.32^{e}	19.15	13	50.2
		-13.12	(9.15)^{c}	(7.48)^{d}	(6.31)^{e}	(8.12)^{e}	-5.98	(4.43)^{d}	(3.67)^{ef}	(7.12)^{h}
Verticillium lecanii	2000 g	189.12	184.71	182.41	161.89	148.6	117.47^{g}	143.7	160.96	134.49
		-13.77	(13.61)^{j}	(13.52)^{j}	(12.74)^{i}	(12.21)^{f}	-10.86	(12.01)^{h}	(12.71)^{i}	(11.62)^{i}
Un treated Control	—	192.73	200.77	198.28	175.97	161.53	127.69^{h}	156.29	174.95	146.19
		-13.9	(14.19)^{k}	(14.10)^{k}	(13.28)^{j}	(12.73)^{g}	-11.32	(12.52)^{i}	(13.25)^{j}	(12.11)^{j}
SEm +		1.98	0.06	0.04	0.05	0.11	0.05	0.1	0.07	0.1
CD (p= 0.05)	NS	0.18	0.12	0.14	0.33	0.14	0.29	0.19	0.3	

DBS – Day before spraying DAS – Days after spraying

In vertical columns means followed by similar letters are not different significantly (P = 0.05) by DMRT.

* Figures in the parentheses are " (x+1) values

profenophos 50 EC @ 1500 ml/ha alone and buprofezin 25 SC @ 1000 ml/ha which recorded seed cotton yield of 30.98 and 29.98 q/ha, respectively and all the above mentioned treatments were significantly superior over rest of the treatments. Minimum seed cotton yield of 20.88 q/ha was recorded in soap water (1%) treatment which was *on par* with *Cryptolaemus* released treatment (21.47 q/ha) and neemark 1500 ppm @ 5000 ml/ha (22.66 q/ha) treatment but significantly superior over control which recorded lowest seed cotton yield of 18.49 q/ha during 2010-2011 season (Table 3).

During 2011-2012 season profenophos 50 EC @ 2000 ml/ha recorded maximum good opened bolls of 53.09/plant with significantly highest seed cotton yield of 28.58 q/ha. It was *on par* with its lower dosage profenophos 50 EC @ 1500 ml/ha, buprofezin 25 SC @ 1500 ml/ha and 1000 ml/ha which recorded seed cotton yield of 27.28 and 28.19 and 27.25 q/ha, respectively and all the above mentioned treatments were significantly superior over rest of the treatments.

The superiority of profenophos 50 EC and buprofezin 25 SC are in agreement with Balikai (2005) reported that buprofezin 25 SC @ 1000 and 1125 ml/ha recorded maximum protection of 80.4 per cent of mealybug, *M. hirsustus* population on grape when sprayed along with fish oil rosin soap (Meenark) @ 3125 g/ha.

The effectiveness of profenophos 50 EC

Table 3. Effect of different treatments on seed cotton yield under irrigated ecosystem during 2010-2011 and 2011-2012

Treatments	Dosage (ml/g /ha)	2010-2011			2011-2012		
		GOB/ plant	BOB/ plant	Seed cotton yield (q/ha)	GOB/ plant	BOB/ plant	Seed cotton yield (q/ha)
Thiodicarb 75WP	625 g	45.21 ^{c}	8.32 ^{bc}	26.87 ^{b}	41.14^{b}	7.57^{d}	21.81^{c}
Profenophos 50EC	1500 ml	55.12 ^{b}	6.12 ^{ab}	30.98 ^{a}	50.16^{a}	5.57^{abc}	27.28^{a}
Profenophos 50EC + Soap water	1500 ml + 1(%)	58.34 ^{a}	5.47 ^{a}	31.41 ^{a}	—	—	—
Profenophos 50EC	2000 ml	—	—	—	53.09^{a}	4.98^{ab}	28.58^{a}
Quinalphos 25EC	2000 ml	41.23 ^{d}	8.44 ^{c}	25.10 ^{bc}	37.52^{bc}	7.68^{d}	22.84^{bc}
Acephate 75SP	2000 g	40.56 ^{d}	7.36 ^{abc}	26.49 ^{b}	36.91^{bc}	6.70^{bcd}	24.11^{b}
Chlorpyriphos 20EC	2500 ml	40.64 ^{d}	8.68 ^{c}	24.16 ^{cd}	36.98^{bc}	7.90^{d}	21.99^{cd}
Buprofezin 25 SC	1000 ml	52.44 ^{b}	6.11 ^{ab}	29.98 ^{a}	47.72^{a}	5.56^{abc}	27.25^{a}
Buprofezin 25 SC	1500 ml	—	—	—	36.69^{bc}	4.14^{bcd}	28.19^{a}
Neem oil	2000ml	40.32 ^{d}	6.88 ^{abc}	23.97 ^{cd}	34.69^{bc}	6.69^{bcd}	20.62^{c}
Neemark 1500 ppm	5000 ml	38.12 ^{de}	7.35 ^{abc}	22.66 ^{de}	32.87^{c}	6.90^{cd}	19.54^{cd}
Cryptoleamus grubs	10/plant	36.12 ^{e}	7.58 ^{abc}	21.47 ^{e}	—	—	—
Fish oil rosin soap	3125 ml	—	—	—	19.72^{d}	6.26b^{a}	19.00^{cd}
Soap water	(1%)	34.82 ^{e}	8.58^{c}	18.88 ^{f}			
Verticillium lecanii	2000 g	—	—	—	31.96^{c}	6.93^{cd}	16.83^{d}
Un treated Control	—	28.11 ^{f}	15.48 ^{d}	18.49 ^{f}	25.58^{d}	14.0^{e}	11.72^{e}
SEm +	1.07	0.67	0.86	2.06	0.53	1.22	
CD (p=0.05)	3.15	1.96	2.58	6.01	1.62	3.55	

GOB- Good opened bolls BOB- Bad opened bolls

In vertical columns means followed by similar letters do not differ significantly (P = 0.05) by DMRT.

Figures in the parentheses are arc sine transformed values

in the present study is also in conformity with Agarwal *et al.*,(2009) who reported that profenophos 50 EC (check) recorded 93.73 per cent mortality over control. Similarly, Patel *et al.*, (2010) reported that more than 95 per cent reduction in mealy bug population over control after 3 DAS in buprofezin at all the 3 doses (250, 312.5 and 625 g a.i./ha) tested. Superiority of profenophos 50 EC was also confirmed by Suresh *et al.*,(2010) who reported that profenophos and methyl parathion were found to be quite effective and caused cent per cent mortality of *P. solenopsis* on one day after treatment while imidacloprid, fish oil rosin soap and dimethoate caused cent per cent mortality after 2 days of the treatment imposition.

Insect growth regulators (IGRs) represent the newest of all approaches to operational and commercial insect control. Buprofezin being biorational insecticide offered both effective control of mealybug and selectivity to many of the beneficial insects and have a novel mode of action was effective against all the stages of mealybug and useful in pest resistance management tool. These 2 insecticides can be used judiciously in IPM program of mealybug on cotton.

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