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Management of shoot fly through seed treatments and also to study their phytotoxicity in *Rabi* sorghum

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Abstract
The field trial was conducted on management of shoot fly through seed treatments and also to study their phytotoxicity in *rabi* sorghum 2014-15. The results revealed that, imidacloprid 70 WS (5 g/kg) and on par with chlorpyriphos 20 EC (5 ml/kg) found superior over all treatments by recording 0.73 eggs/plant. Next best treatments were spinosad 45 SC (2 ml/kg) (0.97 eggs/plant), acetamiprid 20 SP (5 g/kg) (1.07 eggs/plant) and fipronil 5 SC (5 ml/kg) (1.17 eggs/plant). Imidacloprid 70 WS (5 g/kg) and chlorpyriphos 20 EC (5 ml/kg) recorded significantly least deadhearts (14.83% and 15.17%, respectively) followed by fipronil 5 SC (5 ml/kg) (18.28%). Spinosad 45 SC (2 ml/kg), acetamiprid 20 SP (5 g/kg) and emamectin benzoate 5 SG (5 g/kg) recorded 25.40, 24.06 and 23.71 per cent deadhearts respectively followed by 1 per cent neem oil (25.60%). Flubendiamide 480 SC (4 ml/kg) and untreated control recorded higher damage due to shoot fly (27.80%). Highest net returns among all the treatments was recorded in imidacloprid 70 WS (21357.14 ₹/ha) followed by chlorpyriphos 20 EC (5 ml/kg) (19981.75 ₹/ha).

Keywords: Shoot fly, seed treatment, phytotoxicity

Introduction
Sorghum is an important crop in Asia, Africa, USA, Australia, and Latin America. Sorghum ranks fourth among the world cereals in the order of wheat, maize and rice. The productivity levels under subsistence farming conditions are quite low (500–800 kg/ha) mainly because of biotic and abiotic constraints. Among 150 species of insect pests of sorghum crop, sorghum shoot fly (*Atherigona soccata* Rondani) is the most important pest in Asia, Africa, and the Mediterranean Europe. Sorghum shoot fly (*Atherigona soccata* Rondani) is an important seedling pest sorghum crop. That attacks the crop up to 30 days from sowing. It is reported that the phosphate insecticides, e.g. fenitrothion, monocrotophos and trichlorfon have caused phytotoxicity to sorghum in Australia. The earlier recommendation of endosulfan is banned and hence there is an urgent need to find out alternative to endosulfan.

Material and Methods
The field experiment was laid out in Randomized block design composed of seven treatments in three replications. Experiment was conducted by selecting only those treatments which have resulted in the highest seed germination percentage from previous pot experiment studies. Sorghum cultivar DSV- 4 with spacing of 45x15 cm was sown during *rabi* season *i.e.* during mid October. Different seed dressers were used for field experiment, like Fipronil 5 SC @5 ml/kg, Spinosad 45 SC@2 ml/kg, Imidacloprid 70 WS@5 g/kg, Emamectin benzoate 5 SG@5 g/kg, Acetamiprid 20 SP@5 g/kg, Neem oil@1%, Flubendiamide 480 SC @ 2 ml/kg and Chlorpyriphos 20 EC (RPP) @ 5 ml/kg.
Egg count in each plot was done7, 14 and 21 DAE (Days After Emergence). Deadheart observation was made on 14, 21 and 28 DAE of the crop. Observation on Effect of seed dressers on Coccinellid and chrysoperla population was done on 14, 21 and 28 DAE. The data was subjected to statistical analysis. Cost economics for the treatments which found better than untreated control was also calculated.

Results and Discussion

Table 1: Effect of seed dressers on per cent seed germination in *rabi* sorghum at 9 DAS

Sl. No.	Insecticides	Dose	Germination (%)
1	Fipronil 5 SC	5 ml/kg	74.00 (59.35)^{cd}
2	Spinosad 45 SC	2 ml/kg	78.00 (62.03)^{b}
3	Imidacloprid 70 WS	5 g/kg	84.33 (66.79)^{a}
4	Emamectin benzoate 5 SG	5 g/kg	72.00 (58.05)^{d}
5	Acetamiprid 20 SP	5 g/kg	76.00 (60.67)^{bc}
6	Neem oil	1%	84.00 (66.42)^{a}
7	Flubendiamide 480 SC	2 ml/kg	78.00 (62.03)^{b}
8	Chlorpyriphos 20 EC (RPP)	5 ml + 20 ml water	86.00 (68.04)^{a}

*Figures in parentheses are arc sine transformed values
Means followed by same alphabet in a column do not differ significantly (0.05) by DMRT.
DAS - Days after sowing.
RPP: Recommended package of practice

There are no much reviews available to support the present findings. However, these results can be supported by the findings of Alisson *et al.* (2014) [1] who reported that imidacloprid (0.600 kg ai/ha) and fipronil (0.025 kg ai/ha) seed treatments recorded 84.25 and 87.75 per cent germination, respectively. However the per cent germination percentage declined in all the treatments as the dosage increased. The decline in germination percentage might be due to toxicity of insecticides which has hampered the same (Table 1).

Table 2: Effects of seed dressers on oviposition of shoot fly in *rabi* sorghum

Sl. No.	Treatments	Dosage	Number of eggs/plant		
			7 DAE	14 DAE	21 DAE
1	Fipronil 5 SC	5 ml/kg	0.60 (1.26)^{b}	0.83 (1.35)^{c}	0.97 (1.40)^{bc}
2	Spinosad 45 SC	2 ml/kg	0.60 (1.26)^{b}	0.87 (1.36)^{c}	1.17 (1.47)^{bc}
3	Imidacloprid 70 WS	5 g/kg	0.40 (1.18)^{c}	0.53 (1.24)^{d}	0.73 (1.32)^{c}
4	Emamectin benzoate 5 SG	5 g/kg	0.67 (1.29)^{b}	0.89 (1.37)^{c}	1.20 (1.48)^{b}
5	Acetamiprid 20 SP	5 g/kg	0.67 (1.29)^{b}	0.83 (1.35)^{c}	1.07 (1.44)^{bc}
6	Neem oil	1%	1.00 (1.41)^{a}	0.87 (1.37)^{c}	1.33 (1.53)^{b}
7	Flubendiamide 480 SC	2 ml/kg	0.97 (1.40)^{a}	1.13 (1.46)^{b}	1.30 (1.52)^{b}
8	Chlorpyriphos 20 EC (RPP)	5 ml/kg	0.40 (1.18)^{c}	0.53 (1.24)^{d}	0.73 (1.32)^{c}
9	Untreated control		1.03 (1.42)^{a}	1.66 (1.63)^{a}	2.00 (1.73)^{a}

* Figures in parentheses are ($\sqrt{x+1}$) transformed values
Means followed by same alphabet in a column do not differ significantly (0.05) by DMRT.
DAE: Days After Emergence
RPP: Recommended package of practice

On 7 DAE among all the seed dressers, imidacloprid 70 WS (5 g/kg) and chlorpyriphos 20 EC (5 ml/kg) recorded a significantly less number of eggs (0.40 eggs/plant). Next best treatments were fipronil 5 SC (5 ml/kg) and spinosad 45 SL (2 ml/kg) recording 0.60 eggs/plant. Acetamiprid 20 SP (5 g/kg) and emamectin benzoate 5 SG (5 g/kg) recorded 0.67 eggs/plant. Including flubendiamide 480 SC (4 ml/kg) (0.97eggs/plant) and 1 per cent Neem oil (1 egg/plant) all treatments found superior over untreated control (1.03 eggs/plant) (Table 2).

On 14 DAE most effective seed dresser were imidacloprid 70 WS (5 g/kg) and chlorpyriphos 20 EC (5 ml/kg) by recording 0.53 eggs/plant. Next best treatments were acetamiprid 20 SP (5 g/kg) and emamectin benzoate 5 SG (5 g/kg) recording 0.83 eggs/plant followed by spinosad 45 SL (2 ml/kg) and 1 per cent neem oil, which recorded 0.87 eggs/plant, where as fipronil 5 SC (5 ml/kg) recorded 0.89 eggs/plant. Flubendiamide 480 SC (4 ml/kg) recorded comparatively higher number of eggs (1.13 eggs/plant). However, all treatments were proved superior over untreated control (1.66 eggs/plant) (Table 2).

Same trend was followed on 21 DAE, imidacloprid 70 WS (5 g/kg) and on par with chlorpyriphos 20 EC (5 ml/kg) found superior over all treatments by recording 0.73 eggs/plant. Next best treatments were spinosad 45 SC (2 ml/kg) (0.97 eggs/plant), acetamiprid 20 SP (5 g/kg) (1.07 eggs/plant) and fipronil 5 SC (5 ml/kg) (1.17 eggs/plant). Emamectin benzoate 5 SG (5 g/kg), flubendiamide 480 SC (4 ml/kg) and neem oil (1%) recorded comparatively higher number of eggs (1.2 eggs/plant, 1.30 eggs/plant and 1.33 eggs/plant respectively). Compared to all other treatments highest numbers of eggs were recorded in untreated control (2 eggs/plant) (Table 2).

These results are in agreement with findings of Anita (2009) who reported that imidacloprid 70 WS (2 g/kg) and endosulfan 35 EC (0.07%) were effective in recording reduced number of shoot fly eggs/plant (0.75 and 0.76 eggs/plant, respectively).

On 14 DAE chlorpyriphos 20 EC (5 ml/kg) (5.58% deadhearts) was significantly superior among all treatments, which recorded the least damage due to shoot fly, followed by imidacloprid 70 WS (5 g/kg) (5.67% deadhearts). Next best treatments were fipronil 5 SC (5 ml/kg) (6.42% deadhearts) and acetamiprid 20 SP (5 g/kg) (6.43% deadhearts). Spinosad 45 SC (2 ml/kg), emamectin benzoate 5 SG (5 g/kg) and neem oil (1%) showed comparatively higher damage and recorded 7.19, 7.65 and 8.8 per cent deadhearts respectively. Highest damage due to shoot fly was recorded in flubendiamide 480 SC (4 ml/kg) and untreated control (9.30% deadhearts) (Table 3).

Table 3: Evaluation of seed dressers against shoot fly in *rabi* sorghum

Sl. No.	Treatments	Dosage	Per cent deadhearts		
			14 DAE	21 DAE	28 DAE
1	Fipronil 5 SC	5 ml/kg	6.42 (14.62)^{de}	10.50 (18.90)^{cd}	18.28 (25.28)^{d}
2	Spinosad 45 SC	2 ml/kg	7.19 (15.52)^{cde}	11.00 (19.35)^{cd}	25.40 (30.24)^{bc}
3	Imidacloprid 70 WS	5 g/kg	5.67 (13.76)^{e}	9.16 (17.61)^{d}	14.83 (22.64)^{e}
4	Emamectin benzoate 5 SG	5 g/kg	7.65 (16.04)^{bcd}	14.37 (22.24)^{b}	23.71 (29.12)^{c}
5	Acetamiprid 20 SP	5 g/kg	6.43 (14.68)^{de}	10.66 (19.00)^{cd}	24.06 (29.35)^{c}
6	Neem oil	1%	8.82 (17.17)^{bc}	14.37 (22.24)^{b}	25.60 (30.38)^{bc}
7	Flubendiamide 480 SC	2 ml/kg	9.30 (17.73)^{a}	14.63 (22.44)^{a}	27.80 (31.81)^{a}
8	Chlorpyriphos 20 EC (RPP)	5 ml/kg	5.58 (13.64)^{e}	9.00 (17.45)^{d}	15.17 (22.91)^{e}
9	Untreated control		9.30 (17.73)^{a}	14.63 (22.44)^{a}	27.80 (31.81)^{a}

*Figures in parentheses are arc sine transformed values
Means followed by same alphabet in a column do not differ significantly (0.05) by DMRT.
DAE: Days after Emergence
RPP: Recommended package of practice

On 21 DAE chlorpyriphos 20 EC (5 ml/kg) recorded significantly least deadhearts (9.00%), imidacloprid 70 WS (5 g/kg) was found next best in recording low per cent deadhearts (9.16%). Followed by fipronil 5 SC (5 ml/kg), acetamiprid 20 SP (5 g/kg) and spinosad 45 SL (2 ml/kg) (10.50, 10.66 and 11 per cent deadhearts, respectively). Neem oil (1%) and emamectin benzoate 5 SG (5 g/kg) recorded 14.37 per cent deadhearts. Flubendiamide 480 SC (4 ml/kg) and untreated control recorded comparatively higher per cent deadhearts (14.63%) (Table 3).

On 28 DAE imidacloprid 70 WS (5 g/kg) and chlorpyriphos 20 EC (5 ml/kg) recorded significantly least deadhearts (14.83% and 15.17%, respectively) followed by fipronil 5 SC (5 ml/kg) (18.28%). Spinosad 45 SC (2 ml/kg), acetamiprid 20 SP (5 g/kg) and emamectin benzoate 5 SG (5 g/kg) recorded 25.40, 24.06 and 23.71 per cent deadhearts respectively followed by 1 per cent neem oil (25.60%). Flubendiamide 480 SC (4 ml/kg) and untreated control recorded higher damage due to shoot fly (27.80%)(Table 3).

Table 4: Effect of seed dressers on Coccinellid population in *rabi* sorghum

Sl. No.	Treatments	Dosage	Number of Coccinellids/ plant		
			14 DAE	21 DAE	28 DAE
1	Fipronil 5 SC	5 ml/kg	0.54 (1.23)^{ab}	0.74 (1.32)^{a}	0.86 (1.35)^{b}
2	Spinosad 45 SC	2 ml/kg	0.50 (1.22)^{ab}	0.73 (1.31)^{a}	0.79 (1.33)^{b}
3	Imidacloprid 70 WS	5 g/kg	0.76 (1.31)^{a}	1.00 (1.40)^{a}	1.07 (1.43)^{b}
4	Emamectin benzoate 5 SG	5 g/kg	0.53 (1.23)^{ab}	0.73 (1.31)^{a}	0.98 (1.40)^{b}
5	Acetamiprid 20 SP	5 g/kg	0.50 (1.22)^{ab}	0.73 (1.31)^{a}	0.92 (1.38)^{b}
6	Neem oil	1%	0.64 (1.27)^{ab}	0.0.73 (1.31)^{a}	1.04 (1.42)^{b}
7	Flubendiamide 480 SC	2 ml/kg	0.36 (1.16)^{b}	0.75 (1.32)^{a}	0.88 (1.37)^{b}
8	Chlorpyriphos 20 EC (RPP)	5 ml/kg	0.76 (1.31)^{a}	0.73 (1.31)^{a}	1.00 (1.41)^{b}
9	Untreated control		0.77 (1.32)^{a}	1.97 (1.40)^{a}	1.37 (1.53)^{a}
	SEm±		0.03	0.03	0.03
	CD at 5%		NS	NS	NS

*Figures in parentheses are ($\sqrt{x+1}$) transformed values
Means followed by same alphabet in a column do not differ significantly (0.05) by DMRT.
DAE: Days after Emergence
RPP: Recommended package of practice

Phytotoxicity symptoms

All of the tested seed dressers like imidacloprid 70 WS (5 g/kg), fipronil 5 SC (5 ml/kg), spinosad 45 SC (2 ml/kg), acetamiprid 20 SP (5 g/kg), emamectin benzoate 5 SG (5 g/kg), flubendiamide 480 SC (4 ml/kg), neem oil (1%) and chlorpyriphos 20 EC (5 ml/kg) found safe to the sorghum plants. None of them revealed any phytotoxicity symptoms like chlorosis, white blotch, necrosis and bronzing at 3, 5 and 7DAE (Days after emergence).

There are no much reviews available to support the present findings, however these results can be supported by the findings of Alisson *et al.* (2014) [1] who reported that imidacloprid (0.600 ai/ha) and fipronil (0.025 kg ai/ha) did not cause any phytotoxic symptoms to sorghum plants.

Table 5: Effect of seed dressing on chrysoperla population in *rabi* sorghum

Sl. No.	Treatments	Dosage	Number of chrysoperla/ plant		
			14 DAE	21 DAE	28 DAE
1	Fipronil 5 SC	5 ml/kg	0.63 (1.27)^{a}	0.74 (1.32)^{a}	0.76 (1.32)^{a}
2	Spinosad 45 SC	2 ml/kg	0.43 (1.20)^{a}	0.53 (1.24)^{a}	0.63 (1.28)^{a}
3	Imidacloprid 70 WS	5 g/kg	0.73 (1.31)^{a}	0.83 (1.35)^{a}	0.91 (1.38)^{a}
4	Emamectin benzoate 5 SG	5 g/kg	0.63 (1.28)^{a}	0.74 (1.32)^{a}	0.75 (1.32)^{a}
5	Acetamiprid 20 SP	5 g/kg	0.47 (1.21)^{a}	0.57 (1.25)^{a}	0.72 (1.31)^{a}
6	Neem oil	1%	0.55 (1.24)^{a}	0.67 (1.29)^{a}	0.80 (1.34)^{a}
7	Flubendiamide 480 SC	2 ml/kg	0.49 (1.22)^{a}	0.70 (1.30)^{a}	0.80 (1.34)^{a}
8	Chlorpyriphos 20 EC (RPP)	5 ml/kg	0.75 (1.32)^{a}	0.86 (1.36)^{a}	0.94 (1.39)^{a}

9	Untreated control	0.75 (1.32)[a]	0.73 (1.32)[a]	1.03 (1.43)[a]
	SEm±	0.05	0.05	0.05
	CD at 5%	NS	NS	NS

*Figures in parentheses are (√x+1) transformed values
Means followed by same alphabet in a column do not differ significantly (0.05) by DMRT.
DAE: Days after Emergence
RPP: Recommended package of practice

Natural enemies

There was no significant difference in the number of coccinellids and chrysoperla per plant recorded in all seed treatments and they were on par with untreated control on 14 DAE in various treatments. On 21 DAE and 28 DAE also the trend of Coccinellid and chrysoperla population being on par in all treatments including untreated control. These results can be supported by findings of Anita (2009) [2] who reported that number of coccinellids/plant in imidacloprid 70 WS (2 g/kg) and endosulfan 35 EC (0.07%) treated plots are on par with untreated control (Table 5).

Among all the treatments highest grain yield obtained in Imidacloprid 70 WS (5 g/kg) (28.57q/ha) and it was on par with chlorpyriphos 20 EC (5 ml/kg) (27.35q/ha). Next best treatments in obtaining higher yields were fipronil 5 SC (5 ml/kg), acetamiprid 20 SP (5 g/kg), neem oil 1% and spinosad 45 SC (2 ml/kg) (26.56, 23.39, 20.95, 20.63 q/ha, respectively). Emamectin benzoate 5 SG (5 g/kg) and flubendiamide 480 SC (2 ml/l) recorded comparatively lower yields (19.05 and 15.66 q/ha, respectively). All the treatments were superior over untreated control, which has recorded 14.81 q/ha. However, in the present findings the yields were higher as compared to previous reports as it was mainly due to very good unseasonal rains during November (48.8 mm) and December (26.2 mm). These results are in agreement with findings of Anita (2009) who reported that the higher yield (16.81 q/ha) was obtained in imidacloprid 70 WS (2 g/kg) as compared to all other treatments. Balikai (1998) [3] obtained 26.2 q/ha grain yield by treating sorghum seeds with imidacloprid 70 WS (5 g/100 g). Balikai (2007) [4] also obtained the grain yield of two sorghum genotypes M-35-1 (26.4 q/ha) and CSH-15R (28.3 q/ha) by treatment of imidacloprid 70 WS (10 g/kg). Anon. (2010) reported that seed treatment with imidacloprid 70 WS (3 g/kg) recorded 19.56q/ha yield, which was better compared to other treatments.

Table 6: Yield and yield economics influenced by seed dressers in *rabi* sorghum

Sl. No.	Treatments	Dose	Grain yield (q/ha)	Total cost of cultivation ₹₹	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
1	Fipronil 5 SC	5 ml/kg	26.56 (5.17)[ab]	21320	39841.27	18521.27	1.87
2	Spinosad 45 SC	2 ml/kg	20.63 (4.52)[abc]	21540	30952.38	9412.38	1.44
3	Imidacloprid 70 WS	5 g/kg	28.57 (5.38)[a]	21500	42857.14	21357.14	1.99
4	Emamectin benzoate 5 SG	5 g/kg	19.05 (4.40)[abc]	21400	28571.43	7171.43	1.34
5	Acetamiprid 20 SP	5 g/kg	23.39 (4.83)[abc]	21160	35079.37	13919.37	1.66
6	Neem oil	1%	20.95 (4.61)[abc]	21170	31428.57	10258.57	1.48
7	Flubendiamide 480 SC	2 ml/kg	15.66 (4.02)[bc]	21540	23492.06	1952.06	1.09
8	Chlorpyriphos 20 EC (RPP)	5 ml + 20 ml water	27.35 (5.27)[a]	21050	41031.75	19981.75	1.95
9	Untreated control	-	14.81 (3.91)[c]	21000	22222.22	1222.22	1.06

*Figures in parentheses are (√x+1) transformed values
Means followed by same alphabet in a column do not differ significantly (0.05) by DMRT.
RPP: Recommended package of practice

Highest net returns among all the treatments was recorded in imidacloprid 70 WS (21357.14 ₹/ha) followed by chlorpyriphos 20 EC (5 ml/kg) (19981.75 ₹/ha). However, all the treatments were superior over untreated control by recording net returns ranging from 1952.06 ₹/ha to 19981.75 ₹/ha. Lowest net returns was found in untreated control (1222.22 ₹/ha). Imidacloprid 70 WS (5 g/kg) and chlorpyriphos 20 EC (5 ml/kg) gave highest B:C ratio (1:1.99 and 1:1.95, respectively). In remaining treatments B:C ratio ranges from 1:1.09 to 1:1.87. lowest B:C ratio (1:1.06) was seen in untreated control. As compared to earlier works higher net returns were obtained, it was mainly due to higher yields supported by good rains as well as good support price by the government of Karnataka. The present findings can be supported by results placed on records by Anita (2009) [2] who reported increased net returns in imidacloprid 70 WS (2 g/kg) and endosulfan 35 EC (0.07%) (24848.00 and 24469.00 ₹/ha). Chikkarugi *et al.* (2008) [5] found that imidacloprid 70 WS (5 g/kg) was effective in increasing net returns (5123.00 ₹/ha) compared to other treatments (Table 6).

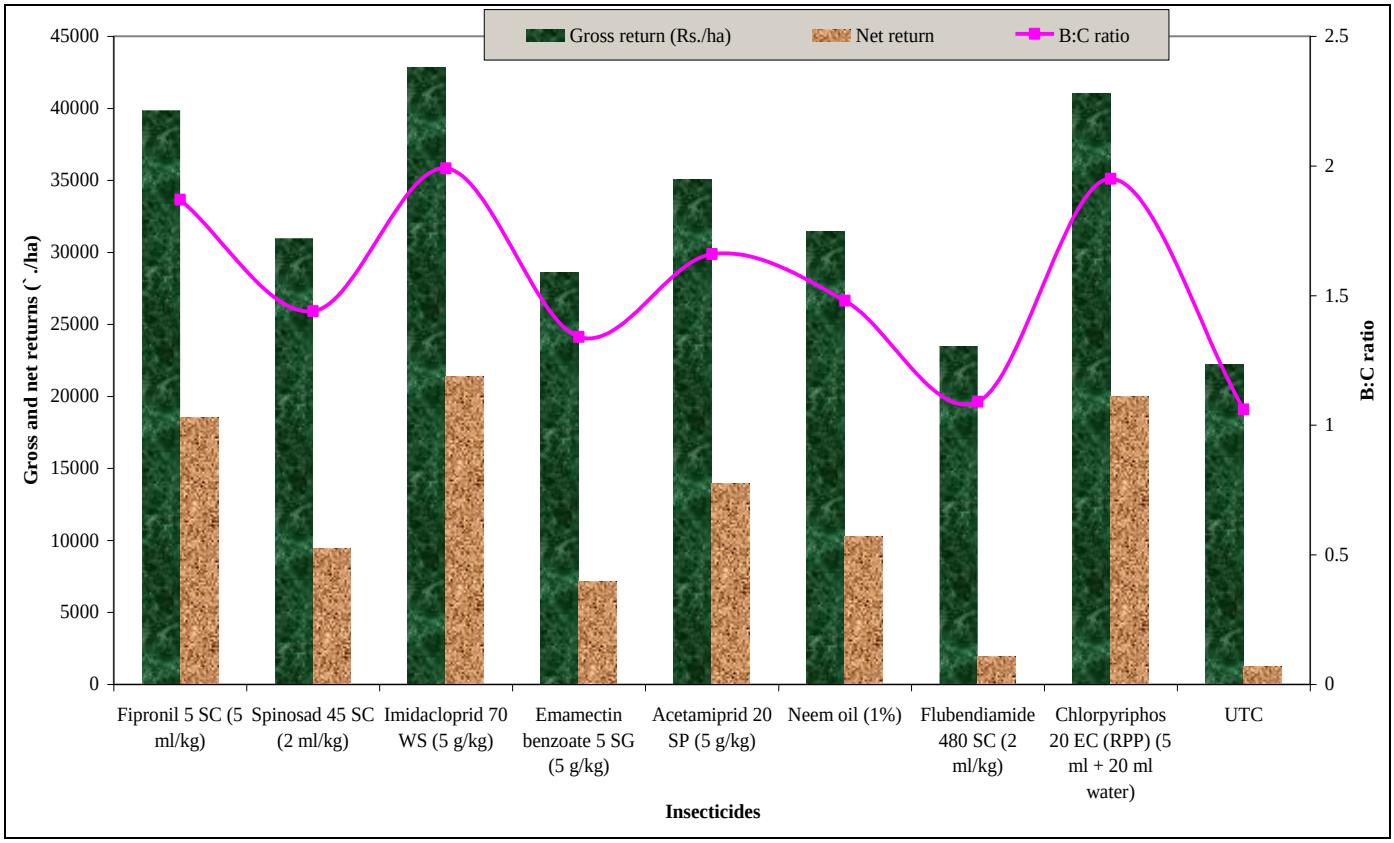

Fig 1: Economics of sorghum as influenced by seed dressers

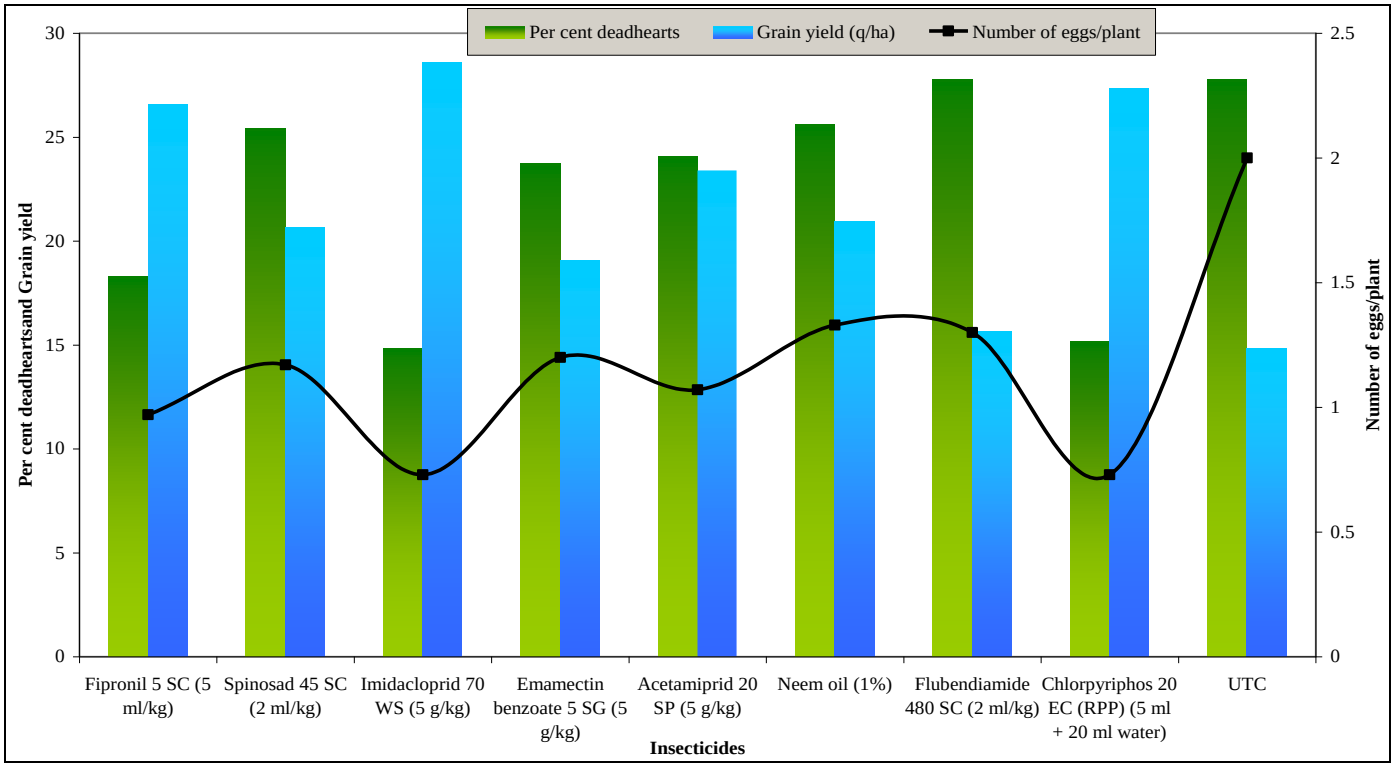

Fig 2: Effect of seed dressers on oviposition, percent deadhearts and yield of *rabi* sorghum

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