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Impacts of newer molecules of insecticides on management of maize stem borers

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Abstract
A two year investigation on impacts of newer molecules of insecticides on management of maize stem borers was carried out at Main Agricultural Research Station, Dharwad during *kharif* and *rabi-summer* 2010-11 and 2011-12. Among the different newer molecules of insecticides evaluated, single spray of endosulfan 35EC @ 2 ml/l or emamectin benzoate 5SG @ 0.2 g/l or spinosad 45SC @ 0.2 ml/l at 25 DAS as well as whorl application of carbofuran 3G @ 7.5 kg/ha being on par with each other proved superior over untreated control. Maximum net profit was realised in carbofuran and endosulfan treatments (37851.00 and 37197.90 Rs./ha, respectively). The lower net profit was found in imidacloprid and thiomethoxam. The maximum IBC ratio of 28.62 was registered in endosulfan followed by imidacloprid (23.13), carbofuran (17.19), emamectin benzoate (13.44), indoxacarb (11.22), spinosad (7.63) and thiodicarb (6.84) and the lower IBC ratio was recorded in flubendiamide (5.07) and thiomethoxam (6.72).

Keywords: insecticides, maize, stem borers, spinosad, emamectin benzoate

1. Introduction
Maize (*Zea mays* Linn.) is the most important crop in the world after wheat and rice. It is as much a significant crop in the American countries like rice and wheat in Asia [15]. Maize is grown in more than 70 countries of the world including USA, China, Brazil, Mexico, France, Argentina, Romania, India, Italy, Indonesia and South Africa [11]. The production of maize is constantly increasing because of the rising demand from the industries since maize is used as raw material [16].

Presently, maize cultivation is gaining importance in Karnataka particularly in rainfed tracts of northern and southern transitional zones due to its increasing demand as animal feed and raw material for industry [14]. In spite of increase in the area under this crop, the productivity is still considerably low which may be due to several reasons. One of the important constraints responsible for low productivity is undoubtedly the attack of various insect pests particularly the stem borers and cob caterpillars which have gained major importance in the state by inflicting greater loss to the crop [14]. The scenario with respect to insect pests of this crop has changed a lot in the recent past owing to increased area under single cross hybrids and monocropping practiced by the farmers using indiscriminate quantity of chemical fertilizers [14]. Very little information is available on the insect pests of maize in India, in general and Karnataka, in particular except for some stray reports on the incidence, biology and control of the major insects like, *Helicoverpa armigera* (Hubner), *Mythimna separata* (Walker), *Rhopalosiphum maidis* (Fitch), *Chilo partellus* (Swinhoe) and *Atherigona soccata* (Rondani) [14].

Insect pests are one of the major limitations for low yield of maize. In India, nearly 32.1 per cent of the actual produce is lost due to insect pests [3]. Yield losses in different agro climatic regions of India due to *C. partellus* and *S. inferens* ranged from 26.7 to 80.4 and 25.7 to 78.9 per cent, respectively [4]. The infestation by stem borers varied from 6.31 to 20.01 per cent during 2008-09 and 2009-10 in different districts of Karnataka [12]. Further, the infestation ranged from 28.07 to 60.15 and 32.60 to 61.15 per cent during *kharif* 2010-11 and 2011-12, respectively. During *rabi* 2010-11 and 2011-12, it ranged from 31.30 to 67.07 and 32.48 to 66.39 per cent, respectively [13].

Till recently, the stem borers (*C. partellus* and *S. inferens*), have been considered as major pests in India, the former throughout the union and the latter in south India. The stem borers initially damage by feeding on the leaf tissues, followed by tunneling and feeding within the stem and sometimes the maize cobs [22]. Infestation by *C. partellus* on maize starts with oviposition on the leaves [2]. and *S. inferens* lays in between the leaf sheath and stem of the plant [7]. After hatching, the first instars move into the leaf whorls where they feed and develop on the bases of the leaves, causing lesions. The late third or early-fourth instars bore into the stem, feeding on tissues and making tunnels. When the infestation is severe, the larvae, either in the leaf whorl or in the stem, can cut through the meristematic tissues; the central leaves dry up to produce the 'dead heart' symptom, resulting in the death of the plant [6]. Before pupation make exit holes on stem and pupate and adults will emerge. It also feeds at flowering stage interfere with pollination and also feeds within the cob and prone to secondary infection.

In Karnataka, stem borers have become regular pests of maize crop during the recent past, with severe outbreaks becoming a common feature in the state [13]. The pest outbreak caused severe losses in maize crop and even, the crop was completely resown by the farmers in some districts of the state. The principal aim of management of pest populations is to hold pest below economic injury level which has more relevance in a relatively short duration crops like maize [13]. As stem borers are widely distributed and cause extensive damage to maize crop, thorough investigations are required. Keeping all these points in view, investigation was undertaken on impacts of newer molecules of insecticides on management of maize stem borers.

2. Material and Methods

Investigation on impacts of newer molecules of insecticides on management of maize stem borers was carried out at Main Agricultural Research Station, Dharwad during *kharif* and *rabi-summer* 2010-11 and 2011-12.

Dharwad is situated in the transitional tract of Karnataka state at 15°-26' North latitude and 75°-07' East longitude at an altitude of 761.8 meters above mean sea level. The materials used and methodologies followed in conducting the studies are described here under.

The field experiment was carried out during the *kharif* and *rabi* season of 2010-11 using randomized block design with three replications. The popular maize hybrid 900 M Gold was sown over a plot size of 5X4m at a spacing of 60X30cm for each treatment. The crop was raised by following all the recommended package of practices with an exception of plant protection measures. Ten treatments along with untreated check were selected. High volume knapsack sprayer was used for spraying different insecticides. A spray volume of 600 l/ha was used at 25 days after sowing. Details of treatments and dosages are stated Table 1.

Ten plants were randomly selected in each treatment and observations were made at one day before spraying and 5, 10 and 15 days after spraying.

The total number of leaves showing phytotoxicity symptoms like leaf injury on tips and leaf surface, wilting, necrosis, vein clearing, epinasty or hyponasty were recorded at 5, 10 and 15 days after spray on five randomly selected plants from each plot. The data collected were converted into percentage. The extent of phytotoxicity was recorded based on the score stated in Table 2.

The number of plants showing the leaf-feeding symptoms, leaf-feeding score evaluated on 1-9 scale and dead hearts were recorded. At the time of harvest, plants on which leaf injury scores recorded were selected for observation on stem tunneling. The grain yield from individual treatment was recorded separately and converted to hectare basis.

$$\text{Per cent infestation} = \frac{\text{No. of infested plants}}{\text{Total No. of plants}} \times 100$$

$$\text{Length of tunneling} = \frac{\text{Length of tunneling (cm)}}{\text{Total length of stem (cm)}} \times 100$$

2.1 Economic analysis

2.1.1 Cost of cultivation

The prevailing price of input materials and labour cost were considered for computing the cost of cultivation which was expressed in Rs/ha.

2.1.2 Gross return

The income from grain yield of maize was considered for accounting gross return. The prices prevailed at APMC, Dharwad, were considered to calculate the gross return (Rs/ ha).

2.1.3 Net Return

Net return (Rs/ ha) was calculated by subtracting the cost of cultivation (Rs/ ha) from the gross return.

2.1.4 Incremental Benefit: Cost ratio

Incremental benefit was calculated by taking the difference in Gross returns from the respective treatments over the control. Further the IBC ratio was obtained by taking the ratio of incremental benefit to the cost of insecticide.

Incremental benefit = gross return from respective treatment-gross return from control

$$\text{IBC ratio} = \frac{\text{Incremental benefit (Rs/ha)}}{\text{Cost of insecticide (Rs/ha)}}$$

The statistical analysis was done using randomized block design.

3. Results and Discussion

3.1 Leaf scraping and pinhole damage

The data showed that minimum leaf scraping and pinhole damage was observed in imidacloprid and thiomethoxam treatments which recorded 32.43 and 32.64 per cent damage, respectively. In the remaining treatments, the damage varied from 34.99 to 36.16 per cent. Observations made at fifteen days after treatment revealed the superiority of carbofuran, endosulfan, emamectin benzoate and spinosad over other treatments by recording 22.39, 22.95, 24.03 and 24.49 per cent leaf scraping and pinhole damage, respectively. The next best was flubendiamide (27.22%) which also stood at par with latter two treatments. In other treatments, the leaf scraping and pinhole damage varied from 32.07 to 34.75 per cent while, maximum damage (43.51%) was recorded in the untreated check (Table 1). The minimum leaf feeding score was observed in carbofuran (3.43) and endosulfan (3.43) treatments.

3.2 Protection over control

Maximum protection over control was recorded in carbofuran treatment (49.04%), followed by endosulfan (47.54%), emamectin benzoate (45.02%) and spinosad (43.93%). In the remaining insecticidal treatments, the protection over control varied from 20.22 to 37.71 per cent (Table 1).

3.3 Dead heart

The observations taken before imposing the treatments revealed that the dead heart incidence (14.71 to 17.64%) did not differ significantly among various treatments. At fifteen days after treatment application, the treatments *viz*., carbofuran, emamectin benzoate, endosulfan, spinosad, thiodicarb and flubendiamide stood significantly superior over other treatments by recording lower dead heart (8.05, 8.91, 9.85, 10.32, 10.93 and 11.10%, respectively) with maximum protection over untreated check (64.17, 60.42, 56.11, 53.33, 51.05 and 50.22%, respectively). The next to follow were indoxacarb, thiomethoxam and imidacloprid (12.08, 15.67 and 15.71% dead heart with 45.81, 29.92 and 29.74% protection, respectively). However, the untreated check recorded maximum (22.44%) dead heart incidence (Table 3).

3.4 Yield and yield increase over control

The impact of different treatments on grain yield was revealed with significantly higher yield (65.40 q/ha) recorded in carbofuran which accounted for 40.48 per cent increase over control. The treatments to follow included emamectin benzoate, endosulfan and spinosad (64.38, 64.19 and 62.07 q/ha grain yield with 38.29, 37.89 and 33.32% increase over control, respectively) which were on par with each other. The other treatments in the order of higher grain yield were flubendiamide, thiodicarb, indoxacarb, thiomethoxam and imidacloprid (58.58, 57.05, 56.36, 54.48 and 54.36 q/ha grain yield with 25.78, 22.55, 21.03, 16.99 and 16.80% increase over control, respectively). However, the untreated check registered lowest grain yield of 46.57 q/ha (Table 4).

Among the different newer molecules of insecticides evaluated, single spray of endosulfan 35EC @ 2 ml/l, emamectin benzoate 5SG @ 0.2 g/l, spinosad 45SC @ 0.2 ml/l at 25 DAS as well as whorl application of carbofuran 3G @ 7.5 kg/ha proved superior over control and were on par with each other.

3.5 Phytotoxicity of newer molecules of insecticides on maize

None of the treatments revealed the phytotoxicity symptoms like leaf injury, wilting, necrosis, vein clearing, epinasty and hyponasty indicating the safety of those molecules to maize crop.

3.6 Cost economics of stem borers management in maize by using newer molecules of insecticides during 2010-11 (*kharif* and *rabi* pooled)

From the data presented in Table 4, it is evident that maximum net profit was realised in carbofuran and endosulfan treatments (37851.00 and 37197.90 Rs./ha, respectively). The treatments to followed included emamectin benzoate (36649.20 Rs./ha), spinosad (Rs. 33723.37), flubendiamide (Rs. 30010.50), indoxacarb (Rs. 29507.70) and thiodicarb (Rs. 29445.43). The lower net profit was found in imidacloprid (₹28210.90) and thiomethoxam (27359.63 Rs./ha).

The maximum IBC ratio of 28.62 was registered in endosulfan followed by imidacloprid (23.13), carbofuran (17.19), emamectin benzoate (13.44), indoxacarb (11.22), spinosad (7.63) and thiodicarb (6.84) and the lower IBC ratio was recorded in flubendiamide (5.07) and thiomethoxam (6.72).

Whorl application will be more useful to conserve the natural enemy population where they will not directly come in contact as compared to foliar sprays of insecticides. In addition, whorl application of carbofuron is more economical than foliar application of any insecticides. Furadan being a systemic insecticide was effective even after the larvae penetrate into the stem. Even though endosulfan resulted in better efficacy and more economical during first year of the experiment compared to other insecticide treatments, in the subsequent year, the chemical has been withdrawn from the market. Therefore, in the present study among five tested chemicals, carbofuron found to be the next best chemical in controlling the stem borers and economical as well.

The above results regarding the superiority of insecticides against maize stem borers are in line with the findings of [21] who observed that carbofuran applied as seed dressing was the most effective treatment followed by spray of endosulfan @ 0.07 per cent. Likewise, [8] reported that endosulfan and carbofuran applied in the plant whorl @ 5 to 7.5 kg per ha were effective in controlling the stem borer on sorghum after 25^{th} and 35^{th} day after sowing. Further, [5] reported that endosulfan 35EC @ 0.10 per cent spray application at 10 days of germination of maize crop followed by an application of endosulfan granules (4%) in the whorl of the plant at a reduced dosage of 5 kg per ha was found to be effective in reducing the stalk borer, *S. inferens* infestation. [19] reported that endosulfan 35EC @ 0.075 per cent applied at 7 to 8 weeks after the emergence of maize and 8 to 9 weeks after the emergence of sorghum gave the best control of *C. partellus*.

The results were also in accordance with the [17] who evaluated the efficacy of different insecticides and bioagents against *S. inferens* in maize and reported that endosulfan 35EC @ 0.07 per cent was found to be highly effective recording lowest leaf injury rating (LIR) followed by carbofuron 3G. Whorl application of carbofuran 3G @ 7.5 kg/ha and phorate 10G @ 7.5 kg/ha proved to be the best followed by emamectin benzoate 5SG @ 0.2g/l which performed highly effective and economical in reducing the stem borers damage in maize [9].

The result of present study with effectiveness of spinosad treatment is in agreement with [1], who swowed spinosad could effectively control the stem borer incidence. [18] also reported that single spray of spinosad at 0.12 ml/l at 25 DAS were found superior in reducing the stem borer damage in maize with higher grain yield and net profit which is in accordance with the present study. More or less similar results were observed by [10] who reported Carbofuron 3G @ 7.5 kg/ha, emamectin benzoate 5SG @ 0.2 g/l, spinosad 45SC @ 0.2 ml/l, flubendiamide 480 SC @ 0.2 ml/l and rynaxypyr 20SC @ 0.3 ml/l spray at 15 and 30 DAS as well as whorl application of carbofuran 3G @ 7.5 kg/ha proved superior over untreated control against maize stem borers which were on par with each other and did not produce any phytotoxicity symptoms on maize plants. Spinosad 45SC, emamectin benzoate 5SG, carbofuron 3G, flubendiamide 480 SC, thiacloprid 21.7 SC, rynaxypyr 20SC and NSKE at four times of their recommended dosage also did not produce any type of phytotoxicity symptoms on the plants.

The lower percent damage (5.3%) with higher crop yield (4.52 t/ha) and lowest insect score (1.00) was observed in plot sprayed with spinosad 45% EC at 0.5 ml/l of water followed by plot treated with chloropyriphos 50EC + cypermethrin 5EC @1.5 ml/l of water with percent damage of 6.60%, crop yield (4.23 t/ha) and insect score of 1.60. Over the years, spinosad 45 EC at 0.5 ml/l of water was effective bio-pesticide to control maize stem borer damage and also increase the yield [20].

Table 1: Treatment details of management of maize stem borers with chemical insecticides

Sl. No.	Common name	Trade name	Dose	Method and time of application
1	Spinosad 45 SC	Tracer	0.2 ml/l	Spray at 25 DAS
2	Emamectin benzoate 5 SG	Proclaim	0.2 g/l	Spray at 25 DAS
3	Imidacloprid 600 FS	Gaucho	6.0 g/kg	Seed treatment
4	Carbofuran 3 G	Furadon	7.5 kg/ha	Whorl application at 25 DAS
5	Endosulfan 35 EC	Endocel	2 ml/l	Spray at 25 DAS
6	Thiodicarb 75 WP	Larvin	1 g/l	Spray at 25 DAS
7	Indoxacarb 14.5 SC	Avaunt	0.3 ml/l	Spray at 25 DAS
8	Thiamethoxam 35 FS	Actara	10 g/kg	Seed treatment
9	Flubendiamide 480 SC	Fame	0.3 ml/l	Spray at 25 DAS
10	Untreated check	-	-	-

DAS: Days after of sowing

Table 2: Visual scoring for phytotoxicity

Score	Phytotoxicity (%)
0	No Phytotoxicity
1	0-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

Table 3: Bioefficacy of insecticides against maize stem borers during 2010-11 (*kharif* and *rabi* pooled)

Treatments	Dose	Leaf scraping + Pin holes (%)				Dead hearts (%)			Grain yield (q/ha)	% yield increase over control
		1 DBT	15DAT	% protection over control	Score (1-9)	1 DBT	15DAT	% protection over control		
Spinosad 45 SC spray	0.2 ml/l	35.12 (36.33)^{b}	24.49 (29.65)^{ab}	43.93	4.13	16.87 (24.24)^{a}	10.32 (18.73)^{bc}	53.33	62.07^{b}	33.32
Emamectin benzoate 5 SG spray	0.2 g/l	34.99 (36.26)^{b}	24.03 (29.34)^{ab}	45.02	3.43	16.01 (23.56)^{a}	8.91 (17.32)^{ab}	60.42	64.38^{ab}	38.29
Imidacloprid 600 FS seed treatment	9 ml/kg	32.43 (34.70)^{a}	33.55 (35.39)^{c}	22.93	5.02	14.83 (22.64)^{a}	15.71 (23.33)^{d}	29.74	54.36^{d}	16.80
Carbofuran 3 G whorl application	1 kg/ha	35.26 (36.42)^{b}	22.39 (28.17)^{a}	49.04	3.43	16.24 (23.75)^{a}	8.05 (16.44)^{a}	64.17	65.40^{a}	40.48
Endosulfan 35 EC spray	2 ml/l	35.83 (36.76)^{b}	22.95 (28.61)^{a}	47.54	3.43	16.46 (23.92)^{a}	9.85 (18.17)^{abc}	56.11	64.19^{ab}	37.89
Thiodicarb 75 WP spray	1 g/l	36.82 (37.35)^{b}	32.07 (34.48)^{c}	26.55	6.63	16.33 (23.83)^{a}	10.93 (19.28)^{bc}	51.05	57.05^{cd}	22.55
Indoxacarb 14.5 SC spray	0.3 ml/l	36.17 (36.97)^{b}	33.03 (35.07)^{c}	24.23	6.63	16.34 (23.84)^{a}	12.08 (20.33)^{c}	45.81	56.36^{cd}	21.03
Thiomethoxam 35 FS seed treatment	10 ml/kg	32.64 (34.84)^{a}	34.75 (36.12)^{c}	20.22	5.07	14.71 (22.50)^{a}	15.67 (23.29)^{d}	29.92	54.48^{d}	16.99
Flubendiamide 480 SC spray	0.3 ml/l	35.82 (36.76)^{b}	27.22 (31.42)^{b}	37.71	4.05	16.95 (24.31)^{a}	11.10 (19.45)^{bc}	50.22	58.58^{c}	25.78
Untreated check		36.16 (36.96)^{b}	43.51 (41.26)^{d}	43.93	8.10	17.64 (24.82)^{a}	22.44 (28.24)^{e}	-	46.57^{e}	33.32
S.Em. ±		0.48	0.84	-		0.51	0.71	-	0.87	
C.D. (0.05)		1.41	2.49	-		1.52	2.10	-	2.60	

Figures in parentheses are arc sine transformed values, means followed by same alphabet do not differ significantly (0.05) by DMRT,
DBT: Day before treatment   DAT: Days after treatment

Table 4: Cost economics of stem borers management in maize by using newer molecules of insecticides during 2010-11 (*kharif* and *rabi* pooled)

Treatments	Dose	Grain yield (q/ha)	Gross returns (`/ha)	Cost of plant protection (`/ha)	Total cost (`/ha)	Net profit (`/ha)	IBC ratio
Spinosad 45 SC spray	0.2 ml/l	62.07	58347.37	2124.00	24624.00	33723.37	7.63:1
Emamectin benzoate 5 SG spray	0.2 g/l	64.38	60517.20	1368.00	23868.00	36649.20	13.44:1
Imidacloprid 600 FS seed treatment	9 ml/kg	54.36	51098.40	387.50	22887.50	28210.90	23.13:1
Carbofuran 3 G whorl application	7.5 kg/ha	65.40	61476.00	1125.00	23625.00	37851.00	17.19:1
Endosulfan 35 EC spray	2 ml/l	64.19	60333.90	636.00	23136.00	37197.90	28.62:1
Thiodicarb 75 WP spray	1 g/l	57.05	53625.43	1680.00	24180.00	29445.43	6.84:1
Indoxacarb 14.5 SC spray	0.3 ml/l	56.36	52973.70	966.00	23466.00	29507.70	11.22:1
Thiamethoxam 35 FS seed treatment	10 ml/kg	54.48	51209.63	1350.00	23850.00	27359.63	6.72:1
Flubendiamide 480 SC spray	0.3 ml/l	58.58	55060.50	2550.00	25050.00	30010.50	5.07:1
Untreated check	-	46.57	43771.10	0.00	22500.00	21271.10	-

Spinosad: Rs.15200/l : Emamectin benzoate: Rs.8900/kg : Imidacloprid: Rs.2700/kg : Carbofuran: Rs.80/kg: Endosulfan: Rs.280/l : Thiodicarb: Rs.2100/kg : Indoxacarb: Rs.3600/l : Thiamethoxam: Rs.5000/kg : Flubendiamide: Rs.16000/l : Labour charge: Rs.100/ labourer (3 labourers required for one ha for 1 spray, 6 labourers required for one ha for whorl application of carbofuron) (1 labourers required for one ha of seed treatment), IBC: Incremental benefit cost

4. Conclusion

Among the different newer molecules of insecticides evaluated, single spray of emamectin benzoate 5SG @ 0.2 g/l or spinosad 45SC @ 0.2 ml/l at 25 DAS as well as whorl application of carbofuran 3G @ 7.5 kg/ha being on par with each other proved superior over untreated control. The recorded response of new insecticides towards stem borers showed less or no adverse effect on environment. None of the treatments revealed phytotoxicity symptoms on maize at recommended dosage. These new insecticides which can replace the endoslfan for the management of maize stem borers.

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6. References
1. Ahmed S, Saleem MA, Rauf I. Field efficacy of some bioinsecticides against maize and jowar stem borer, *Chilo partellus* (Pyralidae: Lepidoptera). International Journal of Agricultural Biology. 2002; 4(3):332-334.
2. Ajala SO, Saxena KN. Interrelationship among *Chilo partellus* (Swinhoe) damage parameters and their contribution grain yield reduction in maize (Zea mays L.). Applied Entomology and Zoology. 1994; 29:469-476.
3. Borad PK, Mittal VP. Assessment of losses caused by pest complex to sorghum hybrid CSH 5: in Crop losses due to insect pests (Krishnamurthy Rao, B. H. and Murthy, K. S. R. K., eds.). Special issue of the Indian Journal of Entomology. Entomological Society of India, Rajendranagar, Hyderabad, Andhra Pradesh, India. 1983, 271-278.
4. Chatterji SM, Young WR, Sharma GC, Sayi JV, Chabai BS, Khare BP *et al*. Estimation of loss in yield of maize due to insect pests with special reference to borers. Indian Journal of Entomology. 1969; 31:109-115.
5. Godbole SD. A review of the work done on the maize stalk borer, Sesamia inferens (Walker) under co-ordinated maize improvement project In Joginder Singh (Compiled) twenty five years of maize research in India (1957-1982) Silver Jubilee workshop of the All India Co-ordinated Maize improvement Project. 1983. Indian Agricultural research Institute, New Delhi, 1983, 421-429.
6. Groote HD. Maize yield losses from stemborers in Kenya. Insect Science and its Application. 2002; 22(2):89-96.
7. Kishore M. Evolving management strategies for pests of millets in India. Journal of Entomology Research. 1996; 20(4):287-297.
8. Kulkarni KA, Jotwani MG. Chemical control of sorghum stem borer, Chilo partellus (Swinhoe). The Karnataka University of Journal Science. 1976; 21:286-292.
9. Kulkarni S, Mallapur CP, Balikai RA. Bioefficacy of insecticides against maize stem borers. Journal of Experimental Zooloogy, India. 2015; 18(1):233-236.
10. Mallapur CP, Chouraddi Manjunath. Bioefficacy of insecticides against stem borers and their phytotoxicity on maize plants. Journal of Experimental Zooloogy, India. 2014; 17(1):197-202.
11. Mallapur CP, Chouraddi Manjunath. Stenachroia elongella Hampson- A new threat to maize cultivation in karnataka, India. Journal of Experimental Zooloogy, India. 2015; 18(1):327-329.
12. Mallapur CP, Manjunath Chouraddi, Prabhu Nayak, Prashanth K, Balikai RA. Incidence and distribution of maize stem borers in farmer's fields of Karnataka state. Journal of Experimental Zooloogy, India. 2012; 15(1):245-249.
13. Manjunath Chouraddi, Mallapur CP, Basavana Goud K, Patil RH. Status of stem borers in major maize growing areas of Karnataka, India. Journal of Experimental Zooloogy, India. 2012; 15(2):505-511.
14. Manjunath Chouraddi, Mallapur CP, Balikai RA. Status of natural enemies of maize stem borers in karnataka. Annuals of Entomology. 2014-15; 32-33:17-22.
15. Manjunath Chouraddi, Mallapur CP, Balikai RA. Evaluation of biopesticides/bio-control agents against maize stem borers. Annuals of Entomology. 2016; 34:15-21.
16. Pal R, Singh G, Prasad CS, Ali N, Kumar A, Dhaka SS. Field evaluation of bio-agents against *Chilo partellus* (Swinhoe) in maize. Annals of Plant Protection Sciences. 2009; 17(2):325-327.
17. Pavani T, Uma Maheshwari, Sekhar SC. Evaluation of efficacy of different insecticides and bioagents against *Sesamia inferens* in maize. International conference on plant health management for food security, Hyderabad, 2012, 164.
18. Pragati Meti. Dynamics of arthropod fauna in conservation agriculture based maize system and management of insect pests. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Raichur, Karnataka, India. 2013, 303.
19. Rensburg JBJ, Berg JV, Van RJBJ, Van BJ. Timing of insecticide application for stem borer control in maize and grain sorghum. Appl. Pl. Sci. 1992; 6:24-27.
20. Saraswati N, Ghanashyam B. Management of stem borer (*Chilo partellus* Swinhoe) in maize using conventional pesticides in Chitwan, Nepal. Journal of Maize Research and Development. 2016; 2(1):13-19.
21. Srivastava KP. Chemical control of sorghum pests and studies on persistence of insecticides used on sorghum crop. Entomology News Letter. 1976; 6:12-14.
22. Swaine G. The maize and sorghum stalkborer, Busseola fusca in peasant agriculture in Tanganyika territory. Bulletin of Entomology Research. 1957; 48:711-722.