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Management of Sweet Potato Weevil *Cylas formicarius* (Fab.)

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Abstract

Sweet potato is one of the major tuber crops cultivated in Telangana. Sweet potato weevil *Cylas formicarius* (Fab.) is one of the major constraints in its production. The present study was conducted under All India Coordinated Research Project on Tuber Crops at Vegetable Research Station, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, during the year 2016-17 and 2017-18. Among the different treatments evaluated for the management of SPW, installation of pheromone traps @ one per 100 m^2 was found to be the best treatment in the management of SPW with lowest number of weevils in the collar region at 30 days (0.45) which increased during later period of 60 days (0.90), 90 days (1.40) compared to the other treatments. This treatment resulted in very good marketable yield of 14.20 t ha^{-1} compared to the total yield of 16.09 t ha^{-1} indicating better management of SPW with use of pheromones.

Key words: Sweet potato, *Cylas formicarius*, weevil, pheromone traps

Introduction

Sweet potato is one of the most important tuber crops ranked seventh most important food crop of the world after wheat, rice, maize, potato, barley and cassava (ASHS, 2007; Jan low et al., 2015; CIP, 2017). Globally sweet potato is cultivated in 117 countries in an area of 8.62 million ha producing 105.19 million tons with a yield of 12.20 t ha^{-1} (FAO, 2016). It is an herbaceous perennial vine with smooth skin, tapering and long. It has wide colour range of tuber skin i.e. purple, brown and white which contains wide range of flesh i.e. yellow, orange, white and purple. Sweet potato has several nutritional advantages and it is consumed in various forms. Young and succulent sweet potato leaves, rich in protein and vitamins which are used as a leafy vegetable in SSA (Sub Saharan Africa). The storage root is rich in carbohydrate and β carotene, especially in the orange-fleshed sweet potato (OFSP) varieties. In the recent years, sweet potato is used for animal feed and industrial starch instead of being used as staple food. In India, it is cultivated in almost all the states but major contribution comes from four states namely Odisha, Kerala, West Bengal and Uttar Pradesh. Odisha is the largest producer of sweet potato in India. The area under sweet potato cultivation in India is 0.13 million ha with a production of 1.47 million tons (FAO, 2016). Sweet potato is traditionally considered to be a hardy crops and it is a rich source of carbohydrates, vitamins and minerals for the poor farmers in many developing countries and also it can produce more edible energy per ha per day than wheat, rice and cassava (Jan low et al., 2015; CIP, 2017). However, sweet potato was traditionally grown as a food crop after cereals in major sweet potato growing districts of Odisha as it gives more returns with less inputs (Gains project, 2013). For optimum yield, tubers should be sown in nursery beds in the month of January to February and the optimum time for planting vines in the field is in the month of April to July. In Telangana state sweet potato is grown in rabi from October to April months under irrigated conditions. It is grown in variety of soil types ranging from sandy to loamy soil, but it gives best result when grown under sandy loam soil having high fertility and good drainage system. Cultivation of sweet potato in very light sandy and heavy clayey soil is not good for tuber development. It requires pH ranging from 5.8-6.7 which is best for sweet potato cultivation. Punjab Sweet Potato-21, Varsha, Konkan Ashwini, Sree Arun, Sree Kanaka, Sree Varun, H-41, H-42, Co 3, Co CIP 1, Sree Vardhini, Sree Rethna, Sree Bhadra, Sree Nandini, Kanjanghad, Gouri, Sankar and Kiran are some of the popular varieties grown in India.

The major constraints in sweet potato production are availability of quality planting materials and management of SPW, *Cylas formicarius* (Fab.) (Fuglie, 2007). Sweet potato weevil is present in tropical and subtropical regions of the world and it can survive even in the higher altitude areas and can tolerate low temperatures also (Kandori et al., 2006). In India, farm surveys revealed that 25.45% yield loss due to SPW in Odissa, 5-50% in Bihar, 4-50% in Kerala (Pillai et al., 1993). Though several strategies were worked out for the management of SPW, it continues to be a major pest of sweet potato and still more management strategies are required to contain the pest. *Cylas formicarius* is an Asian species usually found in North America, the Caribbean, Europe, Africa and Asia. *Cylas brunneus* and *Cylas puncticollis* are African species and are restricted to Africa. Rough SPW (*Blosyrus* spp) and striped SPW (*Alcidodes dentipes* and *Alcidodes erroneous*) also cause damage to sweet potato but their damage is not as that of main sp, *Cylas* spp. (Ames et al., 1996).

SPW damages all parts of the plant. While laying eggs the female weevils excavate cavities and lay eggs which will be deposited near the collar region and root (tubers). The eggs are covered with dark colour excrement from female adults (Capinera, 2001). Hatched larvae making tunnels inside tubers and feed inside galleries (Onwueme and Charles, 1994). As the larvae feed, sweet potato will impart a bitter flavor due to terpene odour, making it unsuitable for consumption by livestock and humans. The presence of terpenoides will reduce the root quality of tubers and marketable yield (Uritaini et al., 1975).

There are several factors that influence the SPW infestation. Larvae also mine the vines of sweet potato causing cracks and vines collapse. Yellowing of vines will be observed only if the vine is severely infested. The cultivars with pink and red coloured tubers as well as lobed leaves and thin foliage are more susceptible compared to brown and white coloured tubers (Teliand and Salunkhe, 1996). The cultivars with deep storage roots and early maturing (80-90 days) have recorded reduced SPW infestation (Lima and Morales, 1992). Female weevils tend to lay eggs in older portions of vines compared to younger vines (AVRDC, 1990).

Studies conducted in India indicated that tuber damage was higher (71%) during February-May compared to June-September (45%) (Rajamma and Goel, 1983). The damage of tuber by SPW is more in dry season compared to wet season because it mostly relies on cracks in dry soil to reach the storage roots (Hahn and Leuschner, 1982; Sutherland, 1986). Strategies to overcome SPW infestation include mixed cropping or inter-cropping, mulching, irrigation, re-ridging, sanitation, use of entomopathogenic fungi, bacterial insect pathogens, sterile insect technique, chemical control and use of sex pheromone traps (Seow-Mun Hue and Minyang low 2015).

Various synthetic chemical insecticides are being used in sweet potato fields for the management of SPW. Sex pheromone trap is widely used to capture adult SPW. The trap is usually designed with synthetic pheromone lure such as (Z)-3-dodecen-1-ol (E)-2-butenoate together with ethyl acetate. It is usually placed at the ground level to facilitate the entrance of adult weevils, which will be killed by the insecticide inside the trap. Pheromones are used in three ways: mass trapping to reduce insect pest population, monitoring insect populations using pheromone traps and mating disruption by applying high dosage of pheromone in the atmosphere (Kydonieus and Beroza, 1982). This study focus on evaluation of different strategies to manage SPW.

Material and Methods

The present study was conducted under the All India Coordinated Research Project on Tuber Crops at Vegetable Research Station, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University under irrigated conditions. The sweet potato crop was raised as per the standard package of practices with five treatments and four replications in a randomized block design. Both the years, the crop was raised during two consecutive seasons viz., November 2016 to December 2017 and November 2017 to December 2018. The following five treatments for the management of SPW were:

T_1 - Installation of pheromone traps @ one per 100 m^2 (This treatment should be minimum 50 m away from treatment 2 to 5).

T_2 - Neem oil spray 5 ml /litre, at 45, 60 and 75 days after planting (DAP).

T_3 - Emamectin benzoate 5 SG @ 0.55 g/ litre of water at 45 and 65 DAP.

T_4 - Dipping the planting material in 0.02% chlorpyriphos (20 EC) for 10 min, earthing up along with weeding and fertilizer application, Spray 0.02% chlorpyriphos (20 EC) at 30 &60 days after planting, Spray Nanma at45,75 DAP.

T_5 - Control (as a general recommendation, the wines were treated with chloropyriphos at the rate of 2ml/ l for 10 minutes and planted.

1. Incidence of weevil

Randomly selected 10 plants were observed at the collar region (the region just above the ground level) for weevil infestation. Observations were taken during 30 and 60 days after planting and at harvest. Plants uprooted at 30 and 60 days after planting.

2. Tuber damage by weevil

After harvest, the tubers were segregated based on weevil infestation and scores were given as score 0 with no infestation, score at 1, 2, 3 as less than 10% (usually seen at the neck of the tuber), 11-20% (the infestation spreads form neck region to the middle of the tuber) and above 20% (the entire tuber will be infested).

Yield at harvest, marketable tubers and infested tubers were recorded. The infested tubers again be classified as mild (<10% infestation), medium (<50%) and high (>50%). Data on SPW infestation was subjected to square root transformation and statistical analysis was done. Yield data was recorded and BC ratio was calculated.

Results and Discussion

When compared to T_5 control treatment values in 30 DAP (2.54), 60 DAP (4.48) and 90 DAP (9.37), T_1 treatment block installed with sex pheromone effect was shown during early period of crop growth in 30 DAP (0.45) which increased during later period of 60 DAP (0.90), 90 DAP (1.40). Treatment T_2 with neem oil application had better effect even during early period of crop as in 30 DAP (2.17), increased during 60 DAP (3.38) and 90 DAP (8.27). Treatment T_3 with application of emamectin benzoate had effective control as from the beginning 30 DAP (2.42) till later period of 60 DAP (4.15) and 90 DAP (6.84). Treatment T_4 had lesser control over SPW when compared to other chemical treatments as from the beginning as in 30 DAP (1.55), 60 DAP (2.20) and in 90 DAP (4.92). Among the five treatments, treatment T_1 resulted in maximum reduction of weevil infestation. Rajasekhara Rao et al., 2010 reported that the female sex pheromone (Z)-3-dodecen-1-ol (E)-2-butenoate occupied an inclusive component in the management of SPW worldwide. Z-3-dodecane-1-01 (E)-2-butanoate isolated from female SPW and chemically synthesized(Heath 1998) is a successful mating disruptant of SPW (Reddy et al., 2012). This novel compound provides several applications such as detection of weevil outbreaks, monitoring of existing weevil population to schedule eradication programme and control of mating in adult population by attracting a large portion of male weevils or by disrupting of mating true inhibitory properties. Reddy et al., 2012 evaluated pheromone trap size, trap colour, trap design and height of trap placement that will influence the effectiveness sex pheromone trap used along with Z-3-dodecane-1-01 (E)-2-butanoate. It was observed that medium-sized red pherocon (USA) unitraps (13cm x 17.5cm) were more effective for the management of SPW.

Pheromone traps can be used as one of the components in the integrated pest management. The potential of sex pheromone as a mating disruptant for the control of *C. formicarius* was studied in sweet potato (Mason and Jansson 1991, Yasuda, 1995).This sex pheromone has changed the pest dynamics in the field and has become an important tool in *C. formicarius* IPM (Rajashekara Rao et al., 2012). The sex ratio of the population in such traps is largely female based and the mating rate of females is reduced (Yasuda, 1995). Palaniswami et al., (2000) reported that dichloromethane extract of sweet potato periderm contained a pentacyclic triterpenoid compound boebmeryl acetate which attracts both sexes of SPW.

The tuber infestation was lowest in treatment T_1 i.e, 22.77 per cent at 90 DAP and 26.35 per cent at 120 DAP compared to other treatments. After harvest, yield was taken into account in two categories as total yield and marketable yield which can indicate the effect of different treatments (Table 3). Lowest marketable yield

Table 1. Effect of different treatments on the number of weevils in collar region (Grubs and adults/5 plants)

Treatment	Vine infestation								
	30 DAP			60 DAP			90 DAP		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T_1	0.50	0.40	0.45	1.00	0.80	0.90	1.69	1.10	1.40
	(1.22)	(0.91)	(0.67)	(1.40)	(1.12)	(0.94)	(1.61)	(1.23)	(1.17)
T_2	2.33	2.00	2.17	3.75	3.00	3.38	8.93	7.60	8.27
	(1.82)	(1.58)	(1.47)	(2.16)	(1.82)	(1.83)	(3.14)	(2.83)	(2.87)
T_3	2.63	2.20	2.42	4.30	4.00	4.15	7.28	6.40	6.84
	(1.90)	(1.63)	(1.55)	(2.29)	(2.11)	(2.03)	(2.87)	(2.61)	(2.61)
T_4	1.69	1.40	1.55	2.33	2.20	2.27	5.23	4.60	4.92
	(1.62)	(1.36)	(1.24)	(2.07)	(1.61)	(1.50)	(3.19)	(2.24)	(2.21)
T_5	2.88	2.20	2.54	4.75	4.20	4.48	9.93	8.80	9.37
	(1.96)	(1.58)	(1.58)	(2.37)	(2.16)	(2.11)	(3.30)	(3.04)	(3.05)
CD (0.05)	0.26	0.99	0.96	0.41	1.30	0.72	0.53	1.38	0.62
CV	10.03	44.81	17.85	9.67	34.14	8.59	7.41	18.08	3.66

* Values in parenthesis are square root transformed values.

Table 2. Effect of different treatments on the weevil infestation in collar region at 60, 75 and 90 DAP

Treatment	Weevil infestation in collar region								
	60 DAP			75 DAP			90 DAP		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T_1	1.30	1.27	1.29	2.13	2.50	2.32	5.00	5.33	5.17
	(6.47)	(1.09)	(1.13)	(8.36)	(1.57)	(1.52)	(12.83)	(2.29)	(2.27)
T_2	4.50	4.73	4.62	8.89	8.90	8.90	13.00	15.00	14.00
	(12.21)	(2.17)	(2.14)	(17.27)	(2.98)	(2.98)	(21.07)	(3.86)	(3.73)
T_3	4.70	4.33	4.52	11.54	10.50	11.02	13.35	14.33	13.84
	(12.45)	(2.07)	(2.12)	(19.76)	(3.23)	(3.31)	(21.47)	(3.77)	(3.71)
T_4	2.35	2.37	2.36	7.04	6.50	6.77	8.75	8.23	8.49
	(8.63)	(1.53)	(1.53)	(15.36)	(2.54)	(2.60)	(17.18)	(2.86)	(2.91)
T_5	8.30	7.10	7.70	15.05	16.63	15.84	19.15	20.20	19.68
	(16.72)	(2.66)	(2.77)	(22.71)	(4.07)	(3.97)	(25.93)	(4.49)	(4.43)
CD (0.05)	2.18	1.11	1.10	2.94	1.79	1.93	1.93	2.94	1.83
CV	12.39	14.95	9.71	11.30	10.57	7.77	6.29	12.39	5.39

* Values in parenthesis are angular transformed values.

Table 3. Effect of different treatments on tuber infestation (%)

Treatment	90 DAP			120 DAP		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T_1	21.54(27.69)	24.00(29.30)	22.77(28.49)	25.90(30.65)	26.80(30.27)	26.35(30.46)
T_2	41.68(40.16)	42.00(40.37)	41.84(40.26)	48.50(42.15)	51.60(45.48)	50.05(43.81)
T_3	39.13(38.6)	38.60(38.38)	38.86(38.49)	42.30(39.11)	41.50(37.67)	41.90(38.39)
T_4	36.40(36.67)	33.47(35.32)	34.93(35.99)	35.80(36.63)	39.60(38.76)	37.70(37.69)
T_5	72.79(58.66)	80.07(63.49)	76.43(61.07)	81.50(61.34)	84.50(62.18)	830(61.76)
CD(0.05)	1.51	2.50	2.00	3.86	4.50	4.18
CV	8.40	10.90	9.65	5.90	6.80	6.35

Table 4. Effect of different treatments on tuber infestation

Treatment	Marketable Yield (t ha^{-1})			Total Yield (t ha^{-1})		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean
T_1	13.12	15.28	14.20	17.06	19.68	18.37
T_2	6.81	7.28	7.05	16.53	16.94	16.74
T_3	8.13	8.02	8.08	18.86	17.56	18.21
T_4	11.08	12.66	11.87	16.22	18.18	17.20
T_5	4.85	5.14	5.00	15.47	16.70	16.09
CD(0.05)	3.05	2.50	1.87	NS	2.45	2.98
CV	18.44	19.23	7.29	10.46	10.26	6.20

Table 5. Benefit cost ratio of different treatments

Treatments	Cost of cultivation (`)		Total cost	Yield (t ha^{-1})	Rate (` kg^{-1})	Gross income (`)	Net income (`)	Benefit Cost Ratio
	Fixed	variable						
T_1	77,880	2000	79,880	18.37	10	1,83,700	1,03820	1.30
T_2	77,880	6000	83,880	16.74	10	1,67,400	83,520	1.00
T_3	77,880	3975	81,855	18.21	10	1,82,100	1,00,245	1.22
T_4	77,880	8500	85,380	17.20	10	1,72,000	85,620	0.99
T_5	77,880	00	77,880	16.09	10	16,090	83,020	1.07

(5.00 t ha^{-1}) was recorded in T_5 treatment as compared to total yield (16.09 t ha^{-1}) whereas T_2 and T_3 treatments also shown lower performance as 7.05 t ha^{-1} and 8.08 t ha^{-1} compared to total yield 16.74 t ha^{-1} and 18.21 t ha^{-1} respectively. T_4 treatment has shown better performance as 11.87 t/ha compared to total yield of 18.37 t ha^{-1}. T_1 treatment has shown best control measure with very good marketable yield of 14.20 t ha^{-1} compared to total yield of 18.37 t ha^{-1} indicating better control of SPW with use of pheromones.

Similar studies were also conducted on chemical control of SPW. Mason and Jansson (1991) conducted an experiment to compare the toxicity of five insecticides: parathion, carbamate, methomyl, chlorpyrifos, chlorinated hydrocarbon endosulfan, and carbamate carbaryl, against adult *Cylas formicarius* using Petri dish bioassays in laboratory and suggested chlorpyrifos and parathion for the control of SPW due to their higher toxicity. Hwang and Hung (1994) conducted a field experiment to test the efficacy of five insecticides: chlorpyrifos, phorate, terbufos, fensulfothion and carbofuran, in controlling SPW, by applying the insecticide twice to soil before planting and during earthing up. The results showed that chlorpyrifos had the highest rate of control (76.8%), followed by fensulfothion (51.3%), phorate (44.9%), carbofuran (38.8%), and lastly terbufos (38.0%). In both studies, chloprryrifos demonstrated a high efficacy in suppressing SPW infestation and hence it is widely used in the integrated pest management of this pest.

Reddy et al., (2014) conducted a field study in Guam to determine the efficacy of controlling *Cylas formicarius* using bucket traps with (Z)-3-dodecen-1-ol (E)-2-butenoate. Their effectiveness were measured by the total damages caused by weevil and the total sweet potato yield for that season. The results showed that sweet potato roots damage in both locations with traps was very low (< one feeding hole per root) from June to September, compared to locations without traps (approximately 38 feeding holes per root) during the same duration. In a separate study, Smit et al., (2001) conducted field experiments to determine the efficacy of mass trapping of *C. brunneus* and *C. puncticollis* by using decyl (E)-2 butenoate and dodecyl (E)-2-butenoate, one of the important components of adult sweet potato female weevil sex pheromones and proved that pheromone traps baited with female sex pheromone could reduce the male SPW population effectively and ultimately reduced the chances of mating in the population.

Considering the benefit cost ratio of different treatments,T_1 and T_3 treatments resulted in significant benefit cost ratio of 1.30 and 1.22 respectively which indicates that T_1 treatment with the use of sex pheromones had best control of SPW with cost effective measures. Number of weevils in collar region, weevil infestation on the collar region at 60,75 and 90 DAP were also minimum in (T_1) i.e, installation of pheromone traps @ one per 100 m^2.

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