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To evaluate efficacy of neem oil spray in comparison to pesticide applied to control armyworm (*Spodoptera exigua* L.) population in sugar beet

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Abstract
Sugar beet Armyworm is an important pest of vegetables and other crops throughout the world. Field experiments were conducted to evaluate efficacy of neem oil spray in comparison to pesticide on sugar beet armyworm S*podoptera exigua* during 2006-07 and 2007-08 at PARC-NSTHRI farm, Thatta. The armyworm infestation data indicated that minimum average population of armyworm was (1.43 and 0.88) in T-3 followed by (1.65 and 1.07), (1.77 and 1.04) and (1.81 and 1.58) in T-5, T-2 and T-4 respectively as compared control plot (3.64 and 3.58) during 2006-07 and 2007-08. However, from the results of yield, it was observed that T-5 produced significantly higher yield (116.940 and 115.205 t ha^{-1}) followed by T-3 (115.078 and 112.675 t ha^{-1}), T-4 (113.666 and 112.687 t ha^{-1}) and T-2 (110.315 and 110.658 t ha^{-1}) as compared control plot (68.280 and 68.500 during the year 2006-07 and 2007-08 respectively. Furthermore, the result of sugar content % showed no significant different among treatments. However, the data of sugar yield indicated that maximum (13.250 and 13.052 t ha^{-1}) yield was observed in T-5 followed by in T-3 (12.993 and 12.766 t ha^{-1}), T-2 (12.412 and 12.482 t ha^{-1}), T-7 (8.073 and 7.958 t ha^{-1}), T-6 (7.850 and 7.824 t ha^{-1}) and in T-1 control (7.630 and 7.619 t ha^{-1}) during 2006-07 and 2007-08 respectively.

Keywords: Sugar beet, S*podoptera exigua*, neem oil, pesticide

1. Introduction
Sugar beet (*Beta vulgaris* L.) is a most important sugar crops in the world which has great importance to accomplish the requirement of market for sugar supply and it is one of the better choices for the production of sugar which contains a sufficient amounts 16-20% of sucrose over than in sugarcane (Duraisam, *et al.*, 2017) [5]. Sugar beet is a also high value cash crop of central zone of NWFP and play a vital role in the economy of farming community and industrial sector (Khan *et al.*, 2004) [16]. Sugar beet is 2nd to sugarcane contribute 35% of world sugar production (Deho, 2002) [4]. It possesses 30% more sugar than sugarcane (Abdullah *et al.*, 2003) [1]. Like sugarcane, sugar beet also generates national income, employment and earns foreign exchange through white sugar, provides by product i.e. green fodder and pulp etc for cattle at critical stage for southern area of NWFP, it is new introduction and found very successful (Bahadur *et al.*, 2005) [3]. Sugar beet root yield and quality is greatly affected due to attack of sugar beet armyworm.

The beet armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae) is an extremely polyphagous pest which causes significant economic losses to cotton and many vegetable crops (Hafeez *et al.*, 2019) [11]. The *S. exigua* considered to be a secondary pest in some crops (Eveleens *et al.*, 1973) [6] and it is native to Southeast Asia and is key insect pest of edible vegetables in several regions of the world (Lai, 2011; Xia-lin, 2011) [17, 25]. The beet armyworm is a serious pest of Indonesia, Thailand and part of the world (Huffman *et al.*, 1996; Idris, 1998) [12, 13]. It is a pest of vegetables and field crops i.e. been, cabbage, cauliflower, chickpea, corn, cowpea, eggplant, lettuce, onion, potato, radish, spinach, tomato, turnip, alfalfa, corn, cotton, peanut, safflower, sorghum, sugar beet and tobacco (Greenberg, 2001, Saeed, 2010) [10, 20]. Generally BAW could cause extensive damage to the economic crops and it is a prominent problem due to its insecticide resistance, which has been widely documented.

The indiscriminate use of pesticides without pest inspection is main causes of resistance to insects (Ahmad and Arif, 2010) [2]. The pesticide application lead to many serious problems like air and water pollution, health hazards, death of beneficial organism, pest resistance, secondary pest outbreak, interruption of eco-cycle and environmental pollution with the result insect predator gaining more importance in pest management programs (Kapadia and Puri, 1991; Fisher *et al*., 1992) [15, 7]. However, it was reported that BAW have developed resistant to almost all insecticides used against it (Huffman *et al.*, 1996) [12]. Resistance and residue problem with conventional pesticides have caused scientists to seek better to control the BAW outbreak. The use of botanical pesticides for plant protection has assumed greater importance in recent years all over the world due to environmental deterioration and health hazards associated with the use of synthetic pesticides.

Neem *Azadirachta indica* belongs to family Meliaceae and its main active ingredient is Azadirachtin (Xie *et al*., 1995; Zender and Warthen, 1988) [26, 27]. It exhibit antifeedant, insect repellent and insect sterilization properties. It interference with ecdysone, the key insect molting hormone and prevent larvae and pupa, from completing the molting process (Vanathi and Rathika, 2004) [23]. Neem insecticide used to control more than 400 species of insects, such as armyworm, leaf miners, aphids and flies (Schmutterer, 1990; Isman, 1999; Walter, 1999) [22, 14, 24]. It is hoped that extensive use of plant based pesticides in integrated pest management will help in conservation environmental quality. The neem based pesticides are relatively safe and do not leave any residue on agriculture produce. The use of neem products for plant protection will help minimizing atmospheric pollution and prevent food poisoning. It will also reduce the demand for costly chemical pesticides (Patil and Patil, 2008) [19].

This study was amid to investigate the effect of different day's intervals of neem oil spray on the population of *S. exigua*. Information derived from this study could be used in an integrated management of beet armyworm.

2. Materials and Methods

The study was conducted in field to observe the efficacy of Neem oil spray in comparison to pesticide applied on sugar beet on different intervals at PARC-NSTHRI farm, Thatta, during 2006-07 and 2007-08. The experiment was laid out in a randomized complete block design with three replications and seven treatments. The each treatment consisted 7 meters long with 6 ridges; the space was 50 cm between row to row and 20 cm between plants to plant. The treatments was arranged as T-1 control (No spray), T-2 Pesticide spray after 7 days intervals, T-3 Neem oil after 7 days intervals, T-4 Pesticide spray after 14 days intervals, T-5 Neem oil after 14 days intervals, T-6 Pesticide spray after 21 days intervals, T-7 Neem oil after 21 days intervals. The Polyplus variety was used as planting material, after irrigation seed were sown at the rate of 3-4 seeds/ hole. The hoeing was done at 14, 28 and 42 days after planting and thinning was completed 21 days after planting. Recommended fertilizer dose and other agronomic practices were followed uniformly in all treatments. Spray solution were prepared by mixing separately one-litter Neem oil and one-litter Thiodan pesticide in 120 liters of water/ acre. Adjuvant was added to spray volume at the rate of 0.5 gram/ liter for better adhesion of neem oil on plant surface. Data was collected at third day after each spray application. Direct observation method was followed for data collection, for this purpose, 10 plants per plot was randomly selected for counting larvae. The efficacy of neem oil was calculated by comparing them with the untreated control plot and pesticide applied plots. Yield was recorded with in the centre of each plot from 6 m^2 area at harvest.

3. Results and Discussion

The efficacy of neem oil and pesticide were investigated in the field for the controlling sugar beet armyworm during 2006-07 and 2007-08. It was obvious from the experiment that neem oil 7 and 14 day interval provided better control by reducing insect pest in both years. The reduction of larval population of *S. exigua* was observed at all sampling days in neem oil treated plots except 21 day intervals and armyworm population also reduce in pesticide plots which are treated after 7 and 14 days intervals expect 21 day. Greenberg *et al.*, (2005) [9] observed that direct contact with neem-based insecticides decreased the survival of beet armyworm eggs. Survival reduction of beet armyworm larvae fed for 7 days on leaves treated neem based insecticides was recorded 27, 33, 60 and 61% for neem leaf powder, Ecozine, Agroneem and Neemix, respectively. The data of 2006-07 depicted in table-1 revealed that neem oil spray showed better results as compared to pesticide spray in all treatments. It was observed that highest average population of armyworm 3.64, 3.52 and 3.50 was recorded in T-1, T-6 and T-7 respectively and minimum average population 1.43 in T-3, 1.65 in T-5, 1.77 in T-2 and 1.81 in T-4.

The estimated co-efficient of variation for beet weight (kg) 2.57%. The data in table-2 revealed that maximum beet weight 1.821 (kg) obtained in T-5 followed by T-3 (1.792kg), T-4 (1.770kg), T-2 (1.718kg) and that differed significantly. The lowest beet weight was found in T-1 (1.066), T-6 (1.095kg) and in T-7 (1.223kg). However, the estimated co-efficient of variation for beet yield t ha^{-1} 2.63%. The data of beet yield presented in table-2 revealed that highly significant beet yield (t ha^{-1}) was recorded 116.940 in T-5 followed by 115.078, 113.666 and 110.315 in T-3, T-4 and T-2 respectively. But no significant difference was observed among T-7 (72.089t ha^{-1}), T-6 (70.347 t ha^{-1}) as compared to control T-1 (68.50t ha^{-1}). Gohokar *et al.*, (1985) [8] observed that the application of 0.009% cypermethrin and neem seed extract were made at 50% flowering and 15 days later reduced the incidence of *H. armigera* followed by 0.006 cypermethrin and the highest yield was obtained by from plots treated with 0.006% cypermethrin followed by neem seed extract.

The estimated co-efficient of variation for sugar content 1.60%**.** The data presented in table-2 revealed that maximum sugar content of 11.33% was recorded in T-5 followed by 11.29, 11.27, 11.25, 11.20, 11.16 and 11.14 in T-3, T-4, T-2, T-7, T-6 and T-1 respectively. The estimated co-efficient of variation for sugar yield t ha^{-1} 3.30%**.** The data presented in table-2 revealed that maximum sugar of 13.25 t ha^{-1} was obtained in T-5 followed by 12.993, 12.809 and 12.412 in T-3, T-4 and T-2 respectively which are statistically identical but highly significantly differed over T-7 (8.073), T-6 (7.850) and T-1 (7.630) t ha^{-1}.

The data of 2007-08 depicted in table-3 revealed that neem oil spray showed better results as compared to pesticide spray in all treatments. It was observed that highest average population of armyworm 3.58 was in T-1 followed by 2.75, 2.15 in T-6 and T-7, respectively and minimum average population 0.88 in T-3 followed by 1.04, 1.07 and 1.58 in T-2, T-5 and T-4,

respectively. The estimated co-efficient of variation for beet weight (kg) 4.83%. furthermore, the data of beet weight presented in table-4 revealed that maximum beet weight 1.793 (kg) was in T-5 followed by 1.753 and 1.750 in T-4 and T-3 respectively which is significantly differed from T-7 (1.106 kg), T-6 (1.086 kg) and T-1 (1.063 kg). Furthermore, the estimated co-efficient of variation for beet yield t ha^{-1} 4.92%. The data in table-4 revealed that highly significant beet yield of 115.205 t ha^{-1} obtained in T-5 followed by 112.687, 112.675 and 110.658 tha^{-1} in T-4, T-3 and T-2 respectively over the T-7 (71.119), T-6 (69.740) and T-1 (68.280 t ha^{-1}).

The estimated co-efficient of variation for sugar content 0.57%. The data presented in table-4 showed that no significantly difference was found in sugar content; the maximum sugar content 11.33% was recorded in T-3 and in T-5 as compared control T-1 (11.14). The estimated co-efficient of variation for sugar yield t ha^{-1} 4.83%. The data presented in table-4 revealed that highly significant difference was observed in sugar yield 13.052 t ha^{-1} in T-5 followed by 12.766 in T-3, 12.674 in T-4 and 12.482 t ha^{-1} in T-2, over the other treatments T-7 (7.958), T-6 (7.824) and T-1 control (7.619 t ha^{-1}). Sarode and Sonalkar (1999) [21] reported that insecticide belonging to pyrethroid and organophosphorus group showed toxic effect on parasitoids whereas neem seed extract were moderately safe. Ma *et al.*, (2000) [18] reported that neem oil reduce egg hatching and survival of larvae of *H. armigera*.

4. Conclusion

From this study it was observed that neem oil after 14 days intervals has better efficacy in controlling sugar beet armyworm resulting high yield (t ha^{-1}), beet weight (kg) and sugar yield (t ha^{-1}) among all other treatments in both the crop season. It was also observed that natural enemies of insects i.e. *Chrysoperla carnea*, ants and spiders were found in those plots which are treated with neem oil. Thus, it can be suggested to the control of armyworm in sugar beet the application of neem oil 14 days interval is better to control

Table 1: The average population of Armyworm (*Spodoptera exigua* L.) in sugar beet at PARC-NSTHRI, farm Thatta during 2006-07.

Date	T-1	T-2	T-3	T-4	T-5	T-6	T-7
04-01-2007	4.60	4.73	4.40	4.73	4.38	4.60	4.66
11-01-2007	5.40	3.93	3.33	3.60	3.41	4.73	4.93
18-01-2007	5.00	4.20	3.40	5.06	3.36	4.66	4.80
25-01-2007	3.06	2.20	2.26	2.60	2.34	4.60	4.53
01-02-2007	3.33	2.26	2.06	2.26	2.40	4.66	3.20
08-02-2007	3.40	1.93	1.80	1.93	2.01	4.46	3.20
15-02-2007	3.26	2.00	0.73	1.20	1.23	4.80	4.66
22-02-2007	3.46	1.06	0.73	1.06	1.00	3.33	3.53
01-03-2007	3.40	1.20	0.66	0.73	0.86	3.56	4.00
08-03-2007	3.46	0.73	0.33	0.60	0.73	3.26	3.86
15-03-2007	3.20	00	00	0.73	0.73	2.06	3.06
22-03-2007	3.30	0.33	00	0.33	0.28	2.30	2.30
29-03-2007	4.20	0.33	0.33	0.33	0.26	2.13	2.26
05-04-2007	2.00	00	00	0.20	0.21	0.20	0.20
Average	3.64	1.77	1.43	1.81	1.65	3.52	3.50

Table 2: Beet yield and quality performance of sugar beet under Neem oil and pesticide spray at PARC-NSTHRI, farm Thatta during 2006-07.

Treatment	Numbers of roots ha^{-1}	Beet Weight (kg)	Beet Yield (t ha^{-1})	Sugar %	Sugar Yield (t ha^{-1})
T-1	64212a	1.066g	68.500f	11.147d	7.630e
T-2	64206a	1.718d	110.315c	11.250abcd	12.412c
T-3	64219a	1.792b	115.078b	11.290ab	12.993b
T-4	64227a	1.770c	113.666b	11.270abc	12.809b
T-5	64229a	1.821a	116.940a	11.330a	13.250a
T-6	64210a	1.095f	70.347e	11.160cd	7.850de
T-7	64213a	1.223e	72.089d	11.200bcd	8.073d
CV%	1.30	2.57	2.63	1.60	3.30
F	0.0003NS	2.47.83HS	267.0916HS	0.4381NS	174.42HS
LSD0.05	559.9	0.02126	1.680	0.123	0.2377

Table 3: The average population of Armyworm (*Spodoptera exigua* L.) in sugar beet at PARC-NSTHRI, farm Thatta during 2007-08.

Date	T-1	T-2	T-3	T-4	T-5	T-6	T-7
03-01-2008	4.66	4.33	4.26	4.40	4.46	4.13	3.97
10-01-2008	5.66	3.46	2.80	3.13	3.40	3.46	3.20
17-01-2008	4.60	2.40	1.60	2.46	1.93	3.66	2.80
24-01-2008	4.26	1.53	1.20	1.73	0.80	3.20	2.40
31-01-2008	4.00	0.93	0.93	1.66	0.53	1.86	1.26
07-02-2008	4.20	0.73	0.60	0.60	0.26	2.13	1.20
14-02-2008	3.20	0.46	0.13	1.00	0.46	2.73	1.86
21-02-2008	3.46	0.13	0.40	0.53	0.20	1.53	0.86
28-02-2008	2.80	0.33	0.13	1.93	1.66	3.26	2.46
06-03-2008	4.20	0.26	0.20	1.33	0.73	3.80	3.26
13-03-2008	4.13	0,06	0.20	1.13	0.33	2.53	1.60
20-03-2008	2.93	0.06	00	0.93	0.46	3.66	3.00
27-03-2008	1.33	00	00	1.00	0.53	2.80	1.46

03-04-2008	0.80	00	00	0.40	0.06	2.40	0.46
Average	3.58	1.04	0.88	1.58	1.07	2.75	2.15

Table 4: Beet yield and quality performance of sugar beet under Neem oil and pesticide spray at PARC-NSTHRI, farm Thatta during 2007-08.

Treatment	Numbers of roots ha^{-1}	Beet Weight (kg)	Beet Yield (t ha^{-1})	Sugar %	Sugar Yield (t ha^{-1})
T-1	64233a	1.063c	68.280c	11.230cd	7.619c
T-2	64247a	1.722b	110.658b	11.280b	12.482b
T-3	64387a	1.750ab	112.675ab	11.330a	12.766ab
T-4	64274a	1.753ab	112.687ab	11.250bc	12.674b
T-5	64257a	1.793a	115.205a	11.330a	13.052a
T-6	64202a	1.086c	69.740c	11.200cd	7.824c
T-7	64286a	1.106c	71.119c	11.190d	7.958c
CV%	0.49	4.83	4.92	0.57	4.80
F	0.15053NS	76.62HS	74.32HS	2.174NS	8.9393HS
LSD0.05	210.5	0.0475	3.118	0.0425	0.3429

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