EVALUATION OF NEEM BASED FORMULATIONS AGAINST *Helicoverpa armigera* (Hubner) ON CHICKPEA

THESIS

Submitted to the
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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By
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Enrolment Number - RR-3256 **2021**

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled **"EVALUATION OF NEEM BASED FORMULATIONS AGAINST *Helicoverpa armigera* (Hubner) ON CHICKPEA"**or part there of has neither been submitted for any other degree or diploma of any university, nor the data have been derived from any thesis/publication of any university or scientific organization. The source of materials used and all assistance received during the course of investigations have been duly acknowledged.

Place: Akola **(POOJA C R)**

Date: / /2021 Enrolment No: RR-3256

CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF NEEM BASED FORMULATIONS AGAINST *Helicoverpa armigera* (Hubner) ON CHICKPEA"** submitted in partial fulfillment of the requirement for the degree of **"Master of Science in Agriculture (Agricultural Entomology)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **POOJA C R** under my guidance and supervision.

The subject of the thesis has been approved by the student's Advisory Committee.

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Date: / /2021

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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA-VOCE)

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Place: Akola **(POOJA C R)**

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(D) ABBREVIATIONS

%	-	Per cent
/	-	Per
@	-	at the rate of
Bt	-	*Bacillus thuringenesis*
CD	-	Critical difference
CV	-	Coefficient of variation
DAS	-	Days after spraying
EC	-	Emulsifiable concentrate
ETL	-	Economic Threshold Level
et al.	-	et alia (and his associates)
etc.	-	Et cetera
Fig.	-	Figure
ha	-	Hectare
i.e.	-	id est (that is)
ICBR	-	Incremental Cost Benefit Ratio
kg	-	kilogram
Kg/ha	-	Kilogram per hectare
L	-	Litre
Ltd.	-	Limited.
M	-	meter
MCBR	-	Marginal cost benefit ratio
ml/L	-	mili litre per litre
No.	-	Number
NS	-	Non significant
NPV	-	Nuclear polyhedrosis virus
NSE	-	Neem seed extract

NSKE	-	Neem seed kernel extract
PDKV	-	Panjabrao Deshmukh Krishi Vidyapeeth
PPM	-	parts per million
Pvt	-	Private
q.	-	Quintal
RBD	-	Randomized Block Design
SE (m) ±	-	Standard error of mean
Sig.	-	Significant
viz.,	-	Videlicet (Namely)

E) THESIS ABSTRACT

a) Title of the thesis	:	**EVALUATION OF NEEM BASED FORMULATIONS AGAINST *Helicoverpa armigera* (Hubner) ON CHICKPEA**
b) Name of student	:	**POOJA C R**
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ABSTRACT

The present investigation entitled “Evaluation of neem based formulations against *Helicoverpa armigera* (Hubner) on chickpea” was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Rabi* season of 2020-21. The experiment was laid in Randomized Block Design with ten treatments replicated thrice. The treatments included were, azadirachtin 00.30% EC, azadirachtin 0.15% EC, azadirachtin 01.00% EC,

neem oil 1%, neem oil 2%, neem oil 3%, NSE 5%, NSE 7.5% and NSE 10% along with untreated control. Three treatment sprays were applied at 10 days interval to study the comparative efficacy of neem based formulations against chickpea pod borer. The observations on *H.armigera* larval population were recorded at an interval of 3, 7 and 10 days after each treatment spray. Similarly, the observations on pod damage were also recorded. The chickpea grain yield data was recorded from each of the net plot to find out most economical and effective treatment for the management of chickpea pod borer.

Application of azadirachtin 01.00% EC proved effective in minimizing larval population. However, this treatment was found at par with NSE 5%, NSE 7.5% and NSE 10%. The latter treatment in turn found statistically equal to neem oil 3%. Whereas, treatments *viz.,* azadirachtin 00.30% EC, neem oil 2% and azadirachtin 0.15% EC found moderately effective. The treatment of neem oil 1% proved relatively less effective against larval population of *H.armigera*.

The treatment of azadirachtin 01.00% EC recorded minimum pod damage and was found statistically equal to NSE 5%, NSE 7.5% and NSE 10% in reducing pod damage. The next treatments in order of efficacy were neem oil 3%, azadirachtin 00.30% EC, azadirachtin 0.15% EC and neem oil 1%. The treatment of neem oil 2% proved relatively less effective in this respect. The untreated control plots showed maximum per cent pod damage.

All the treatments under the trial recorded significant increase in the grain yield of chickpea compared to untreated control plots. The highest grain yield was obtained in the plots sprayed with azadirachtin 01.00% EC. However, this treatment was found at par with NSE 5%, NSE 7.5%, NSE 10% and neem oil 3%. The next effective treatments were azadirachtin 00.30% EC and neem oil 2%. Whereas, azadirachtin 0.15% EC and neem oil 1% proved moderately effective in recording the grain yield data. Whereas, lowest yield was harvested in untreated control.

On the basis of economics the treatment azadirachtin 01.00% EC proved as most economically viable treatment giving the highest ICBR. It was followed by the treatments *viz.,* NSE 5%, azadirachtin 00.30% EC, NSE 7.5% and neem oil 1%.

The study indicates that neem based formulations has marked effect on chickpea pod borer, *H.armigera* and can be used as an alternative to conventional pesticides in integrated pest management strategies.

CHAPTER I

INTRODUCTION

1.1 Background Information

Chickpea is the world's second largest cultivated food legume and one of the most important pulse crops in India. It is the potent source of dietary constituent i.e. lysine, phosphorous, calcium, vitamin C and minerals. Chickpea being a legume crop fixes atmospheric nitrogen in the soil. India is the world's largest producer of chickpea accounting for 65% of global production. In India it is cultivated on 9.44 M ha with a production of 10.13 M tonnes and the average productivity of chickpea is 1073 Kg/ha (Anonymous, 2019). In Maharashtra, chickpea is being grown on an area of 1.29 M ha with a production of 1.07 M tonnnes with average productivity 829 Kg/ ha (Anonymous, 2019).

About 60 insect species are known to feed on chickpea of which, pod borer, *Helicoverpa armigera,* cutworm, *Agrotis ipsilon*, leaf caterpillar, *Spodoptera exigua* are the important and area specific pests in India. *Helicoverpa armigera* (Hubner) (Noctuidae; Lepidoptera) popularly known as gram pod borer is a *cosmopolitan*, polyphagous and dynamic insect pest causing drastic yield losses in chickpea. It begins their feeding at the seedling stage and feeds on the leaves by scraping green tissue and pods and later infests buds, flowers and developing pods until the crop maturity. The typical symptom shows circular bore holes on gram pods plugged by the head of a larva. The avoidable losses of 55.07% due to *H.armigera* in chickpea are recorded. Due to its polyphagous, high fecundity and migratory nature and its resistance to the various group of insecticides led to the pod damage of 90-95 % in chickpea and yield losses of 400 Kg/ha. (Biradar *et al*., 1998).

1.2 Importance of study

In the present scenario the menace caused by *Helicoverpa armigera* (Hubner) becomes stumbling block in chickpea production. No doubt, several chemical insecticides have been found effective against this pest. However, due to overuse and misuse of these chemical insecticides,

natural balance has been disturbed, leading to enormous problems such as resistance, residues, resurgence and destruction of natural enemies, pollination and health hazards. Pesticides have also entered into the food chain and have bioaccumulated in the higher tropic level. Therefore, it has now become necessary to search for the alternative means of pest control, which can minimize use of synthetic pesticides. Botanical pesticides are the important alternatives to minimize or replace the use of synthetic pesticides. Botanicals with different modes of action may minimize insecticide resistance and pest resurgence problems while being safe and ecologically acceptable. Among the numerous plant botanicals studied during last 20 years, extracts and components derived from neem tree (leaves, seed kernel etc.) have shown promising results in insect suppression. Neem derivatives affect more than 105 species of insects in India belonging to 10 orders namely Orthoptera, Dictyoptera, Lepidoptera etc. (Singh and Kataria, 1991).

Neem (*Azadirachta indica*) commonly called as “Indian Lilac” and belongs to the family *Meliaceae*, subfamily *Meloideae* and tribe *Melieae*. Neem is one of the most reliable botanicals sources of biopesticides. Neem leaves and seed extract have been observed for their deleterious effects on insects. The important bioactive compounds of neem belong to the limonoid class of triterpenoids, such as azadirachtin, salanin, salannnol, nimbin, nimbinin, nimbidin, nimbidiol etc.The properties of neem viz., antifeedent, growth disruption, ovipositional repellance to adult moth, ovicidal and growth regulator (Kaur *et al*., 2001, Atawodi and Atawodi, 2009). In the compound azadirachtin present in neem seed kernel extract appear to block the neurosecretory cells and resulting in disruption of development of eggs and preventing adult maturation in *Aphis gossypii.* (Vimala *et al.,* 2010).The neem seed kernel extract is known to suppress the feeding, growth and reproduction of insects due to its biochemicals (Natarajan and Sundaramurthy, 1990).

Keeping in view the potential of the neem in pest management, the present investigation was carried out on “Evaluation of

neem based formulations against *Helicoverpa armigera* (Hubner) on chickpea" with the following objectives.

1.3 Objectives:

1. To evaluate the efficacy of different neem based formulations against chickpea pod borer.
2. To workout the economics of various neem based formulations.

1.4 Scope and limitations

Neem has acquired commercial recognition due to its various beneficial properties, which have been extensively investigated over time. Compared to conventional chemicals, which are generally persistent in the environment and highly toxic, botanical pesticides are biodegradable, leave no harmful residues and are also more selective toward the target pest. In terms of commercial applications, biopesticides can provide substantial economic advantages, since the infrastructure required is inexpensive, compared to conventional pesticides (Pant et al., 2016).

Botanical pesticides such as neem have limited persistence in the environment. Temperature, ultraviolet light, rainfall and other environmental factors can degrade them. Repeated applications may be needed to achieve the desired result. Being growth regulator it is effective against immature stages of insects. Absence of immediate knockdown effect. However, due to its repellent effects, insect feeding will be reduced. Phytotoxicity may be of concern for certain formulations of neem based products with flowers being particularly sensitive.

1.5 Hypothesis

The evaluation of neem based formulations against *H.armigera* will help in deciding the economically effective neem formulation as a bioinsecticide against the *H.armigera* as this pest is devasting polyphagous mainly on chickpea crop, the effect of neem based formulation can promote the IPM strategy. Thereby reducing the environmental pollution which results from indiscriminate use of chemical insecticides.

CHAPTER II

REVIEW OF LITERATURE

The present investigation was conducted with a view to evaluate neem based formulations against chickpea pod borer and to assess their effect on yield of chickpea. The literature collected pertaining to the objectives of the experiment is reviewed and presented below.

Srivatsava *et al*. (1984) conducted a field trial in which evaluation of synthetic insecticides and neem extracts in the field revealed that NSKE @ 8% significantly reduced the damage due to *H.armigera* on red gram recording 12.2% pod damage as against 35.5 in untreated control and was comparable with quinalphos (16.39%) and fenvalerate (8.06%). The highest grain yield was recorded from plots treated with fenvalerate (13.61q/ha) followed by plots treated with NSKE (9.18 q/ha) and quinolphos (7.26 q/ha).

Srinivasan and Krishna Moorthy (1993) compared the efficacy of aqueous NSKE (4 and 5%) with cartap hydrochloride (0.1%), endosulfan (0.07%), Neemark and Repelin (both @1%) and reported that NSKE @ 4 and 5% consistently recorded significant reduction in DBM larvae with consequent increase in marketable heads compared to insecticides. The percent marketable heads harvested in 4 and 5 % NSKE treated plots were 94.0 and 96.6 respectively compared to 85.7, 85.6, 88.9 and 44.9 percent in cartap hydrochloride, endosulfan, Neemark and Repelin treated plots and untreated control, respectively.

Panchabhavi *et al.* (1994) evaluated the efficacy of insecticides and neem seed kernel extract against *H.armigera* on pigeonpea. Lower pod damage and higher seed yield was recorded when fenvalerate was applied twice at 15 days interval. However, highest cost benefit ratio was obtained in NSKE sprayed at 15 days interval with a seed yield of 12.0q/ha.

Sarode *et al.* (1995) evaluated NSKE at different concentrations for the control of *Helicoverpa armigera* and observed that HaNPV and neem seed kernel extract gave better control of *H.armigera* on

chickpea when applied in combination than applied singly. Application of the virus at 500 LE/ha + neem seed kernel extract of 6% gave the maximum reduction in larval number i.e 79.8 and 65.2 % after 7 and 14 days of spraying respectively.

Sanap and Pawar (1997) reported that among the neem based formulations, 0.2% Nimbecidin and 0.5% Achook were quite effective in reducing the pod borer damage and obtaining higher yield of chickpea.

Mahadevan (1998) carried out field study during winter and summer seasons of 1994 to study the efficacy of econeem against *H.armigera* on tomato revealed that spraying two rounds of econeem @ 10 ppm was the best treatment in controlling the test insect with 6.8% fruit damage as compared to 28.9% fruit damage in non-treated plots.

Shivaprakasam (1998) evaluated NSKE 5% and neem oil 2% along with NPV and insecticides for the management of tomato fruit borer, *H.armigera*. The results revealed that NSKE 5% and neem oil 2% were moderately effective recording 21 percent and 20 percent fruit damage, respectively.

Singh and Mathur (1998) observed that two applications of 5% NSKE i.e at 50% flowering and 15 days thereafter were quite effective which recorded 46.77 and 41.54% pod damage and larval reduction of 65.43 and 52.89% at 7 and 14 days after spray, respectively. It also have a minimum grain damage of 33.45% with the highest yield of 1015 kg/ha.

Singh *et al.* (1998) reported that Nimbecidine 1.5% (2.3 larave/10 plants), Repelin 1.5% and Achook 1.5% (3 larvae/ 10 plants) provided better protection to chickpea against *H.armigera* and maximum larvae (28.76/10 plants) were recorded in untreated plot.

Shivaramu (1999) observed the effect of botanicals and biological pesticides against *H.armigera* on chilli. Among the plant products, NSKE 5%, Neem oil 5ml/L and Achook 5 ml/L were found to be on par with each other recording 9.77, 12.99 and 9.60 % fruit damage, respectively but were inferior to carbaryl 0.15% (6.10%)

Bajpai and Sehgal (2003) reported that Green Mark @ 0.4%, Neem Guard @ 0.4%, Achook @ 0.4%, neem oil @ 2%, neem seed kernel water extract (NSKWE) @ 5% were tested against *H.armigera* infesting chickpea. The botanical insecticides were effective against the pest and resulted in significant reduction in pod damage and increased grain yield. Neem oil resulted in the highest yield (16.5q/ha) with 59% pod damage.

Wankhede *et al.* (2007) carried a field experiment to assess the performance of some insecticides and biopesticides against tomato leaf miner. Neem oil 1% was found to be an effective treatment recording the lowest leaf miner infestation of 4.37 % at 14 days after second spraying followed by the treatment of spinosad 0.01% and NSE 5% which exhibited 4.60 and 5.07 % infestation.

Mehta *et al*. (2010) conducted field experiment using neem based formulations (Nimbicidine 300 ppm, azadirachtin and Neem azal 10 ppm) against tomato fruit borer, *H.armigera.* They reported that application of neem based formulations were effective in reducing *H.armigera* larval population with higher fruit yield and lowest fruit infestation.

Nollet *et al.* (2010) reported that neem oil 3% and NSKE (5%) were as effective as endosulphan 0.05% against gram pod borer on green gram.

Bhushan *et al.* (2011) conducted experiment to evaluate the bioefficacy of certain biopesticides against pod borer, *Helicoverpa armigera* in chickpea. The pooled data of the two years revealed that neem seed kernel extract (NSKE 5%) found most effective with minimum of 0.37 larvae per plant, resulted in minimum pod damage (10.87%) and harvested higher yield of 15.9 q/ha with C:B ratio of 1: 2.47. This was followed by neem oil with 0.54 larval population per plant, 12.3 % pod damage, 14.5 q/ha grain yield and C: B ratio of 1: 2.23.

Chakraborty (2011) reported that all treatments were significantly effective in checking stem borer infestation causing the decrease of both dead heart and white head number numerically, least damage was noted for monocrotophos 36 WSC. This was followed by

carbofuran 3G, nimbecidine 2.5%, NSKE 5%, Bt 2 ml/L, Neem leaf extract 2%, Neem oil 2%, Karanj seed kernel extract 5%, mahua oil 2%, *Vitex negundo* extract in ascending order against rice stem borer infestation.

Rudramuni *et al.* (2011) carried out the field experiment to evaluate the bioefficacy of neem based formulations against bollworms of cotton. They reported that NSKE, Neemazal and Nimbecidine were found to be highly effective in reducing the damage in cotton bolls. The cotton plots treated with NSKE 5% recorded the highest yield followed by Neemazal and Nimbecidine.

Singh *et al.* (2011) conducted experiment on bioefficacy of neem based formulations against tomato fruit borer, *Helicoverpa armigera.* The results revealed that Nimbecidine was significantly effective with 28.94 and 24.05% infestation after 3 and 7 days after spraying. The maximum yield of 368.15 q/ha (49.70 kg/plot) was recorded from nimbecidine treated plots.

Chakraborthy (2012) reported that experiment for three consecutive years (2008-2010) at the upper Gangetic plains of West Bengal (India) was done to assess the relative efficacy of some selected insecticide formulations on both *Scirpophaga incertulus* and its natural enemies in field condition. In consideration of yield, neem based application of new generation pesticide like flubendiamide (48 SC) together with the conventional application of NSKE 5%, Neem leaf extract 5%, deltamethrin 1% + triazophos (35%) gave best result. Though yield was comparatively low in treatment of NSKE 5%, but it has supported second highest number of natural enemies.

Borkar and Sarode (2012) carried out a field experiment to assess the efficacy of botanicals and biopesticides against cotton bollworm complex. The minimum egg and larval population of *Helicoverpa armigera* was reported in the application of NSE 5% and azadirachtin 1500 ppm.

Lulie and Raja (2012) evaluated certain botanicals against *Helicoverpa armigera* in chickpea. All tested plant extracts showed 100% protection at 5% and 10% concentration. Among the various botanical

NSKE 5% at different concentrations was found most effective with minimum pod damage and maximum reduction of larval population. Moreover, highest grain yield was also obtained from NSKE 5% treated plots.

Shah *et al.* (2013) investigations were carried out on the effect of extracts of different botanicals i.e. neem seed extract (2.5%), turmeric extract (5%), honge extract (1.25%), garlic extract (5%) and insecticide (emamectin benzoate) (0.07%) on tomato fruit worm, *Helicoverpa armigera*, at Developmental Farm of the University of Agriculture, Peshawar, Pakistan. The results revealed that minimum number of *H.armigera* larvae was recorded in neem seed extract and emamectin benzoate treated plots as against untreated control. They concluded based on total yield and lower toxicity to the environment as well as human being, neem seed extract as the most promising insecticide for the effective management of tomato fruit worm larvae.

Pachundkar *et al.* (2013) carried an investigation on management of gram pod borer, *H.armigera* in chickpea. The results revealed that neem seed kernel extract (5%) effectively reduced the *H.armigera* larval population when used in regular three sprays.

Chandra Shekhara *et al.* (2014) using different biorationals for ecofriendly management of gram pod borer, *Helicoverpa armigera* on chickpea. Among biorationals tested, different concentrations of azadirachtin recorded lowest larval population and pod damage resulted in highest grain yield.

Meena and Raju (2014) evaluated the efficacy of botanicals and insecticides against tomato fruit borer under field conditions. The results of efficacy revealed that. All the treatments differ significantly with each other except 1DAT NSKE (20.08) and NPV (20.02) 5 DAT indoxacarb (34.02) and NSKE (33.41) and again, 10 DAT indoxacarb (33.14) and NSKE (32.28) of 2nd spray were found at par with each other.

Rahman *et al.* (2014) evaluated botanicals against *H.armigera* in tomato and reported lowest fruit infestation both by number

and weight in NSKE treated plots. The per cent infestation reduction over control was highest in neem seed kernel extract (30.08%) with the highest yield and MCBR.

Khuhro *et al.* (2014) carried out a field study on efficacy of NSKE 5% and neem oil against *Helicoverpa armigera* sunflower. The overall result showed that the neem products reduced the *H.armigera* population progressively as compared to synthetic pesticides.

Golvankar *et al.* (2015) conducted the field experiment on management of chickpea pod borer, *H.armigera* by using microbial pesticides and botanicals. The results revealed that on 7th day after first spray minimum number of larvae were recorded in the treatment azadirachtin 50000 ppm. Moreover, azadirachtin recorded minimum (4.82%) pod damage and found to be best treatment at 14 days. Similarly, this treatment also harvested maximum grain yield of 1183.03 Kg/ha with highest C: B ratio of 1:15.15.

Chandra Shekhara *et al.* (2016) evaluated the efficacy of neem products and chemicals against *H.armigera* on chickpea. The per cent population reduction of gram pod borer revealed that neem products were superior over control with 59.86 and 54.43% reduction respectively, in NSKE 5% and neem oil 1% treated plots. Moreover, these neem products also recorded minimum pod damage and higher grain yield as compared to control with C:B ratio of 1:1.20 and 1:0.90, respectively.

Faqiri and Kumar (2016) conducted the experiment on tomato crop against *H.armigera* with neem products and chemicals. They reported that the plots treated with NSKE 5% and neem oil @ 2ml/L recorded 5.90 and 6.65% infestation of fruit borer, respectively and were found superior over the untreated control. The maximum yield was harvested with neem oil followed by NSKE.

Reza *et al.* (2016) conducted the experiment on ecofriendly management of chickpea pod borer at Agricultural University, Dhaka. The results revealed that among the botanicals neem oil treatment was most effective in reducing pod infestation and larvae number i.e. 42.52% and

69.85%, respectively followed by NSKE @ 100 g/l. Neem oil treatment was also most effective in increasing the pod number, seed number and yield. The treatment NSKE was most effective in increasing grain weight and 1000 seed weight followed by neem oil. Whereas, highest yield was recorded in the treatment of neem oil followed by NSKE.

Choudhary *et al.* (2017) carried out the experiment on assessment of efficacy of different neem based insecticides against yellow stem borer in paddy field. As per the performance of different treatments Nimbecidine @ 5ml/L was found most effective against the pest and it was followed by neem oil. They concluded that neem based insecticides were quite effective compared to untreated control.

Kumar *et al.* (2017) studied the effect of botanical insecticides on the population of *H.armigera* on maize. The minimum *H.armigera* larval population was recorded in plots sprayed with Indoxacarb which was at par with NSKE 5% followed by neem oil 2%. Among the botanicals neem oil 2% recorded maximum grain yield followed by NSKE 5%.

Lyall (2017) studied the comparative efficacy of botanicals against *Helicoverpa armigera* on field bean. The results revealed that NSKE 5% was found superior over all the treatments after 1st and 2nd spray with highest larval population reduction of 15.4%.

Kumar *et al.* (2017) conducted field experiment on maize cob borer, *Helicoverpa armigera* and reported that the minimum cob borer larvae were recorded in plots sprayed with Indoxacarb (0.23 larvae/cob) which was at par with NSKE 5% @ 25 litres/ha, (0.27 larvae/cob), followed by Neem oil 2% @ 10 litres/ha, (0.33 larvae/cob). The descending order among the botanical insecticides with regard to yield was Neem oil 2% (26.03 q/ha), Karanj oil (25.50 q/ha), NSKE 5% (24.83 q/ha), Karanj seed powder (23.58 q/ha) and chilli-garlic solution (21.91 q/ha), respectively.

Berani *et al.* (2018) conducted field experiment on bioefficacy of botanicals against lepidopteran pests infesting black gram reported that among the different botanicals azadirachtin 0.15 EC 0.0006%, neem seed kernel extract (NSKE) 5%, neem oil 0.3% and neem leaf extract (NLE) 10%

were found highly effective in managing lepidopteran pests and registered higher grain yield.

Kumar *et al.* (2018) conducted field experiment with seven treatments of biopesticides, against *Helicoverpa armigera*. The biopesticides like NSKE, *Bacillus thuringiensis*, Neem leaf extract, Neem oil, Nimbicidine and nuclear polyhedrosis virus in reducing the infestation of gram pod borer, *Helicoverpa armigera* and providing a higher net return per rupee invested. The higher grain yield of 24.07 and 22.65 q/ha was recorded with application of NSKE @ 5%/ha during both the years. The most favourable cost benefit ratio was obtained from the plot treated with neem oil @ 2% and NSKE @ 5%.

Gautam *et al.* (2018) the results revealed that among the botanicals neem seed oil @ 5 ml/L was found effective in managing population of *Helicoverpa armigera* on chickpea and gave maximum grain yield compared to other treatments with highest net income of 18300 Rs/ha.

Meena *et al.* (2018) to evaluate the efficacy of biopesticides against gram pod borer *Helicoverpa armigera* on chickpea. The reported that NSKE 5% and azadirachtin 0.3 EC were found effective in reducing pod borer population with minimum pod damage and obtained maximum grain yield in comparison to other biopesticides.

Kumar *et al.* (2018) conducted the experiment against *H.armigera* infesting oats and concluded that among the botanicals NSKE 5% was found to be the most effective in managing larval population of *H.armigera*.

Kumar *et al.* (2019) studied the economics of botanicals and biopesticides in reference to management of *H.armigera* on chickpea. On the basis of two years results, they reported that neem based formulations namely NSKE @ 5%, Neem Leaf Extract @ 5%, Neem oil @ 2%, Nimbicidine @ 2% were found effective in reducing *H.armigera* and provided higher net return per rupee invested. The higher grain yield of 24.07 and 22.65 q/ha was recorded with application of NSKE @ 5%/ha

during both the years. The most favourable cost benefit ratio was obtained from the plot treated with neem oil @ 2% and NSKE @ 5%.

Singh *et al.* (2019) conducted a field experiment to study the bioefficacy of neem products against *Spodoptera litura* on cauliflower. They concluded that biopesticides namely, neem oil @ 5 ml/L, NSKE 5% was found safe and cost effective for the management of larval population of *Spodoptera litura*.

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled “Evaluation of neem based formulations against *Helicoverpa armigera* (Hubner) on chickpea” was carried out at Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Rabi* 2020. The material used and methods adopted during the course of investigation are described below.

Table 1: List of neem based formulations included in the trial

Sr. No	Common name	Trade name	Source/Manufacturer
1.	Azadirachtin 00.30% EC	Neem fighter	Maharashtra Bio Fertilizers India Pvt. Ltd
2.	Azadirachtin 0.15% EC	Neem Azal	Coromandel International Ltd.
3.	Azadirachtin 01.00% EC	Neem fighter	Maharashtra Bio Fertilizers Ltd.
4.	Neem oil	-	Green Rise Agro Industries
5.	NSE	-	Manually prepared

3.1 Materials

For conducting this experiment material like, chickpea seed (JAKI-9218), neem based formulations, agricultural implements, bullock pairs, labours, rope, tags, marker, wooden pegs, measuring tape, polythene bags, manures and fertilizers, knapsack sprayer, weighing balance etc, were used.

3.2 Methods

3.2.1 Experimental details

1. Design of experiment : Randomized block design (RBD)
2. Number of treatments : Ten (10)
3. Number of replications : Three (3)
4. Season : *Rabi* (2020)

5. Crop : Chickpea

6. Variety : JAKI-9218

7. Gross plot size : 4.5 m x 3 m

8. Net plot size : 3.9 m x 2.8 m

9. Spacing : Row to Row : 30 cm

Plant to Plant : 10 cm

10. Fertilizer dose : 20:50:20 kg NPK /ha

11. Date of sowing : 02 December 2020

12. Date of emergence : 07 December 2020

3.2.2 Treatment details

Sl. No	Treatments	Dose (ml or g/lit)
T1	Azadirachtin 00.30% EC	5 ml/L
T2	Azadirachtin 0.15 % EC	3 ml/L
T3	Azadirachtin 01.00% EC	2 ml/L
T4	Neem oil 1%	10 ml/L
T5	Neem oil 2%	20 ml/L
T6	Neem oil 3%	30 ml/L
T7	NSE	5%
T8	NSE	7.5%
T9	NSE	10%
T10	Untreated control	

3.2.3 Experimental site

The present investigation was conducted on the Experimental farm at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Rabi* 2020. The layout of plan for the experiment is illustrated in (Fig.1).

3.2.4 Cultural operations

3.2.4.1 Preparatory tillage

The soil was thoroughly prepared by ploughing, followed by repeated harrowing. The field was cleaned by picking stubbles of previous

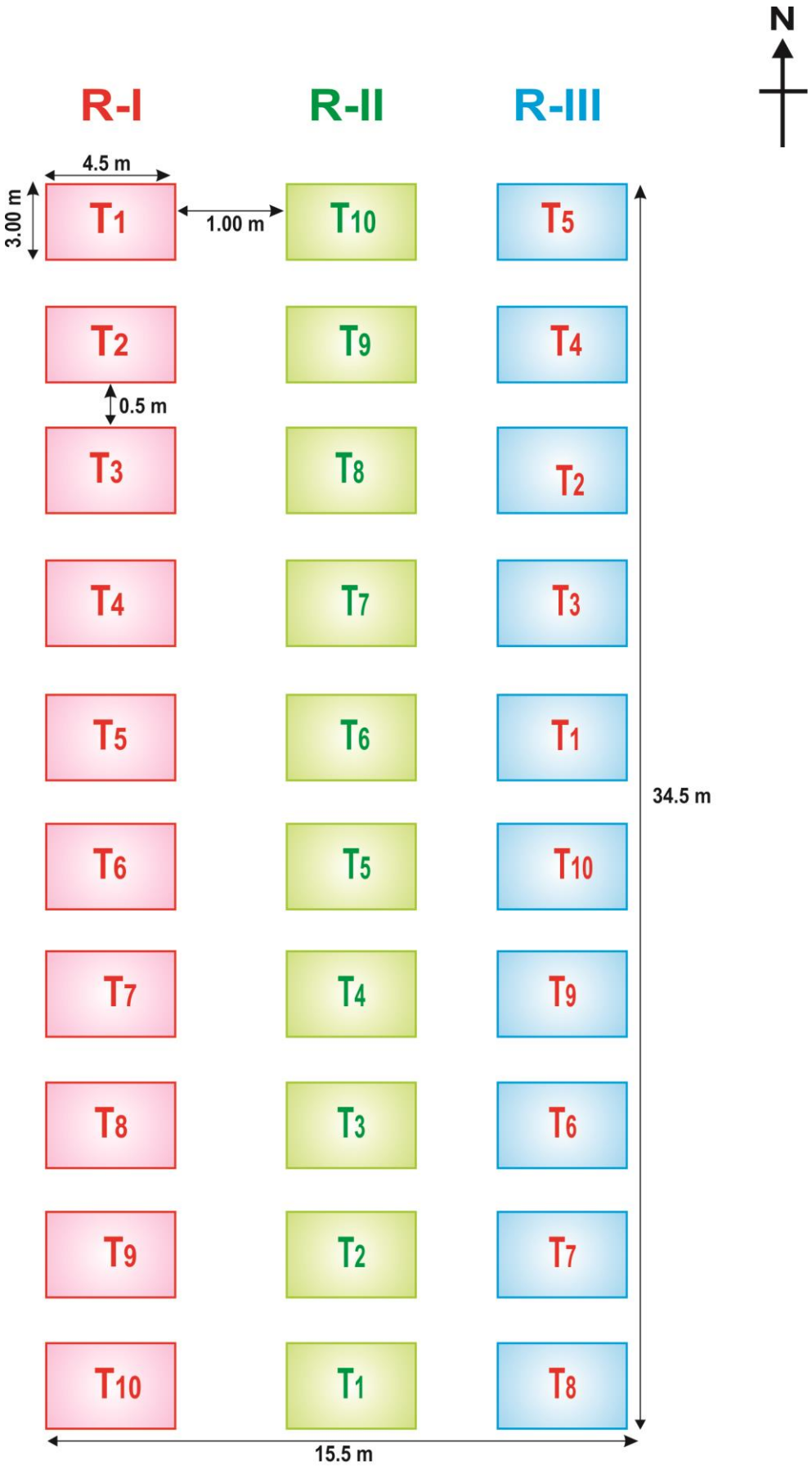

Fig. 1. Plan of experimental layout

Plate 1: View of experimental plot

crop. Before sowing one harrowing was given and the experimental plot was laid out as per statistical design.

3.2.4.2 Layout of experiment

Field experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The gross plot size 4.5 x 3 m^2 and spacing was 30 x 10 cm.

3.2.4.3 Sowing

Marking of lines was done by wooden marker at spacing of 30 cm. Sowing of experimental plot was done on 2nd December 2020 by dibbling 1 to 2 seeds per hill at the depth of about 3-4 cm at a distance of 10 cm and then covered with soil carefully.

3.2.4.4 Gap filling

Gap filling was done on 7th day after emergence.

3.2.4.5 Application of fertilizers

The recommended dose of fertilizers was applied at the rate of 20:50:20 kg of N, P_2O_5 and K_2O per hectare, respectively. The half dose of nitrogen and full dose of phosphorus and potassium was applied at the time of sowing. The remaining half dose of nitrogen was given one month after the basal dose.

3.2.4.6 Intercultural operation

Timely hoeing and weeding operations were carried out to remove weeds, to improve the soil aeration, to conserve the soil moisture and to promote the growth of crop.

3.2.5 Neem Seed Extract (NSE)

One day before 50 gm neem seed powder was soaked for an overnight in plastic bucket in 900 ml of water and similarly 2 gram detergent powder was also soaked in 50 ml of water for an overnight separately. Next day morning the extract was decanted through muslin cloth and homogenous detergent solution was added to the extract. Thereafter the water was added to make up the volume of one-liter extract.

3.3 Method of recording observations:

3.3.1 Observations on *H. armigera* larval population and chickpea pod borer damage

Periodical observations were taken to record the incidence of chickpea pod borer, *Helicoverpa armigera* prior to application of treatments. The treatment spray was initiated at ETL i.e. one larvae per meter row length (Zahid et al. 2008). The subsequent sprayings were applied at ten days interval. In total three treatment sprays were undertaken.

For recording the observations five spots of one meter row length were selected randomly from each net plot. The pretreatment observations were recorded at 24 hours before the application of treatment spray. Whereas, the post treatment observations were recorded at 3, 7 and 10 days after each treatment sprays to assess the efficacy of different treatments against chickpea pod borer.

$$\text{Pod damage \%} = \frac{\text{Total No. of damaged pods/meter row length}}{\text{Total No. of pods/meter row length}} \times 100$$

3.4 Yield

The chickpea grain yield obtained from each net plot was recorded. Total yield was worked out. The chickpea grain yield in q/ha was calculated in order to compare the effect of different treatments.

3.5 Statistical analysis

As per Gomez and Gomez (1984), the data obtained during the present course of investigation was converted to appropriate transformations and was subjected to statistical analysis to test the level of significance.

In addition, the “Incremental Cost Benefit Ratio” based on total grain yield, in terms of rupees, cost of treatments, labour charges and cost of application was calculated at the prevailing market rates during the period of experimentation to find out the cost effective treatment against pod borer of chickpea.

3.6 Meteorological data

The weekly Meteorological data on maximum and minimum temperature, relative humidity, rainfall, rainy days and sunshine hours, during the crop season of 2020-21 recorded at Agricultural Meteorological Observatory, Dr. PDKV, Akola is presented in Appendix –I.

CHAPTER IV

RESULTS AND DISCUSSION

The present investigation was conducted with a view to evaluate the efficacy of neem based formulations against *Helicoverpa armigera* (Hubner) on chickpea. The experiment was carried out at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Rabi* 2020-21.The data obtained during the present investigation were subjected to statistical analysis by following standard procedures and are discussed as under.

4.1 Efficacy of neem based formulations against chickpea pod borer after first spray

The data on larval population of *H.armigera* on chickpea recorded a day before first spray in different plots found statistically non significant. The population in the different treatments plots ranged between 1.47 to 1.87 larvae per meter row length.

4.1.1 Three days after first spray

The data presented in Table 2 (Fig.2) pertaining to larval population of chickpea pod borer at three days after first spray was found statistically significant. The lowest population of *H.armigera* larvae was recorded in plot treated with azadirachtin 01.00% EC (0.40 larvae/meter row length). However, this treatment was found at par with NSE 5% (0.47 larvae/meter row length), NSE 7.5% (0.53 larvae/meter row length) and NSE 10% (0.67 larvae/meter row length). These were followed by the treatment of neem oil 3% (1.53 larvae/meter row length), neem oil 2% (1.60 larvae/meter row length) and azadirachtin 00.30 % EC (1.67 larvae/meter row length). Whereas, treatment of azadirachtin 0.15% EC (1.87 larvae/meter row length) and neem oil 1% (2.20 larvae/meter row length) were found at par with untreated control (2.40 larvae/meter row length).

4.1.2 Seven days after first spray.

The data tabulated in Table 2 (Fig.2) pertaining to larval population of chickpea pod borer at seven days after first spray revealed that the minimum larval population of *H.armigera* was recorded in plot treated with azadirachtin 01.00% EC (0.33 larvae/meter row length). This

was followed by NSE 5% (0.40 larvae/meter row length), NSE 7.5% (0.47 larvae/meter row length) and NSE 10% (0.60 larvae/meter row length). However, all these treatments were found at par with each other. The next effective treatments were neem oil 3% and azadirachtin 00.30 % EC which recorded 1.13 and 1.20 larvae/meter row length, respectively. Whereas, plots treated with neem oil 2% (1.60 larvae/meter row length), azadirachtin 0.15% EC (1.67 larvae/meter row length) and neem oil 1% (2.00 larvae/meter row length) recorded relatively more number of larvae and were found at par with untreated control (2.27 larvae/meter row length).

4.1.3 Ten days after first spray.

The data pertaining to larval population of chickpea pod borer at ten days after first spray presented in Table 2 (Fig.2) was found statistically significant. Among the treatments azadirachtin 01.00% EC recorded minimum larval population i.e. 0.27 larvae/meter row length and found at par with NSE 5% (0.33 larvae/meter row length), NSE 7.5% (0.40 larvae/meter row length) and NSE 10% (0.53 larvae/meter row length). However, the treatments *viz.,* neem oil 3% (1.00 larvae/meter row length), azadirachtin 00.30% EC (1.07 larvae/meter row length), neem oil 2% (1.40 larvae/meter row length) and azadirachtin 0.15% EC (1.53 larvae/meter row length) proved moderately effective in this respect. The treatment neem oil 1% (2.00 larvae/meter row length) was found at par with untreated control (2.60 larvae/meter row length).

4.1.4 Mean

The data on mean larval population of *H.armigera* after first spray presented in Table 2 (Fig. 2) revealed that treatments *viz.,* azadirachtin 01.00 % EC (0.33 larvae/meter row length), NSE 5%(0.40 larvae/meter row length), NSE 7.5% (0.46 larvae/meter row length) and NSE 10 % (0.60 larvae/meter row length) proved statistically equal in recording minimum larval population. The next effective treatments *viz.,* neem oil 3%, azadirachtin 00.30 % EC, neem oil 2% and azadirachtin 0.15% EC recorded larval population within the range of 1.22 to 1.69 larvae per meter row length and found at par with each other. Whereas, neem oil 1% (2.06 larvae/meter row length) proved relatively less effective in this

Plate 2: *Helicoverpa armigera* larvae observed during experimentation

respect and found statistically equal to untreated control (2.42 larvae/meter row length).

Table 2: Efficacy of neem based formulations against chickpea pod borer after first spray

Sr. No	Treatments	Dose ml/ L	*H.armigera* larvae/ meter row length				Mean
			1 DBS	3 DAS	7 DAS	10 DAS	
1	Azadirachtin 00.30%EC	5ml /L	1.60 (1.61)	1.67 (1.63)	1.20 (1.48)	1.07 (1.44)	1.31 (1.51)
2	Azadirachtin 0.15%EC	3ml/L	1.80 (1.67)	1.87 (1.69)	1.67 (1.63)	1.53 (1.59)	1.69 (1.63)
3	Azadirachtin 01.00%EC	2ml/L	1.47 (1.57)	0.4 (1.18)	0.33 (1.15)	0.27 (1.12)	0.33 (1.15)
4	Neem oil 1%	10ml/L	1.87 (1.69)	2.20 (1.79)	2.00 (1.73)	2.00 (1.73)	2.06 (1.75)
5	Neem oil 2%	20ml/L	1.87 (1.69)	1.60 (1.61)	1.60 (1.61)	1.40 (1.55)	1.53 (1.59)
6	Neem oil 3%	30ml/L	1.60 (1.61)	1.53 (1.59)	1.13 (1.46)	1.00 (1.41)	1.22 (1.48)
7	NSE	5%	1.53 (1.59)	0.47 (1.21)	0.40 (1.18)	0.33 (1.15)	0.40 (1.18)
8	NSE	7.5%	1.67 (1.63)	0.53 (1.23)	0.47 (1.21)	0.4 (1.18)	0.46 (1.20)
9	NSE	10%	1.60 (1.61)	0.67 (1.29)	0.60 (1.26)	0.53 (1.23)	0.6 (1.26)
10	Untreated control		1.67 (1.63)	2.40 (1.84)	2.27 (1.80)	2.60 (1.90)	2.42 (1.84)
	F test	-	NS	Sig	Sig	Sig	Sig
	SE (m) ±	-	-	0.05	0.06	0.05	0.05
	CD @ 5%	-	-	0.17	0.19	0.18	0.18
	CV (%)	-	-	6.22	7.09	6.75	6.68

Note: Figures in the parentheses are corresponding square root transformation values

DBS- Days Before Spraying, DAS - Days After Spraying

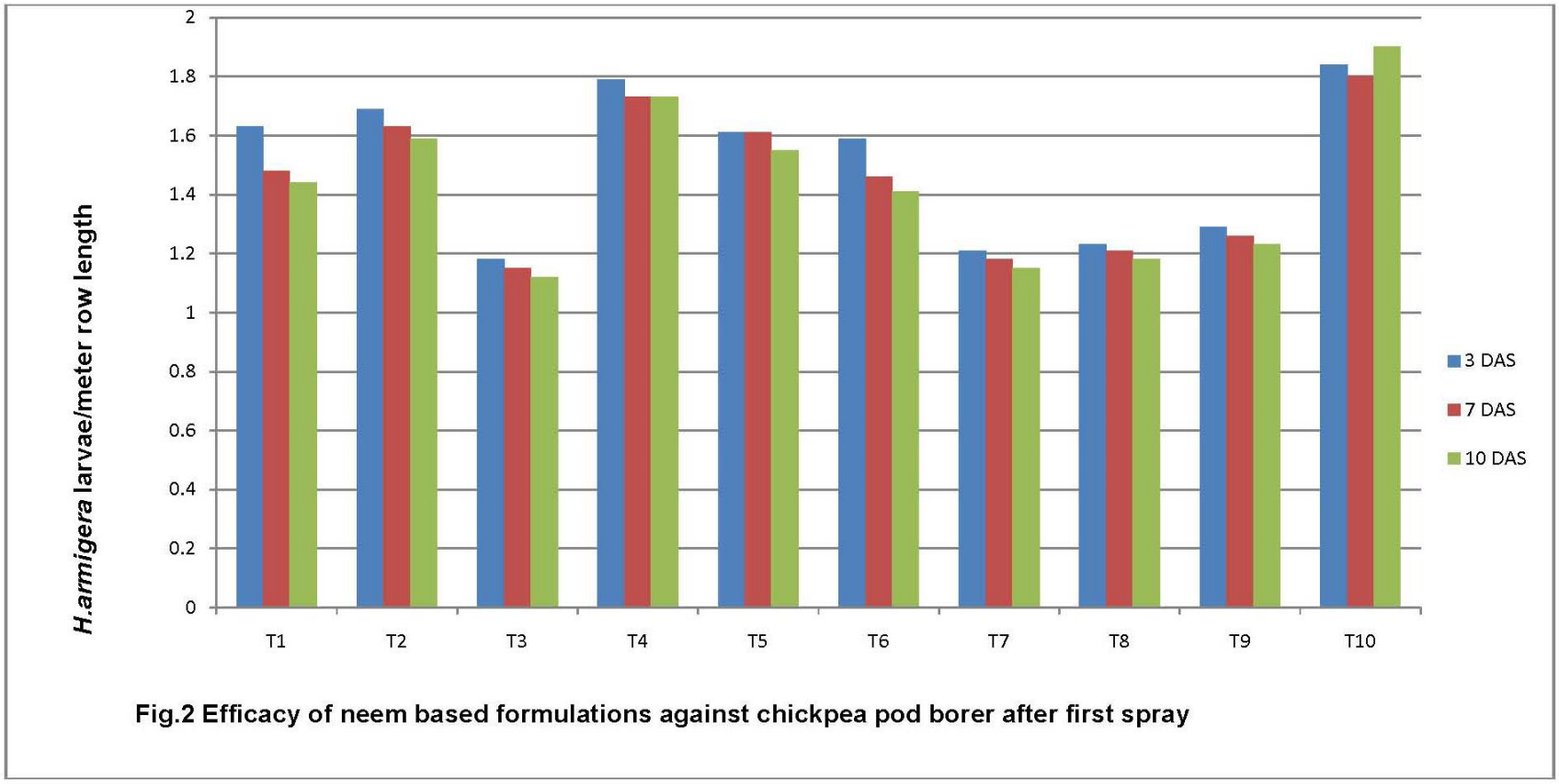

Fig.2 Efficacy of neem based formulations against chickpea pod borer after first spray

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

4.2 Efficacy of neem based formulations against chickpea pod borer after second spray

4.2.1 Three days after second spray

Data presented in Table 3 (Fig.3) revealed that all the treatments were significantly superior over untreated control in recording minimum number of chickpea pod borer larval population at three days after second spray. The lowest number of larvae (0.20 larvae/meter row length) were recorded in plot treated with azadirachtin 01.00% EC found at par with NSE 5% (0.27 larvae/meter row length), NSE 7.5% (0.33 larvae/meter row length) and NSE 10% (0.47 larvae/meter row length). The next effective treatments were neem oil 3% (0.80 larvae/meter row length), azadirachtin 00.30% EC (0.80 larvae/meter row length) and azadirachtin 0.15% EC (1.27 larvae/meter row length). However, these treatments were found at par with each other. Whereas, neem oil 2% (1.40 larvae/meter row length) and neem oil 1% (1.67 larvae/meter row length) showed moderate efficacy against chickpea pod borer. Whereas, untreated control recorded highest number i.e. 2.27 larvae/meter row length.

4.2.2 seven days after second spray.

The data on effect of different treatments against *H.armigera* larval population at seven days after second spray (Table 3 and Fig.3) revealed that application of azadirachtin 01.00% EC (0.33 larvae/meter row length) recorded lowest larval population. However, this treatment was found at par with NSE 5% (0.47 larvae/meter row length), NSE 7.5% (0.53 larvae/meter row length), NSE 10% (0.67 larvae/meter row length) and neem oil 3% (0.73 larvae/meter row length). The next in order of efficacy were azadirachtin 00.30% EC (0.87 larvae/meter row length), neem oil 2% (1.13 larvae/meter row length) and neem oil 1% (1.27 larvae per meter row length). All these treatments were found at par with each other. The treatment azadirachtin 0.15% EC (1.53 larvae/meter row length) showed moderate efficacy against larval population. Whereas, untreated control recorded highest number of larvae (2.13 larvae/meter row length).

Table 3: Efficacy of neem based formulations against chickpea pod borer after second spray

Sr. No	Treatments	Dose ml/L	*H.armigera* larvae/meter row length			
			3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 00.30%EC	5ml/L	0.80 (1.34)	0.87 (1.37)	0.73 (1.31)	0.8 (1.34)
2	Azadirachtin 0.15%EC	3ml/L	1.27 (1.50)	1.53 (1.59)	0.93 (1.39)	1.24 (1.49)
3	Azadirachtin 01.00%EC	2ml/L	0.20 (1.10)	0.33 (1.15)	0.40 (1.18)	0.31 (1.14)
4	Neem oil 1%	10ml/L	1.67 (1.63)	1.27 (1.50)	1.53 (1.59)	1.49 (1.57)
5	Neem oil 2%	20ml/L	1.40 (1.55)	1.13 (1.46)	1.00 (1.41)	1.17 (1.47)
6	Neem oil 3%	30ml/L	0.80 (1.34)	0.73 (1.32)	0.87 (1.37)	0.8 (1.34)
7	NSE	5%	0.27 (1.12)	0.47 (1.21)	0.4 (1.18)	0.38 (1.17)
8	NSE	7.5%	0.33 (1.15)	0.53 (1.23)	0.47 (1.21)	0.44 (1.19)
9	NSE	10%	0.47 (1.21)	0.67 (1.29)	0.60 (1.26)	0.58 (1.25)
10	Untreated control	-	2.27 (1.81)	2.13 (1.77)	1.73 (1.65)	2.04 (1.74)
	F test	-	Sig	Sig	Sig	Sig
	SE(m) ±	-	0.05	0.05	0.05	0.05
	CD @ 5%	-	0.17	0.17	0.15	0.16
	CV (%)	-	6.53	6.56	5.8	6.29

Note: Figures in parentheses are corresponding square root transformation values
DAS - Days after spraying

4.2.3 Ten days after second spray.

The data on larval population at ten days after second spray presented in Table 3 (Fig.3) was found statistically significant. Among the treatments azadirachtin 01.00% EC (0.40 larvae/meter row length)

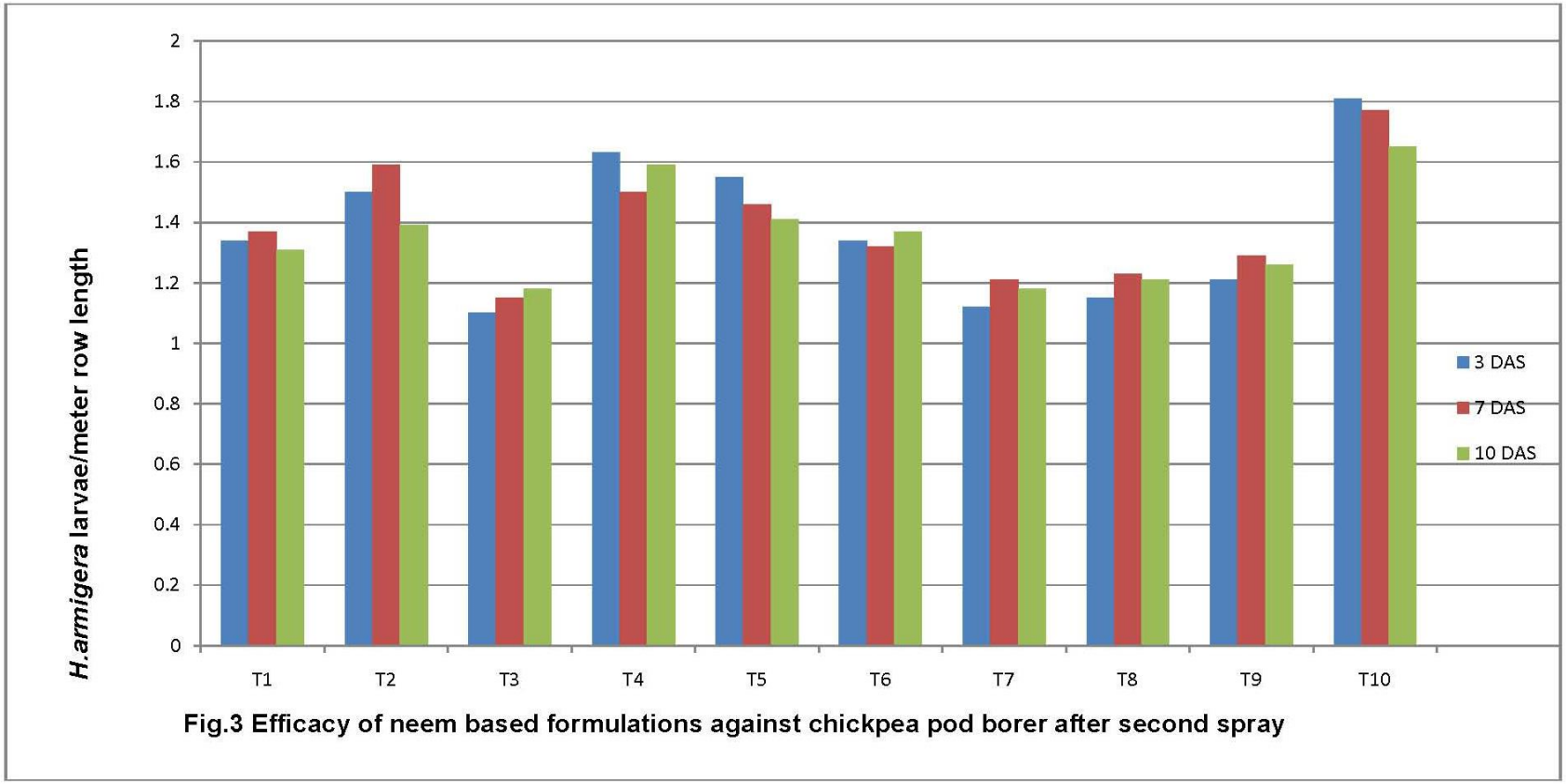

Fig.3 Efficacy of neem based formulations against chickpea pod borer after second spray

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

recorded minimum larval population and found statistically equal with NSE 5% (0.40 larvae/meter row length), NSE 7.5% (0.47 larvae/meter row length), NSE 10 % EC (0.60 larvae/meter row length) and azadirachtin 00.30 % EC (0.73 larvae/meter row length). The next effective treatments were neem oil 3% (0.87 larvae/meter row length), azadirachtin 0.15% EC (0.93 larvae/meter row length) and neem oil 2% (1.00 larvae/meter row length). Whereas, the treatment neem oil 1% (1.53 larvae/meter row length) recorded relatively highest number of larvae and was found at par with untreated control (1.73 larvae/meter row length).

4.2.4 Mean

The data on mean larval population after second spray displayed in Table 3 (Fig.3) revealed that treatments *viz.,* azadirachtin 01.00 % EC (0.31 larvae/meter row length), NSE 5% (0.38 larvae/meter row length), NSE 7.5% (0.44 larvae/meter row length) and NSE 10% (0.58 larvae/meter row length) proved equally effective in recording minimum larval population. The next effective treatments were azadirachtin 00.30% EC (0.8 larvae/meter row length), neem oil 3% (0.8 larvae/meter row length), neem oil 2% (1.17 larvae/meter row length) and azadirachtin 0.15% EC (1.24 larvae/meter row length). Whereas, neem oil 1% (1.49 larvae/meter row length) showed moderate effect against larval population. Maximum larval population was recorded in untreated control (2.04 larvae/meter row length).

4.3 Efficacy of neem based formulations against chickpea pod borer after third spray.

4.3.1 Three days after third spray

Among the different treatments the larval population recorded at three days after third spray (Table 4 and Fig.4) was significantly lowest in the plots treated with azadirachtin 01.00% EC (0.27 larvae/meter row length). However, this treatment was found at par with NSE 5% (0.33 larvae/meter row length), NSE 10% EC (0.40 larvae/meter row length) and NSE 7.5% (0.53 larvae/meter row length). Next in order of efficacy were neem oil 3% (0.73 larvae/meter row length), azadirachtin 00.30% EC (0.80

larvae/meter row length), azadirachtin 0.15% EC (0.87 larvae/meter row length) and neem oil 2% (0.87 larvae/meter row length). All this treatments were found at par with each other. Whereas, the treatment neem oil 1% (1.40 larvae/meter row length) was found at par with untreated control (1.80 larvae/meter row length).

4.3.2 Seven days after third spray.

The data tabulated in Table 4 (Fig.4) revealed that all the treatments except azadirachtin 0.15% EC (1.67 larvae/meter row length) and neem oil 1% (1.73 larvae/meter row length) were found statistically superior over untreated control (1.87 larvae/meter row length) in recording minimum larval population at seven days after third spray. Among the different treatments azadirachtin 01.00% EC (0.33 larvae/meter row length) recorded lowest number of larvae and was found at par with NSE 5% (0.47 larvae/meter row length), NSE 10% EC (0.53 larvae/meter row length) and NSE 7.5% (0.60 larvae/meter row length). Next in order of efficacy were treatment of azadirachtin 00.30% EC (1.00 larvae/meter row length), neem oil 3% (1.07 larvae meter row length) and neem oil 2% (1.27 larvae/meter row length).

4.3.3 Ten days after third spray.

The data on larval population recorded at ten days after third spray presented in Table 4 (Fig.4) was found statistically significant. The treatments viz., azadirachtin 01.00% EC, NSE 5%, NSE 7.5% and NSE 10% proved statistically equally effective and recorded 0.40, 0.53, 0.60 and 0.67 larvae per meter row length, respectively. Whereas, azadirachtin 00.30% EC (0.93 larvae/meter row length), neem oil 3% (1.00 larvae/meter row length), neem oil 2% (1.07 larvae/meter row length) and azadirachtin 0.15% EC (1.13 larvae/meter row length) proved moderately effective in this respect. However, the treatment neem oil 1% (1.60 larvae/meter row length) recorded relatively more number of *H.armigera* and was found at par with untreated control (1.93 larvae/meter row length).

Table 4: Efficacy of neem based formulations against chickpea pod borer after third spray

Sr. No	Treatments	Dose ml/L	*H.armigera* larvae/meter row length			
			3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 00.30%EC	5ml/L	0.80 (1.34)	1.00 (1.41)	0.93 (1.39)	0.91 (1.38)
2	Azadirachtin 0.15%EC	3ml/L	0.87 (1.37)	1.67 (1.63)	1.13 (1.46)	1.22 (1.48)
3	Azadirachtin 01.00%EC	2ml/L	0.27 (1.12)	0.33 (1.15)	0.4 (1.18)	0.33 (1.15)
4	Neem oil 1%	10ml/L	1.40 (1.55)	1.73 (1.65)	1.60 (1.61)	1.57 (1.60)
5	Neem oil 2%	20ml/L	0.87 (1.37)	1.27 (1.50)	1.07 (1.44)	1.07 (1.43)
6	Neem oil 3%	30ml/L	0.73 (1.31)	1.07 (1.43)	1.00 (1.41)	0.93 (1.38)
7	NSE	5%	0.33 (1.15)	0.47 (1.21)	0.53 (1.24)	0.44 (1.2)
8	NSE	7.5%	0.53 (1.23)	0.60 (1.26)	0.60 (1.26)	0.57 (1.25)
9	NSE	10%	0.40 (1.18)	0.53 (1.23)	0.8 (1.34)	0.57 (1.25)
10	Untreated control	-	1.80 (1.67)	1.87 (1.69)	1.93 (1.71)	1.86 (1.69)
	F test	-	Sig	Sig	Sig	Sig
	SE (m) ±	-	0.05	0.06	0.04	0.05
	CD @ 5%	-	0.18	0.18	0.14	0.16
	CV (%)	-	7.19	6.76	5.48	6.47

Note: Figures in parentheses are corresponding square root transformation values
DAS - Days after spraying

4.3.4 Mean

The data (Table 4 Fig.4) pertaining to mean larval population after third spray revealed that treatment with azadirachtin 01.00% EC proved significantly effective with lowest larval population (0.33 larvae/meter row length). However, this treatment was found statistically

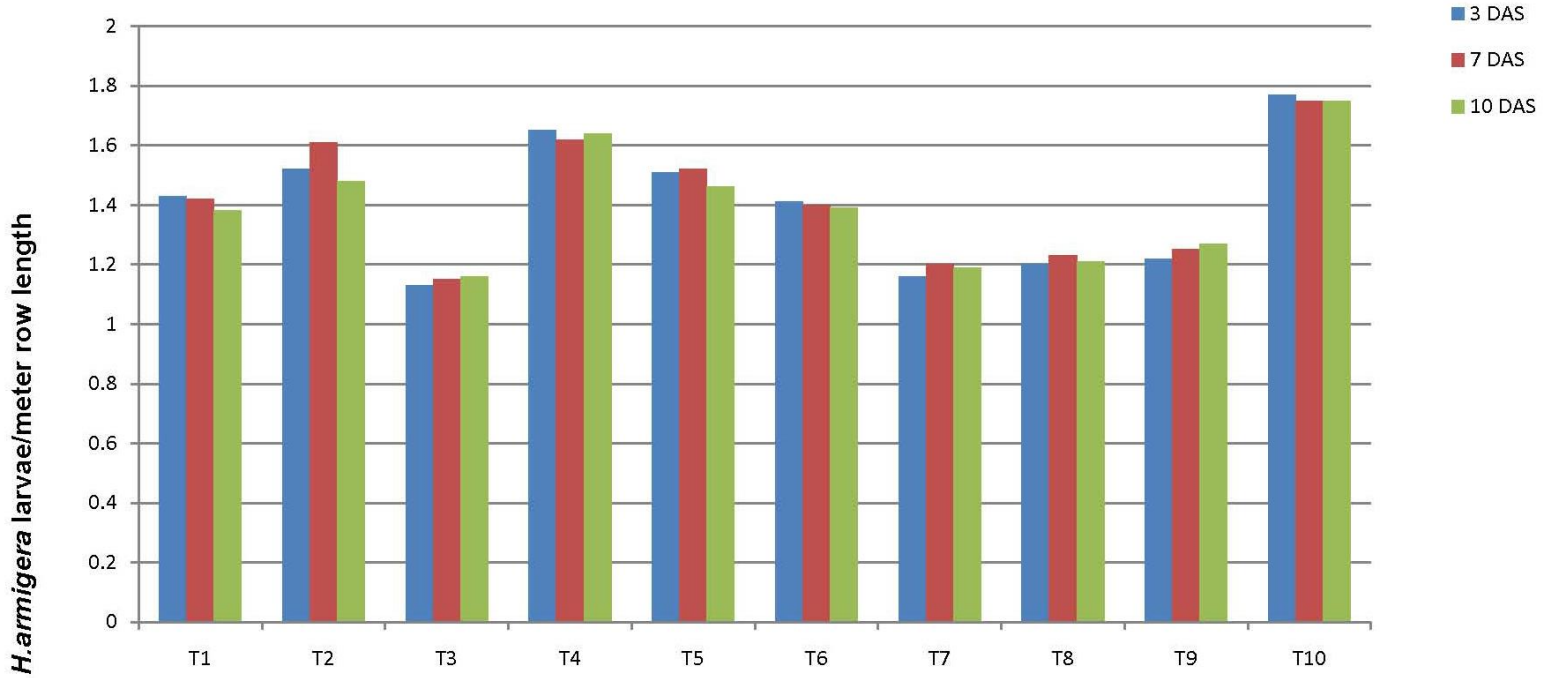

Fig.4 Efficacy of neem based formulations against chickpea pod borer after third spray

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

equal with NSE 5% (0.44 larvae/meter row length), NSE 7.5% (0.57 larvae/meter row length) and NSE 10% (0.57 larvae/meter row length). The next in order of efficacy were the treatments of azadirachtin 00.30% EC, neem oil 3%, neem oil 2% and azadirachtin 0.15% EC recorded larval population with in the range of 0.91 to 1.22 larvae per meter row length. However, all this treatments were found at par with each other. Whereas, the treatment neem oil 1% (1.57 larvae/meter row length) proved less effective against larval population and was found at par with untreated control (1.86 larvae/meter row length).

4.4 Cumulative effect of neem based formulations against chickpea pod borer

4.4.1 Three days after spray

The data displayed in Table 5 (Fig.5) pertaining to cumulative effect of neem based formulations against larval population at three days after spray revealed that azadirachtin 01.00% EC (0.29 larvae/meter row length) proved most effective in recording the lowest larval population and was found at par with NSE 5% (0.35 larvae/meter row length), NSE 7.5% (0.46 larvae/meter row length) and NSE 10% (0.51 larvae/meter row length). This was followed by neem oil 3% (1.02 larvae/meter row length), azadirachtin 00.30% EC (1.06 larvae/meter row length), neem oil 2% (1.29 larvae/meter row length) and azadirachtin 0.15% EC (1.33 larvae/meter row length). However, all these treatments were found at par with each other. Whereas, the treatment neem oil 1% (1.75 larvae/meter row length) proved relatively less effective and was found at par with untreated control (2.15 larvae/meter row length).

4.4.2 Seven days after spray

The data on cumulative effect of different treatments against larval population at seven days after spray (Table 5 and Fig.5) showed that application of azadirachtin 01.00% EC, NSE 5%, NSE 7.5%, and NSE 10% proved statistically equal in recording minimum larval population i.e. 0.33, 0.44, 0.53 and 0.57 per meter row length, respectively. Next in order of efficacy were neem oil 3% (0.97 larva/meter row length), azadirachtin 00.30% EC (1.20 larvae/meter row length) and neem oil 2% (1.33

larvae/meter row length). These treatments were found at par with each other. Whereas, the plots treated with azadirachtin 0.15% EC and neem oil 1% recorded relatively more number of *H.armigera* larvae i.e. 1.62 and 1.66 per meter row length respectively. These treatments were found at par with untreated control (2.09 larvae/meter row length).

Table 5: Cumulative effect of neem based formulations against chickpea pod borer

Sr. No	Treatments	Dose ml/L	*H.armigera* larvae/meter row length			
			3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 00.30%EC	5ml/L	1.06 (1.43)	1.20 (1.42)	0.91 (1.38)	1.05 (1.41)
2	Azadirachtin 0.15%EC	3ml/L	1.33 (1.52)	1.62 (1.61)	1.19 (1.48)	1.38 (1.53)
3	Azadirachtin 01.00%EC	2ml/L	0.29 (1.13)	0.33 (1.15)	0.35 (1.16)	0.32 (1.14)
4	Neem oil 1%	10ml/L	1.75 (1.65)	1.66 (1.62)	1.71 (1.64)	1.70 (1.63)
5	Neem oil 2%	20ml/L	1.29 (1.51)	1.33 (1.52)	1.15 (1.46)	1.07 (1.49)
6	Neem oil 3%	30ml/L	1.02 (1.41)	0.97 (1.40)	0.95 (1.39)	0.98 (1.4)
7	NSE	5%	0.35 (1.16)	0.44 (1.20)	0.42 (1.19)	0.40 (1.18)
8	NSE	7.5%	0.46 (1.20)	0.53 (1.23)	0.49 (1.21)	0.49 (1.21)
9	NSE	10%	0.51 (1.22)	0.57 (1.25)	0.64 (1.27)	0.57 (1.24)
10	Untreated control	-	2.15 (1.77)	2.09 (1.75)	2.08 (1.75)	2.10 (1.75)
	F test	-	Sig	Sig	Sig	Sig
	SE(m) ±	-	0.05	0.05	0.46	0.18
	CD @ 5%	-	0.17	0.18	0.15	0.16
	CV (%)	-	6.64	6.8	6.01	6.48

Note: Figures in parentheses are corresponding square root transformation values
DAS - Days After Spraying

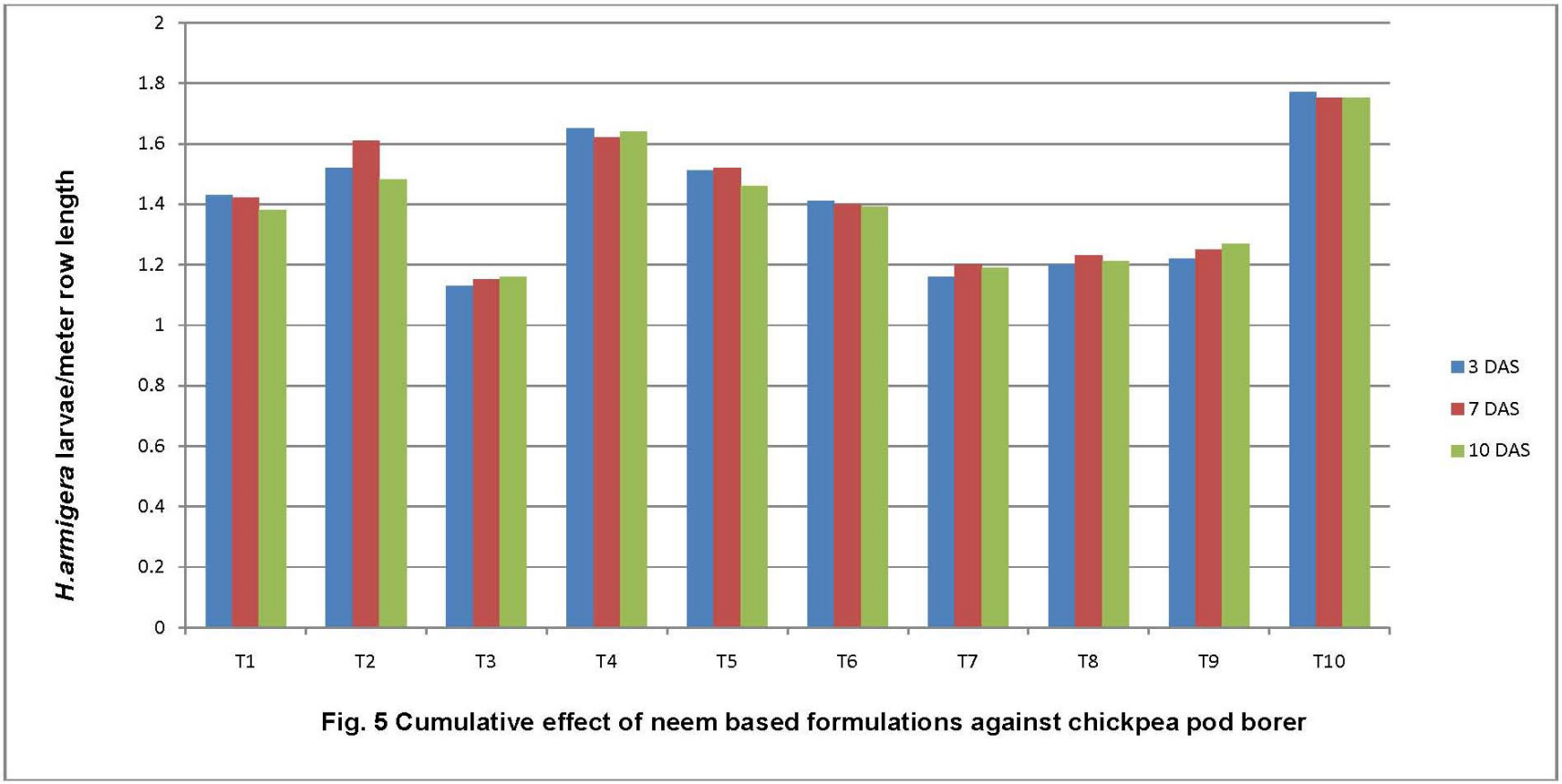

Fig. 5 Cumulative effect of neem based formulations against chickpea pod borer

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

4.4.3 Ten days after spray

Amongst the different treatments cumulative larval population at ten days after spray (Table 5 and Fig.5) was lowest in the plots treated with azadirachtin 01.00% EC (0.35 larvae/meter row length). This treatment was found at par with NSE 5% (0.42 larvae/meter row length), NSE 7.5% (0.49 larvae/meter row length) and NSE 10% (0.64 larvae/meter row length). However, the latter treatment in turn found statistically equal to azadirachtin 00.30% EC (0.91 larvae/meter row length) and neem oil 3% (0.95 larvae/meter row length). The treatment neem oil 2% (1.15 larvae/meter row length) and azadirachtin 0.15% EC (1.19 larvae/meter row length) showed moderate efficacy against chickpea pod borer. Whereas, neem oil 1% (1.71 larvae/meter row length) recorded relatively more number of larvae and found at par with untreated control (2.08 larvae/meter row length).

4.4.4 Mean

It is evident from the cumulative mean data presented in Table 5 and illustrated under Fig.5 that after three sprays treatment with azadirachtin 01.00% EC proved effective with minimum number of larvae (0.32 per meter row length). This treatment was found at par with NSE 5% (0.40 larvae/meter row length), NSE 7.5% (0.49 larvae/meter row length) and NSE 10% (0.57 larvae/meter row length). However, the latter treatment in turn found statistically equal to neem oil 3% (0.98 larvae/meter row length). Whereas, the next effective treatments viz., azadirachtin 00.30% EC, neem oil 2% and azadirachtin 0.15% EC recorded larval population with in the range of 1.05 to 1.53 per meter row length. The treatment neem oil 1% (1.70 larvae/meter row length) proved less effective and found at par with untreated control (2.10 larvae/meter row length).

4.5. Effect of neem based formulations on chickpea pod damage due to *H.armigera* after first spray

The data on pod damage recorded a day before the first spray in different treatments found statistically non-significant which ranged from 4.97 to 5.92 percent.

Plate 3: Pod damage due to *H.armigera* larvae observed during experimentation

4.5.1. Three days after first spray

The data tabulated in Table 6 (Fig.6) revealed that all the treatments except neem oil 2% (5.88 per cent/meter row length) and neem oil 1% (6.56 per cent/meter row length) were found significantly superior over untreated control (7.04 per cent/meter row length) in recording minimum pod damage at three days after first spray. Among the different treatments azadirachtin 01.00% EC (2.59 per cent/meter row length) recorded minimum pod damage and was found at par with NSE 5% (2.66 per cent/meter row length), NSE 7.5% (2.96 per cent/meter row length) and NSE 10% (3.37 per cent/meter row length). Next in order of efficacy were neem oil 3% (4.43 per cent/meter row length), azadirachtin 0.15% EC (4.53 per cent/meter row length) and azadirachtin 00.30% EC (5.21 per cent/meter row length). However, all these treatments were found at par with each other.

4.5.2 Seven days after first spray

The data displayed in Table 6 (Fig.6) pertaining to pod damage at seven days after first spray was found statistically significant. Among the treatments azadirachtin 01.00% EC (2.71 per cent/meter row length) recorded lowest pod damage and was found at par with NSE 5% (2.94 per cent/meter row length), NSE 7.5% (3.11 per cent/meter row length) and NSE 10% (3.26 per cent/meter row length). The next effective treatments were azadirachtin 00.30% EC (4.54 per cent/meter row length), neem oil 3% (4.80 per cent/meter row length) and neem oil 1% (5.06 per cent/meter row length). These treatments were found at par with each other. Whereas, the treatment azadirachtin 0.15% EC (5.95 per cent/meter row length) and neem oil 2% (6.48 per cent/meter row length) proved less effective and found at par with untreated control (7.15 per cent/meter row length).

Table 6: Effect of neem based formulations on chickpea pod damage due to *H.armigera* after first spray

Sr. No	Treatments	Dose ml/L	Per cent pod damage/meter row length				Mean
			1 DBS	3 DAS	7 DAS	10 DAS	
1	Azadirachtin 00.30%EC	5ml /L	5.35 (13.37)	5.21 (13.18)	4.54 (12.27)	4.29 (11.94)	4.68 (12.46)
2	Azadirachtin 0.15%EC	3ml/L	5.51 (13.57)	4.53 (12.27)	5.95 (14.11)	5.10 (13.05)	5.19 (13.14)
3	Azadirachtin 01.00%EC	2ml/L	4.97 (12.86)	2.59 (9.26)	2.71 (9.45)	2.31 (8.73)	2.53 (9.14)
4	Neem oil 1%	10ml/L	5.73 (13.84)	6.56 (14.82)	5.06 (12.99)	4.44 (12.10)	5.35 (13.30)
5	Neem oil 2%	20ml/L	5.63 (13.70)	5.88 (14.03)	6.48 (14.74)	6.58 (14.84)	6.31 (14.53)
6	Neem oil 3%	30ml/L	5.47 (13.52)	4.43 (12.11)	4.80 (12.65)	4.21 (11.79)	4.48 (12.18)
7	NSE	5%	5.16 (13.13)	2.66 (9.38)	2.94 (9.86)	2.55 (9.18)	2.71 (9.47)
8	NSE	7.5%	5.71 (13.82)	2.96 (9.90)	3.11 (10.12)	2.87 (9.74)	2.98 (9.92)
9	NSE	10%	5.82 (13.94)	3.37 (10.55)	3.26 (10.37)	3.01 (10.00)	3.21 (10.30)
10	Untreated control	-	5.92 (14.08)	7.04 (15.38)	7.15 (15.51)	6.72 (15.00)	6.97 (15.29)
	F test	-	NS	Sig	Sig	Sig	Sig
	SE (m) ±	-	-	0.42	0.45	0.52	0.46
	CD @5%	-	-	1.35	1.44	1.68	1.49
	CV (%)	-	-	6.06	6.38	7.79	6.74

Note : Figures in the parentheses are corresponding arc sine transformation values
DBS- Days Before Spraying , DAS- Days After Spraying

4.5.3 Ten days after first spray

Among the different treatments pod damage recorded at ten days after first spray (Table 6 and Fig.6) was minimum in the plots treated with azadirachtin 01.00% EC (2.31 per cent/meter row length). However,

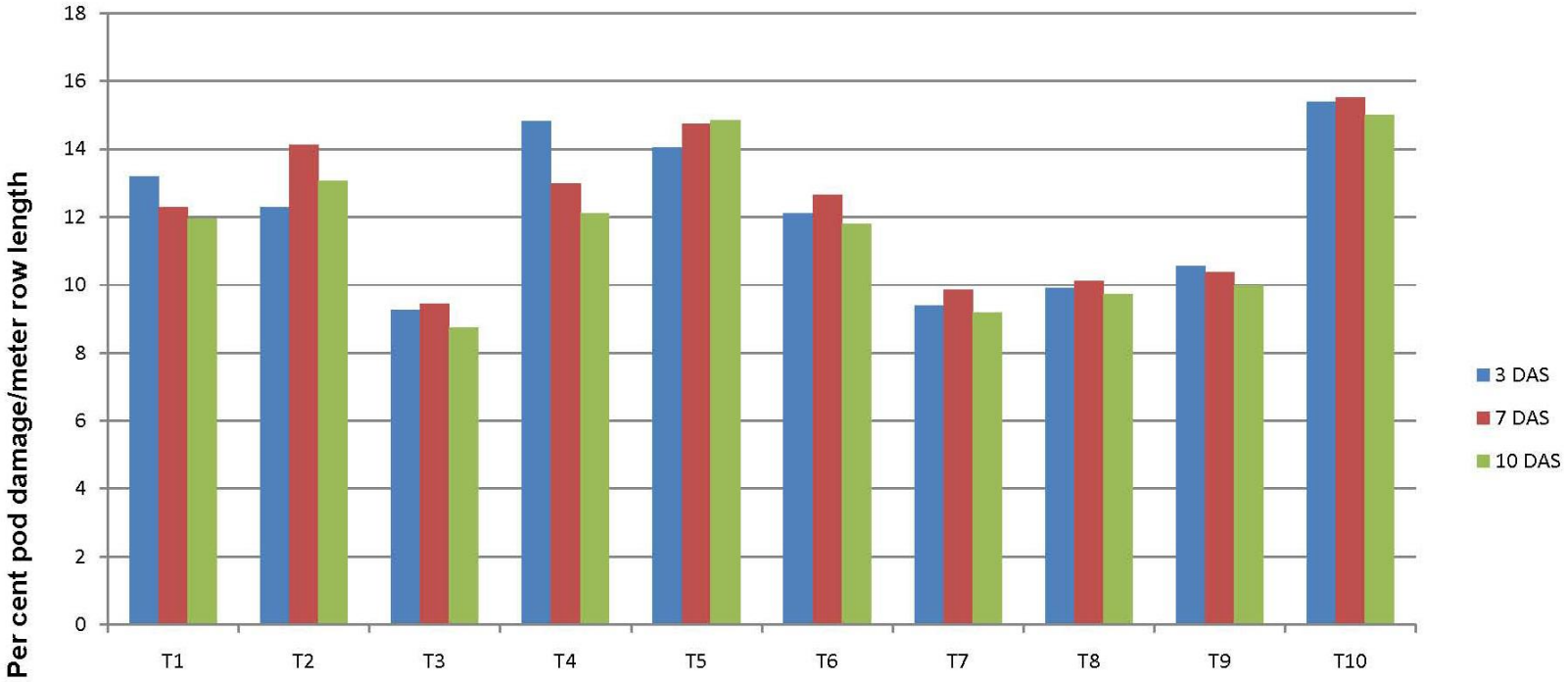

Fig.6 Effect of neem based formulations on chickpea pod damage due to *H.armigera* after first spray

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

this treatment was found statistically equal with NSE 5% (2.55 per cent/meter row length), NSE 7.5% (2.87 per cent/meter row length) and NSE 10% (3.01 per cent/meter row length). These were followed by treatment neem oil 3% (4.21 per cent/meter row length), azadirachtin 00.30% EC (4.29 per cent/meter row length) and neem oil 1% (4.44 per cent/meter row length). However, all these treatments found statistically equal with each other. The treatment azadirachtin 0.15% EC (5.10 per cent/meter row length) proved moderately effective in this respect. The treatment neem oil 2% (6.58 per cent/meter row length) found at par with untreated control (6.72 per cent/meter row length).

4.5.4 Mean

The data depicted in Table 6 (Fig.6) regarding mean pod damage after first spray was significant. Amongst the treatments azadirachtin 01.00% EC (2.53 per cent/meter row length), NSE 5% (2.71 per cent/meter row length), NSE 7.5% (2.98 per cent/meter row length) and NSE 10% (3.21 per cent/meter row length) found statistically equal in recording the minimum pod damage. The next effective treatments were neem oil 3% (4.48 per cent/meter row length), azadirachtin 00.30% EC (4.68 per cent/meter row length), azadirachtin 0.15% EC (5.19 per cent/meter row length) and neem oil 1% (5.35 per cent/meter row length) found at par with each other. However, neem oil 2% (6.31 per cent/meter row length) proved less effective and found at par with untreated control (6.97 per cent/meter row length).

4.6. Effect of neem based formulations on chickpea pod damage due to *H.armigera* after second spray

4.6.1 Three days second spray

The data pertaining to effect of neem based formulations on pod damage due to *H.armigera* at three days after second spray presented in Table 7 (Fig.7) revealed that lowest pod damage was recorded in plots treated with azadirachtin 01.00% EC (1.85 per cent/meter row length). However, this treatment was found at par with NSE 5% (2.17 per cent/meter row length), NSE 10% (2.33 per cent/meter row length) and NSE 7.5% (2.38 per cent/meter row length). The next in order of efficacy

were neem oil 3% (3.24 per cent/meter row length), azadirachtin 00.30% EC (3.49 per cent/meter row length) and neem oil 1% (3.80 per cent/meter row length). The treatments neem oil 2% (4.78 per cent/meter row length) and azadirachtin 0.15% EC (5.58 per cent/meter row length) proved least effective and found at par with untreated control (5.65 per cent/meter row length).

4.6.2 Seven days after second spray.

The data tabulated in Table 7 (Fig.7) revealed that all the treatments were significantly effective over untreated control in reducing the pod damage at seven days after first spray. Among the treatments azadirachtin 01.00% EC (1.74 per cent/meter row length), NSE 5% (2.06 per cent/meter row length), NSE 7.5% (2.10 per cent/meter row length) and NSE 10% (2.37 per cent/meter row length) proved statistically equal and significantly superior over other treatments in recording minimum pod damage. The next effective treatments were azadirachtin 00.30% EC (3.29 per cent/meter row length), neem oil 3% (3.36 per cent/meter row length) and azadirachtin 0.15% EC (3.98 per cent/meter row length). These treatments were found at par with each other. Whereas, the treatments neem oil 1% (4.75 per cent/meter row length) and neem oil 2% (5.41 per cent/meter row length) proved relatively less effective in this respect. The maximum pod damage was recorded in untreated control (6.65 per cent/meter row length).

4.6.3 Ten days after second spray

The data on the efficacy of various treatments against pod borer damage at ten days after second spray (Table 7 and Fig.7) revealed that the lowest pod damage was recorded in plot treated with azadirachtin 01.00 % EC (1.57 per cent/meter row length). However, this treatment was found at par with NSE 5% (1.74 per cent/meter row length), NSE 10% (2.12 per cent/meter row length) and NSE 7.5% (2.15 per cent/meter row length).The next effective treatments were azadirachtin 00.30% EC, neem oil 3% and azadirachtin 0.15% EC recorded 3.13, 3.25 and 3.58 per cent pod damage, respectively and found at par with each other. The treatment neem oil 1% (4.40 per cent/meter row length) proved moderately effective

in this respect. Whereas, the treatment neem oil 2% (5.76 per cent/meter row length) found at par with untreated control (6.84 per cent/meter row length).

Table 7: Effect of neem based formulations on chickpea pod damage due to *H.armigera* after second spray

Sr. No	Treatments	Dose ml/L	Per cent pod damage/meter row length			
			3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 00.30%EC	5ml /L	3.49 (10.76)	3.29 (10.43)	3.13 (10.13)	3.30 (10.44)
2	Azadirachtin 0.15%EC	3ml/L	5.58 (13.66)	3.98 (11.50)	3.58 (10.89)	4.38 (12.01)
3	Azadirachtin 01.00%EC	2ml/L	1.85 (7.81)	1.74 (7.56)	1.57 (7.19)	1.72 (7.52)
4	Neem oil 1%	10ml/L	3.80 (11.21)	4.75 (12.57)	4.40 (12.09)	4.31 (11.95)
5	Neem oil 2%	20ml/L	4.78 (12.61)	5.41 (13.45)	5.76 (13.88)	5.31 (13.31)
6	Neem oil 3%	30ml/L	3.24 (10.36)	3.36 (10.55)	3.25 (10.38)	3.28 (10.43)
7	NSE	5%	2.17 (8.47)	2.06 (8.24)	1.74 (7.58)	1.99 (8.09)
8	NSE	7.5%	2.38 (8.85)	2.10 (8.32)	2.15 (8.41)	2.21 (8.52)
9	NSE	10%	2.33 (8.74)	2.37 (8.80)	2.12 (8.36)	2.27 (8.63)
10	Untreated control	-	5.65 (13.75)	6.65 (14.92)	6.84 (15.15)	6.38 (14.6)
	F test	-	Sig	Sig	Sig	Sig
	SE (m) ±	-	0.37	0.44	0.4	0.4
	CD @ 5%	-	1.19	1.4	1.27	1.28
	CV (%)	-	6.06	7.15	6.58	6.59

Note : Figures in the parentheses are corresponding arc sine transformation values

Sig- Significant, DAS- Days After Spraying

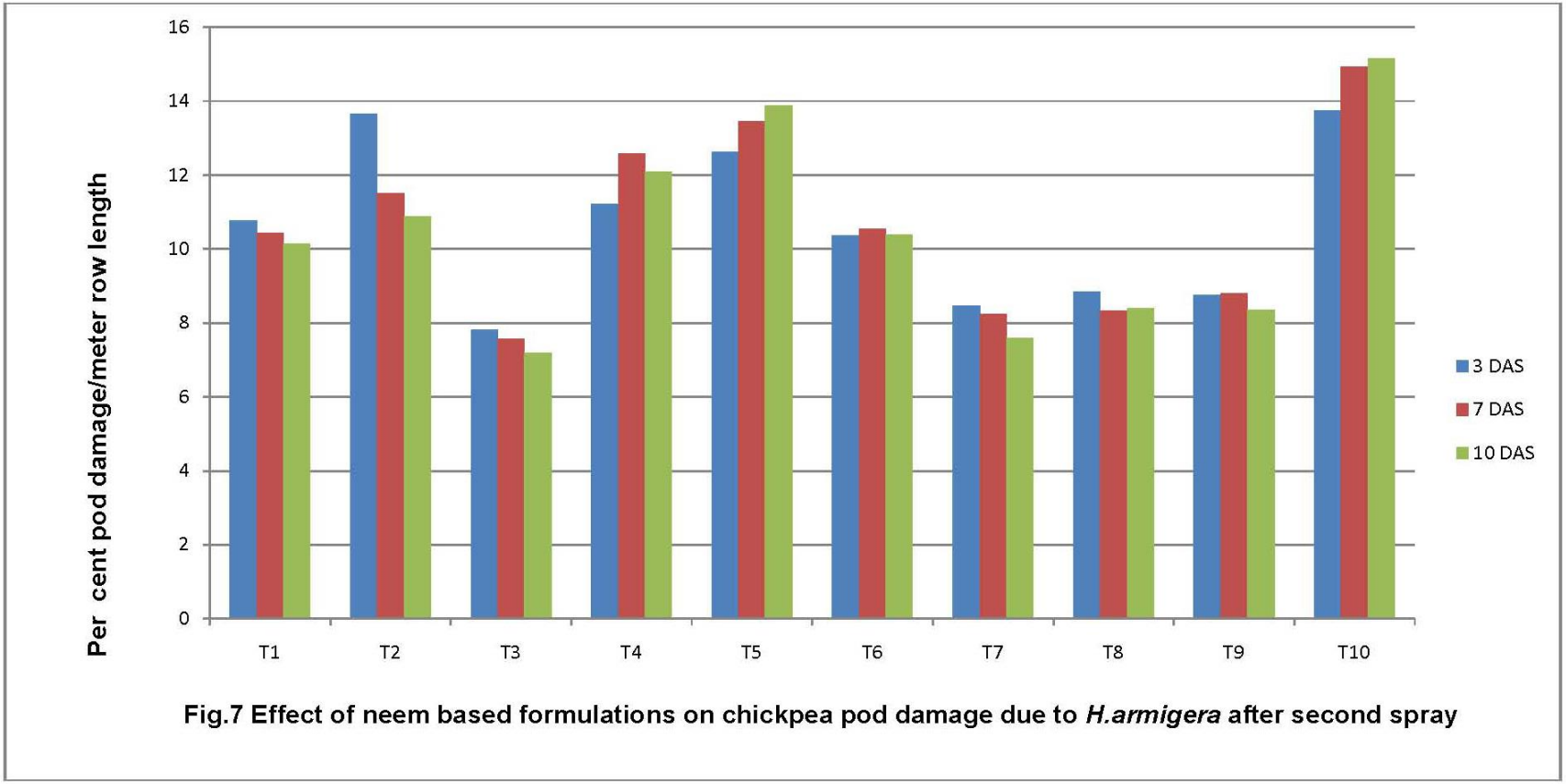

Fig.7 Effect of neem based formulations on chickpea pod damage due to *H.armigera* after second spray

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

4.6.4 Mean

It is evident from the mean data presented in Table 7 (Fig.7) that after second spray treatment with azadirachtin 01.00% EC (1.72 per cent/meter row length) proved effective with minimum pod damage. However, this treatment was found at par with NSE 5% (1.99 per cent/meter row length), NSE 7.5% (2.21 per cent/meter row length) and NSE 10% (2.27 per cent/meter row length). These were followed by neem oil 3% (3.28 per cent/meter row length) found at par with azadirachtin 00.30% EC (3.30 per cent/meter row length).

However, the treatment neem oil 1% (4.31 per cent/meter row length) and azadirachtin 0.15% EC (4.38 per cent/meter row length) proved moderately effective in this respect. Whereas, the treatment neem oil 2% recorded relatively higher pod damage i.e. 5.31 per cent but found significantly superior over untreated control (6.38 per cent/meter row length).

4.7 Effect of neem based formulations on chickpea pod damage due to *H.armigera* after third spray.

4.7.1 Three days after third spray

The data pertaining to pod damage at three days after third spray presented in Table 8 (Fig.8) was found statistically significant. Among the treatments azadirachtin 01.00% EC (1.36 per cent/meter row length) recorded minimum pod damage and was found at par with NSE 5% (1.60 per cent/meter row length), NSE 7.5% (1.85 per cent/meter row length) and NSE 10% (1.91 per cent/meter row length). Whereas, treatment neem oil 3% (3.08 per cent/meter row length), azadirachtin 00.30% EC (3.63 per cent/meter row length) and neem oil 1% (4.21 per cent/meter row length) showed moderate efficacy in this respect. The treatment azadirachtin 0.15% EC (4.48 per cent/meter row length) and neem oil 2% (5.72 per cent/meter row length) were found at par with untreated control (5.83 per cent/meter row length).

Table 8: Effect of neem based formulations on chickpea pod damage due to *H.armigera* after third spray.

Sr. No	Treatments	Dose ml/L	Per cent pod damage/meter row length			
			3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 00.30%EC	5ml /L	3.63 (10.97)	3.37 (10.56)	3.50 (10.73)	3.50 (10.75)
2	Azadirachtin 0.15%EC	3ml/L	4.48 (12.16)	5.04 (12.92)	5.46 (13.51)	4.99 (12.86)
3	Azadirachtin 01.00%EC	2ml/L	1.36 (6.68)	1.27 (6.45)	1.14 (6.13)	1.25 (6.42)
4	Neem oil 1%	10ml/L	4.21 (11.79)	5.45 (13.47)	4.33 (11.98)	4.66 (12.41)
5	Neem oil 2%	20ml/L	5.72 (13.83)	3.79 (11.21)	4.83 (12.69)	4.78 (12.57)
6	Neem oil 3%	30ml/L	3.08 (10.09)	2.84 (9.65)	2.68 (9.33)	2.68 (9.69)
7	NSE	5%	1.60 (7.24)	1.35 (6.67)	1.30 (6.54)	1.41 (6.81)
8	NSE	7.5%	1.85 (7.80)	1.55 (7.09)	1.64 (7.32)	1.68 (7.40)
9	NSE	10%	1.91 (7.92)	1.87 (7.84)	1.86 (7.77)	1.88 (7.84)
10	Untreated control	-	5.83 (13.96)	5.89 (14.02)	7.20 (15.56)	6.30 (14.51)
	F test	-	Sig	Sig	Sig	Sig
	SE (m) ±	-	0.56	0.56	0.6	0.57
	CD @5%	-	1.8	1.79	1.91	1.83
	CV (%)	-	9.54	9.73	10.17	9.81

Note: Figures in the parentheses are corresponding arc sine transformation values Sig- Significant, DAS- Days After Spraying

4.7.2 Seven days after third spray

The Table 8 (Fig.8) pertaining to pod damage recorded at seven days after third spray showed that the minimum pod damage was

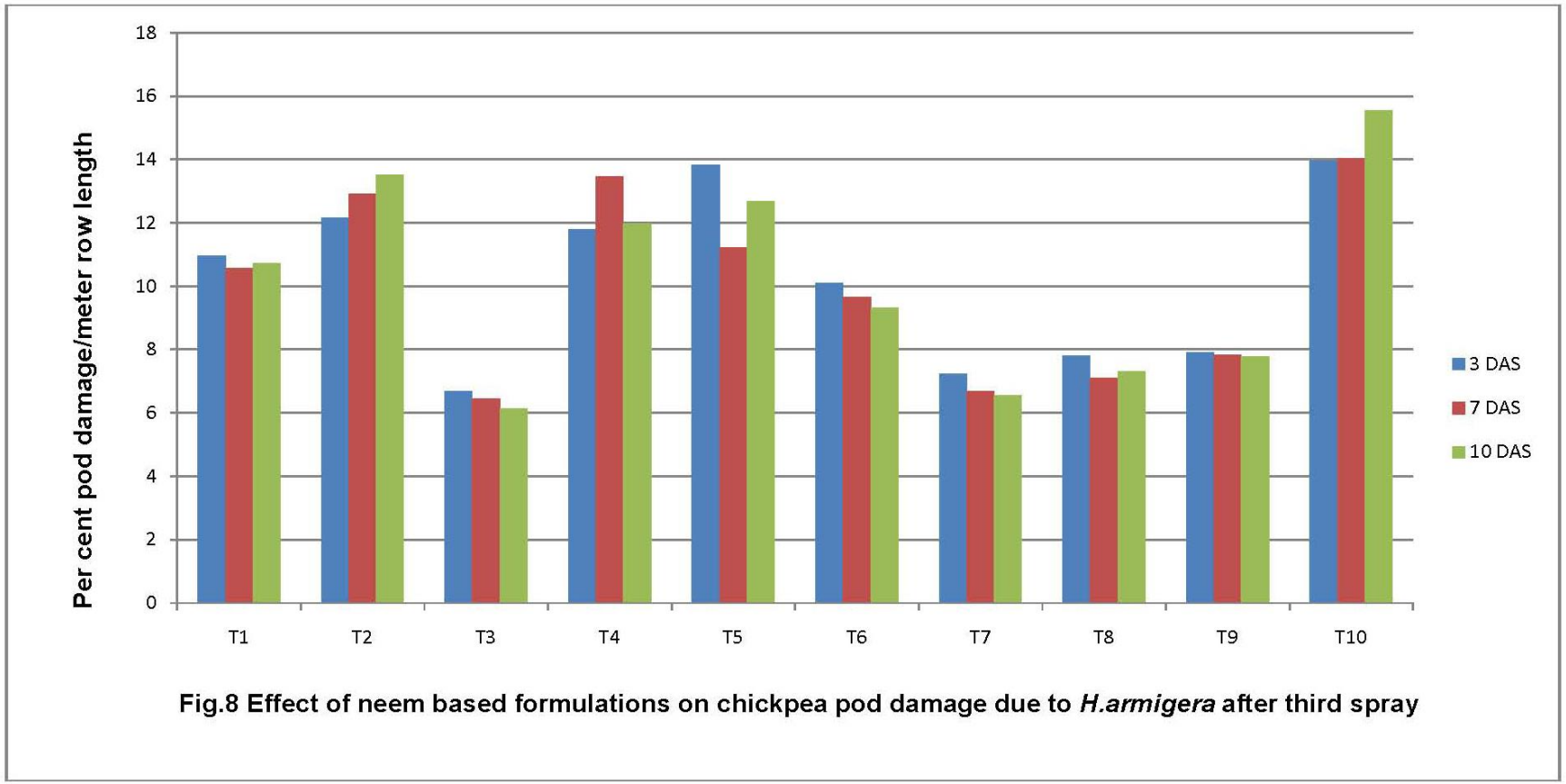

Fig.8 Effect of neem based formulations on chickpea pod damage due to *H.armigera* after third spray

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

observed in plots treated with azadirachtin 01.00% EC (1.27 per cent/meter row length). However, this treatment was found at par with NSE 5% (1.35 per cent/meter row length), NSE 7.5% (1.55 per cent/meter row length) and NSE 10% (1.87 per cent/meter row length). The next effective treatments were neem oil 3% (2.84 per cent/meter row length), azadirachtin 00.30%EC (3.37 per cent/meter row length) and neem oil 2% (3.79 per cent/meter row length) found at par with each other. Whereas, the treatment azadirachtin 0.15% EC (5.04 per cent/meter row length) and neem oil 1% (5.45 per cent/meter row length) recorded higher pod damage and were found at par with untreated control (5.89 per cent/meter row length).

4.7.3 Ten days after third spray

The data on efficacy of different treatments against pod borer damage at ten days after third spray (Table 8 and Fig.8) revealed that all the treatments were significantly superior over untreated control in recording minimum pod damage.

Among the different treatments azadirachtin 01.00% EC (1.14 per cent/meter row length) recorded minimum pod damage and was found at par with NSE 5% (1.30 per cent/meter row length), NSE 10% (1.45 per cent/meter row length) and NSE 7.5% (1.64 per cent/meter row length). The next effective treatments were neem oil 3% (2.68 per cent/meter row length) and azadirachtin 00.30% EC (3.50 per cent/meter row length) found at par with each other. The treatment with neem oil 1% (4.33 per cent/meter row length), neem oil 2% (4.83 per cent/meter row length) and azadirachtin 0.15% EC (5.46 per cent/meter row length) proved moderately effective in this respect. The maximum pod damage of 7.20 per cent was recorded in untreated control plots.

4.7.4 Mean

The data on mean pod damage after third spray (Table 8 and Fig.8) revealed that the treatments azadirachtin 01.00% EC, NSE 5%, NSE 7.5% and NSE 10% proved equally effective in recording minimum pod damage i.e 1.25, 1.41, 1.68 and 1.88 per cent respectively and found significantly superior over other treatments. These were followed by

treatments of neem oil 3% (2.68 per cent/meter row length) and azadirachtin 00.30% EC (3.50 per cent/meter row length). However, the treatments neem oil 1% (4.66 per cent/meter row length) and neem oil 2% (4.78 per cent/meter row length) proved moderately effective. Whereas, the plots treated with azadirachtin 0.15 % EC recorded 4.99 per cent pod damage and found at par with untreated control (6.30 per cent/meter row length).

4.8 Cumulative effect of neem based formulation on chickpea pod damage due to *H.armigera*

4.8.1 Three days after spray

The data depicted in Table 9 (Fig.9) regarding cumulative effect of neem based formulations at three days after spray on chickpea pod damage revealed that treatment with azadirachtin 01.00% EC (1.93 per cent/meter row length), NSE 5% (2.14 per cent/meter row length), NSE 7.5% (2.39 per cent/meter row length) and NSE 10% (2.72 per cent/meter row length) proved statistically equal with each other. However, these treatments were found significantly superior in recording minimum pod damage with each other. Whereas, neem oil 3% (3.58 per cent/meter row length) and azadirachtin 00.30% EC (4.11 per cent/meter row length) were next effective treatments found at par with each other. The treatment neem oil 1% (4.85 per cent/meter row length), azadirachtin 0.15% EC (4.86 per cent/meter row length) and neem oil 2% (5.46 per cent/meter row length) proved relatively less effective and found at par with untreated control (5.80 per cent/meter row length).

4.8.2 Seven days after spray

The cumulative data on pod damage at seven days after spray presented in Table 9 (Fig.9) found statistically significant. The minimum pod damage was recorded in plots treated with azadirachtin 01.00% EC (1.90 per cent/meter row length), NSE 5% (2.11 per cent/meter row length), NSE 7.5% (2.25 per cent/meter row length) and NSE 10% (2.50 per cent/meter row length). However, all these treatments found at par with each other.

Table 9: Cumulative effect of neem based formulations on chickpea pod damage due to *H. armigera*

Sr. No	Treatments	Dose ml/L	Per cent pod damage/ meter row length			
			3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 00.30%EC	5ml /L	4.11 (11.63)	3.73 (11.08)	3.64 (10.93)	3.82 (11.21)
2	Azadirachtin 0.15%EC	3ml/L	4.86 (12.69)	4.51 (12.84)	4.71 (12.48)	4.69 (12.67)
3	Azadirachtin 01.00%EC	2ml/L	1.93 (7.91)	1.90 (7.85)	1.67 (7.35)	1.83 (8.10)
4	Neem oil 1%	10ml/L	4.85 (12.60)	5.08 (13.01)	4.40 (12.05)	4.77 (12.55)
5	Neem oil 2%	20ml/L	5.46 (13.49)	5.22 (13.13)	5.72 (13.80)	5.46 (13.47)
6	Neem oil 3%	30ml/L	3.58 (10.85)	3.66 (10.95)	3.38 (10.50)	3.54 (10.76)
7	NSE	5%	2.14 (8.36)	2.11 (8.25)	1.86 (7.76)	2.03 (8.12)
8	NSE	7.5%	2.39 (8.85)	2.25 (8.51)	2.22 (8.49)	2.28 (8.61)
9	NSE	10%	2.72 (9.07)	2.5 (9.00)	2.33 (8.77)	2.51 (8.94)
10	Untreated control	-	5.8 (13.93)	6.56 (14.81)	6.94 (15.26)	6.43 (14.66)
	F test	-	Sig	Sig	Sig	Sig
	SE (m) ±	-	0.45	0.48	0.49	0.47
	CD @5%	-	1.44	1.54	1.62	1.53
	CV (%)	-	5.19	7.75	8.18	7.04

Note: Figures in the parentheses are corresponding arc sine transformation values, Sig- Significant, DAS- Days After Spraying

The next effective treatments in order of efficacy were neem oil 3% (3.66 per cent/meter row length) and azadirachtin 00.30% EC (3.73 per cent/meter row length) which proved statistically equal to each other. The treatment azadirachtin 0.15% EC (4.51 per cent/meter row length),

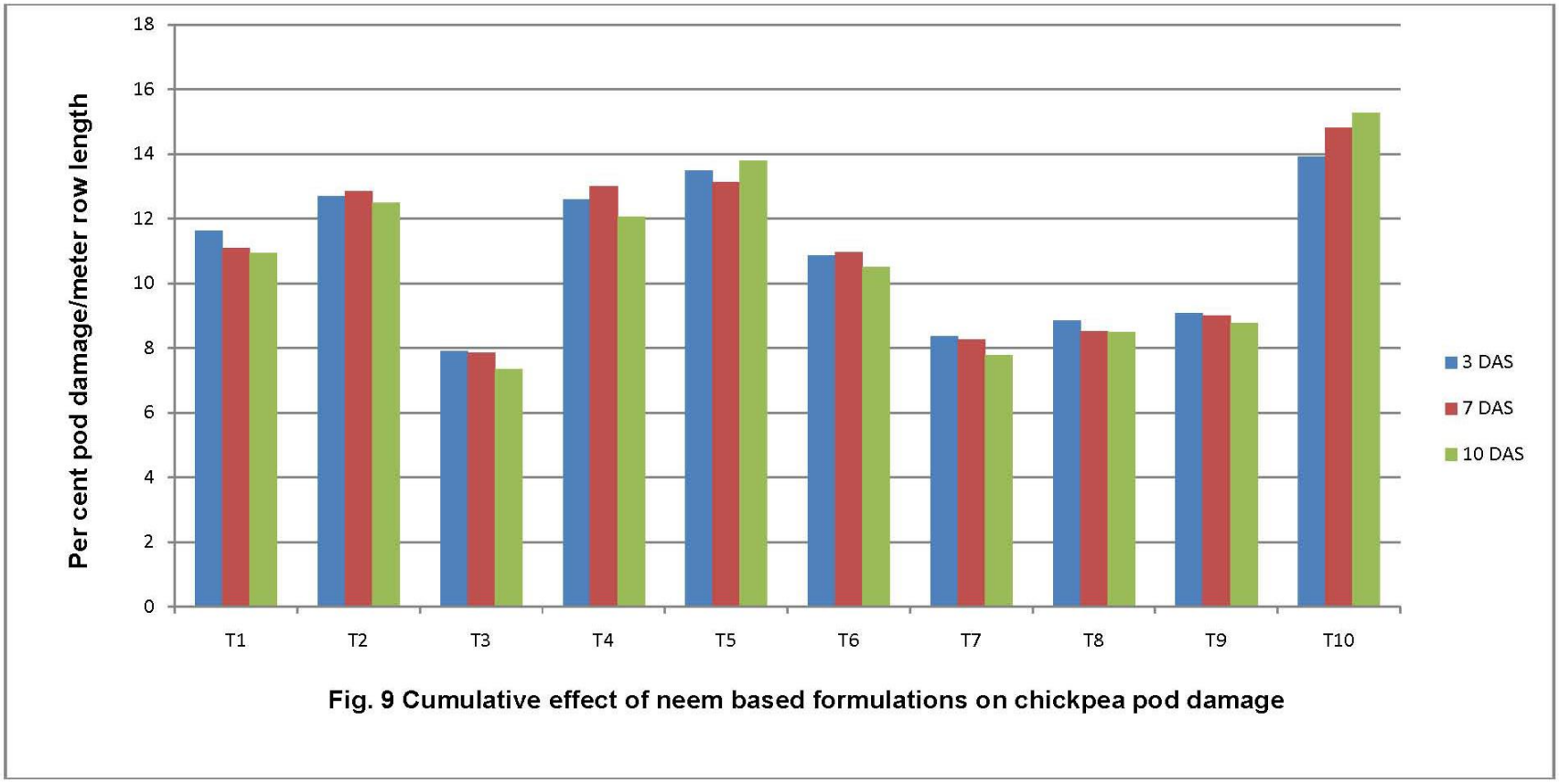

Fig. 9 Cumulative effect of neem based formulations on chickpea pod damage

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

neem oil 1% (5.08 per cent/meter row length) and neem oil 2% (5.22 per cent/meter row length) showed moderate efficacy in this respect. The highest pod damage was recorded in untreated control (6.56 per cent/meter row length).

4.8.3 Ten days after spray

The cumulative data pertaining to pod damage recorded at ten days after each spray (Table 9 and Fig.9) was found statistically significant. Among the treatments the lowest pod damage was observed in the plots treated with azadirachtin 01.00 % EC (1.67 per cent/meter row length). However, this treatment was found at par with NSE 5% (1.86 per cent/meter row length), NSE 7.5% (2.22 per cent/meter row length) and NSE 10% (2.33 per cent/meter row length). These were followed by neem oil 3% (3.38 per cent/meter row length), azadirachtin 00.30 %EC (3.64 per cent/meter row length), neem oil 1% (4.40 per cent/meter row length) and azadirachtin 0.15% EC (4.71 per cent/meter row length). Whereas, neem oil 2% (5.72 per cent/meter row length) proved least effective. The maximum pod damage was recorded in untreated control (6.94 per cent/meter row length).

4.8.4 Mean

The cumulative mean data (Table 9 and Fig.9) of three sprays regarding pod damage revealed that azadirachtin 01.00% EC (1.83 per cent/meter row length) recorded minimum pod damage. However, this treatment was found statistically equal with NSE 5% (2.03 per cent/meter row length), NSE 7.5% (2.28 per cent/meter row length) and NSE 10% (2.51 per cent/meter row length). The next treatments in order of efficacy were neem oil 3% (3.54 per cent/meter row length) and azadirachtin 00.30% EC (3.82 per cent/meter row length) proved statistically equal with each other. Whereas, the treatment azadirachtin 0.15% EC (4.69 per cent/meter row length) and neem oil 1% (4.77 per cent/meter row length) showed moderate efficacy in this respect. The treatment of neem oil 2% (5.46 per cent/meter row length) proved least effective and found statistically equal with untreated control (6.43 per cent/meter row length).

4.9 Effect of neem based formulations on grain yield of chickpea

The grain yield data of chickpea presented in (Table 10 Fig.10) was found statistically significant. All the treatments produced significantly higher grain yield than that of control. However, maximum grain yield (12.72 q/ha) was harvested from the plots treated with azadirachtin 01.00% EC. However, it was found at par with NSE 5% (12.47 q/ha), NSE 7.5% (12.32 q/ha), NSE 10% (12.05 q/ha) and neem oil 3% (11.58 q/ha). These were followed by azadirachtin 00.30% EC and neem oil 2% which recorded chickpea grain yield of 9.29 and 8.46 q/ha, respectively and found statistically equal with each other.

Table 10: Effect of neem based formulations on grain yield of chickpea (q/ha)

Sr. No.	Treatments	Dose ml/L	Grain yield of chickpea (q/ha)			
			R I	RII	RIII	Mean
1.	Azadirachtin 00.30% EC	5 ml/L	9.52	9.34	9.02	9.29
2.	Azadirachtin 0.15% EC	3ml/L	7.78	7.50	7.69	7.66
3.	Azadirachtin 01.00% EC	2ml/L	13.23	12.63	12.31	12.72
4.	Neem oil 1%	10ml/L	8.56	6.22	7.68	7.49
5.	Neem oil 2%	20ml/	7.69	9.23	8.45	8.46
6.	Neem oil 3%	30ml/L	11.80	11.71	11.23	11.58
7.	NSE	5%	12.27	13.00	12.71	12.47
8.	NSE	7.5%	11.63	13.21	12.13	12.32
9.	NSE	10%	12.94	11.68	11.53	12.05
10.	Untreated control	-	3.75	3.84	3.93	3.84
	F test	-	-	-	-	Sig
	SE (M) ±	-	-	-	-	0.59
	CD at 5%	-	-	-	-	1.16
	CV %	-	-	-	-	6.48

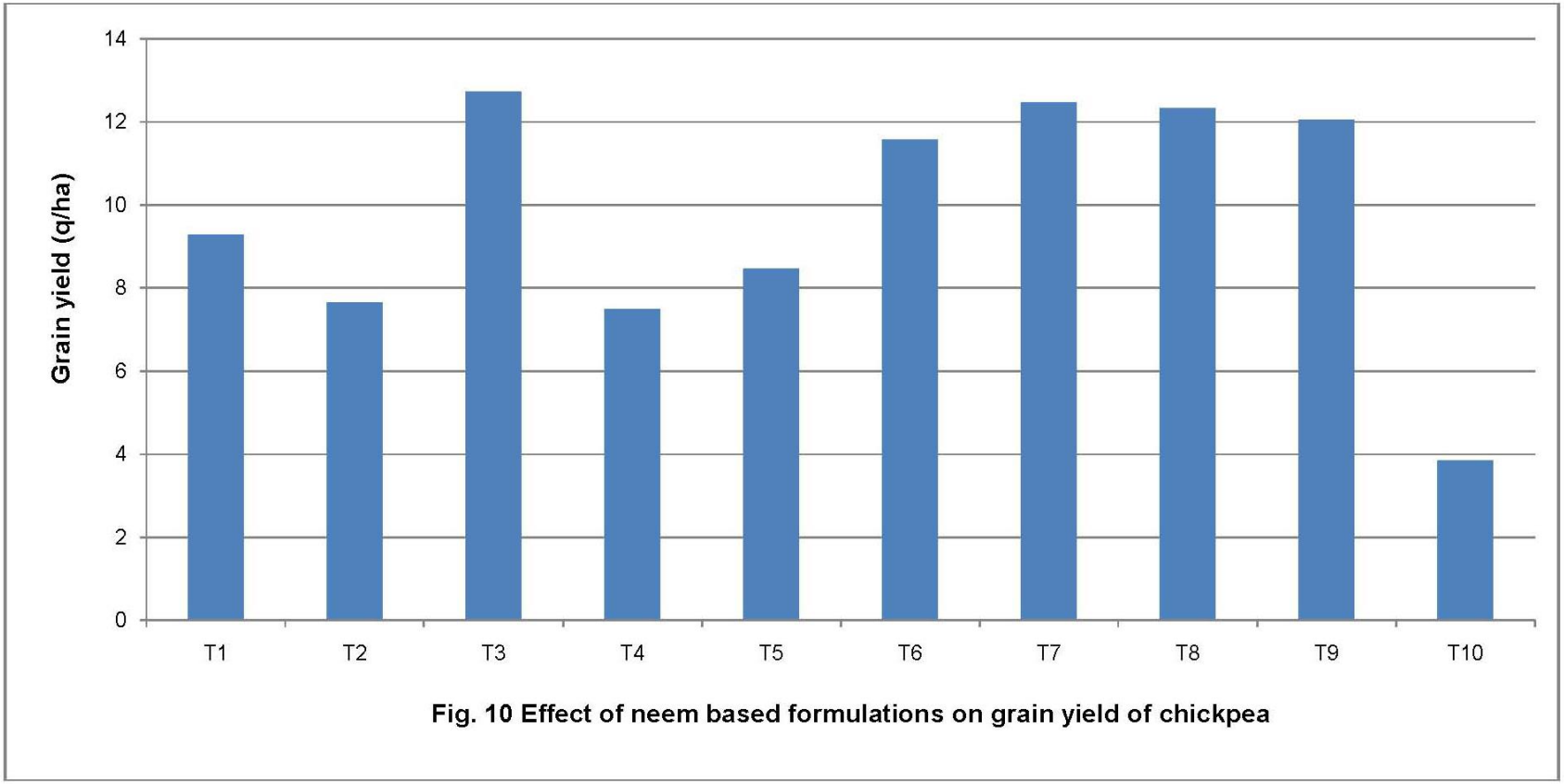

Fig. 10 Effect of neem based formulations on grain yield of chickpea

T1: Azadirachtin 00.30% EC **T2: Azadirachtin 0.15% EC** **T3: Azadirachtin 01.00% EC** **T4: Neem oil 1%**
T5: Neem oil 2% **T6: Neem oil 3%** **T7: NSE 5%** **T8: NSE 7.5%**
T9: NSE 10% **T10: Untreated control**

The remaining treatments *viz.,* azadirachtin 0.15% EC and neem oil 1% were moderately effective in this regard, producing grain yield of 7.66 and 7.49 q/ha, respectively as against 3.84 q/ha harvested from untreated control.

4.10 Economics of various treatments

The data presented in Table 11 revealed that treatment with azadirachtin 01.00%EC emerged as the most economically viable treatment giving the highest ICBR of 1: 6.82, followed by NSE 5% (1:5.80). These were followed by the treatment with azadirachtin 00.30% EC, NSE 7.5%, neem oil 1%, neem oil 3% and NSE 10% with ICBR of 1:5.05, 1:3.85, 1:3.66, 1:3.49 and 1:2.69, respectively.

The remaining treatments *viz.,* neem oil 2% and azadirachtin 0.15% EC were found to be comparatively less economical exhibiting ICBR of 1:2.68 and 1:1.01, respectively.

The present findings pertaining to effectiveness of neem based formulations against chickpea pod borer are in confirmation with the result obtain by earlier wokers like Kumar *et al.* (2019) on the basis of the two years data concluded that neem based formulations found effective in reducing chickpea pod borer damage. The higher grain yield of 24.07 and 22.65 q/ha was recorded with application of NSKE @ 5%, respectively during the two years of experiment. The most favourable cost benefit ratio was obtained from the plot treated with neem oil @ 2% and NSKE @ 5%. Meena *et al.* (2018) reported the effectiveness of NSKE 5% and azadirachtin 0.3% EC against chickpea pod borer, *H.armigera* with minimum pod damage and maximum grain yield in comparison to other biopesticides. Similarly, Gautam *et al*. (2018) reported that among the botanicals neem seed oil @ 5 ml/L was found effective in managing population of *Helicoverpa armigera* on chickpea and gave maximum grain yield compared to other treatments with highest net income of 18300 Rs/ha. According to earlier worker Chandra Shekhara *et al.* (2016) the per cent population reduction of gram pod borer on chickpea revealed that neem products were superior over control with 59.86 and 54.43% reduction respectively, in NSKE 5% and neem oil 1% treated plots.

Table 11: Incremental cost benefit ratio of various treatments

Sr. No	Treatments	Quantity of pesticides (L or Kg/ha)	No. of sprays	Cost of pesticides (Rs/ha)	Labour and spray charges (Rs/ha)	Cost of Plant protection (Rs/ha) (A)	Grain yield of chickpea (q/ha)	Increase in yield over control (q/ha)	Value of increased yield over control (Rs/ha) (B)	Net gain over control (Rs/ha) (B-A)	ICBR	Rank
1	Azadirachtin 00.30% EC	2.5	3	3000	1590	4590	9.29	5.45	27795	23205	1 : 5.05	III
2	Azadirachtin 0.15% EC	1.5	3	8100	1590	9690	7.66	3.82	19482	9792	1 : 1.01	IX
3	Azadirachtin 01.00% EC	1	3	4200	1590	5790	12.72	8.88	45288	39498	1 : 6.82	I
4	Neem oil 1%	5	3	2400	1590	3990	7.49	3.65	18615	14625	1 : 3.66	V
5	Neem oil 2%	10	3	4800	1590	6390	8.46	4.62	23562	17172	1 : 2.68	VIII
6	Neem oil 3%	15	3	7200	1590	8790	11.58	7.74	39474	30684	1: 3.49	VI
7	NSE 5%	25	3	4875	1590	6465	12.47	8.63	44013	37548	1: 5.80	II
8	NSE 7.5%	37.5	3	7313	1590	8903	12.32	8.48	43248	34345	1: 3.85	IV
9	NSE 10%	50	3	9750	1590	11340	12.05	8.21	41871	30531	1 :2.69	VII
10	Untreated control	-	-	-	-	-	3.84	-	-	-	-	-

1) Labour charges for one spray/ha. @ Rs. 240/labour/day, 2) Spray pump charges/ha. @Rs. 50/day/pump,
2) Price of chickpea grain Rs. 5100/qtl. **4) Cost of insecticides:** Azadirachtin 00.30% EC @ Rs.1000/2500ml, Azadirachtin 0.15% EC @ Rs.2700/1500ml, Azadirachtin 01.00% EC @ Rs.1400/1000ml, Neem oil @ Rs.160/1000ml, NSE @ Rs.65/Kg

Moreover, these neem products also recorded minimum pod damage and higher grain yield. The treatment of these botanicals resulted with C:B ratio of 1:1.20 and 1:0.90, respectively. Whereas, Reza *et al.* (2016) reported that among the botanicals neem oil treatment was most effective in reducing chickpea pod infestation and *H. armigera* larval population i.e. 42.52% and 69.85%, respectively followed by NSKE @ 100 g/l. Neem oil treatment also resulted in increasing the pod number, seed number and yield. The treatment NSKE was most effective in increasing grain weight and 1000 seed weight followed by neem oil. The highest yield was recorded in the treatment of neem oil followed by NSKE.

Whereas, Golvankar *et al.* (2015) reported azadirachtin 5% as most effective against chickpea pod borer with minimum number of larvae and pod damage with highest yield of 1183.03 Kg/ha and highest C: B ratio of 1:15.15. Similarly, Chandra Shekhara *et al.* (2014) recorded minimum number of *H. armigera* larvae and pod damage with higher chickpea grain yield at different concentrations of azadirachtin. Moreover, Pachundkar *et al.* (2013) revealed that neem seed kernel extract (5%) effectively reduced the *H.armigera* larval population infesting chickpea when used in regular three sprays. Lulie and Raja (2012) concluded that all tested plant extracts showed 100% protection against *Helicoverpa armigera* on chickpea at 5% and 10% concentration. Among the various botanical NSKE 5% at different concentrations proved most effective with minimum pod damage and maximum reduction of larval population. Moreover, highest grain yield was also obtained from NSKE 5% treated plots. Similarly, according to Bhushan *et al.* (2011) the pooled data of the two years revealed neem seed kernel extract (NSKE 5%) as most effective with minimum of 0.37 *H. armigera* larvae/plant, resulting in minimum chickpea pod damage (10.87%) and harvested higher chickpea grain yield of 15.9 q/ha with C:B ratio of 1:2.47. This was followed by neem oil with 0.54 larvae/plant resulting in 12.3% pod damage and harvesting 14.5 q/ha grain yield with C:B ratio of 1:2.23.

However, the workers like Singh *et al.* (2019) concluded that biopesticides namely, neem oil @ 5 ml/L, NSKE 5% were found safe and

cost effective for the management of larval population of *Spodoptera litura* on cauliflower. The earlier worker Berani *et al.* (2018) reported that among the different botanicals azadirachtin 0.15 EC 0.0006%, neem seed kernel extract (NSKE) 5%, neem oil 0.3% and neem leaf extract (NLE) 10% were found highly effective in managing lepidopteran pests infesting black gram and registered higher grain yield. Whereas, Kumar *et al.* (2018) conducted the field experiment and concluded that among the botanicals NSKE 5% was found to be the most effective in managing larval population of *H.armigera* infesting oats. Choudhary *et al.* (2017) reported that as per the performance of different treatments Nimbecidine @ 5ml/L was found most effective against yellow stem borer in paddy. This treatment was followed by neem oil. They concluded that neem based insecticides were quite effective compared to untreated control. Moreover, Lyall (2017) studied the comparative efficacy of botanicals against *Helicoverpa armigera* infesting field bean. The results revealed that NSKE 5% was found superior over all other treatments after 1st and 2nd spray with highest larval population reduction of 15.4%. Kumar *et al.* (2017) evaluated the botanical and insecticides and observed minimum population of *H.armigera* on maize in plots sprayed with Indoxacarb which was at par with NSKE 5% followed by neem oil 2%. Among the botanicals neem oil 2% recorded maximum grain yield followed by NSKE 5%. Nollet *et al.* (2010) reported that neem oil 3% and NSKE (5%) were as effective as endosulphan 0.05% against gram pod borer on green gram.

According to Faqiri and Kumar (2016) NSKE 5% and neem oil @ 2ml/L recorded 5.90 and 6.65% infestation of fruit borer, *H. armigera* on tomato, respectively and found superior over the untreated control. The maximum yield was harvested with neem oil followed by NSKE. Similarly, Rahman *et al.* (2014) evaluated botanicals against *H.armigera* in tomato and reported lowest fruit infestation both by number and weight in NSKE treated plots. The per cent infestation reduction over control was highest in neem seed kernel extract (30.08%) resulted in highest yield and MCBR. However, the earlier worker Khuhro *et al.* (2014) carried out a field study on efficacy of NSKE 5% and neem oil against *Helicoverpa armigera* sunflower.

The overall result showed that the neem products reduced the *H.armigera* population progressively as compared to synthetic pesticides. Whereas, Borkar and Sarode (2012) observed minimum eggs and larval population of *Helicoverpa armigera* on cotton in the application of NSE 5% and azadirachtin 1500 ppm. Similarly, Rudramuni *et al.* (2011) reported that NSKE, Neemazal and Nimbecidine were found to be highly effective in reducing the bollworm damage in cotton. The cotton plots treated with NSKE 5% recorded the highest yield followed by Neemazal and Nimbecidine. Similar findings were also made by Mehta *et al.* (2010) reported that application of neem based formulations (Nimbicidine 300 ppm, azadirachtin and Neem azal 10 ppm) were effective in reducing tomato fruit borer, *H.armigera* with higher fruit yields and lowest fruit infestation.

These research findings reported by earlier workers supports the present results pertaining to the economical effectiveness of neem based formulations against chickpea pod borer which resulted in higher grain yield and increased cost benefit ratio.

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation entitled “Evaluation of neem based formulations against *Helicoverpa armigera* (Hubner) on chickpea” was carried out on the field at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Rabi* 2020-21. The experiment was laid out in randomized block design with three replications and ten treatments.

The treatments included *viz.,* Azadirachtin 00.30% EC, Azadirachtin 0.15% EC, Azadirachtin 01.00% EC, Neem oil 1%, Neem oil 2%, Neem oil 3%, NSE 5%, NSE 7.5% and NSE 10% were tested against chickpea pod borer along with untreated control. In all three treatment sprays were applied at 10 days interval, of which the first spray was initiated at ETL of chickpea pod borer. The data were collected on the larval population and pod damage at an interval of 3, 7 and 10 days after each treatment spraying to assess the efficacy of different treatments against chickpea pod borer. Finally, grain yield was recorded in each of the net plot, so as to compare the effect of different treatments against chickpea pod borer. The results of investigations are summarized in this chapter.

5.1 Efficacy of neem based formulations against chickpea pod borer

The treatment azadirachtin 01.00% EC, NSE 5%, NSE 7.5% and NSE 10% appeared as the best treatments in recording minimum larval population after first spray. However, the treatment neem oil 3%, azadirachtin 00.30% EC, neem oil 2% and azadirachtin 0.15% EC showed moderate effect in this respect. Whereas, neem oil 1% proved relatively less effective and found at par with untreated control.

Same trend of efficacy was also observed after second spray. The treatments *viz.,* azadirachtin 01.00% EC, NSE 5%, NSE 7.5% and NSE 10% proved equally effective in recording minimum larval population. Whereas, azadirachtin 00.30% EC, neem oil 3%, neem oil 2% and azadirachtin 0.15% exhibited moderate impact in this respect. However, the

plots treated with neem oil 1% proved relatively less effective. The maximum larval population was recorded in untreated control.

Significantly lowest larval population after third spray was recorded from the plots treated with azadirachtin 01.00% EC. However, this treatment was found at par with NSE 5%, NSE 7.5% and NSE 10%. Whereas, azadirachtin 00.30% EC, neem oil 3%, neem oil 2% and azadirachtin 0.15% EC appeared as next better treatments in this respect. Significantly higher number of larvae was recorded in neem oil 1% which was found at par with untreated control.

The cumulative effect of three sprays of different treatments inferred that, azadirachtin 01.00% EC proved most effective with minimum number of larvae recorded and found at par with NSE 5%, NSE 7.5% and NSE 10%. However, the latter treatment was in turn found statistically equal to neem oil 3%. Whereas, the treatments viz, azadirachtin 00.30% EC, neem oil 2% and azadirachtin 0.15% EC were the next in order of efficacy. The treatment neem oil 1% showed least efficacy and found at par with untreated control.

5.2 Effect of neem based formulations on chickpea pod damage due to *H.armigera*

Among the different treatments tested significantly minimum pod damage was recorded in azadirachtin 01.00% EC, NSE 5%, NSE 7.5% and NSE 10% after first spray. Whereas, neem oil 3%, azadirachtin 00.30% EC, azadirachtin 0.15% EC and neem oil 1% appeared as next better treatments in this respect. However, neem oil 2% recorded higher pod damage and found at par with untreated control.

After second treatment spray same trend of efficacy was observed more or less. The treatment azadirachtin 01.00% EC proved effective with minimum pod damage. This treatment was found at par with NSE 5%, NSE 7.5% and NSE 10%. The treatments *viz.,* neem oil 3%, azadirachtin 00.30% EC, neem oil 1%, azadirachtin 0.15% EC and neem oil 2% showed the efficacy in descending order. The highest percent

chickpea pod damage due to *H. armigera* was recorded in untreated control plots.

Minimum pod damage after third spray was recorded from the plots treated with azadirachtin 01.00% EC. However, this proved statistically equal with NSE 5%, NSE 7.5% and NSE 10%. Whereas, neem oil 3% and azadirachtin 00.30% EC were next effective treatments. The plots treated with neem oil 1% and neem oil 2% proved moderately effective in this respect. The treatment azadirachtin 0.15% EC recorded higher pod damage and found at par with untreated control.

The cumulative effect of three sprays of different treatments, inferred that, treatment azadirachtin 01.00% EC recorded minimum pod damage. However, this treatment was found statistically equal with NSE 5%, NSE 7.5% and NSE 10%. The treatment neem oil 3% and azadirachtin 00.30% EC appeared as next better treatments. Whereas, the treatments azadirachtin 0.15% EC and neem oil 1% showed moderate effect in this respect. The treatment neem oil 2% proved least effective and found statistically equal with untreated control.

5.3 Effect of neem based formulations on grain yield of chickpea

The result showed that, application of azadirachtin 01.00% EC was found most promising treatment in increasing grain yield of chickpea. However, this treatment was found at par with NSE 5%, NSE 7.5%, NSE 10% and neem oil 3%. The remaining treatments *viz.,* azadirachtin 00.30% EC and neem oil 2%, azadirachtin 0.15% EC and neem oil 1% recorded grain yield in descending order and found superior over untreated control.

5.4 ICBR

The economics of different treatments indicated that application of azadirachtin 01.00% EC proved to be the most economically viable treatment with maximum ICBR. While, NSE 5%, azadirachtin 00.30% EC, NSE 7.5% and neem oil 1% emerged as the next best treatments in this respect. The other treatments *viz.,* neem oil 3%, NSE

10%, neem oil 2% and azadirachtin 0.15% EC appeared to be moderately economical.

Conclusions

Finally, it is concluded that the treatment azadirachtin 01.00% EC and NSE at different concentrations proved effective in combating the menace of chickpea pod borer, *H.armigera* and resulted in highest grain yield. Moreover, azadirachtin 01.00% EC and NSE 5% also proved as the most economically viable treatments.

Thus, these neem based formulations can be a good alternative for the management of chickpea pod borer, *H.armigera* showing resistance to different insecticides. These neem based formulations could be included in integrated pest management programme of chickpea pod borer as a promising component.

The present investigation entitled “Evaluation of neem based formulations against *Helicoverpa armigera* (Hubner) on chickpea” was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Rabi* season of 2020-21. The experiment was laid in Randomized Block Design with ten treatments replicated thrice. The treatments included were, azadirachtin 00.30% EC, azadirachtin 0.15% EC, azadirachtin 01.00% EC, neem oil 1%, neem oil 2%, neem oil 3%, NSE 5%, NSE 7.5% and NSE 10% along with untreated control. Three treatment sprays were applied at 10 days interval to study the comparative efficacy of neem based formulations against chickpea pod borer. The observations on *H.armigera* larval population were recorded at an interval of 3, 7 and 10 days after each treatment spray. Similarly, the observations on pod damage were also recorded. The chickpea grain yield data was recorded from each of the net plot to find out most economical and effective treatment for the management of chickpea pod borer.

Application of azadirachtin 01.00% EC proved effective in minimizing larval population. However, this treatment was found at par with NSE 5%, NSE 7.5% and NSE 10%. The latter treatment in turn found statistically equal to neem oil 3%. Whereas, treatments *viz.,* azadirachtin

00.30% EC, neem oil 2% and azadirachtin 0.15% EC found moderately effective. The treatment of neem oil 1% proved relatively less effective against larval population of *H.armigera*.

The treatment of azadirachtin 01.00% EC recorded minimum pod damage and was found statistically equal to NSE 5%, NSE 7.5% and NSE 10% in reducing pod damage. The next treatments in order of efficacy were neem oil 3%, azadirachtin 00.30% EC, azadirachtin 0.15% EC and neem oil 1%. The treatment of neem oil 2% proved relatively less effective in this respect. The untreated control plots showed maximum per cent pod damage.

All the treatments under the trial recorded significant increase in the grain yield of chickpea compared to untreated control plots. The highest grain yield was obtained in the plots sprayed with azadirachtin 01.00% EC. However, this treatment was found at par with NSE 5%, NSE 7.5%, NSE 10% and neem oil 3%. The next effective treatments were azadirachtin 00.30% EC and neem oil 2%. Whereas, azadirachtin 0.15% EC and neem oil 1% proved moderately effective in recording the grain yield data. Whereas, lowest yield was harvested in untreated control.

On the basis of economics the treatment azadirachtin 01.00% EC proved as most economically viable treatment giving the highest ICBR. It was followed by the treatments *viz.,* NSE 5%, azadirachtin 00.30%EC, NSE 7.5% and neem oil 1%.

The study indicates that neem based formulations has marked effect on chickpea pod borer, *H.armigera* and can be used as an alternative to conventional pesticides in integrated pest management strategies.

CHAPTER VI

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Appendix –Weekly Weather data for the year 2020 recorded at Meteorological Observatory, Dr.PDKV.,Akola																				
		Actual				2020								Normal				1971-2000		
Weeks	Dates	TMAX(oC)		TMIN(oC)		BSH(hrs)		WS(km/hr)		RHI(%)		RHII (%)		Evap (mm)		RF(mm)		CRF(mm)	Rainy Days	
		N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A		N	A
1	1-7Jan	29.0	29.8	10.3	9.4	8.7	8.4	4.9	0.7	78	68	30	22	4.2	4.0	1.7	0.0	0.0	0.2	0.0
2	8-14	29.2	28.1	11.3	10.0	8.6	7.8	6.3	1.2	71	72	30	30	4.5	5.4	3.4	0.0	0.0	0.2	0.0
3	15-21	29.9	29.4	11.6	10.4	8.9	7.6	5.4	1.2	69	66	28	24	4.8	5.2	0.9	0.0	0.0	0.1	0.0
4	22-28	30.8	28.1	11.8	14.0	9.1	6.1	5.5	1.7	67	75	27	36	5.2	5.0	1.1	0.0	0.0	0.2	0.0
5	29-4Feb	31.1	28.1	12.1	10.7	9.3	7.9	5.8	1.5	61	61	25	22	5.6	5.3	2.8	0.0	0.0	0.2	0.0
6	5-11	31.3	29.6	11.9	13.3	9.1	8.2	5.6	3.6	59	49	23	20	5.9	6.3	4.9	0.0	0.0	0.4	0.0
7	12-18	32.5	32.2	13.4	15.9	9.4	7.9	6.1	2.3	56	54	22	24	6.6	5.9	0.1	0.0	0.0	0.0	0.0
8	19-25	33.0	35.5	13.8	18.6	9.5	8.6	6.5	2.4	57	55	22	21	7.3	6.1	3.3	1.9	1.9	0.5	0.0
9	26-4Mar	34.7	33.2	14.8	17.7	9.6	8.9	7.0	4.0	50	47	17	23	8.1	7.8	3.4	0.0	1.9	0.3	0.0
10	5-11	36.1	33.7	16.7	16.2	9.6	9.1	6.8	3.2	44	48	18	21	9.0	7.5	2.1	0.0	1.9	0.3	0.0
11	12-18	37.3	36.8	17.5	16.9	9.6	8.5	6.9	3.1	42	43	17	21	9.5	8.1	2.5	0.0	1.9	0.3	0.0
12	19-25	38.5	37.9	18.3	15.9	9.6	8.9	6.9	2.2	37	47	13	18	10.5	8.4	0.3	0.0	1.9	0.1	0.0
13	26-1Apr	39.0	41.2	19.7	18.9	9.6	9.1	7.6	3.1	36	34	15	15	11.3	9.6	2.9	0.0	1.9	0.3	0.0
14	2-8Apr	40.1	42.1	21.1	21.3	9.8	8.9	7.9	4.4	36	39	15	20	11.7	10.0	0.6	0.0	1.9	0.1	0.0
15	9-15	40.8	43.1	22.5	23.3	9.9	9.4	9.3	4.6	34	43	12	24	13.4	10.8	0.3	0.0	1.9	0.1	0.0
16	16-22	41.7	38.4	23.5	19.7	10.2	7.3	9.1	2.5	34	53	14	31	13.7	8.6	0.3	13.5	15.4	0.0	1.0
17	23-29	42.1	44.3	24.8	24.0	10.1	9.6	10.2	3.3	37	32	14	15	14.4	11.4	0.0	0.0	15.4	0.1	0.0
18	30-6May	42.7	42.7	26.0	25.5	9.9	8.8	11.4	9.9	38	42	14	23	15.4	13.9	0.3	0.0	15.4	0.2	0.0
19	7-13	42.6	42.0	26.5	25.6	10.1	9.5	12.7	7.9	43	43	17	22	16.4	15.4	0.3	0.0	15.4	0.1	0.0
20	14-20	42.6	42.9	27.3	25.7	9.7	9.7	14.6	7.9	48	37	18	17	17.3	15.1	1.8	0.0	15.4	0.2	0.0
21	21-27	42.4	44.4	27.4	27.7	9.8	9.7	15.7	7.4	50	38	20	17	17.0	15.6	4.1	0.0	15.4	0.5	0.0
22	28-3Jun	41.9	44.6	27.6	27.9	9.7	9.3	16.2	9.7	56	39	23	16	16.3	15.9	5.7	0.0	15.4	0.5	0.0