COMPARATIVE EFFICACY OF DIFFERENT INSECTICIDES AGAINST GRAM POD BORER OF CHICKPEA UNDER FIELD CONDITIONS

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF

Master of Science (Agriculture)

In

Entomology & Agricultural Zoology

Supervisor

Prof. P. S. Singh

Submitted By

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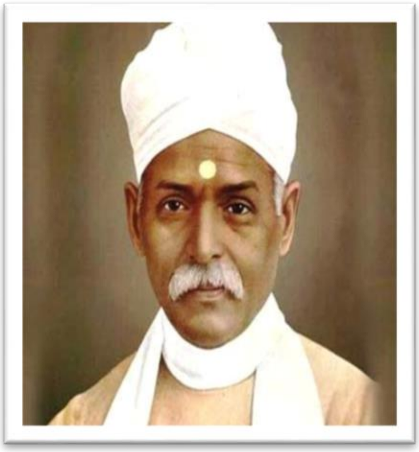

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CERTIFICATE

To,
The Registrar (Academic)
Banaras Hindu University,
Varanasi-221005 (India).
Through: The Head, Department of Entomology & Agricultural Zoology,
Institute of Agricultural Sciences, B.H.U., Varanasi.

Dear Sir,

I have great pleasure in forwarding the thesis entitled **"Comparative efficacy of different insecticides against gram pod borer of chickpea under field conditions"** submitted by ***Mr. Ram Ratna Upadhyay*** in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture)** in **Entomology and Agricultural Zoology**, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and placing on record that he has completed the requisite residential requirements as contained in the statues of the University.

I certify that the entire scheme of investigation presented herein was planned and carried out solely by the candidate under my guidance and supervision. The data presented in the thesis, to the best of my knowledge and belief, are genuine and original.

Thanking you.

Yours faithfully,

Forwarded by

(P. S. Singh)
Supervisor

Comparative Efficacy of Different Insecticides against Gram Pod Borer of Chickpea under Field Conditions

काशी हिन्दू विश्वविद्यालय BANARAS HINDU UNIVERSITY

By

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2018

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Above all, my humble and whole hearted prostration to ***Lord Baba Vishwanath, Sankat Mochan Baba*** *and* ***Goddess Saraswati*** *for their blessings.*

Date:

Place : *Varanasi*

(Ram Ratna Upadhyay)

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LIST OF ABBREVIATIONS AND SYMBOLS

%	percentage
/	Per
@	at the rate of
℃	Degree Celsius
CD	Critical Difference
Cm	centi meter
DAS	Days after Spraying
et al.	And others
Fig.	Figure
g	gram
H. armigera	*Helicoverpa armigera*
Ha	Hectare
kg	kilogram
L	Linneaus
mg	milligram
mg/g	milligrams per gram
Mha	million hectares
ml	milli litre
q	Quintal
RH	Relative humidity
Spp.	Species
viz.	Namely

INTRODUCTION

CHAPTER I

INTRODUCTION

Pulses constitute an important part of Indian diet. They are used in India as source of protein for people, irrespective of socio- economic conditions, since promotion of vegetarianism being one of the reasons since ancient times (Rammohan *et al.,* 2012). However, importance of pulses increases for people in India and in world as it constitutes an important alternative to other protein rich diets as milk, meat, eggs etc. (Reddy *et al.,* 1986) that lack availability in parts of world due to socio-economic reasons.

Pulses are rich in protein and many essential amino acids; amount of protein in various pulses varies from 17 percent to 35 percent on a dry weight basis (Boye *et al.*, 2010). They are rich in soluble dietary fibers (Sathe *et al.,* 1984), they are helpful in decreasing blood sugar level and cholesterol (Burkitt *et al.*1985). Also, carbohyderate content of pulses is high (Reddy *et al.,* 1985; Oke *et al.,* 1995). These abilities of pulses makes them important supplement recommended by international organisations for quenching needs of protein in deprived population of undeveloped or under developed countries, specially India (Mohanty *et al.,* 2015).

The pulses form an important component of Indian cropping system also. The use of pulses in cropping system is more relevant since the symbiotic association of bacteria to the roots of leguminous plants that gives them ability to fix nitrogen from atmosphere and make it available to soil. Hence, increasing soil fertility (Dwivedi *et al.,* 2015) and undermining the use of any synthetic fertilizer to the fields and decreasing the cost of cultivation (Reddy *et al.,* 2013).

The humongous requirement of the pulses for supporting needs of such a huge population had rather compelled India to be the largest producer and also the largest consumer of the pulses. Even years after independence and green revolution country is still not self sufficient in production of pulses, and pulses are imported to meet the requirements, and occasionally it still leads to unequal distribution and high inflation hence, poor availability to needy people (IIPS and ORC Macro 2007).

As per the annual records of production of Directorate of Economic Survey (2017) the production of pulses in India for year 2015-16 the maximum production share of produced pulses in India would be of chickpea as 70.60 thousand tonnes *i.e.* 43.18 per cent of the total production. This will be followed by the Tur with a production share of 15.60 per cent and 2560 thousand tonnes. The urd, mung and other pulses produced will make up rest of the share as 11.92, 9.72 and 19.92 per cent respectively with production of 1950, 1590 and 3190 thousand tonnes. The total production of pulses in the year 2015-16 was 16350.00 thousand tonnes which is slightly down to the production in 2014-15 being 17150.00 thousand tonnes. The total export of pulses in the year 2015-16 was 255.60 thousand tonnes. Chickpeas contribute the single largest share in India's export basket of pulses registering 85.64% and 84.87% share in the total pulses export during 2014-15 and 2015-16, respectively.

Chickpea is cultivated all over the world in many countries. In India, chickpea seeds are usually consumed at the raw green and tender stage (unripe stage), called Channa, or in the form of mature dry seeds after parching as a popular snack food. The dry seeds can also be consumed as whole or decorticated after cooking and processing in different ways. In addition to these uses, the flour of decorticated chickpea seeds is used in several dishes and as a supplement in weaning food mixes, bread and biscuits (van der Maesen, 1972). The chemical composition and oligosaccharides of raw and germinated chickpea seeds were reviewed by (Singh *et al.,* 1991). The effect of cooking on the constituents of chickpea seeds Archaic disclosed by (Attia *et al.,* 1994).

India is largest in terms of area and production of chickpea in world i.e. approx. 70% of total chickpea production in world (Wallace *et al*. 2016). History of chickpea can be traced since ancient times in India but it was reported first cultivated 7000years ago in Middle East Asia from where it descended to Afghanistan and finally to India (Toker 2009). Chickpea is the second most important food legume crop after common bean (FAOSTAT 2015). Currently chickpea is being cultivated in about 40 countries in world and it is a very important part of pulse cultivation in world , contributing about 58 million tonns produced which is approx. 15% of total pulse harvested all over world (Kapoor *et al.,*, 2010). Nearly 90% 0f total global area and 88% of total production is concentrated to Asia. India with first rank in production is followed by Turkey (11%), Pakistan (8%), Iran and Syria.

Chickpea may be lessen-qualify grain cultivated that could close to withstand hot temperatures all through turn out and ripening (Ecoport, 2013). It is famous to enjoy figure out South-East Anatolia and neighbouring Syria and Iran, site the rudimentary remains accelerate to through 7000 BC. It reaches to the Mediterranean Basin, Africa and the Indian subcontinent prior to 2000 BC. *Cicer arietinum* grows starting with water level up to an ascent of 2500 m in areas case temperatures ranges beginning at 15°C to 29°C (van der Maesen, 1989). Chickpeas are principally delicate inside dampen, dry time of one's semi-arid wasteland on enduring drizzle. The plant is certainly adjust to humid climates simultaneously impede temperatures and is strongly adept under flood in the undersized wintry weather of just a few humid countries (Bejiga *et al.,* 2006)

It is likely one of the most crucial feed legume plants in feasible cultivation structure due to its low yielding cost, wider compliance, ingenuity to fix nitrogen from atmosphere and slot in a variety of snip rotations (Singh 1997) and existence of spawning tap seed technique. Chickpea can fix nitrogen from atmosphere as much as 140 kg/ha straight its crucial organization near Rhizobium and meets its 80 % precondition (Saraf *et al.,* 1998). It too is helping in enhancing the soil good quality for consecutive grain crop planting by adding organic matter for the upkeep of soil and phytohealth and ecostructure. Deep and faucet seed arrangement of chickpea is famous to assist in opening up of the soil to the deeper strata, making certain surpass smoothness and aeration of your soil for succeeding cultivation. It is really a important origin of good quality protein (20-22 %) to the mostly vegan society in Indian subcontinent. Besides proteins, it's far intense in fibre and iron (phosphorus, calcium, magnesium, iron and mineral), and its lipid portion is rich in unsaturated fatty acids (Williams and Singh 1987). It has no anti-nutritional factors (Mallikarjuna *et al.,* 2007) and contains richer amounts of carotenoids prefer β-carotene than naturally engineered 'golden rice (Abbo *et al.,* 2005).

Two kinds of chickpea cultivars determined without exception– kabuli and desi. The kabuli samples are in general cultivated within the Mediterranean part inclusive of Southern Europe, Western Asia and Northern Africa, and the desi strains are developed principally in Ethiopia and Indian subcontinent. Desi chickpeas are containing plants of differing colours, skinny to round seeds including tan seed coat, anthocyanin complexion on curb or alternative plant parts, raw seed materialize and amidst assemble, semi erect or semi-spreading production manner, while kabuli strains in general know bolder seeds, neutral plant life, shiny seed coat, loss of anthocyanin tinge and rig growing to hoist improvement manner (Pundir *et al.,* 1985). Of the entire management, the desi and kabuli chickpeas make contributions about 80 % and 20 %, precisely. Kabuli sample is primarily adult stringent parts, although the desi sample chickpea is adult most commonly inside the semi arid tropical zone (Malhotra *et al.,* 1987; Muehlbauer and Singh 1987).

1.1 Nutritional value of chickpea

The Chickpea grains have protein present (19-25% DM) in addition energy, as they are also a rich source of glycogen. Though the desi gram types has limited glycogen (35% DM) and also fibre (10% DM rudimentary fibre) than kabuli type (around 50% DM glycogen and 4% DM rudimentary fibre), respectively. Chickpeas are especially lush in lysine (6-7% of the protein) but sulphur-curbing amino acids and theonine might be scant for monogastric case. Chickpeas Encompass non-negligible amounts of lipids (on occasion under 5% DM). Chickpea Oats stops trivial protein than the grain (13-19% DM) but much too fibre (24-30% DM). Chickpea Grain incorporates lightly similarly protein than a wheat straw (Nearby 5% DM) but Remains a hairy scour (30-40% DM as Simple fibre). Pod husks have a exact same consistent pubescence presence as it compared to wheat. Even though chickpea scrounge and hay is every so usually clear to find livestock, reveal more or less the good quality of those scours is nearly inexistent. In 1938 in India, samples of chickpea hay and fresh scrounge had protein integrity of 13 and 11% DM and primitive fibre high qualities of 35 and 27% DM, one at a time (Sen, 1938; D.L. Hadsell *et al.* 1998).

1.2 Pest problem in chickpea

One of the main constrains in increasing the production of chickpea are the insect pests. The number of insect pest species attacking the chickpea in Indian terrain is 57, and the economically important pests among them are nearly half a dozen. The most important insect species in terms of damage to the crop is the Gram Pod Borer, *Helicoverpa armigera* Hubner (Lepidoptera:Noctuidae). The insect causes most damage in terms of attacking the economical part of the plant i.e. the pod, and hence decreases the yield of the crop drastically. The pod borer has been a significant problem with a variety of crops for its polyphagous nature. The attack of pod borer is reported on nearly 182 economically important crop plant species ranging from food to fiber crops, horticulture crops and oil seeds etc (Gowda, 2010).

The estimation of yield losses in case of *Helicoverpa* in case of chickpea are variable in case of variations of the weather conditions i.e. under normal weather conditions the losses by pod borer to chickpea crop may vary between 10-60 percent while in case of favourable weather conditions the loss can be in range of 50-100 percent leading to total devastation of the crop (Khare and Ujagir, 1977).The referred favourable weather conditions could imply to the cloudy weather conditions and frequent rains occurrence along the cropping season

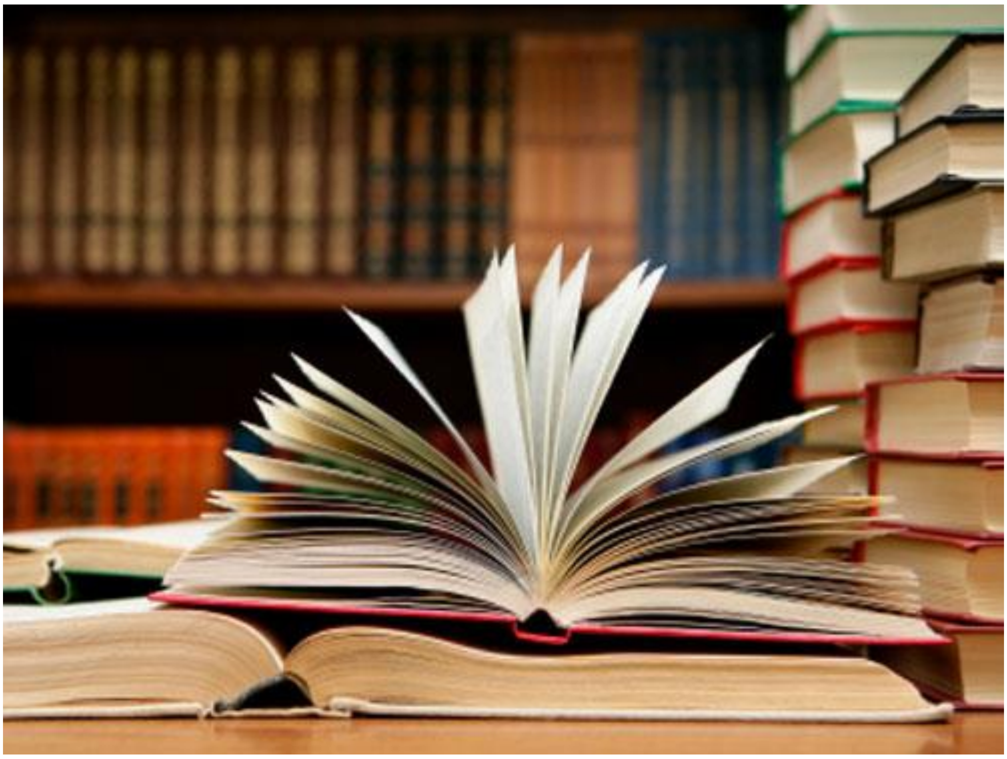
(Mathur *et al*, 2003). The importance of the pest could be understood by the finding that the pod borer accounts for nearly half of the consumption of total insecticides used in India for different crops (Suryavanshi *et. al.*, 2011). The insect even after much efforts of management accounts for loss of nearly Rs. 35000 million across India (Kumar and Kapur, 2010). The management of pod borer has been a challenge for certain reasons particular to its living and feeding habits as voracious feeding of crop economic parts, polyphagous nature ,high fecundity , high mobility, overlapping generations, direct attack of fruiting structure, nocturnal behaviour, host selection by learning and developing quick resistance to insecticides. The attack on wide range of crops had lead to a problem to Indian farmers, especially to poor and marginalised farmers. Also, the problem has been intensified due to heavy chemical resistance issues hiking the loss figures in India due to pod borer as high as 158 million USD.

The mode of feeding of *Helicoverpa* larvae initially starts with feeding on tender leaves leading to the defoliation in plants. Then it does straight damage to main economic part of the chickpea, the pod by boring it and then the larvae feeds on the grains, damaging the whole structure. The eggs are laid underside of the leaves by female moth, brown in colour, white in colour and single. The caterpillar are hatched out from the eggs in 3-4 days, yellowish in colour and in 2-3 weeks attain a maximum length of about 3-3.5 cm under optimum conditions. The fully mature larva then goes to plant debris to pupate for 6-12 days. The average life cycle of the insect generally in summer and autumn is generally about 4 weeks.

The management efforts of the pest management has included attempts from various techniques including cultural, mechanical, physical, chemical ,biological and even use of host plant resistance. While none had been fully successful chemical control has been most important and effective method. The chemicals being easily available to farmers are most important method of the management to be used of crop protection (Sarwar, 2012). However the availability had lead to non judicious use of the chemicals leading to the development of resistance to chemicals in nearly 600 pest species globally including various insects, pathogen, weeds etc. in India this resistance scenario has been identified with 13 species including *Helicoverpa armigera*. The studies have shown that the insect had developed resistance to nearly all the major insecticide classes and hence, difficult to manage the population increasingly in India (Suryavanshi *et al.*,, 2011). The resistance had leaded us to need of newer and better insecticide classes so that the single insecticide resistance could be tackled.

Considering the following aspects the evaluations of certain novel insecticides were done in field against gram pod borer on chick pea at Varanasi district during *Rabi* season of 2016-17 and 2017-18. The present study was proposed on following objectives:

1. To study the effects of chemical treatment on reduction of larval population of *H. armigera* in chickpea.
2. To study the effects of chemical treatment on pod damage by pod borer.
3. To study the effect of chemical treatment on grain yield.



REVIEW OF LITERATURE

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CHAPTER II

REVIEW OF LITERATURE

The well established fact is known about a comprehensive review of literature being the foundation of any research undertaken. The sole purpose of the extensive review of literature is to get acquainted with the past efforts made and current happenings occurring in field of research regarding the experiment being performed. The review guides us about "What already had been done?" and "What has to be done?" with reference to any topic. Other important features of the review are as follows -

(A) In fixing the direction of problem.
(B) To provide an outline of methods and procedures employed.
(C) To provide a non-obligatory definition for of predefined major concepts.
(D) To provide evidence of judgements for the findings.

An attempt has been made in this chapter to collect possible recent researches in line with objectives and variables of the study are presented in following:

2.1 Effects of treatment of chemicals on larval population of *Helicoverpa armigera* (Hubner)

Karabhantanal and Awaknavar (2004) estimated the efficiencies of Indoxacarb (47g/ha), spinosad (30g/ha), beta-cyfluthrin (7.81g/ha), thiodicarb (469g/ha), methomil (125g/ha), alanycarb (281g/ha) against *H. armigera* in the experiment. The results show that the maximum reduction of larval population is given by spinosad, hence making it maximum effective.

Yadav *et al*. (2004) concluded about efficiency of entomopathogens against *H. armigera* in chickpea cv. Dahod yellow during Rabi season of 1998-99 and 1999-2000 in Anand, Gujrat, India. The observations on larval population of *H. armigera* mortality were recorded after 2 hrs of the chemical spray. The observations continued for every alternate day till 15 days after treatment, these trends of observations show the reduction in larval population from 2 years data due to various chemical treatments from day 3 onwards. The data analysis shows the lowest larval population with treatment from Delfin (2.31 larvae on 5 plants), even few other chemicals used in the experiments showed similar results in case of larval population (on 5 plants). These include use of HaNPV (2.86 larvae), Achook (2.34 larvae) and endosulfan (2.47 larvae) for treatment of plants. The larval count (on 5 plants) was found lowest on 7th day on plants treated with endosulfan (1.06 larval count) followed by Delfin (1.56 larvae).

Murray *et al*. (2005) conducted studies for evaluating efficiencies of certain new insecticides for management of *H. armigera* on grain crops including chickpea. The chemicals used were indoxacarb, methoxyfenozide, spinosad, thiodiocarb, pyridalyl and petroleum oil. The results for reported effectiveness of these chemicals was shown equivalent or in some cases astonishingly higher than the standard commercial dose standards. Characteristically, use of Spinosad, indoxacarb and thiodiocarb in doses 50% less than the recommended doses for cotton, showed better results and also superior residue retention protection for 14 days. The use of pyridalyl however gives standard results in cases but still need a further evaluation in case of grain crops. Also, the use of insect growth regulating compound methoxyfenoxide resulted in slow management of the *Helicoverpa* insect.

Sood and Mondal (2005) evaluated in a field conditions five insecticides were against gram pod borer, *Helicoverpa armigera* (Hubner) during the summer season of 2001. The results concluded that lambda cyhalothion 0.004%, deltamethrin 0.0028% and cypermethrin 0.0075% were the best working compounds with 9.26, 10.61 and 11.26 per cent pod infestation, respectively as compared to 30.79 per cent in case of untreated control. Chlorpyriphos 0.05% was the least effective amongst the insecticides, however, better than the control. Further the yield was higher in all the treatments as compared to unsprayed control. The benefit cost ratio tended to be maximum due to lambda cyhalothion (Rs. 8.64) followed by deltamethrin (Rs. 6.41) and cypermethrin (Rs. 3.12).

Boomati *et al*. (2006) estimated the effects of various insecticides, on 2nd and 5th larval instar stages of *H. armigera* in laboratory. The insecticides used were spinosad (75g a.i/ha), HaNPV (1.5x 10^{12} POBs/ha) and spicturin (1lt/ha) alone and also in combination. Spinosad alone or along with combinations with HaNPV and /or spicturin recorded for 100% mortality of 2nd instar larvae within 24 hrs of treatment. However, spinosad alone or in combination with various mentioned chemicals. The treatment was tested along with a standard control of endosulfan (0.07%) effects on same larval. The effects of Spinosad on mortality of 5th instar larvae with spicturin was recorded as 77, 90 and 100 per cent while the effect of spinosad alone was 50, 83, 100 per cent ,respectively on the same. The data was recorded at time intervals of 24, 48 and 72 hrs after treatments. Also the combinations of Spinosad and HaNPV and Spinosad with HaNPV and spictrucin resulted in mortality of 83 per cent after 72 hrs of treatment.

Gowda and Patil (2007) concluded a feild trial in during the *Rabi* season of 2002-03 to study the effects of use of battery operated controlled droplet applicator (ultralow volume), Aspee Mist Blower (low volume) and as per Knapsack sprayer (high volume) on efficacy of indoxacarb (25g a.i/ha) and chlorpyriphos (250g a.i./ha) against chickpea pod borer *H. armigera*. The following trial concluded that the best control was accorded by the use of the high and low volume sprayers when compared with high volume equipment. The results of yield show the high efficacy of Indoxacarb irrespective of mode of application to the field has the best effect on the yield of the chickpea since it has a better effect on the pod borer as when compared to chlorpyrifos treatment.

Patil *et al*. (2007) tested a newer insecticides viz., Proclaim 05 SG @ 8, 9 and 11 g.a.i./ha, novaluron 10 EC @ 50, 75 and 100 g.a.i./ha, spinosad 45 EC @ 60 g.a.i./ha, and profenofos 50 EC @ 750 g.a.i./ha were tested and compared with conventional recommended insecticide, endosulfan 35 EC @ 350 g.a.i./ha. The Minimal larval frequency of 1.68 larvae/m row limit was listed in novaluron 10 EC @ 100 g/ha at 3 DAS while in profenofos 50 EC @ 750 g/ha, it registered 1.17 larvae/MRL followed by Proclaim 05 SG @ 11 g.a.i./ha (1.18 larvae/MRL). The Practice with declare 05 SG @ 11 g.a.i./ha come across impending simpler in reducing the pod loss (3.0%) and Improvement in surpassing grain yield (2346 kg/ha) followed by spinosad 45 SC @ 60 g.a.i./ha Whichever documented pod loss of 3.3% and direction give way of 2256 kg/ha in comparison to endosulfan that meet. The Best cost: Benefit correlation was documented in endosulfan 35 EC @ 350 g.a.i./ha (1:15.08).

Altaf Hossain (2007) evaluated the efficacy of a few artificial and biopesticides opposed to pod borer, *Helicoverpa armigera* (Hubner) loss in chickpea throughout rabi cropping period of 2004-05. Synthetic and bio-pesticides diminished pod borer losses fairly. Significantly Minimum pod damage was detected in cypermethrin (5.75%) and HNPV (5.86%) sprayed plots followed by carbaryl (6.05%) and dimethoate (7.92%) treated plots. The bio-control agent, HNPV, showed Impartially the finest results over synthetic insecticides and likewise showed more advanced competence than neem primarily based insecticides as nimbicidine (azadiractin 0.03% EC). Pod damage rebate by artificial insecticides and bio pesticides too untreated control ranged starting with 24.98 to 64.08%. It ranged originating at 50.53 to 64.08% in synthetic fungicide and 24.98 to 63.40% in bio-pesticides. Significantly the very best yield (1,856 kg/ha) obtained beginning at HNPV treated plots that was statistically just like cypermethrin followed by azadiractin 0.03% EC. The best economic profit ($ 105/ha) and marginal benefit Input rate (3.35) was Reported beginning at HNPV Spray followed by cypermethrin ($ 87/ha) and (2.12), aside. Hence, it would be concluded a well known HNPV is the finest medium in coping with pod borer in chickpea thinking about competence, Appositeness and status friendly.

Singh and Yadav (2007) tested the efficacy of four insecticides i.e. indoxacarb, thiamethoxam, spinosad and endosulfan; three bio-pesticides (two *Bacillus thuringiensis* based bio-insecticides) namely halt, biolep and Ha NPV and two neem based insecticides viz., nimbicidine and neemarine was assessed. Indoxacarb caused maximum larval mortality back of one future of two sprays i.e. 99.4 and 98.3% afterwards antecedent and double spraying of 2005–2006, respectively amongst was thoughtfully followed by thiamethoxam and spinosad. Among bio-pesticides, the utmost elementary being subsequently one week of spraying was achieved in halt i.e. 42.2% later initially spraying and 42.8% later second spraying whichever was intently followed by Ha NPV. Both the neem based institution were on par among each other but significantly better than the more control. The maximum direction yield (1425 kg/ha) was Reported in indoxacarb with minimum per cent pod loss (12.5%) and a CB Proportion of 1:12.38 was found among all the treatments but greatest CB correlation was listed in spinosad (1:15.45). Among bio-pesticides and neem derivatives halt and nimbicidine staged high-caliber grain yield, Lower pod loss and confirmed CB Correlation up remainder of the bio-pesticides and neemarine population.

Ghure *et al.* (2008) did an investigation was undertaken with an objective to evaluate bioefficacy of new pesticides *viz.*, lambda-cyhalothrin 5 EC, spinosad 45 SC, indoxacarb 14.5 SC, profenofos 50 EC, Dipel 8L (Bt formulation) along with endosulfan 35 EC and NSKE 5% against bollworms of cotton. Three sprays of insecticide treatments were given at an interval of 20 days by initiating the first 45 days after sowing. All the insecticides were found effective against bollworms of cotton. Among the insecticide treatments lambda-cyhalothrin 5 EC @ 100 g a.i/ha was found most effective against cotton bollworms in which square and green boll damage was observed in the range of 8.49 to 10.22 and 10.12 to 12.42 per cent, respectively as against maximum in untreated control(24.90 to 27.11 and 26.80 to 29.23, respectively) in all three sprays . The minimum locule damage of 11.92 per cent was recorded in the same treatment. However, this treatment was at par with indoxacarb 14.5SC @ 75 g a.i/ha, spinosad 45 SC @ 75 g a.i/ha and profenofos 50 EC @1000 g a.i/ha. All the insecticide treatments recorded significantly higher seed cotton yield in the range of 1371 to 1931 kg/ha as against 968 kg/ha in untreated control. New pesticides *viz.*, lambda-cyhalothrin 5 EC, indoxacarb 14.5 SC, spinosad 45 SC and profenofos 50 EC were found highly effective against cotton bollworms.

Ravi *et al*. (2008) did an extensive study about effects of application of various formulations to field viz. Microbials, i.e. HaNPV (Delfin 25 WG at 1kg/ha), Spinosad 45 SC (75 a.i./ha) and Neem extracts (Neemazole 1.2 EC at 1000ml/ha) against gram pod borer (*H. armigera*). The results showed that both the classes of the chemicals used i.e. Microbials and Neemazols are equally effective for control of the *H. armigera* as was the sequential application of the synthetic compounds Quinolphos, Indoxacarb and Endosulfan for control of larval population and also economic yield loss. The characteristic higher population of the predatory mirids (*Macrolophus* spp.) and spiders (*Argiope* spp. and *Thomisus* spp.) was noted clearly in case of treatments with microbials and neem extract treated plots.

Ghosh *et al*. (2010) conducted a field experiment during *Rabi* seasons two years 2006-07 to study effects of novel insecticides viz. Spinosad 45%SC , Quinolphos 25% EC, Lambda cyhalothrin 5% EC and Cypermethrin 10 EC against fruit borer on tomato crop at Gayespur village, Nadia, West Bengal. The experiment result was recorded as Spinosad 45% SC being most effective on *H.armigera* at conc. of 73 to 84 g a.i./ha than Quinolphos, Lambda cyhalothrin and cypermethrin.

Reddy *et al.* (2010) calculated the efficacy of certain insecticides for *Helicoverpa armigera* (Hubner) management viz., neem seed kernel extract (NSKE), *Helicoverpa armigera* (Hubner) Nuclear Poly Hrdrosis Virus (HaNPV) and Endosulfan both single and in respective combinations against gram pod borer *Helicoverpa armigera* (Hubner) on chickpea. It was observed that larval count reduction was highest with a combination of NSKE 1.66% + HaNPV 250LE/ha + Endosulfan 0.023% followed by results opted with combination of NSKE 1.66% + Endosulfan 0.023%, NSKE 2.5% + HaNPV 250LE sprayed twice at 15 days interval.

Deshmukh *et al*. (2010) conducted a Land trial to figure out the potency of other chemicals opposed to *Helicoverpa armigera* (Hubner) Attacking chickpea at Junagadh

Agricultural University area, Junagadh for the duration of *Rabi* winter of 2008-09. The results found out the fact that flubendiamide 0.007 per cent, indoxacarb 0.0075 per cent, spinosad 0.009 per Cent and emamectin benzoate 0.0015 per cent prevailing the best in decreasing the *H. armigera* community and pod loss of chickpea. The best possible yield was too documented with the use of flubendiamide 0.007 per cent (1850 kg/ha) followed by indoxacarb 0.0075 per cent (1805 kg/ha), spinosad 0.009 per Cent (1760 kg/ha) and emamectin benzoate 0.0015 per Cent (1665 kg/ha). The Best require get advantages correlation was obtained within the application of indoxacarb 0.0075 per cent (1: 7.08), followed by flubendiamide 0.007 per Cent (1:6.10), spinosad 0.009 per cent(1:5.24) and emamectin benzoate 0.0015 per Cent (1:4.25). Thus, Pondering the cost benefit correlation, Anyone of those fungicide scatter at 50 per cent flowering and moment at 15 days subsequently initial spray may well be recommended for the useful keep an eye on of ancestor pod borer on chickpea.

Hossain *et al.* (2010) estimated for the least pod damage (2.55%) and lowest grain yield loss (34.90 kg-ha) being observed in the treatment where lamda cyhalothrin applied three times at 7 days interval from flowering stage as being compared with neem seed extract . Chickpea seed yield was maximum (1338 kg-ha) with lamda cyhalothrin sprayed thrice which was identical to sprayed twice (1280 kg-ha). Neem seed extract showed a marginal performance to control chickpea pod borer. The highest benefit cost ratio (3.19) was recorded from twice spray of lamda cyhalothrin.

Anadhani *et al*. (2011) conducted field experiment in year 2008-09 to conclude efficacy of various chemical and biomolecules viz. Emmamectin benzoate, Spinosad, Indoxacarb, Quinolphos along with pongamia, NSKE and Garlic extracts over *H.armigera* on chickpea crop. Each feild plot was treated twice with insecticides at 15 days interval at time of occurance of *H.armigera* larva in Rabi season. The larval count was recorded at 5 selected plants in each plot. The pre treatment larval count was done before each spray for each treatment a day before, followed by post treatment observations after every spray. the results concluded Indoxacarb being most effective for control of larval population followed by spinosad. The best treatment for plant population was NSKE and Garlic Extract. The cost benefit ratio obtained was also best for Indoxacarb followed by Quinolphos, Emmamectin benzoate, Spinosad, NSKE, Garlic extract and *Pomgamia* extract.

Babariya *et al*. (2011) conducted a trial with chemicals for control of pod borer infesting pigeon pea indicating various insecticides as Indoxacarb 0.0075%, Spinosad 0.009%, Profenphos+cypermethrin 0.044% and endosulfan 0.07%. The highest grain yield was recorded by Indoxacarb 0.0075% as 1486 kg/ha and cost benefit ratio of 1:18.94.

Babar *et al.* (2012) evaluated ten insecticides [emamectin benzoate (Proclaim 5 WG) 0.0025%, thiodicarb (Larvin 75 WP) 0.075, indoxacarb (Fego 15.5 SC) 0.007%, spinosad (Spintor 45 SC) 0.0135%, novaluron (Remon 10 EC) 0.01%, lufenuron (Match 5 EC) 0.005%, flubendiamide (Fame 480 SC) 0.01%, rynaxypyr (Coragen 20 SC) 0.006% and endosulfan (Thiodan 35 EC) 0.07% in laboratory and as well as in field condition against *Helicoverpa armigera* (Hubner) in chickpea during *Rabi* 2009-10. Results reveled flubendiamide and thiodicarb recorded more than 70% egg mortality in the laboratory experiment and found most effective as ovicide. Flubendiamide, emamectin, rynaxypyr and spinosad recorded more than 90% larval mortality in the laboratory experiment and found most effective as larvicide.

Ali *et al*. (2012) conducted a study to estimate effect of certain chemicals as emmamectin benzoate 19% EC. (Proclaim), spinetorm 120% SC. (Radiant) and Bifenthrine 60% EC. (Jatara) Certified action on H. armigera on chickpea showed that each one of the three insecticides performed conversant lowering larval count including (0.36, 0.44 and 0.49), (0.33, 0.51 and 0.56) and (0.29, 0.44 and 0.48) per plant in comparison to the control (1.23, 2.21 and 2.68) for ruling, runner-up and third spray, Individually immediately upon practiced at new bud presence, at fifteenth day of the Initial spray and third at twentieth day of the subsequent double spray.

Sahito *et al.* (2012) tested the efficacy of three insecticides Proclaim, Radiant and Jatara against *H. armigera* applied thrice at the interval of 15 and 20 days of second and third spray, respectively. The results showed that all three insecticides to an extent performed well in reducing pest population. However, Proclaim gave best results against gram pod borer. At the time of first spray the overall mean population of *Helicoverpa armigera was* recorded 0.36, 0.44 and 0.49 per plant in the plots treated with Proclaim, Radiant and Jatara, respectively as compared to control plot (1.23 larvae per plant). At the second spray the overall mean population of *H. armigera* 0.33, 0.51 and 0.56 per plant as recorded in the plots treated with Proclaim (emamectin benzoate), Radiant and Jatara, respectively as compared to control plot (2.21 larvae per plant). Whereas, during third spray the overall mean population of *H. armigera* 0.29, 0.44 and 0.48 per plant was recorded in the plots treated with Proclaim, Radiant and Jatara, respectively as compared to control plot (2.68 larvae per plant).

Patil *et al*. (2012) conducted Field operation to find out about the virtue of profenophos 50 EC and diverse new insecticide for the management of gram pod borer, H. armigera in chickpea during 2010-11. Among Different chemicals certified the larval population was significantly least with regards to spinosad 45% SC @ 0.10 ml/lit (0.99 and 0.33/10 plants), emamectin benzoate 5% SG @ 0.20 g/lit (1.40 and 0.46 larvae/10 plants) and Match with indoxacarb 14.5 SC @ 0.3 ml/ l (1.73 and 0.73 larvae/10 plants) and profenophos 4 ml/l (2.00 and 0.86 larvae/10 plants) for Initially and subsequent sprays, aside. The best possible benefit cost ratio was obtained originating at spinosad 45 EC @ 0.1 ml/l (4.95) followed by indoxacarb 14.5 SC (0.3 ml/l) emamectin benzoate 5 SG (0.25 g/l), profenophos 50 EC (4.00 ml/l) whichever recorded BC ratios of 4.60, 4.52 and 3.76, precisely.

Singh *et al.* (2012) on field experiment found chickpea var. 'SAKI9516' was shown on Agricultural Research Farm of Banaras Hindu University during *Rabi* season 2010–11 and 2011–12 for the evaluation of bio-efficacy of certain new insecticides viz., *Ha*NPV@250 LE/ha, spinosad 45SC@ 100 g a.i./ha, fenvalerate 20 EC @ 300 g a.i./ha, quinalphos 25EC @ 450 g a.i./ha, emamectin benzoate 5SG @ 11 g a.i./ha, azadirachtin 1500 ppm@5ml/lit, cartap hydrochloride 50 SP @ 500 g a.i./ha, fipronil 15 SC @ 50 g a.i./ha and indoxacarb 14.5 EC @ 75 g were applied twice at 15 days interval against gram pod borer, (*H. armigera)*. Spinosad as observed the best amongst all the other treatments with 81.2% reduction in larval population over control followed by indoxacarb, fipronil, emamectin benzoate, cartap hydrochloride, fenvalerate, and quinalphos, azadirachtin and HaNPV. Data taken after 7 days of second application, spinosad was found best again in reduceding 79.8% larval population followed by indoxacarb (with 78.3% reduction in larval populations). The highest yield was obtained in spinosad (1.79 t/ha) while low in azadirachtin (1.06 t/ha). The cost:benefit ratio was high in treatment fipronil (1: 8.2) while low in treatment indoxacarb (1: 5.3).

Kambrekar *et al*. (2013) conducted experiment to evaluate efficacy of molecules as Emmamectin Benzoate 5% SG and Indoxacarb 14.5% SC on gram pod borer at the research station Annigeri on variety Annigeri-1 in Rabi of year 2010-11. The maximum protection was gained by Emmamectin benzoate 5% SG @ 13g a.i./ha to the crop and natural enemies without any phytotoxic effect. The effects were followed by Indoxacarb 14.5 SC @75gm a.i/ha for larva reduction and yield protection.

Rohit and Singh (2013) conducted field experiment during Rabi of year 2008 for evaluation of various insecticides for their efficacy on pod borer *Helicoverpa armigera* on sunflower crop. The insecticides included were Spinosad, Endosulfon , *Bacillus thuringenesis* (Bt) *Kurstaki* and Cypermethrin. The best effects were seen by max larval mortality with Spinosad (84.81%) and maximum yield (3294 kg/ha), followed by Endosulfon (82.28% and 3255 kg/ha) and finally with Quinolphos. The minimum control was by Bt and cypermethrin for insect. The Endosulfan provided maximum cost:benefit ratio 1:21.3 followed by 1:15.8.

Singh *et al.* (2013) evaluated that, amongst insecticides quinalphos (0.05%), lambda cyhalothrin (0.004%) and emmamectin benzoate (0.002%) two sprays of indoxacarb (0.007%) and spinosad (0.007%) were most effective and amongst them as moderately effective were *Ha*NPV and *B.t.* as less effective in reducing pod borer population of chickpea. NSKE (5%) and azadirachtin (5 ml/lit.) were least effective in case of gram pod borer. The maximum yield obtained in plots treated with indoxacarb (17.42 q ha^{-1}) while minimum yield was obtained in the plots treated with azadirachtin (11.17 q ha^{-1}).

Shindey *et al*. (2013) concluded that the least larval count was observed from the treatment of Spinosad 45 SC , followed by HaNPV and Bt. The highest grain yeid recorded was by plot treated with Spinosad (19.11 q/ha) followed by HaNPV (16.78 q/ha) , Bt (14.93q/ha) , Bb (14.41 q/ha) and Vl (13.27 q/ha). The best benefit cost ratio was obtained for Bb (1:17.98) followed by HaNPV (1:12.79) and Vl (1:7.25)

Iqbal *et al.* (2014) evaluated feild efficacy of five insecticides *viz.*, Emamectin 1.9 EC (emamectin benzoate), Lannate 40SP (methomyl), Coragen 20SP (rynaxypyr), Match 50 EC (lufenuron), Profenofos 50 EC (profenofos) for gram pod borer (*Helicoverpa armigera*) on chickpea (*Cicer arietinum* L.) variety BRC-390. The highest mortality of gram pod borer was recorded in plots treated with Profenofos (85%, 90% & 94%) and Coragen (85%, 90% & 92%) at 3, 5 and 7 days after treatment (DAT), respectively. No plant mortality was recorded in untreated plots from 3 to 7 DAT. Thus, these insecticides proved highly effective for the management of gram pod borer on chickpea under field conditions.

Sambathkumar *et al*. (2014) conducted a field experiment during *Kharif* 2012 to evaluate the efficacy of newer insecticides and botanicals followed by Indoxacarb against pod borers infesting redgram variety CO 6. Among newer insecticides, the significant least incidence of *Maruca vitrata* was recorded in indoxacarb 15.8 EC @ 75 g a.i./ha (3.1 webbings/ 10 plants) and chlorantraniliprole 18.5 SC 30 g a.i./ha (3.9 webbings/ 10 plants). The minimum larval population of *Helicoverpa armigera* was recorded in chlorantraniliprole 18.5 SC @ 30 g a.i./ha (9.5 nos./ 10 plants) and indoxacarb 15.8 EC @ 73g a.i/ha (10.3 nos./ 10 plants). Low per cent pod fly grain damage (11.7) was recorded in chlorantraniliprole 18.5 SC @ 30 g a.i./ha with the highest yield of 892.2 kg/ha in indoxacarb 15.8 EC @ 75g a.i/ha. Among botanicals and combination of botanicals and indoxacarb spray, least number of *Maruca* webbings, minimum *Helicoverpa* larval population (18.3), *Helicoverpa* pod damage (16.3%) were recorded in Neem soap (10g) followed by indoxacarb (0.5ml) (5.7/ 10 plants) with maximum yield of 732.9 kg/ha in *Pongamia* soap (10g) followed by indoxacarb (0.5ml).

Carneiro *et al*. (2014) tested the insecticides deriving out of the various synthetic chemical groups were tested by laboratory bioassay to verify the percentage mortality of *Helicoverpa armigera* (Hubner 1808) (Lepidoptera: Noctuidae). The experiment was conducted between January to June, 2013.Third instar larva of H. armigera were acclimated to run the bioassay.The empirical form was positively randomized, upon 13 treatments and 4 reproductions. Five larva were passed down per replication, Upon 12 Insecticide deriving out of 9 the various synthetic groups along with a regulation. Each Treatment consisted of 3 doses. The methods of treatments applied were topical contact and ingestion in artificial diet. According to the results the percentage mortality of *H. armigera* larva varied among the treatments. The results demonstrated that chlorpyrifos and spinosad were effective against third instar *H. armigera* larva both on contact and by ingestion. Flubendiamide, acephate, methomyl, Bacillus thuringiensis, dimethoate, chlorantraniliprole and fipronil had good responses to keep watch over of *H. armigera.*

Sharma *et al*. (2014) recorded that fact, use of rynaxypyr 20 SC @ 75 ml/ha find planned the best in decreasing the elementary population of larva, pod loss and fetched absolute best cereal yield. Although, rynaxypyr gave the absolute best net returns however the cost benefit ratio of flubendiamide 48 SC @ 50 ml/ha was overhead rynaxypyr. Rynaxypyr 20 SC @ 75 ml/ha or flubendiamide 48 SC @ 50 ml/ha might be an efficient and efficient pointing to management of *Helicoverpa armigera* in chickpea.

Shreekanth *et al*. (2014) conducted experiments in *Kharif* season of 2010 and 2011 on pigeonpea crops for evaluation of affordability and efficiency of certain chemicals and insecticides against pod borer (*H. armigera*) .The experiments concluded that lowest larval count for pod borer was recorded for Chlorantriniprole 20 SC (0.43), followed by Flubendamide 48 SC (0.59) and Spinosad 45 SC (0.85) as compared to control plot (4.17) with 89.7, 85.9 and 79.6 per cent reduction, respectively. The most crop loss was recorded by control plot about 10.22%. In comparison to various treatments the highest economic yield was from Chlorantriniprole (686.1kg/ha) with 127% increase over control followed by Flubendamide (595.8 kg/ha) and Spinosad (589.0 kg/ha) with an increase of 97.6 and 95.3 per cent over control plot without treatment which gave an yield of 301.6 kg/ha as minimum yield form check plot. The cost benefit ratio was best for Chlorantraniprolre and flubendamide of 1:4.64 and 1:4.50 respectively which is highly favourable for insecticides followed by Indoxacarb (1:3.67), Emmamectin benzoate (1:3.13) and Spinosad (1:2.97).

Sukumar *et al*. (2014) certified chlorpyriphos 20 EC, indoxacarb 14.5 SC, profenophos 50 EC, neem oil 1%, pongamia leaf elicit 5% and NSKE 5%. Among the treatments, indoxacarb 14.5 SC stumbled on preferable more to each of the treatments subsequently initially and assist sprays and neem oil came upon preferable more alternative phyto-products. Minimum pod ravage of 13.7% and best possible pod concede of 1745 kg/ha was enrolled in indoxacarb. Thus, easiest come to receive advantages proportion was more reported in indoxacarb (1:2.34) followed by chlorpyriphos (1:1.77), profenophos (1:1.51), neem oil (1:1.32), NSKE (1:1.07), Pongamia leaf elicit (1:0.49) proven planned third active treatment.

Yogeswarudu and Venkata (2014) approved the potency of other treatments against chickpea pod borer (*Helicoverpa armigera*) larvae on chickpea viz., profenofos 50 EC @ 2.0 ml/l, , indoxacarb 14.5 SC @ 0.5 ml/l, novaluron 10 EC @ 1.5 ml/l, fipronil 5 SC @ 2.0 ml/l, imidacloprid 17.8 SL @ 1 m/l and lambda cyhalothrin 5 EC @ 1 ml/l. The studies show that indoxacarb 14.5 SC @ 0.5 ml/l was most effective among all the treatments with the minimal larval count at first spray of 1.53, 0.46, 0.73 larvae/5 plants being 89.45%, 97.01%, 95.83% reduction over control at 3 DAS, 5 DAS & 7 DAS, respectively. The minimal larval count at second spray of 0.00, 0.26 and 0.00 larvae/5 plants by giving 100%, 98.74% & 100% reduction over control at 3 DAS, 5 DAS & 7 DAS, respectively.

Chavan *et al*. (2015) reported efficacy of insecticides for the minimum larval count of H. armigera of 0.95 and 0.36 larva/m row length at use of rynaxypyr 20 SC at readings taken 3 and 7 days after spraying, respectively, so proved to be the best. The treatment also included flubendiamide 48 SC (1.47 & 0.78 larvae/m row length) and emamectin benzoate 5 SG (1.55 & 0.89 larvae/m row length) over conventional insecticide profenophos 50 EC which recorded 2.09 and 1.49 larva/m row length. The treatment with rynaxypyr 20 SC was found significantly effective in reducing the pod damage (3.5%) followed by flubendiamide 48 SC (4.8%) and emamectin benzoate 5 SG (6.05%) as compared to profenophos (13.9%). The highest (2590 kg/ha) grain yield recorded was in rynaxypyr 20 SC followed by flubendiamide 48 SC (2365 kg/ha) and emamectin benzoate 5 SG (2292 kg/ha). However, the highest (1:19.2) cost benefit ratio was recorded in flubendiamide 48 SC followed by rynaxypyr 20 SC (1:11.1), profenophos 50 EC (1:7.8), emamectin benzoate 5 SG (1: 4.2) and lufenuron 5.4 EC (1:3.5).

Adsure and Mohite (2015) conducted the experiment to learn about and figure out the potency of Clothianidin 50 WDG, Indoxacarb, Flubendiamide 480 SC, Fipronil 5 SC, Spinosad 45 SC, Indoxacarb 14.5 SC, Rynaxypyr 20 SC, Chorpyriphos 20 EC opposed to the residual larval count of chickpea pod borer, *Helicoverpa armigera* (Hub.) on chickpea in the experiential analyze zone of farmers retrieve in Chandre suburb , Dist -Kolhapur throughout Rabi inter 2009-10. In more recent insecticide slightest variety of extant culture of insect was taped in practice Rynaxypyr 20 SC @ 40 g a.i./ha i.e. 0.70 larva/plant, best yield registered 15.00q/ha and lessen pod loss registered 8.10%.

Dhaka *et al.* (2015) made a feild study for determining the efficacy of insecticides on chickpea var. Surya for gram pod borer (*H.armigera*) in *Rabi* of year 2011-12 and 2012-13. The insecticides used included carbosulfan 25 EC @ 1000 ml/ha, flubendiamide 39.35 EC @ 75 ml/ha, spinosad 45 SC @ 500 ml/ha, indoxacarb 14.5 SC @ 500 ml/ha, lambda cyhalothrin 5 EC @ 500 ml/ha, bifenthrin 20 EC @ 500 ml/ha, novaluron 10 EC @ 750 ml/ha, cypermethrin 25 EC @ 1250 ml/ha ,biopesticide *viz., B t* @ 1.5 kg/ha and botanical *viz.*, Neemarin 1500 ppm @ 3000 ml/ha. The estimated attributes were recorded on basis of yield and other parameters. The best effects were by flubendiamide being pod infestation of 10.73 and 12.59%, respectively and 16.84 q/ha yield , followed by indoxacarb, spinosad, novaluron, carbosulfan, bifenthrin, lambda cyhalothrin, cypermethrin, neemarin and *Bt.*

Kumar *et al*. (2015) presented an evaluation on study of chickpea (C.arietinum Linn.) over variety ‘PG186’ at N.D. University of Agriculture & Technology Kumarganj, Faizabad. The aim to find out the efficacy of conventional products like Neem oil, Neem Leaf Extract (NLE) and Neem Seed Kernels Extract (NSKE) in comparision to chemical pesticide against the incidence of gram pod borer (*H.armigera* Hubner) during rabi seasons 2011-12. The results showed that indigenous products, Neem Leaf Extract (NLE) 5%, Neem Seed Kernels withdraw (NSKE) 5%, Neem oil (Mingu 1%+Lifebuoy 0.2%) and Indoxacarb (14.5 SC) @ 100 g a.i/ha were applied. However, all treatments were found significantly superior to control. Indoxacarb 14.5 SC @ 100 g a.i. ha-1 was the best of all the treatments and neem leaf elicit 5% at periodical layoff outset amidst inauguration of pod formation was least effective treatment. The maximum benefit cost ratio (1:4.28) was obtained of the plots treated amidst neem leaves extricate 5% at periodical spell origin upon induction of pod formation.

Kumar and Sarada (2015) conducted evaluation studies to calculate the competence and practical fesibility of a few new insecticide opposed to lepidopteran caterpillars viz.,*Spodoptera exigua* and *Helicoverpa armigera* (Hubner) in the course of Rabi period of 2012 and 2013 in chickpea. The pooled represent of 2 seasons showed that one form of *S.exigua* and *H. armigera* larva per 10 plant were minimal in plotted area treated with spinosad 45% SC (0.34 and 0.67), flubendiamide 20% WG (0.50 and 0.84) and chlorantraniliprole 20% SC (0.33 and 0.50) as when compared to the control layout (16.67 and 8.17 larvae/10 plants) with larval reduction in population of *S. exegua* being 98.0%, 97.9% and 97% respectively, along with *H. armigera* larval count reduction being 93.9%, 91.8% and 89.7% respectively. The pod damage recorded was lowest in plots treated with spinosad 45SC (1.53%), flubendamide 20% SC (2.40%), chlorantriniprole 20% SC (2.60%) and Emmamectin Benzoate 5% WG (2.46) with 88.8%, 81.9%, 80.9% and 79.1% respectively, for *Helicoverpa armigera*. In case of seed yield spinosad 45% SC gave best yield (1244.4kg/ha) that is 121.8% higher than control. The other insecticides as chlorantraniliprole 20% SC (1180.5 kg/ha), flubendiamide 20% WG (1157.4 kg/ha) and emamectin benzoate 5% SG (1078.7 kg/ha) with 110.4%, 106.3% and 92.2% increase, respectively as compared to control giving yield of 561.1 kg/ha in this case. In case of economic efficiency, flubendamide 20% WG was high (1:4.08), followed by emamectin benzoate 5% SG (1:3.75), chlorantraniliprole 20% SC and spinosad 45% SC (1:3.57).

Singh *et al*. (2015) conducted a plot evaluation to figure out the potency of various practices throughout Rabi winter of 2013-2014 in chickpea. Efficacy of other insecticides viz. , spinosad 45 SC @ 200 mL/ha, , emamectin benzoate @ 200 g/ha, flubendiamide 480 SC @ 75 ml/hamethomyl 40 SP @ 1000 g/ha, indoxacarb 14.5 SC @ 500 ml/ha and neem come through EC @ 3000 ml/ha was certified for control of *Helicoverpa armigera* . The management amidst flubendiamide 480 SC @ 75 ml/ha prevail most competitive upon minimal count of *H. armigera* at initial spray 1.67 (3 DAS) and 2.33 larva per 5 plants (7 DAS) and the minimal larval count at next (2nd) squirt 2.00 (3 DAS) and 2.67 larva per 5 Plants (7 DAS). The minute active treatment was neem outdid EC @ 3000 ml/ha amidst top larval count at the start spray 5.67 (3 DAS) and 7.33 larva per 5 plants (7 DAS) and the peak larval count at next spray 6.00 (3 DAS) and 9.00 larva per 5 plants (7 DAS). The conclusion discovered was that the flubendiamide 480 SC @ 75 ml/ha came across most competitive treatment for the management of minimal larval population of the two insecticides sprayed.

Turkhade *et al*. (2015) evaluated the exercise of more recent insecticide for *H. armigera,* Hubner was conducted out for the duration of 2011–12. The area was applied twice at 14 days spell including six kinds of insecticide and spray. The treatment of Emamectin Benzoate 5 SG @ 0.0015 was discovered so much encouraging to decrease elementary population of *H. armigera*. That defoliant cut back 92.45 and 93.46 % larval count to control later 7th and 14th days afterwards initial spray, and 99.41 and 99.41 % back of 7th and 14th days subsequent to the second spray, aside. The percent pod loss was calculated within the values of 3.93 to 21.81%. The minimum pod loss was listed with application of Emamectin Benzoate 5 SG @ 0.0015. The best and minimum yield was reported in treated area by Emamectin Benzoate 5 SG @0.0015and as check control, separately.

Sambathkumar *et al*. (2015) conducted field experiment during *Kharif* 2012 to calculate the competence of more recent pesticide and botanicals followed by Indoxacarb opposed to pod borers attacking redgram variety CO 6. Among more modern pesticide, the numerous minute incidence of Maruca vitrata was taped in indoxacarb 15.8 EC @ 75 g a.i./ha (3.1 complexity/ 10 plant) and chlorantraniliprole 18.5 SC 30 g a.i./ha (3.9 webs/ 10 plant). The Minimal larval count of *Helicoverpa armigera* was documented in chlorantraniliprole 18.5 SC @ 30 g a.i./ha (9.5 nos./ 10 plant) and indoxacarb 15.8 EC @ 73g a.i/ha (10.3 nos./ 10 plant).Low per cent pod fly grain Loss (11.7) was Reported in chlorantraniliprole 18.5 SC @ 30 g a.i./ha with all the easiest concede of 892.2 kg/ha in indoxacarb 15.8 EC @ 75g a.i/ha. Among botanicals and sequence of botanicals and indoxacarb spray, minute number of Maruca webbings, Minimal *Helicoverpa* Larval population (18.3), *Helicoverpa* pod losses (16.3%) were Taped in Neem wash (10g) followed by indoxacarb (0.5ml) (5.7/ 10 vegetation) Plus high yield of 732.9 kg/ha in *Pongamia* soap (10g) followed by indoxacarb (0.5ml).

Sharma *et al*. (2016) the outcomes found out that fact the minimal larval count (2.5 & 0.9 larvae/m2) was reported in chrolantyriniprole at 3 and 10 days afterwards spraying followed by flubendiamide (2.6 & 1.1 larvae/m^2) and emamactin benzoate (2.7 & 1.6 larvae/m2), precisely . Chlorantrinoprole shows rather simpler in decreasing the pod damage (3.2%) in when compared with emamactin benzoate (5.6%) and triazophos (8.4%) as when compared with 8.4 and 9.6 larvae/m2, precisely with the control. Among the microbial insecticide, moderately minimal (5.7 & 2.7, precisely at 3&10 days) larval community and pod damage (13.5%) was reported from HaNPV treated plots. The very best grain yield (20.5 q/ha), cost benefit ratio (2.3)and net profit was reported from chlorantriniprole followed by emamactin benzoate (18.1q/ha, 2.2 B: C) and flubendiamide (17.0q/ha, 2.2 B: C).

Patel and Chavadhari (2016), conducted feild experiment on bio-efficacy of other pesticide to check *Helicoverpa armigera* (Hub.) infesting chickpea were conducted out in the course of *Rabi* time of 2010-11 and 2011-12. Results of experiments showed that the best chemical opposed to larva of *H. armigera* was chlorantraniliprole 0.006 per cent (0.10 larva/plant) followed by emamectin benzoate (0.12 larva/plant) and flubendiamide 0.01 per cent (0.15 larva/plant). Pod damage at harvest was lowest in the treatment of chlorantraniliprole 0.006 per cent (0.46 %) followed by flubendiamide 0.01 per cent (1.02 %). The treatment of chlorantraniliprole 0.006 per cent recorded the highest grain yield (2511 kg/ha) followed by emamectin benzoate 0.0025 per cent (2427kg/ha) and flubendiamide 0.01 per cent (2425 kg/ ha).

Nitharwal *et al*. (2017) conducted an experiment was in *Rabi* season during 2014-2015 to study the relative efficacy of different insecticidal treatments. The result of the experiment concluded that amongst all the treatments lowest number of gram pod borer was recorded in Spinosad (2.85). The next followed treatment was Chlorpyriphos (3.40), recoeded a better effect than Quinolphos (3.69), Cypermethrin (3.95). Remaining treatments are Fipronil (4.45) and Indoxcarb (4.63) were seen for better results than Malathion (5.25) which was recorded as least effective within the chemical insecticides. A maximum net return was recorded in treatment by Spinosad (17.45 q/ha), followed by effects of Chlorpyriphos (16.24 q/ha), Quinolphos (15.35q/ha), Cypermethrin (13.92 q/ha), Fipronil (12.20 q/ha), Indoxcarb

(11.90 q/ha), Malathion (9.26 q/ha) as compared to control T0 plane water (7.25q/h). The cost benefit ratio was worked out, for the best and most economical treatment was Spinosad (1:3.40), followed by Chlorpyriphos (1:3.03), Quinolphos (1:2.99), Cypermethrin (1:2.71), Fipronil (1:2.36), Indoxcarb (1:2.30), Malathion (1:1.81) as compared to control plane water Control (1:1.46).

MATERIAL AND METHODS

CHAPTER III

MATERIAL AND METHODS

The establishment of facts from comprehensive reviews of the present investigation, an experiment entitled "**Comparative efficacy of different insecticides against gram pod borer of chickpea under field conditions**" conducted at Agriculture Research Farm, Banaras Hindu University, Varanasi during year 2017-18. The materials and methods employed for the purpose of conducting experiments are as described as follows.

3.1 Details of the experiment

The experiments conducted under field conditions during year 2017-18 in Agriculture Research Farm of Institute of Agricultural Sciences, Banaras Hindu University. The typical sub-tropical climate of the region is characterized by extreme of weather conditions especially in summers and winters. The general reported characteristics of the soil present in locality are of alluvial type, flat, well-drained & moderately fertile. The soil is diagnosed to have a pH of 7.2-8.4 with deficiency of nitrogen and medium in availability of potassium and phosphorus.

3.2 Physiography

The location of Agriculture Research Farm, Banaras Hindu University is on the banks of river Ganges and it is situated in the center of the North Gangetic alluvial plains. The latitudinal and longitudinal extent of the area is $25^{o}20'$N latitude and $83^{o}0'$E longitude, respectively. The altitude of given location is 75.70 meter above the mean sea level.

3.3 Climate Conditions

The location is of the experimental field is in sub tropical area and hence it lies in semi-arid zone. This indicates the annual range of precipitation lays in range of approximately 75-100cm, mainly in *Kharif* season. The two extremes of weather conditions occurring in Varanasi results in temperature reaching as high as 46^{o}C in hot summers and as low as 3°C during harsh winter. The extremes of temperature is reached as the summer peaks in months of May and June while, the harshest of winter conditions are faced in months of last of December till mid January.

3.4 Cultivation Details

3.4.1 Land Preparation

The chickpea grows well in well drained, light, alluvial soil in Gangetic basin. The field, in which this crop is grown, is generally ploughed twice with a disc plough to make a rough and well aerated seedbed. After the first ploughing, well rotten FYM should be added to field to make it supply initial dose of Nitrogen from organic source. Also, the FYM increases the aeration of soil and improves the soil texture. After the FYM, Di-ammonium phosphate (18:46:0) is added to the field at the rate of 120 kg per hectare, just before final ploughing. The final ploughing is done and the fertilizers are mixed in furrows at ploughing to depth of 7-10cm. However, the field gets natural nitrogen ranging 41-134 kg/ ha for next succeeding crop. It also provides 25-30 quintals / ha crop residues.

3.4.2 Variety and Methods of Sowing

The chickpea variety Kiran was sown in the field at plot size of 2.5m×1.5m. The planting was done was done with line to line distance 20cm and plant to plant distance maintained 15 cm. The sowing was done at date of 14th November, 2017.

3.4.3 Irrigation Practices

The water requirement of the crop is generally satisfied by two irrigations to the crop. The irrigation canals are made for purpose of irrigation. The main irrigation canal of 1m width and two sub-irrigation canals of 75cm each were prepared. The irrigations needed for the crop are one at flowering stage and other at pod development stage. However, care should be taken not to give any irrigation after flowering because it could lead to flower drop and reduce the yield drastically. The irrigation provided should always be light because heavy irrigation is generally harmful to pulse crops and specially chickpea.

Preparation of field for sowing of chickpea

Field view of chickpea plots

Plate 1

3.4.4 Layout and Experimental Details

The chickpea (*Cicer arientinum*) variety Kiran, commonly cultivated in this area was sown to the experimental field in a Randomized Block Design in year 2017-18. The crop was cultivated in 10 plots, each of plot size 2.5×1.5m and retaining the row to row distance 30cm and plant to plant distance 10cm, respectively. All the 10 treatments were replicated three times each.

Further details of the experiments are given below as:

Name of Crop	: Chickpea
Botanical Name	: *Cicer arietinum*. L.
Variety	: Kiran
Year of Experiment	: 2017-18
Experimental Design	: Randomized Block Design
Number of Treatment	: 10
Number of Replications	: 03
Total number of Plots	: 30
Plot size	: 2.5m×1.5m
Spacing	: 30×10 cm.
Date of sowing	: 14 November 2017
Date of Harvesting	: 4 April 2017

TABLE 1 : Details of Various treatments and their respective manufacturers

Sr. No.	Common Name	Chemical Name	Trade Name	Manufacturer
01.	Spinosad	1alpha,2beta-[(R)-2-(2-O-Ethyl-3-O,4-O-dimethyl-alpha-L-rhamnopyranosyloxy)propane-1,3-diyl]-8beta-ethyl-12alpha-[[5alpha-(dimethylamino)-6beta-methyltetrahydro-2H-pyran]-2beta-yloxy]-13beta-methyl-1,2,4aalpha,4bbeta,8,9,10,11,12,13-decahydro-7-oxa-7H-cyclododeca[a]indene-6,14(5H,15aalphaH)-dione	Tracer	Dow Agrosciences Pvt. Ltd.
02.	Indoxacarb	Methyl(4aS)-7-chloro-2-[methoxycarbonyl-[4-(trifluoromethoxy)phenyl]carbamoyl]-3,5-dihydroindeno[1,2-e][1,3,4]oxadiazine-4a-carboxylate		Krishi Rasayan Exports Pvt. Ltd.
03.	Chlorantiniprole	5-bromo-N-[2-chloro-4-methyl-6-(methylcarbamoyl)phenyl]-2-(3-chloropyridin-2-yl)pyrazole-3-carboxamide	Koragen	E.L.Dupont Pvt. Ltd
04.	Emamactin Benzoate	4″-Deoxy-4″-epi-methylamino-avermectin B1; Epi-methylamino-4″-deoxy-avermectin	Safari	GSP Crop Sciences Pvt. Ltd.
05.	Novaluron	(±)-1-[3-chloro-4-(1,1,2-trifluoro-2-trifluoro- methoxyethoxy)phenyl]-3-(2,6-difluorobenzoyl)urea	Rim-on	Indofil Industries Ltd.

06.	Flubendamide	1-N-[4-(1,1,1,2,3,3,3-heptafluoropropan-2-yl)-2-methylphenyl]-4-iodo-3-N-(2-methyl-1-methylsulfonylpropan-2-yl)benzene-1,3-dicarboxamide	Flame	Bayer India Pvt. Ltd.
07.	Fipronil	(RS)-5-amino-1-[2,6-dichloro-4-(trifluoromethyl)phenyl]-4-(trifluoromethylsulfinyl)-1H-pyrazole-3-carbonitrile	Microzen	Micro Agro Chemical Ltd.
08.	Acephate	N-dimethoxyphosphinothioylacetamide	Asatarf	Tata Chemical Pvt. Ltd.
09.	Lambda-cyhalothrin	[(S)-cyano-(3-phenoxyphenyl)methyl] (1R,3R)-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropane-1-carboxylate	Lanz	Perfect Cropsciences Pvt. Ltd.
10.	Control			

3.5 Evaluation of Certain New Insecticides against *H. armigera* on Chickpea

The specific efficacy of certain insecticides that are known as chemical molecules for having a novel mode of action viz. Spinosad, Indoxacarb, Chlorantiniprole, Emamactin Benzoate, Novaluron, Flubendamide, Fipronil, Acephate and Lambda-cyhalothrin over *H.armigera* were tested in feild conditions over chickpea crop in recommended doses. The details of insecticide formulations along with their manufacturers are given in table:

Table 2. Dose of insecticides used for treatments

Treatments	Dosage (a.i./ha)	Quantity of chemical (gm per lt. Water)
Spinosad	74	0.33
Indoxacarb	36	0.50
Chlorantiniprole	92	1.00
Emamactin Benzoate	12	0.32
Novaluron	100	2.00
Flubendamide	49	0.25
Fipronil	112	4.50
Acephate	750	2.00
Lambda-cyhalothrin	20	1.00
Control	-	-

3.6 Bio-efficacy of certain novel insecticides against *H. armigera* on chickpea

Bio efficacy of selected insecticides molecules that are known to have novel mode of action viz Cholrantriniprole 18.5 % SC, Flubendamide 39.35 EC, Spinosad 45 SC, Emmamectin Benzoate 10 EC, Indoxacarb 14.5 EC, Lambda-cyhalothrin 5 WP, Novaluron 10 EC, Fipronil 5 SC, Acephate 75 WP were tested at their respective recommended field concentrations against *Helicoverpa armigera* of chickpea. The details of the insecticides formulations along with their manufactures were given in Table 1 & 2.

3.6.1 Character of test insects and their mode of damage:-

Gram pod borer (*Helocoverpa armigera*)

The young caterpillar of *H. armigera* feed on tender leaves. The later stage larvae make conspicuous hole on the pod and make entry into it. There, it feed on the developing grain. Initially greenish looking slender caterpillars become yellowish and stout (maximum length 3.5cm) in 2-3 week under optimum condition. Incubation period lasts 2 to 4 days. The pupation takes place in the plant debris or in the soil and usually takes 6-12 day for developing in to adult. Eggs are laid singly by the adult females on tender parts of the plant. The larvae feed on buds, flowers and pods. On pods conspicuous holes are made by the entry of larvae. Usually, developing and partly matured seeds are eaten completely, sometimes a portion of the seed and testa remain unattached.

During the fruiting stage at each observation the number of fruits damaged to the total number of fruits present was recorded for the selected 5 plants per plot for experiment. The number and weight of infested fruits to the total number and weight of each plot of the experiment was recorded separately at each harvest.

3.6.2 Formulations and Spraying

The spray mixture of each treatment was prepared by mixing of required quantity of the insecticides formulations in water to make it equivalent to 500 liters / ha. The spray mixtures were freshly prepared for each treatment. The spraying was done by knap sack sprayer fitted with cone type nozzle. The sprayer was duly calibrated with water for the application rate of 500 liters spray mixture / ha. In control, the plain water was Sprayed. The details about the insecticides are given in Table I & 2.

Insecticides were applied during early hours of the day where wind velocity was suitable for spraying. This helped in avoiding the drift of spray fluid to the adjacent plots. Due care was also taken to spray each plot uniformly and the sprayer was thoroughly washed after spraying of each insecticides.

3.6.3 Sampling and observation:-

The experiment was laid out in a randomized block design with ten treatments (Table I and 2) replicated three in 1.5×2.5 m^2 plot size during 2017-18 at the Agriculture Research Farm, Banaras Hindu University, Varanasi. The chickpea variety- Kiran was raised as per the recommended package of practices except plant protection measures. The crop received 2 sprays, the first being given at time of pod formation while second spray was imposed on the basis of insect population. The number of larvae of pod borer was counted on 3 randomly selected plants in each plot during 2017-18.

Pre-treatment larval count was made a day before spraying while post treatment counts were done after weekly interval. The per cent reduction in larval population was calculated on the basis of number of larvae recorded in treated and control plots. The data were statistically analyzed after arc sin transformation.

Percent reduction in larval population =

$$\frac{Larval\ population\ in\ control\ plot - larval\ population\ in\ treated\ plot}{Larval\ population\ in\ control\ plot} \times 100$$

Data on healthy and damaged pods of plants from each plot were also recorded and per damaged pods were calculated before statistically analysis by using formula.

$$Percent\ \inf ested\ pod = \frac{Number\ of\ \inf ested\ pods}{Total\ number\ of\ pods} \times 100$$

Observation of plant for larval count

Initial infestation of *H. armigera* larva

Plate 2

Pod infestation by *H. armigera* in chickpea plant

Pod damage by *H. armigera*

Plate 3

3.7 Efficacy of chemical treatment:-

To study the relative efficacy of various chemical treatments, the percentage pod damage and plot yield were recorded after the crop harvest in both cropping year. After harvesting, all the pod of 3 plants in center of individual plot were collected and pooled together. Finally 50 pods were picked up randomly and per cent pod damage was recorded. For recording the yield, all the pod from individual treatment were threshed and grain weight so obtained were converted into q/h.

3.7.1 Statistical analysis:-

The percentage reduction of the pod borer over untreated check in different treatments was calculated using Henderson and Tiltons (1955) formula as given below.

$$Percent\ efficacy = \left[\frac{T_a}{T_b} \times \frac{C_b}{C_a}\right] \times 100$$

Where,

T_a = Population in the treated plot after spray.

T_b = Population in the treated plot before spray.

C_a = Population in the control plot after spray.

C_b = Population in the control plot before spray.

The per cent reduction over control was calculated for fruit border damage and data were analyzed using arc sin transformation in RBD as per Panse and Shukhatme (l983) The significance was tested by referring to F' tables of Fisher and Yates (1963).

3.8 Yield

The yield data of marketable fruits at different pickings in each treatment were recorded separately and subjected to statistical analysis to test the significance of mean yield in different treatments. The per cent increase in yield over control in each treatment was calculated by using the following formula.

$$Yield = \frac{Yield\ in\ treatment - Yield\ in\ control}{Yield\ in\ control} \times 100$$

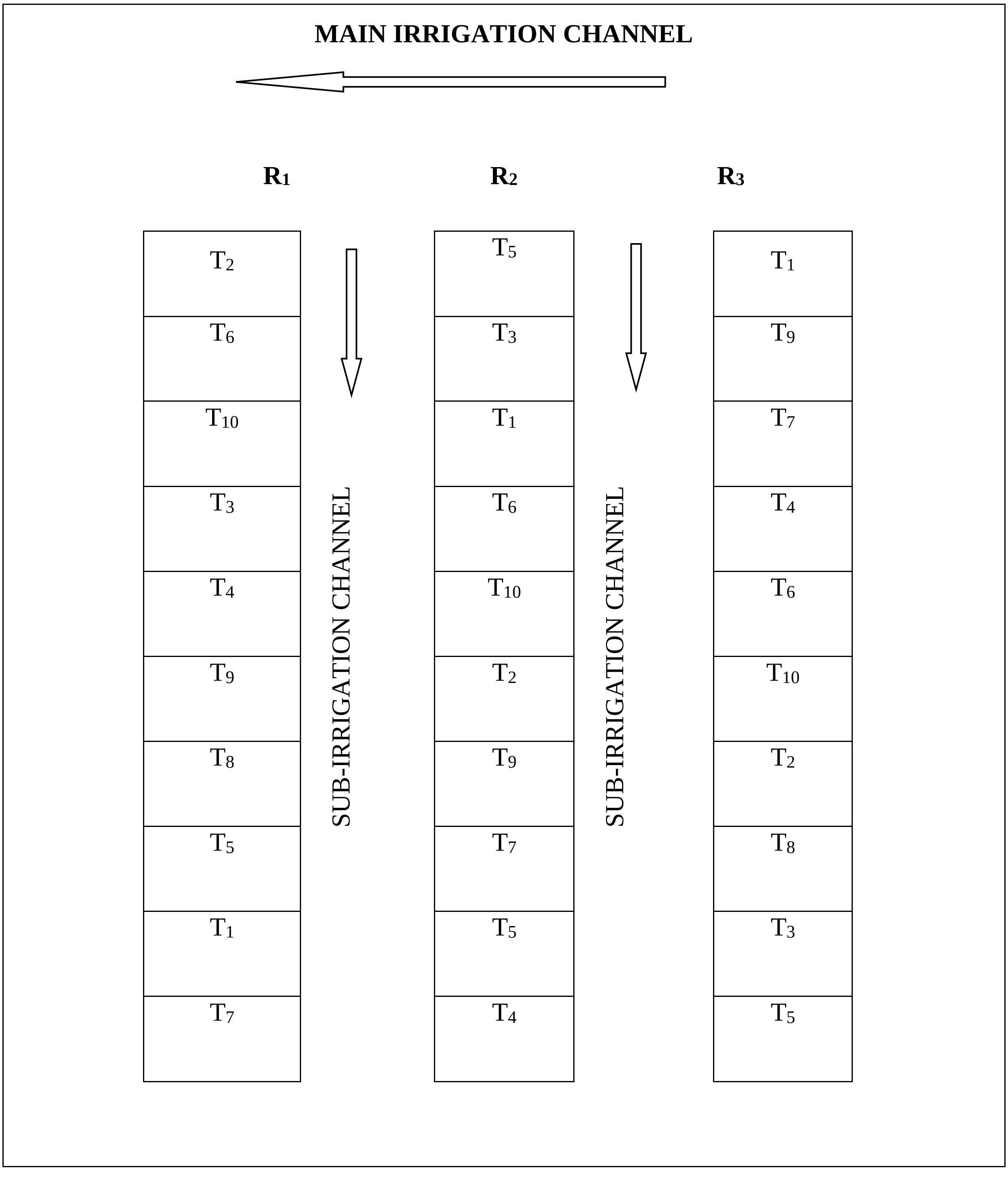
3.9 Materials used

The following materials were used during studies of Bio-efficacy of certain novel insecticide against *H. armigera* in chickpea.

Materials used in field experiment.

S. No.	Name of Equipments/materials
01	Bamboo sticks
02	Plastic Vials
03.	Tractor with plow and plank
04.	Rope
05.	Spade
06.	Kudali
07.	Khurpi
08.	DAP (chemical fertilizer)
09.	Saki, Chickpea seed
10.	Tube Well
11.	Paper tags
12.	Insecticides
13.	Buckets size (15 litre) and Mugs (1& 2 litre)
14.	Knap sack sprayer
15.	Rubber Bands

Fig. 1 Layout of Experimental Field



T1 = Spinosad, T2 = Indoxacarb, T3 = Chlorantriniprole, T4 = Emmamectin Benzoate, T5 = Novaluron, T6 = Flubendamide, T7 = Fipronil, T8 = Acephate, T9 = Lambda-cyhalothrin, T10 = Control

EXPERIMENTAL FINDINGS

CHAPTER IV

EXPERIMENTAL FINDINGS

The field trial was conducted on the "**Comparative efficacy of different insecticides against gram pod borer of chickpea under field conditions**" under the field conditions during Rabi 2017-18. The findings of the experiments were studied as presented below:

4.1 Effects of Different Treatment on the Larval Population Reduction

The results showed that none of the insecticides can completely control the pest in field conditions totally. The insecticide treatments and the population reduction data obtained before and after the insecticide spray are in table mentioned below-

During the *Rabi* 2017-18, the data on the population of *Helicoverpa* larva initially given in table 4.1 shows the homogenous distribution of the pest in field throughout evenly before the 1st spray of the treatment is done on the crop. The observations taken on 3rd and 7th day of the application, every treatment was recorded to be superior over the control, significantly. The observations prove that Cholrantriniprole 18.5 % SC @ 92 gm a.i/ha were the best for decreasing the larval population up to 63.05 per cent. The other treatments used for the application were Flubendamide 39.35 EC @ 49 gm a.i/ha , Spinosad 45 SC @ 74 gm a.I/ha , Emmamectin Benzoate 10 EC @ 12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha , Lambda-cyhalothrin 5 WP @ 20gm a.i/ha, Novaluron 10 EC 100 gm a.i/ha, Fipronil 5 SC @ 112gm a.i/ha , Acephate 75 WP @ 750 gm a.i/ha and had an effect in reduction of larval count as ,57.63 , 54.67,50.73, 48.27, 48.27, 45.32, 36.94 and 30.04 per cent after the first spray. The treatment showing least effect in the field was Acephate 75WP @ 750 gm a.i/ha which was recorded to have a reduction of 30.04 per cent.

The mean larval population recorded before second spray in various treated plots were in a range of 2 to 4.5 larvae per 3 plants. The readings after 3rd and 7th day of the second application the mean larval count varies from 2 to 4.33 per 3 plants. The estimation of larval population after 7th day of the second spray each plot treated was found superior to control plot, significantly. The chlorantriniprole 18.5% SC @ 92 gm a.i/ha had given the best result amongst all treatments at 75.00 per cent followed by flubendamide 39.35EC @ 49 gm a.i/ha with reduction of 69.44 per cent in larval population. The order for actions of further chemicals treatments are Spinosad 45 SC @ 74 gm a.i/ha, Emmamectin Benzoate 10EC

Table 3. Efficacy of insecticidal treatments on *H. armigera* larval population during 2017-18

Treatments	Dose (a.i./ha)	Larval population of *H. armigera* m-1											
		First Spray						Second Spray					
		BS	3 DAS	7 DAS	15 DAS	Overall mean	Overall population reduction	BS	3 DAS	7 DAS	15 DAS	Overall mean	Overall population reduction
Spinosad	74	1.55 (1.43)	0.78 (1.12)	0.55 (1.03)	0.78 (1.13)	0.92 (1.10)	54.67	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	0.22 (0.84)	0.55 (0.95)	61.8
Indoxacarb	36	1.66 (1.47)	1.00 (1.22)	0.66 (1.08)	0.66 (1.08)	1.00 (1.13)	48.27	1.22 (1.31)	1.11 (1.27)	0.78 (1.13)	0.00 (0.71)	0.78 (1.06)	45.83
Chlorantriniprole	92	1.78 (1.51)	0.55 (1.02)	0.22 (0.85)	0.44 (0.97)	0.75 (0.95)	63.05	0.78 (1.12)	0.44 (0.97)	0.11 (0.71)	0.11 (0.78)	0.36 (0.85)	75.00
Emmamectin Benzoate	25	1.70 (1.51)	0.89 (1.18)	0.67 (1.08)	0.89 (1.16)	1.05 (1.14)	50.73	1.11 (1.27)	0.89 (1.18)	0.55 (1.02)	0.00 (0.71)	0.64 (0.99)	55.55
Novaluron	100	1.55 (1.43)	0.66 (1.08)	0.89 (1.18)	1.11 (1.27)	1.05 (1.18)	45.32	1.45 (1.39)	1.33 (1.35)	1.11 (1.22)	0.11 (0.78)	1.00 (1.16)	30.55
Flubendamide	49	1.67 (1.47)	0.78 (1.13)	0.45 (0.97)	0.56 (1.02)	0.86 (1.04)	57.63	0.89 (1.18)	0.56 (1.02)	0.22 (0.84)	0.11 (0.78)	0.44 (0.89)	69.44
Fipronil	112	1.55 (1.43)	1.22 (1.31)	1.11 (1.27)	1.22 (1.31)	1.28 (1.30)	39.94	1.56 (1.43)	1.44 (1.39)	1.33 (1.35)	0.22 (0.84)	1.14 (1.22)	20.83
Acephate	750	1.56 (1.43)	1.33 (1.35)	1.33 (1.35)	1.44 (1.39)	1.42 (1.36)	30.04	1.78 (1.51)	1.56 (1.43)	1.44 (1.35)	0.33 (0.91)	1.28 (1.27)	11.11
Lambda-cyhalothrin	20	1.15 (1.43)	1.11 (1.27)	0.78 (1.13)	1.00 (1.22)	1.11 (1.21)	48.27	1.44 (1.39)	1.22 (1.31)	0.89 (1.08)	0.00 (0.71)	0.89 (1.10)	38.19
Control		1.89 (1.54)	2.00 (1.58)	2.33 (1.68)	1.88 (1.54)	2.03 (1.60)	-	2.11 (1.61)	1.67 (1.47)	1.44 (1.39)	0.56 (1.02)	1.44 (1.31)	-
S.Em±		**NS**	**0.05**	**0.09**	**0.07**	**0.04**	**-**	**0.05**	**0.04**	**0.04**	**0.04**	**0.03**	**-**
CD @ 5%		**NS**	**0.16**	**0.28**	**0.21**	**0.12**	**-**	**0.15**	**0.12**	**0.13**	**0.12**	**0.09**	**-**

Figure given in parentheses are transformed values

DAS- Days After Spraying DBS- Days Before Spraying NS- Non Significant

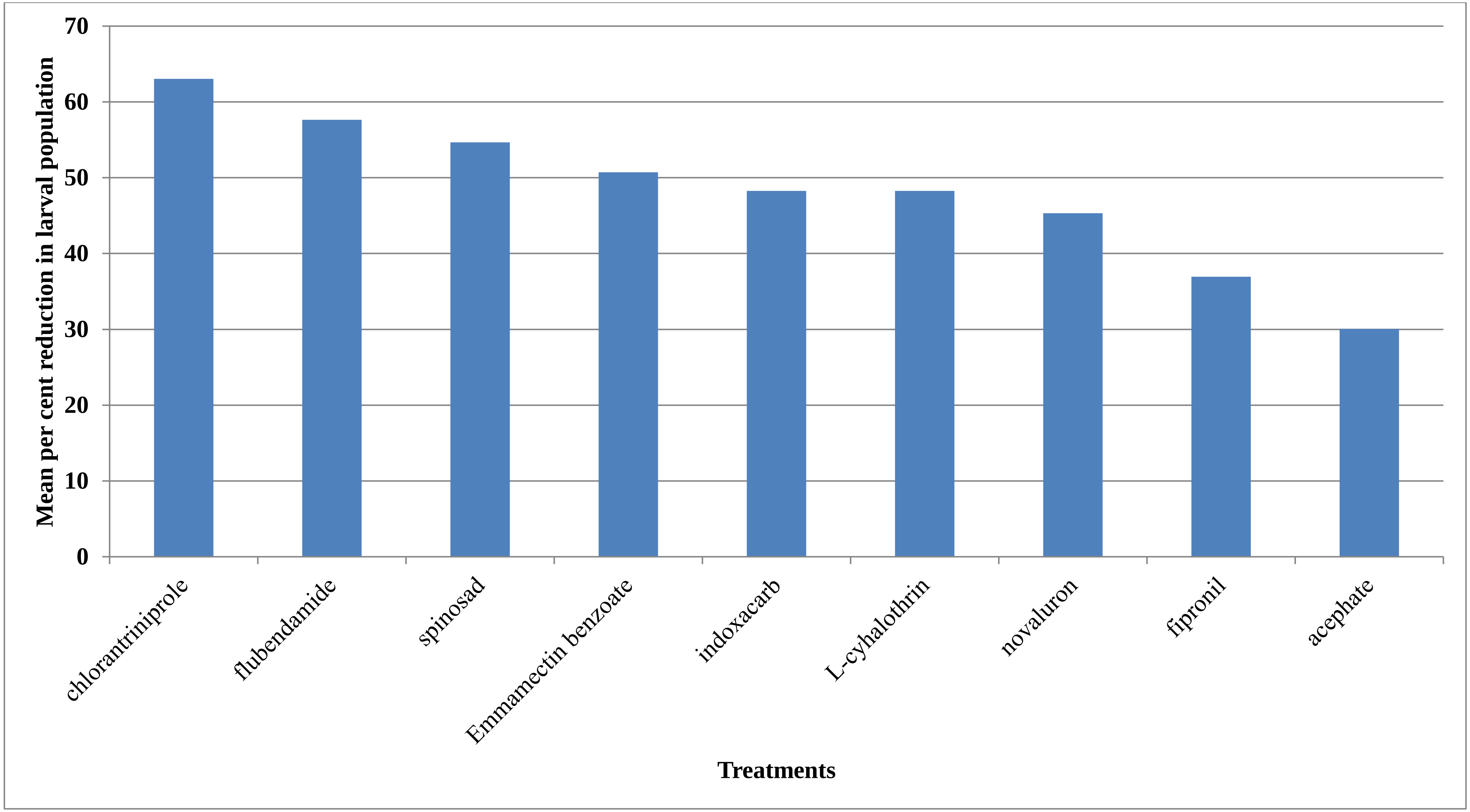


Figure 2. Larval population decrease by 1st spray

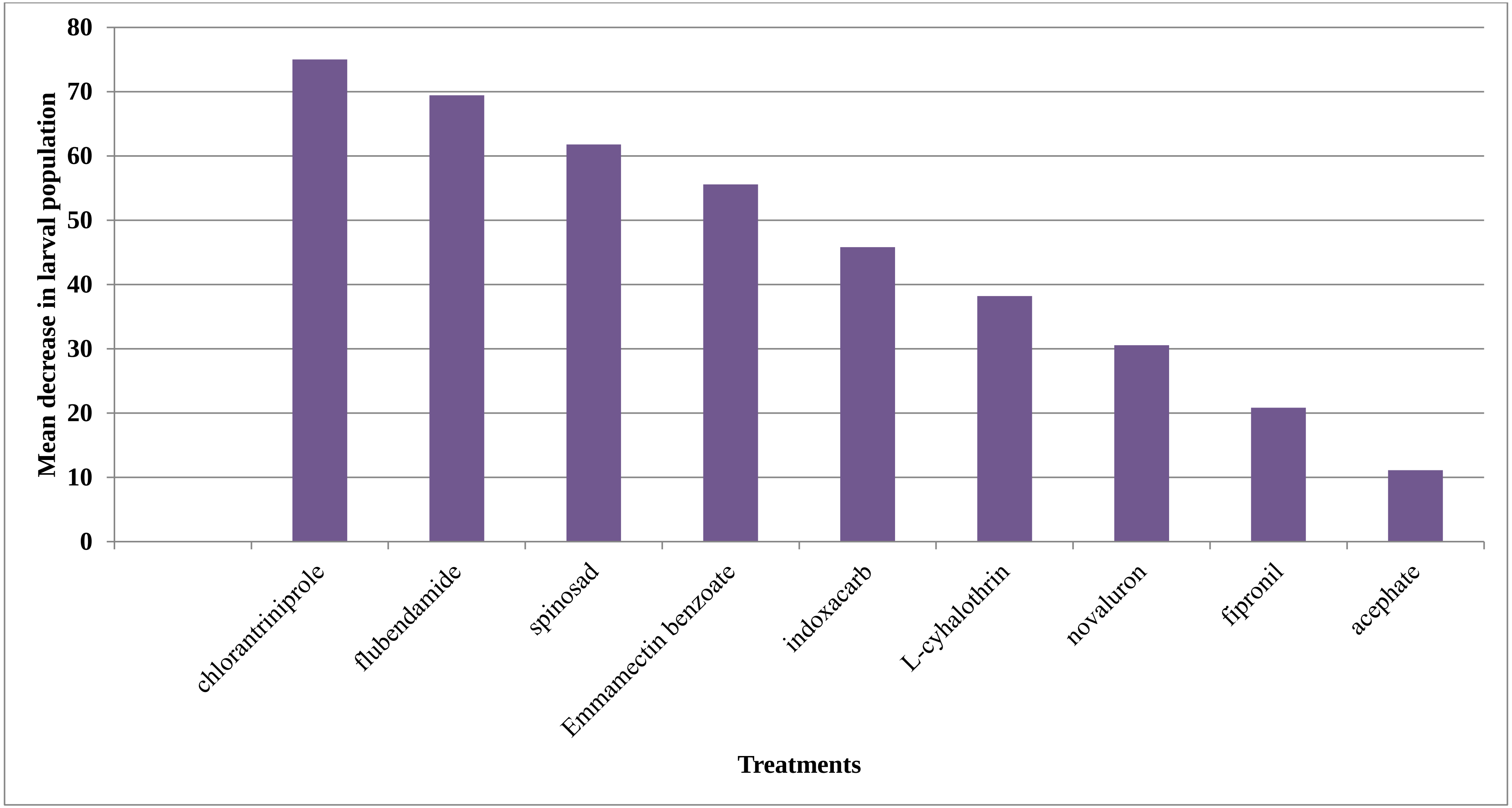


Figure 3. Larval population decrease by 2nd spray

12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha, Lambda-cyhalothrin 5WP @ 20gm a.i/ha, Novaluron 10 EC @ 100 gm a.i/ha, Fipronil 5SC @112gm a.i/ha , Acephate 75 WP @ 750 gm a.i/ha . The respective reduction per cent in larva population with insecticides were 61.80, 55.55, 45.83, 38.19, 30.55, 20.83 and 11.11. The minimal effects of the treatment in case of larval reduction were recorded in second spray for Acephate 75 WP with reduction of 11.11 per cent.

4.2 Effect of Insecticidal Treatments on Percentage Pod Damage

The pod damage percent readings are mentioned in the table for the year 2017-18.

The efficacy of insecticides was tested in terms of pod damage in the field trial for the Rabi season of the year 2017-18. The respective results show that each of the individual treatments were significantly efficient than the control. The best results in terms of minimum pod damage was shown by treatment with Chlorantriniprole 18.5 SC (4.67%) followed by flubendamide 39.35EC (5.33) and further chemicals treatments as Spinosad 45 SC (6.67%) , Emmamectin Benzoate 10EC (7.33%) , Indoxacarb 14.5 EC (8.00%) , Lambda-cyhalothrin 5WP (8.67%), Novaluron 10 EC (10.67%) , Fipronil 5SC (12.00%) and Acephate 75 WP (13.33%). As per the following readings the minimal percent damage in terms of pod was given by Chlorantriniprole 18.5 SC @ 92 gm a.i/ha with a minimal damage of 4.67 per cent. The maximum pod damage percentage was reported by treatment Acephate 75WP @ - with a damage percent of 13.33 per cent.

In terms of percent pod damage data the used chemical treatments could be arranged in order of being most effective to least effective as Chlorantriniprole 18.5% SC @ 92 gm a.i/ha > flubendamide 39.35EC @49 gm a.i/ha > as Spinosad 45 SC @ 74 gm a.I/ha > Emmamectin Benzoate 10EC @ 12 gm a.i/ha > Indoxacarb 14.5 EC @ 36 gm a.i/ha > Lambda-cyhalothrin 5WP @20gm a.i/ha > Novaluron 10 EC @100 gm a.i/ha > Fipronil 5SC @112gm a.i/ha > Acephate 75 WP @750 gm a.i/ha.

However, comparing all the treated plots to the untreated control plots we find the treatments significantly effective, since the pod damage percentage in case of control plot was 22.67 per cent. The result implies that the treatments reduced the pod damage by the larval attack and hence they were of significance in protection of crop from pest.

4.3 Effects of Insecticidal Treatments on Grain Yield

The field trials during *Rabi* 2017-18 shows that all the treatments were superior to the control in terms of efficacy in terms of higher grains yield when compared to the control. The best control of the pod borer and hence the highest grain yield of about 17.33 q/ha was given by Chlorantriniprole 18 % SC @ 92 gm a.i/ha. The order was followed by flubendamide 39.35EC (16.44 q/ha), further by Spinosad 45 SC (15.55 q/ha), Emmamectin Benzoate 10EC (14.48 q/ha), Indoxacarb 14.5 EC (13.51 q/ha), Lambda-cyhalothrin 5WP (12.53 q/ha), Novaluron 10 EC(11.82 q/ha), Fipronil 5SC (10.84 q/ha) and Acephate 75 WP (10.04 q/ha). As from the data the minimum yield recorded was for treatment of Acephate 75 WP @ 750 gm a.i/ha giving an yield of 10.04 q/ha. The comparision was done also to the control plot which gave a yield of 8.77 q/ha.

The avoidable yield loss for Chlorantriniprole 18.5% SC @ 92 gm a.i/ha, Flubendamide 39.35 EC @ 49 gm a.i/ha, Spinosad 45 SC @ 74 gm a.i/ha, Emmamectin Benzoate 10 EC @ 12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha, Lambda-cyhalothrin 5 WP @ 20gm a.i/ha, Novaluron 10 EC @ 100 gm a.i/ha, Fipronil 5 SC @ 112gm a.i/ha, Acephate 75 WP @ 750 gm a.i/ha, shows an avoidable loss of 49.39,46.65,43.60,39.43, 35.08, 30.00, 25.08, 19.09 and 12.64 per cent, respectively.

Moreover, the yield increase over control for Chlorantriniprole 18.5% SC @ 92 gm a.i/ha, Flubendamide 39.35 EC @ 49 gm a.i/ha, Spinosad 45 SC @ 74 gm a.I/ha, Emmamectin Benzoate 10 EC @ 12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha, Lambda-cyhalothrin 5 WP @ 20 gm a.i/ha, Novaluron 10 EC @ 100 gm a.i/ha, Fipronil 5 SC @ 112gm a.i/ha, Acephate 75 WP @ 750 gm a.i/ha, gives a total increase of 97.60, 87.46, 77.33, 65.18, 54.04, 42.87, 34.77, 23.60 and 14.48 per cent, respectively. The best yield over control was given Chlorantriniprole 18.5% SC.

4.4 The Cost Benefit Ratio

During *Rabi* 2017-18, the data reveals that the use of insecticides against *H. armigera* larvae saved the yield of chickpea. The cost benefit ratio 1:7.7 was obtained from the plots which were sprayed with Indoxacarb 14.5 EC @ 36 gm a.i/ha. . It was followed by Lambda-cyhalothrin 5WP @ 20gm a.i/ha (1:7.20), Flubendamide 39.35 EC @ 49 gm a.i/ha (1: 5.52), Spinosad 45 SC @ 74 gm a.i/ha (1:3.16), Chlorantriniprole 18.5 SC @ 92 gm a.i/ha (1:1.15), Emmamectin Benzoate 10 EC @ 12 gm a.i/ha (1:1.66), Acephate 75 WP @ 750 gm a.i/ha

(1:1.53), Novaluron 10 EC @ 100 gm a.i/ha (1:2.13), and Fipronil 5 SC @ 112gm a.i/ha (1:1.50). So, the Chlorantriniprole 18.5 SC was the costliest treatment.

Table 5. Impact of insecticidal treatment on yield of chickpea crop during 2017-18

Treatments	Dose (gm a.i/ha)	Yield (qn/ha)	Yield increase over control (%)	Avoidable yeild loss (%)
Spinosad	74	15.55	77.33	43.60
Indoxacarb	36	13.51	54.04	35.08
Chlorantriniprole	92	17.33	97.60	49.39
Emmamectin Benzoate	12	14.48	65.18	39.43
Novaluron	100	11.82	34.77	25.08
Flubendamide	49	16.44	87.86	46.65
Fipronil	112	10.84	23.60	19.09
Acephate	750	10.04	14.48	12.64
Lambda-cyhalothrin	20	12.53	42.87	30.00
Control	-	8.77	-	-

Table 6. Impact of insecticidal treatment on pod damage by *H.armigera* during 2017-18

TREATMENT	DOSE (a.i./ha)	POD DAMAGE (%)
Spinosad	74	6.67 (14.93)
Indoxacarb	36	8.00 (16.43)
Chlorantriniprole	92	4.67 (12.42)
Emmamectin Benzoate	12	7.33 (15.68)
Novaluron	100	10.67 (19.05)
Flubendamide	49	5.33 (13.30)
Fipronil	112	12.00 (20.23)
Acephate	750	13.33 (21.40)
Lambda-cyhalothrin	20	8.67 (17.10)
Control		22.67 (28.43)
SE(m)	-	0.74
CD	-	2.22

Figure given in parentheses are transformed values

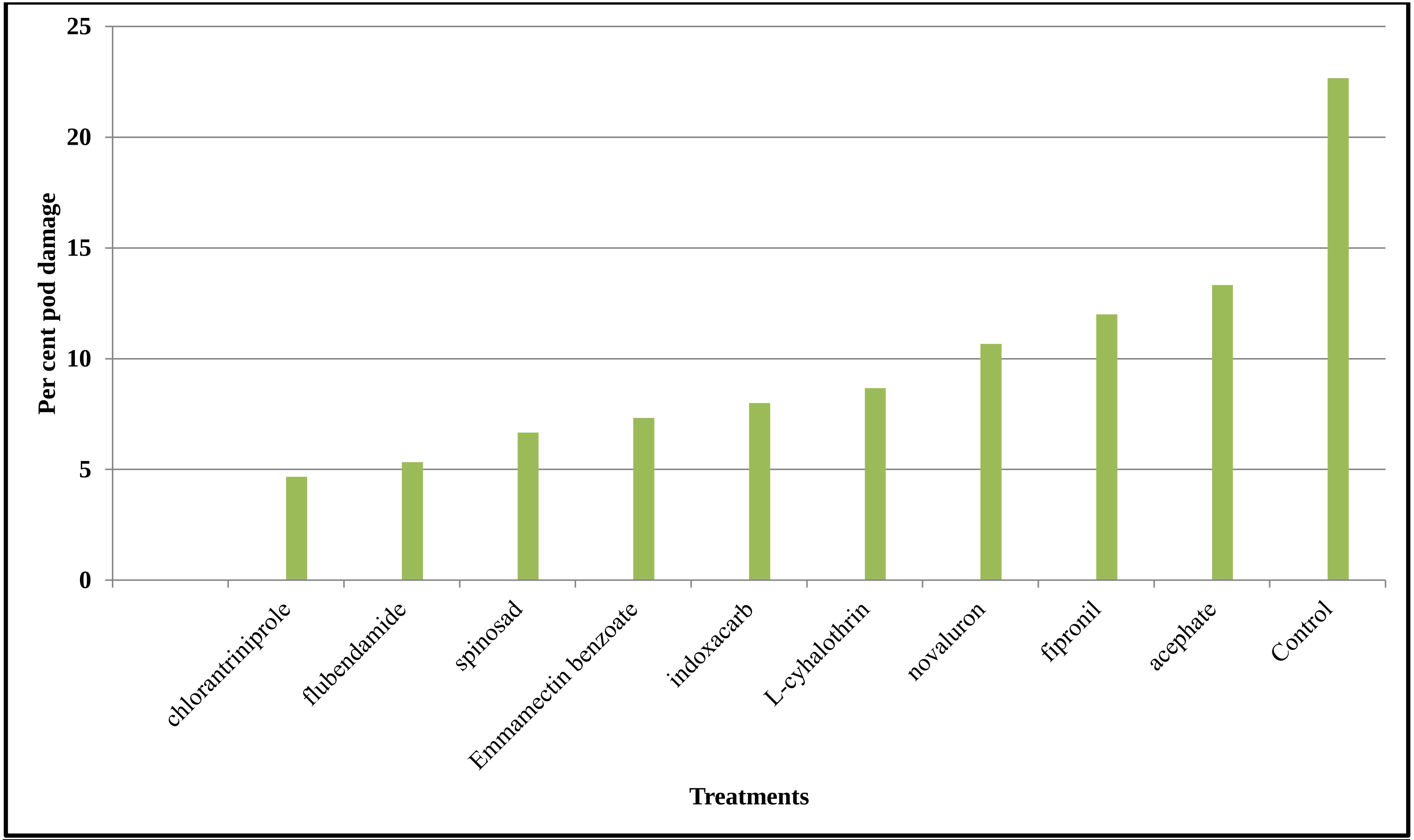


Figure 5. Impact of insecticidal treatments on pod damage by *H. armigera* during 2017-18

Table 7. Benefit Cost Ratio of various Insecticidal treatments on chickpea during 2017-18

Treatment	Cost of spray [labour+ sprayer+ Insecticide (Rs./ha)]	No. of sprays	Total cost of spraying (Rs/ha)	Yield (q/ha)	Additional yield over control (q/ha)	Cost of additional yield @Rs.4400/q	Net profit (Rs./ha)	C:B ratio	Rank
Spinosad	3636	2	7272	15.55	6.78	29832	22560	1:3.16	IV
Indoxacarb	1188	2	2376	13.51	4.74	20856	18474	1:7.70	I
Chlorantiniprole	8600	2	17200	17.33	8.56	37664	20464	1:1.15	IX
Emamactin benzoate	3460	2	6920	14.48	5.71	25124	11324	1:1.66	VI
Novaluron	2130	2	4260	11.82	3.05	13420	9160	1:2.13	V
Flubendamide	2575	2	5150	16.44	7.67	28634	28634	1:5.54	III
Fipronil	1800	2	3600	10.84	2.07	9108	5508	1:1.50	VIII
Acephate	1100	2	2200	10.04	1.27	5588	3388	1:1.53	VII
Lambda-cyhalothrin	1080	2	2160	12.53	3.76	16544	15646	1:7.20	II
Control	-	-	-	8.77	-	-	-	-	X

DISCUSSION

CHAPTER V

DISCUSSION

The field evaluation was carried out at the Agriculture Research Farm, Institute of Agricultural Sciences B.H.U, to study the "**Comparative efficacy of different insecticides against gram pod borer of chickpea under field conditions.**" The results obtained in the present study were discussed in light of available literature as following:

5.1 Effects of Insecticidal Treatments on the Larval Population Reduction:

The efficacy of various insecticides used was evaluated under the field conditions to record their effects on the percentage larval population reduction of *H .armigera* during Rabi season of 2017-18. In the following observations all the treatments were found significantly superior in controlling the pest population over the control.

Chlorantriniprole 18.5% SC @ 92gm a.i/ha was recorded as best control in terms of highest percentage of larval population reduction amongst all the insecticidal treatments. It was recorded at par with flubendamide and spinosad as reported earlier by Iqbal *et al* (2014), Carniero *et al.* (2014), Sharma *et al.* (2014), Shrikanth *et al.* (2014), Chavan *et al.* (2015), Adsure and Mohite (2015), Kumar and Sarada (2015), Sambathkumar *et al.* (2015), Sharma *et al.* (2016) and Patel and Chavadhari (2016) reported chlorantriniprole a promising results in decreasing pod borer larvae infestation on chickpea.

Flubendamide 39.35 EC @ 49 gm a.i/ha was evaluated to be second most effective insecticide for gram pod borer larva reduction. The findings were concurrent to Babar *et al.* (2012), Carneiro *et al.* (2014), Sharma *et al.* (2014), Shreekanth *et al.* (2014), Chavan *et al.* (2015), Adsure and Mohite (2015), Dhaka *et al.* (2015), Kumar and Sarada (2015), Singh *et al.* (2015), Sharma *et al.* (2016) and Patel and Chavadhari (2016) found it effective against chickpea pod borer.

Spinosad 45 SC used at a rate of 74gm a.i/ha gave a significant over larval population and this observation being concurrent to many workers as Patil *et al.* (2012), Rohit and Singh (2013) Shindey *et al.* (2013). Moreover, Emmamectin Benzoate 10 EC @ 12 gm a.i/ha has been reported effective as by various researches as by Deshmukh *et al.* (2010) and Kambrekar *et al.* (2013). Indoxacrab 14.5 EC used at the rate of 36 gm a.i/ha gave a significant population reduction of 71.67% after 7 days of spray and reported effective by workers as Anadhani *et al.* (2011), Babariya *et al.* (2011) and Patil *et al.* (2012).

Lambda-cyhalothrin 5 WP used at rate of 20gm a.i/ha, was found at par with insecticides as Novaluron 10 EC used at 100 gm a.i/ha, Fipronil 5 SC sprayed at rate of 112gm a.i/ha. It gave a larval population reduction of It was also as reported by experiments of 66.52 % as reported by Ghure *et al.* (2008) and Hossain *et al.* (2010).

5.2 Effect of chemical treatment on pod damage.

During the field trials in the year 2017-18, when the efficacy of the insecticides was tested, all the treatments were found significantly superior in controlling the pod damage over the control. The minimum percent pod damage was observed in plots treated with as Chlorantriniprole 18.5% SC (4.67 %) followed by flubendamide 39.35EC (5.33%), Spinosad 45 SC (6.67%), Emmamectin Benzoate 10EC (7.33%O), Indoxacarb 14.5 EC (8.00%), Lambda-cyhalothrin 5WP (8.67%), Novaluron 10 EC (10.67%), Fipronil 5SC (12.00%) and Acephate 75 WP (13.33%) as in Table-4 Fig. 3. The minimum pod damage was observed on plot treated with Cholrantriniprole 18.5 % SC @ 92 gm a.i/ha which was 4.67 per cent. The maximum was observed on plot treated with Acephate 75 WP @ 750 gm a.i/ha which was 13.33 per cent.

5.3 Effect of chemical treatment on grain yield

During the field trials in the year 2017-18, when the efficacy of the insecticides was tested, all the treatments were found significantly superior in grain yield over the control plot. The maximum and minimum yield was obtained from the plots treated with Chlorantriniprole and Acephate, respectively. The maximum yield obtained was 17.33 q/ha and minimum obtained yield was 10.04 q/ha by plots treated with Chlorantriniprole and Acephate, respectively. The present findings are in conformity with findings of Iqbal *et al* (2014), Carniero *et al.* (2014), Sharma *et al.* (2014), Shrikanth *et al.* (2014), Chavan *et al.* (2015), Adsure and Mohite (2015) and Kumar and Sarada (2015) as they reported Chlorantriniprole could perform best over control for the yield concerns.

The efficacy of the insecticides was tested for the avoidable yield loss; all the treatments were found significantly superior in terms of avoiding yield loss over the control plot. The avoidable yield loss for Chlorantriniprole 18.5% SC , Flubendamide 39.35 EC, Spinosad 45 SC , Emmamectin Benzoate 10 EC, Indoxacarb 14.5 EC , Lambda-cyhalothrin 5 WP, Novaluron 10 EC , Fipronil 5 SC, Acephate 75 WP @ 750, shows an avoidable loss of 49.39, 46.65, 43.60, 39.43, 35.08, 30.00, 25.08, 19.09 and 12.64 per cent, respectively. The best avoidable yield loss was given by Cholrantriniprole 18.5 % SC @ 92 gm a.i/ha which was 49.39 per cent and the least effective was seen to be Acephate 75 WP @ 750 gm a.i/ha which gave avoidable yield loss 13.33 per cent.

Moreover, the yield increase over control for Chlorantriniprole 18.5% SC @ 92 gm a.i/ha, Flubendamide 39.35 EC @ 49 gm a.i/ha, Spinosad 45 SC @ 74 gm a.I/ha, Emmamectin Benzoate 10 EC @ 12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha, Lambda-cyhalothrin 5 WP @ 20gm a.i/ha, Novaluron 10 EC @ 100 gm a.i/ha, Fipronil 5 SC @ 112gm a.i/ha, Acephate 75 WP @ 750 gm a.i/ha, gives a total increase of 97.60, 87.46, 77.33, 65.18, 54.04, 42.87, 34.77, 23.60 and 14.48 per cent, respectively. The best yield increase over control was given Chlorantriniprole 18.5% SC 92 gm a.i/ha which was 97.60 per cent and the least effective was seen to be Acephate 75 WP @ 750 gm a.i/ha which gave yield increase over control as 14.48 per cent.

5.3 Cost Benefit Ratio

The cost benefit ratio 1:7.70 was obtained from the plots which were sprayed with Indoxacarb 14.5 EC @ 36 gm a.i/ha. . It was followed by Lambda-cyhalothrin 5WP @ 20gm a.i/ha (1:7.20), Flubendamide 39.35 EC @ 49 gm a.i/ha (1: 5.52), Spinosad 45 SC @ 74 gm a.i/ha (1:3.16), Chlorantriniprole 18.5 SC @ 92 gm a.i/ha (1:1.15), Emmamectin Benzoate 10 EC @ 12 gm a.i/ha (1:1.66), Acephate 75 WP @ 750 gm a.i/ha (1:1.53), Novaluron 10 EC @ 100 gm a.i/ha (1:2.13), and Fipronil 5 SC @ 112gm a.i/ha (1:1.50). So, the Chlorantriniprole 18.5 SC was the costliest treatment.

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

The present investigations on the field experiments entitled **"Comparative efficacy of different insecticides against gram pod borer of chickpea under field conditions"** was conducted at Agriculture Research Farm, Banaras Hindu University, Varanasi during year 2017-18 . The results of the studies are summarized below-

During the *Rabi* 2017-18 all treatments were found significantly superior to control. Chlorantriniprole 18.5% SC @ 92 gm a.i/ha was the best of all the treatments which reduced 63.05 per cent larval population, however it did not differ significantly with Flubendamide 39.35 EC @ 49 gm a.i/ha, Spinosad 45 SC @ 74 gm a.i/ha, Emmamectin Benzoate 10 EC @ 12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha, Lambda-cyhalothrin 5 WP @ 20gm a.i/ha, Novaluron 10 EC @ 100 gm a.i/ha, Fipronil 5 SC @ 112gm a.i/ha, Acephate 75 WP @ 750 gm a.i/ha and which reduced larval population 57.63, 54.67,50.73, 48.27, 48.27, 45.32, 36.94 and 30.04 per cent, respectively.

When the efficacy was tested in terms of pod damage, all the treatments were proved significantly superior over to control. The minimum percentage of pod damage was observed in the plots treated with Chlorantriniprole (4.67%) followed by Flubendamide (5.33%), Spinosad 45 SC (6.67%), Emmamectin Benzoate 10EC (7.33%), Indoxacarb 14.5 EC (8.00%), Lambda-cyhalothrin 5WP (8.67%), Novaluron 10 EC (10.67%), Fipronil 5SC (12.00%) and Acephate 75 WP (13.33%).

When efficacy was tested in terms of yield, Chlorantriniprole 18.% SC @ 92 gm a.i/ha treated plots produced significantly higher yield (17.33 q/ha) than other plots. Fallowed by flubendamide 39.35EC (16.44 q/ha), further by Spinosad 45 SC (15.55 q/ha), Emmamectin Benzoate 10EC (14.48 q/ha), Indoxacarb 14.5 EC (13.51 q/ha), Lambda-cyhalothrin 5WP (12.53 q/ha), Novaluron 10 EC (11.82 q/ha), Fipronil 5SC (10.84 q/ha) and Acephate 75 WP (10.04 q/ha).

The cost benefit ratio 1:7.7 was obtained from the plots which were sprayed with Indoxacarb 14.5 EC @ 36 gm a.i/ha. . It was followed by Lambda-cyhalothrin 5WP @ 20gm a.i/ha (1:7.20), Flubendamide 39.35 EC @ 49 gm a.i/ha (1: 5.52), Spinosad 45 SC @ 74 gm a.i/ha (1:3.16), Chlorantriniprole 18.5 SC @ 92 gm a.i/ha (1:1.15), Emmamectin Benzoate 10 EC @ 12 gm a.i/ha (1:1.66), Acephate 75 WP @ 750 gm a.i/ha (1:1.53), Novaluron 10 EC @ 100 gm a.i/ha (1:2.13), and Fipronil 5 SC @ 112gm a.i/ha (1:1.50). So, the Chlorantriniprole 18.5 SC was the costliest treatment.

The avoidable yield loss for Chlorantriniprole 18.5% SC @ 92 gm a.i/ha, Flubendamide 39.35 EC @ 49 gm a.i/ha, Spinosad 45 SC @ 74 gm a.I/ha, Emmamectin Benzoate 10 EC @ 12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha, Lambda-cyhalothrin 5 WP @ 20gm a.i/ha, Novaluron 10 EC @ 100 gm a.i/ha, Fipronil 5 SC @ 112gm a.i/ha, Acephate 75 WP @ 750 gm a.i/ha, shows an avoidable loss of 49.39,46.65,43.60,39.43, 35.08, 30.00, 25.08, 19.09 and 12.64 per cent, respectively.

Moreover, the yield increase over control for Chlorantriniprole 18.5% SC @ 92 gm a.i/ha, Flubendamide 39.35 EC @ 49 gm a.i/ha, Spinosad 45 SC @ 74 gm a.I/ha, Emmamectin Benzoate 10 EC @ 12 gm a.i/ha, Indoxacarb 14.5 EC @ 36 gm a.i/ha, Lambda-cyhalothrin 5 WP @ 20gm a.i/ha, Novaluron 10 EC @ 100 gm a.i/ha, Fipronil 5 SC @ 112gm a.i/ha, Acephate 75 WP @ 750 gm a.i/ha, gives a total increase of 97.60, 87.46, 77.33, 65.18, 54.04, 42.87, 34.77, 23.60 and 14.48 per cent, respectively.

Conclusion:-

- All treatments were found significantly superior over control. Chlorantriniprole 18.5% SC @ 92 gm a.i/ha was the best of all the treatments for larval population reduction.

- In terms of pod damage, all the treatments proved significantly superior over control. The minimum per cent of pod damage was observed in the plots treated with Chlorantriniprole 18.5% SC @ 92 gm a.i/ha. While maximum per cent of pod damage was observed in the plots treated with Acephate 75 WP @750 gm a.i/ha.

- In terms of grain yield, the maximum yield obtained among the all treated plot with, Chlorantriniprole 18.5% SC @ 92 gm a.i/ha while the minimum yield obtained with Acephate 75 WP @750 gm a.i/ha.

- The avoidable yield loss among the treated plots recorded in Chlorantriniprole 18.5% SC @ 92 gm a.i/ha, while maximum per cent of yield loss obtained with Acephate 75 WP @750 gm a.i/ha.

- The yield increase over control among the treated plots recorded in Chlorantriniprole 18.5% SC @ 92 gm a.i/ha, while maximum per cent of yield loss obtained with Acephate 75 WP @750 gm a.i/ha.

- The maximum cost benefit ratio (1: 7.70) was obtained from the plots which were sprayed with Indoxacarb 14.5 EC @@ 36 gm a.i/ha, while the minimum cost benefit ratio (1:0.2) was obtained from the plots which were sprayed with Fipronil 5 SC @ 112gm a.i/ha.

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