

**In the name of ALLAH the most beneficent**

 **and merciful**

# EFFICACY OF PLANT EXTRACTS AND IGRS ON KHAPRA BEETLE (*TROGODARMA GRANARIUM*)

**By**

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**2018**

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**This humble effort is**

**Dedicated**

**To**

 **My Beloved**

####  PARENTS

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****

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**Abstract**

In current scenario uniform supply of fodder along with its premium quality is recognized an important aim. In order to achieve that aim an experiment was laid to evaluate the effect of different sowing methods along with different cutting intervals on forage quality of alfalfa at Agronomic Research Area, University of Agriculture Faisalabad. Experiment was laid out in randomized complete block design (RBCD) having splits plot arrangement. The experiment was comprise of different sowing methods i.e. broadcast, line sowing 30 cm a-part rows and 45 cm a-part rows and different cutting intervals i.e. 30, 45 and 60 days after sowing. All other treatments like fertilizer, irrigation etc was kept normal and uniform for all the treatment combinations. Data collected was recorded and analyzed statistically by using Fisher analysis of variance technique and treatment means was compared by using least significant difference (LSD) at 5% probability level. From the experiment it was concluded that sowing methods of alfalfa and cutting intervals significantly influenced the agronomic and quality parameters of alfalfa. Delaying in cutting intervals of alfalfa minimize the protein content % of alfalfa and enhance the fiber content % of forage that alternate the quality of alfalfa. The overall following conclusion was detected from experiment. From the results it was concluded that after the harvesting interval of 45 days in combination with broadcast sowing method gives maximum agronomic parameters of alfalfa. Broadcast sowing method gives maximum biomass as compared with rest sowing methods. Cutting intervals of 45 days after first cutting gives more biomass of alfalfa as compared with rest of cutting intervals. With respect to high quality parameters broad cast sowing and 30 cm line sowing of alfalfa at 45 days harvesting intervals gives maximum protein contents % and ash contents % of alfalfa. Maximum fiber content was recorded in broad cast sowing of alfalfa wit cutting intervals of 60 days after first cutting. The results conclude that sowing method and cutting intervals significantly influenced the forage quantity and quality attributes of alfalfa.

**Chapter 1**

**Introduction**

Pakistan is agriculture based country. Different cereals are produced in country including wheat, maize, rice and pulses. Wheat is most popular staple food in Pakistan and ranked top among the other cereals. Wheat contributes for 9.9% in farming and 2.0% to GDP of Pakistan. Wheat production in 2015-2016 recorded as 25.482 million tonnes with the increase of 0.9% as compared to last year. An estimated of global agricultural development appreciated at several billion us dollars is destroyed yearly by over 20,000 kinds of pest in field and in storage area (Mariapackiam and Ignacimuthu, 2008).

The Khapra Beetle *Trogoderma granarium* (Everts) is a significant infestation of stored grain, seeds and their food goods (Banks, 1977 and Burges, 2008). Recently in rising countries pest management is a significant difficulty. *T. granarium* (Everts) triggers quantitative and qualitative loss in whole wheat while storehouse (Prasad *et al*., 1977). The individuals are secure and temporary however the larval phase of the infestations is incredibly detrimental that results in massive economical lack of stored seeds, cereals and their food goods. An evident aspect of the pest infestation is public of the furry larvae and their solid epidermis (Ahmedani *et al*., 2007). Insect invasion is serious issue during the storage of wheat. Different insect pests are involves in the quantitative and qualitative losses in cereals which are khapra beetle (*Trogoderma granarium*), (*Rhizopertha dominica*), weevils (*Sitophilus)* and red flour beetle (*Tribolium castenium*).Among the stored grain pests Khapra beetle is most destructive pest (Mark *et al*, 2010) and pest has been given the class of quarantine pest for EPPO (Anonymous, 2007). *T. granarium* larvae in stored grain pest are the most infected and the most destructive, but adults are undamaging (Parashar, 2006).

The literature confirmed that khapra beetle is very hazardous to your foodstuff safeness. For milling production the portion of insect in whole wheat flour is the primary menace on the market value (Perez *et al*., 2003). The *Trogoderma granarium* normally restricts its activity to the very best 30 cm of the stored food product on the other hand it is rarely bought at depths approaching six feet. The pest has a considerable financial impact, credited to its capacity to cause vast loss to grain during its voracious feeding, warming of grains through natural activity and As capacity to endure hunger in larval level concerning endure on grains having suprisingly small dampness substance and because of its higher charge of duplication (Ahmedani *et al*., 2007).

 The larvae consumed on sound grain and consume the whole kernel, which cause the grain empty and just the husk leftovers. Damage grains are with waste substance and excreta, which badly decline fineness of the grains. Therefore, zero-tolerance to these contaminants. (Canada Grain Act, 1975).

The control of insects shows a serious concern. The chemical control is a very rapid, efficient and trendy method of pest manages, but these make acute and chronic poisoning in man and other non-target animals. Repellents are commonly unstable chemicals and keep their activity in volatile stage. A strong repellent will be detected by insects from a few centimeter distances causing them to fly or crawl away. Plant extracts are measured to be not contaminated, less lethal and simply eco-friendly (Behal, 1998). It is one of the hundred worst intrusive kind’s worldwide (Lowe *et al*., 2000). Therefore, control of the pest isn't only essential to guarantee food safe practices and food protection circumstance (Ahmedani *et al*., 2007).

Severe infestations of grains by Khapra beetle make it indigestible. Grain quality decreases anticipated to reduction of precise nutrition. Infestation degrees of 75.0% in whole *Triticum aestivum*, *Zea mays* and *Sorghum vulgare* grains cause significant reduction in extract fat, sugars necessary aminoacid based protein nitrogen, and true proteins substance and upsurge in wetness, rough fiber content and entirety proteins (Jood and Kapoor, 1993). The Khapra beetle, *Trogoderma granarium* is consider to be oneof the mainly rigorous pests of stored grain,a range of leguminous crops, barley, and ryein the world ( Lowe *et al*., 2000).It is originally occurred in sub-continent, and spread to South Africa,Europe, S. America and Asia (Harris,2009).

Chemicals have been commonly practical, during recent times, as regular apply to handle farming pests in the ﬁeld as well as in the stores grain. For the decision-making of stored grain pest, apply of chemical mostly phosphine chemicals and methyl bromide brand, had been the means process of seed safety as cheaper (Shaaya *et al*., 1997; Islam *et al*., 2010).

The regular utilize of chemicals have been caused range of tolerance to chemicals in farming pests and harmful to human fitness and other benifical insects, bad effect on biological management (weisenburger, 1993 ; Bell and Wilson, 1995). Plant extract based chemical has ability to control and manage the pests in stored grain as they are practical and protected, easy to handle (Regnault-Roger *et al*., 2012). The efficacy of usual substance an establishment to raise latest insecticide is most winning claim for pest organized (Copping and Menn, 2000). However the earlier works were acumulated on neem tree as one of the largely toxic vegetation to many pests (Yousif and Satti, 2008).

Corresponding to sanitary and phytosanitary options contract on agriculture under WTO only those agriculture goods can be exported or brought in that are clear of harmful pesticide residues. Under these situations there's a need to handle focus on safe insecticides especially botanicals for stored grain security. A lot of plants and place products have been examined for the control of stored grain bugs (Dales, 1996). Fumigants and dirt formulations of materials for example pirimiphos-methyl or permethrin (Singh, 1990). These management techniques have been efficient oftentimes, but there is certainly growing concern these organize techniques have limits. These troubles are the progress of level of resistance in pesticides effect of high exploit (Bell, 2000; Benhalima *et al*., 2004). Public consciousness as regards these hazards has urged experts to extend far better, sustainable and relatively secure way for the safeguard of food goods against the problems brought on insect ( Phillips and Throne, 2010).

Botanical insecticides in comparison to fabricated ones may be safer for the surroundings are, generally, less costly, easily refined and employed by farmers and small business (Belmain *et al*., 2001).

Pests control generally in most tropical countries, just as many other parts of the world, is based generally on the use of standard pesticides. But, scheduled to several disadvantages associated with these chemicals, including mainly the introduction of repellent pest strains, toxicity to man and family pets, environmental air pollution and the increasing cost of pesticides, hence the seek out new alternatives was regarded as important. Botanical pesticides were considered among important appealing tools attempted and demonstrated compatibility with other strategies for storage pests' management (Ahmedani *et al*., 2007).

Botanical based insecticides have always been utilized as smart substitute to artificial pesticides for pest infestations supervision as plants extract cause slight risk to the surroundings or even to humanbeing fitness (Behal, 1998 and Isman, 2006). Above 75 herb types of diverse family members have been analyzed and documented as insecticides for stored-grain pest management (Rajendran and Sriranjini, 2008). There is certainly, therefore, an immediate must to build up environmentally satisfying alternatives with the potentials to displace the extremely poisonous chemicals. Across the whole world the novel trend is towards the utilization of botanical extracts having insecticides properties. Several green plants extracts are impressive and not danger for humans and the surroundings, appropriate and low-priced for cover of stored grains. The toxicity of place components has been examined adjacent to lots of stored product pests. The herb territory can be utilized as a abundant resource of a number of chemicals along with the prospect of extension as flourishing pest control agencies (Rahman *et al*.,1999 ).

Appraising the probable of usual materials as a ground work to generate latest pesticides has been the mainly thriving program up to now of biorational pest management (Copping and Menn 2000). Insecticidal action from further more 75.0 flower kinds, owned by unusual family members, have recently been experienced and saved as insecticides alongside numerous stored grain insect pests (Rajendran and Sriranjini 2008). Plant ingredients in handling stored grain pest, may have several attractive effects, which include fumigant activity or change in a few biological guidelines such as progress rate, development and duplication (Papachristos and Stamopoulos, 2002).

Pesticides have sort of properties including toxicity, repellency, anti-feedant and growth regulatory actions against different pests. Plant origin pesticides have been used so far but only neem providing a extremely efficient, harmless and biodegradable means of controlling agricultural as well as stored grain pest which impose losses in agriculture production (Sharma, 2008).

 There is a problem with the stability of botanical pesticide. Various chemicals had been used as a synergist to increase the stability and effectiveness of botanical pesticide (Khalequzzaman and Khanom, 2006) calculated the synergistic outcome of cypermethrin in grouping with leaf and seed extract of *Azadiractin indica* oil on *Tribolium castenum* (Herbst). They observed synergistic increase in LD 50 value after 48hrs. The study estimated 100% death at 6.0 % w/w in groundnut grain treated with *A. sativum* fine powder against Khapra beetle (*T. granarium*) (Musa , 2013).

The results reported that *Moringa oleifera* leaf grind was efficient on equally the larvae and adults of *T. granarium* and indicate repellent properties. The botanical pesticides are usually greatly safer than traditionally used artificial pesticides. Crop and leaf extract showed pest hideous and insecticidal action aligned with *T. granarium.* They regularly do not pretense any unfavorable effect on the flora and fauna. In addition botanical-derived insecticides are not expensive. A few plants have more than single chemical substance as an vigorous standard liable for their natural properties (Bell *et al*., 1990).

The aqueous extracts of *Azadiractin indica* oil, neem seed powder and neem leaves proved useful against the Khapra beetle (Maina and Lale , 2004).

The work of express that *Capsicum* *frutescens* caused significant death (85%) to Khapra beetle at concentrations of 1, 2, 4 and 6% within 7 days. There is increase in elder larvae death, diminution in F1 progeny appearance and grain injure as a consequence of botanical powder and oils appliance against *sitotroga cereallela* in stored *Zea mays* (Gemechu *et al*., 2013).

Chemical insecticides such as malathian, cypermethrin, bifenthrin are used for rapid control, but are expensive, not readily available and may be poisonous to humans and environment (Tsumura *et al*., 1994). Botanical insecticides are optional valuable as organophosphates or different elements like neurotoxins for insect pest management by numerous modes of exploit. Their incorporated toxicity and anti feeding properties has special effects on the pest (Sutherland *et al*., 2002).

 Identifications of plant botanicals extracts exhibited the on top of mensioned harmful effects on insect pest insect composition, activities and represents a capability alternative approach for improvement of directional management that could substitute artificial neurotoxins (Duke, 1990). The toxic properties of liquid, methanol and acetone based extracts of some plants *Rhazya stricta*, *Heliotropium bacciferum,* and neem on Khapra beetle (*Trogoderma granarium* Everts) indicated the mortality rate and increased with the increased in concentrationas well as the time (Nadi, 2001).

 Plant species like *Nerium indicum* Mill, *Eucalyptus* sp.*, Azadirachta* *indica ,Melia azedarach* L.*, Lantana* *camara* L., *Cannabis sativa* L.*, Ricinus communis* L. and *Solanum nigrum* L. are well recognized to acquire prime insecticidal properties, however some of them have been subjugated commerciallyand available in the market. The compounds from these botanical extract have various practical activities like poison, feeding, and oviposition prevention and insect growth regulate action and activity (Mordue, 2004).

Recently work is done on the implemention and use of plants that containg insecticides characteristics. Some experiments results indicated that a few plant extracts are extremely successful and not dangerous for individual and atmosphere, expediency and low-cost for safety of stored grains. The poisonous qualities of plant extracts has been inspect against many of stored manufactured goods pest. Biopesticides symbolize among the finest used toxic chemicals for the launching of ecological friendly and secure approaches for pest supervision (Copping and Menn 2000). All the substances have a variety of internal system and behavioral activities results on stored item for consumption. (Isman, 2006). The toxic insecticidal action of wide-ranging plant based extracts and of some plant based products chemicals utilized for a large number of previous times throughout all the farming parts of the planet (Regnault - Roger *et al*. 2012). The Botanical chemicals are usually a lesser amount of bad effects for the surroundings because almost all of them are degradable speedily and normally, so preventing the buildup in non-targeted microorganisms and the introduction of amount of resistance to pest (Shaaya *et al*., 1997; Palmeri *et al*. 2007). The Botanical can be signify your most excellent alternative in expanding worled wide for producer for the stored grains insect damaging supervision because they are cheaper, valuable, secure, simple to procedure and apply (Belmain *et al.*, 2001; Regnault-Roger *et al*., 2012).

 Some crops such as Melliaceae (*Azadirachta indica*, *Trichilia pallida* and *Melia azadarach*), (Lonchocarpus spp., Derris spp.), Alliaceae (*Allium sativum*), Melanthiaceae (*Schoenocaulon officinale*), Salicaceae (*Ryania speciosa*), Solanaceae (Lycopersicon spp. and Nicotiana tabacum), Asteraceae (*Chrysanthemum cinerariaefolium* and *C. cineum*), Citrus spp., Cucurbitaceae (Piper spp.), Myrtaceae (*Eucalyptus citriodora*), and Euphorbiaceae *(Manihot esculenta*) have regarded harmful activity to insect. Within the last 2 decades, many initiatives have been designed to screen plant life with better botanical insecticides that can be used instead of fabricated insecticide (Moura *et al*., 2005). It had been reported that whenever blended with stored-grains, leaves,branches , seed natural powder, or extracts of plant life decrease egg laying rate, suppress progeny development and dangerous to individuals which eventually leads to low infestation and produce loss (Shaaya *et al*., 1997).

IGRs include chemicals which imitate hormones that manage molting and metamorphosis in pestsand so distress procedure for regular pest growth (Kostykovsky *et al*., 2003).

includes substance division with different methods of mode of action, and can cautiously be split into three classes, Juvenile hormone agonists, Ecdysteroid agonists ( Antagonizing activity) and Chitin synthesis inhibitors inquisitive with cuticle creation) (Oberlander *et al*., 1997).

IGRs was illustrated as new class of bio-rational compounds and found to fit the necessities for third generation pesticides. Usually IGRs are less toxic to higher animals also rapidly degraded in the environment (Kostyukovsky *et al.,* 2000) These unique property generate IGRs as potential alternatives to primitive insecticides. IGRs are categorized in three groups: juvenoids, ecdysteroids and chitin synthesis inhibitors (CSIs), which interfere with cuticle formation (Oberlander, 1997).

There are many insect juvenile human hormones like (JH I, III, JHO) that are made by minute cell clusters know as corpora allata (Miyamoto *et al*., 1993). Various chemicals owned by the JHs class such as igrs hydroprene (Mohandass *et al*., 2006), igrs methoprene (Wilson and Turner, 1992), fenoxycarb (Thind and Edwards, 1986) and pyriproxyfen (Oberlander *et al*., 1997) have been utilized to regulate special insects pest (Oberlander and. Silhacek, 2000).

 JHs at the blastokinesis level are mortal to insect embryos so when put on the larval stage level, ends up with deformed pupae (Oberlander and Silhacek, 2000). These impacts bring about decrease adult introduction (Wijayaratne et al., 2012) and comparative level of high temperature tolerance in pests (Wijayaratne and Domains, 2010).

The ecdysone molting hormone is made by the prothoracic glands in pest that on convertion into 20-hydroxyecdyson influences the procedure of removing skin and metamorphosis in pests (Collins, 2006). Ecdysone agonists bring early molting in larvae anytime of this growth. In addition they respond on overy growth, stopping and preventing oviposition, and also have major influence on progeny creation and death of pest of stored grains (Kostyukovsky *et al*., 2000; Kavallieratos et al., 2012). In the same way, chitin synthesis inhibitors (CSI) participate in IGRs group that stop ordinary molting of pests by distracting the procedure of cuticle development and old skin removing from the body (Dhadialla *et al*., 2005).

A lot of the CSIs action on larval periods, which typically bring about larval fatality through the next molt (Smagghe *et at*., 1996; Parween *et al*., 2001; 'goon *et al*., 2008).

Ovicidal action obtained through the reticence of chitin deposition in the producing embryo also makes up about the effectiveness of the ingredients (Parween, 2003; Trostanetsky and Kostyukovsky, 2008

**Chapter 2**

**Review of Literature**

Hassan *et al.* (2005) was completed experiment to judge the comparative effectiveness of Amaranthus vitidis L. and Salsola baryosma (Schultes) and cypermethrin against *Trogoderma granarium* (Everts). Flower ingredients were obtained in the form of extract by using Rotary Shaker and ethanol utilized as solvent. There were 20 larvae of *T. granarium* (Everts) subjected to three various concentrations (0.50, 1.00 and 1.50%) for publicity intervals of 24 hours, 48, 72 and 168 hours. Experiments were completed in an incubator at 30 centrigrate, 20C and 65.50% R.Humidity Place components (*A. viridis L.* (18.58 %) and S. baryosma (Schultes) (21.18%) provided a smaller amount death rate when compared with cypermethrin (37.63%). Current mortality of *T. granarium* (Everts) improved together with the upsurge in concentration and subjection point.

Odeyem *et al.* (2005) studied on Petroleum ether crude extracts of leaves and Seeds of, *Azadirachta indica* A. Juss. These extracts of numerous dosages of 0, 50.0, 150.0, 250, 350.0 and 0500 mg per ml with peel of groundnut seeds 050 gram, were examined for his potential to operate the *Trogoderma granarium Everts*. The seed crude turned into more effective than the leaves extract. The wide variety of appear old age minimized with crude concentrations for each leaflet and grain. The range of appear old larvae in management (71.21 ± 4.830) was considerably better P value less than 0.050 than all neem extract variations. The death of adults and young one enhanced with growing extract concentrations from 36.41 ± 4.63 % inside the control to 60.0 ± 2.240 % at 0500 mg per ml for shoot extract and to 54.18 ± 3.52 % at 0500 mg/ml for grain extract. Seed injure expressed as the wide variety of seeds and mass reduction of diseased groundnut was extensively decreased (P < 0.05) in each treatment as dose extended. There was no large decline within the capability of groundnut seeds handled with neem extracts while in comparison with the manipulate. Deterioration assessment confirmed fine correlations among dosages, adult and larval death and seed germination in every treatment. A terrible courting becomes located among the dosages and appearance of progeny, seed.

Ahmedani *et al.* (2005) subject has been articulated that stored granule pests particularly the Khapra beetle have bearing severe danger to worldwide food safety and protection. Its extremely good financial significance is suitable to its ability to reason massive failure in saved grains via rapacious nourishment and heatlh of grains, in larval potential to endure hunger for up to three years in its potential to retain on foodstuff with very minute humidity material. *T. granarium* is of seclusion issue as it’s unfold is primarily through worldwide alternate. Scrutiny at dockage and entry factors supplies a powerful manner to constraint access of insect pest. The improvement of resistance in this pest in opposition to traditional pesticides such as phosphine, Malathion, actellic and a few pyrethroid has in addition irritated its economic importance. inspite of the financial significance of this pest, no complete appraisal changed into to be had inside the literature which can also manual the food strategy makers, food safety and plant defense employees approximately the quantitative in addition to qualitative fatalities caused by this pest. The investigation gave a complete overview of the financial losses reason by means of this pest of management quarantine importance, its ecology, environment and IPM.

Kundu *et al.* (2007) observed that the poisonous, repellency and lingering ramifications of Bishkatali plant ingredients in chloroform and ethyl alcoholic liquids were examined up the *Trogoderma granarium*. Five concentrations were used 500.0, 250, 125.0, 62.50 and 32.25mg/ml of Bishkatali herb ingredients of equally solvents were found in the test. The plant ingredients in both liquids were reasonably dangerous to *Trogoderma granarium*. The chemical toxicity of ethyl alcohol was more than chloroform after one day and 3 days treatment on the insect pest. Bishkatali vegetable draw out in both liquid confirmed powerful repellency against khapra beetle where chloroform draw out was much superior to ethyl alcohol liquid extract. The speed of repellency was improved with the increment of amount. Both the ingredients have formed impressive remaining substance impact in minimizing the offspring of *Trogoderma granarium*. The cheapest amounts of F1 adult offspring (32.70, 25.30 and 27) surfaced from the whole wheat fine flour cured with 500.0 mg per 10g chloroform draw out when father or mother released at 7.0, 12.0, 17.0 times after treatment correspondingly. Whereas with 500mg per 10g ethyl alcohol remove, 39.0, 28.7 and 31.3 F1 adult offspring surfaced when progenitress released at 7.0, 12.0, 17.0 days and nights after treatment correspondingly. Bishkatali place components inl chloroform and ethyl alcohol acquired amazing effective residual results on *Trogoderma granarium* by minimizing the development of F1 young offspring and by raising the population death.

Daglish (2008) scrutinized research to review the insect pest management ability of methoprene, spinosad and Chlorpyrifos-methyl only and in grouping aligned with five stored grain pests. Three strains of lessor grain borer and only one straineach of *S*. *oryzae, T. castaneum, O*. *surinamensis* and *C*. *ferrugineus* were preferred. Adults were free on recently cultivated wheat for 14 days and transience in mature and offspring production was resolute. There was nothing of the treatment gave suitable executive based on criteria of greater than 99.0% diminution in F1 progeny birth rate as compared to control. Efficient double combinations were spinosad at one mgkg-1and addition chlorpyrifos-methyl at 10.0 mg per kg which restricted allstrains excluding for OP-resistant *O. surinamensis*, and chlorpyrifos-methyl at 10.0 mg kg-1 methoprene at 0.60 mg kg-1 restricted all inclined species excluding for methoprene defiant *R. dominica*. The results confirmed that it was not easy to make a treatment mixture which gives efficient management in opposition to wide-ranging spectrum of stored grain pests.

Sarmamy *et al.* (2011) several experiments have operated to determine the conclusion of liquid extracts of Tobacco plant (*Nicotiana tabacum L*.), Wild Mustard (*Sinapis arvensis L*.) ,White tope (*Cardaria draba L*.) and at 0, 4.0, 5.0 and 6.0 of raw extracts on manipulate of Khapra (*Trogoderma granarium*) in the stored wheat grains. Information became registered following 24, 48.0, 72 and 96.0 hours of plant extract programs and the effects that each one plant extract concentrations have been powerful towards adult’s pest of Khapra however the consequences reduced after two days after the used of extracts. There were Interactions among 6.0% of extracts and incubation time 1 day revealed that the most excellent effects towards adult pest. Larva stage became persistant more than adults in resistance to plant extracts. White pinnacle extracts have been powerful against the larvae quantity larger than the substitute plant extracts.

Ali *et al*. (2012) reported that Khapra beetle pest is an international issue because is extend in world which influence in globe trade. Examination at ports and entry points which bound the of pest to enter in country. Regular insecticiedes failed to control pest and pest produce resistant against these pesticide .common pesticide are malathion, actellic plus, pyrethroids and phosphine many botanical are used to control the pest like *Trogoderma granarium* and Sitophilus oryzae .these botanical has no effects on human health and safe to used to manage the pest in stored grain.To check the efficacy of the the botanical experiment conducted under control situation. Filter papers were flooded in 3 DLE concentration solvent and with water and acetone as control treatments.The lives pest F zero were shifted to a fresh unprocessed feeding petydish and the inhabitants raised of the two subsequent generations (F1and F2) calculated after one month and two month, respectively. The maximum DLE concentration (2.50 %) has notably maximum death rate with 34.15 and 46.0 % death in *T . granarium* and S. oryzae after one week of experience correspondingly.minute and huge young one of the khapra beetle, *Trogoderma granarium* Everts were shown for 1.0, 3, and 7 days on cement that was cured with at .055 mg vigorous component 2cm and 0.11 mg 2m , deltamethrin at 0.0025 mg 2cm, and 0.0151 mg 2 cm, pirimiphos-methyl at 0.0251 mg cm2 and 0.050 mg 2cm, pyriproxyfen at 0.00115 mg 2cm and 0.00024 mg 2cm, and spinosad at 0.050 mg 2cm and 0.1 mg 2cm. Then, the survived individuals were moved on unprocessed cement for seven more times and the delayed death rate of minute or large larvae was examined. Regarding the instant mortality of small larvae, chlorfenapyr was the very most excellent among the insecticides experienced triggering 070% instantaneous death after one week of treatment at the bigger stage.

Ratnasekera *et al*. (2012) estimated that Pulse beetles *Callosobruchus chinensis* and khapra beetle the most serious pests in stored grain in most exotic countries. Botanical insecticides has been used as the possible derived substances as guaranteeing alternatives to artificial insecticides in managing pest of stored products. A variety of native herb species in several varieties such as extract ethanol (CE) ingredients, plants seed oils, dried out powders residue and mixtures of seed equipment with insecticides and aftereffect of their focus were analyzed against *Callosobruchus spp* and *Trogoderma granarium* in lab situation. The best bioactivity 90 to 100 % death was clear by the ethanol ingredients ofNeem, *Anona reticulata* and *Ocimum sanictum* one of the liquid ethanol components tested. Natural oils of *O.sanctum* at 01.50 μL and *A.reticulata* at 03.0 μL entirely reserved egg laying and adult introduction. Clove natural fine powder was the very best on the list of 4 powders analyzed for adult deathrate. One of the plant powders analyzed, Maduruthala was the very best for conceal egg lying considerably accompanied by Getathumba (*Leucas zeylanica*). Our tests also revealed increased toxicity and perseverance of the insecticide in triggering considerable mortality to *Callosobruchus spp* and *Trogoderma granarium*. When coupled with vegetable oils.

Joseph *et al.* (2012) revealed that the plants based mostly biopesticide product and its own activity up against the financially important pests. Other than discovered botanicals like neem, neem silver etc., about 211 plants species were told have different types of pest management properties in lab conditions against defoliator pests. The biopesticide embraced a broad variety of both substance and microbial substances. Regular insecticides acquire natural toxicities that cause danger to the fitness of the farm providers, regulars and the surroundings. There are Negative possessions on real human physical condition resulted in a resurgence in involvement in botanical insecticides for their little expenses and fewer environmental side effect. Botanicals have recompense over universal typical pesticides. They have an effect on target infestation and tightly allied organisms, work in really small volumes, decomposed quickly and offer the residue complimentary foodstuff and a protected climate to live on. When designed into involved pest executive programs, botanical pesticides can greatly decrease the used of standard pesticides or can be utilized in revolution or in mixture with other pesticides, possibly decreased the entire quantities applied and perhaps extenuating or delaying the introduction of amount of conflict in pest populations.

Khater *et al*. (2012) reported that Standard insecticides have got poisonous activities that harmfull to the health of the farm workers, regular customers and the atmosphere. The bad effects on individuals’ physical condition led to a recovery by botanical insecticides for their little costs and less environmental side effects. Plants and Botanicals have not disadvantages over wide-ranging typical pesticides. They affected only specific pest and strongly allied organisms, work well in very minute quantities, deconstructed speedily and give the residue free food and a secure surroundings enviorment to live. When botanical included into integrated pest management programs, these insecticide can be severely decline the used of conservative insecticides can be utilized in routable or in with another pesticides, potentially reduction the simple quantities useful for the management of coleopertan and cannot produce resistance in pest population.

Satti *et al.* (2012) The Khapra beetle (*Trogoderma granarium*) is one of the major economical store pests in Sudan. Request of chemical insecticides, either in form of fumigation or spraying, is the only real way of measuring control implemented. Since these chemicals were associated with several drawbacks, endeavors are happening to find environmentally sensible and financially feasible alternatives. Therefore, lab experiments were completed to judge the insecticidal actions of numerous extracts well ready from two meliaceous crops, *Azadirachta indica* (neem) and *Khaya senegalensis* (mahogany) in opposition to other instar larvae of *T. granarium*. The outcome results confirmed changing insecticidal actions by the analyzed ingredients. Mahogany plant leaves exerted superior activities as compared to neem extract. Appropriately, the neem seed products hexane remove at 5.0 %v/v was the most excellent treatment induced considerable knock down influence on the pest larvae 2 days post treatments. It demonstrated a rasing upsurge in effectiveness as time passes to realize 93.15% death on the 3rd week of coverage. This draws out also repelled the pest (84.14%) and preserved sorghum seed products (45.15%) considerably in comparison with the unattended control. Furthermore, regardless of what has been talked about about the reduced death aftereffect of mahogany leaves normal water extract, this registered the greater keeping of sorghum grains (53.5%) recommending the occurrence of powerful repellent and or antifeedant effective constituents in this draw out. As a result, further studies must ascertain the real bioactivities in mahogany leaves, also to proceed onward in formulating plants insecticides from the neem olive oil.

Amin *et al.* (2012) Keeping estimated that the insecticidal action of three plant extracts Helencha (*Enhydra flucituans* Lour), Ghetu (*Clerodendrum* *vescosum* Vent) and Kalomegh (*Andrographis peniculata* ) were tested on the pest *Tribolium castaneum* (Herbst). In residual film bioassay, five doses as, 0.629, 0.472, 0.315, 0.157 and 0.078 mg/cm2 of methanol extract of leaves of each plant species were applied on adult *Tribolium castaneum*. After 1.5 days, the minimum LD50 for the liquid methanol crude of leaves of *Enhydra flucituans*, *Clerodiendrum viscosum* and *Andrographis* *peniculata* were got to be .341, .632 and 0.987 mg per cm2, respectively. According to the strength of activity, the toxicity was found in the arrangement of *Enhydra flucituans* > *Clerodendrum viscosium* > *Andrographis peniculata*. The generally results proposed that only three green plants have latent efficient insecticides and caused mortatlity.

Sagheer *et al.* (2013) studied the Repellent and mortality consequence of acetone ingredients of different crops: (*Nicotiana tobaccum, Pegnum hermala, Sassurea costus* and *Salsola barysoma*) to the *Trogoderma granarium* (Evetrs) larvae. The experiment done in labortry condition and maintained temperature and humidity. Five treatments was used in the experiment to obtained the accurate results and there was three repeates in this experiment. Rotary Shaker was utilized for the making of various components and 5.0, 10, 15.0 and 20 % concentrations were found in the test. The plant components gave efficient results. One Plant *N. tobaccum* proved highest average repellency i.e. (54.33%) accompanied by *S. barysoma* (51.33%), *P. hermala* (53.31%) and S. costus (48.68%). The repellency enhanced with upsurge in concentration. Botanical substance that was used in the experiment can shield and saved stored grains to invasion of *T. granarium*.

Tesfu *et al.* (2013) was done experiment to explore the insecticides residences of diverse porportion of *Parthenium hysterophorus* extract fine powder on the *Callosobruchus chinensis* in the laboratory below control situation.carrort grass component’s particals coated on cowpea seeds to made poisonous to *C. Chinensis* and induced sizeable (P < 0.050) death one day after treatment submission apart from shoot fine powder at 0.50 gm and 1.00 gm. The highest dose (2/50 g seed) of leaf and stem powder caused 76.68, 73.13 and 56.68% mortality respectively. Likewise, all of the powders appreciably (P< .05) caused the lower wide variety of F1 progeny appearance as compared with the untreated chickpea seeds. Inhibition and mortatlity of the F1 progeny emergence with the aid of all of the powders was substantially decreased than pirimiphos-methyl resulted in one hundred% inhibition of individuals of pest. The maximum percent inhibition and mortality in grownup appearance became discovered in case of leaf powder death with chickpea seeds (83.333) while the minimum in case of stem powder (52.79). The powder has also performed a fundamental role in stopping seed weight reduction. Based on the effects received, it can be accomplished that the capacity used of *P. Hysterophorus* for safety of legumes throughout storage.

Ahmad *et al.* (2013) was operated experiment to judge the insecticidal toxic activity of *Allium sativum, Zingiber officiinale* and *Nigella sativa* components resistant to the larvae of *T. granarium* in lab situation. The most excellent amount of 6.0 % *Z. officinale* was estimated to be relatively too many poisonous 16.17%, 70 % than those of an*. sativum* (11.46 %) and *N. sativa* (5.50 %) at 96 hours visibility. About dormant aftereffect of the tested place materials*, Z. officinale* provided extensively maximum reduce (55.14 %) in F1 young offspring than *N. sativa* (42.98 %) and *A.sativum* (30.18 %). The analysis view that *Z. officinale* acquired a solid dormant consequence resistant to the larvae of the analysis infestation. Further exmination on the efficiency of far off publicity in blend with maximum concentrations of the liquid extracts are a good idea to lessen the whole wheat store-insect damage.

According to Khan *et al*. (2013) Contact action and repellent ramifications of the acetone centered leaf components of *Murraya exotica, Murraya koenigii* and *Nicotiana tabacum* were analyzed from the adult level of stored grain insect infestation*, Tribolium castaneum*. Different concentrations (5, 10 and 15%) were used and the knockdown result was checked over time of 24, 48, 72, 96, 120,144 and 168 time within the circumstance of mortality, the region desired method was used and impact was examined after durations of 24, 48 and 72 time. Experiments to check on for the poisonous effects unveiled that *N. tabacum* (12.95%) became more effective when compared with M. exotica (9.53%) and *M. koenigii* (4.31%), respectively. Repellent and mortality aftereffect of plant ingredients exhibited different pattern and M. exotica (70.61%) became most effective one of the three extracts accompanied by *N. tabacum* (60.98%) and *M. koenigii* (51.97%) respectively.Toxicological and repellency bioassays proven an absolute impact of place extracts resistant to the adult level of corrosion red flour beetle, *T. castaneum*. Botanical extracts was also become potent to stimulate knockdown and repellence and mortality rate against stored pest and also shown their potential to be utilized as different commercial insecticides dosage. The other insecticides indicated the same death levels apart from pyriproxyfen that was not effective, for just about any of the combos examined, as mortality didn't go beyond 4.14%. Postponed death for chlorfenapyr was also high achieving 75% at 1 week of treatment at the larger dosage. Pirimiphos-methyl and deltamethrin provided the same results, representing that for both of these insecticides obvious postponed result. For pyriproxifen and spinosad, the overdue fatality was small. Outsized youngone were by maximum lenient than small ones in every dose-insecticide-exposure combinations evaluated for equally instantaneous and postponed fatality. The results of today's research showed that not any of them of the insecticides could really completely manage *T. granarium* larvae, illustrating the downward sides in managing these varieties, with poisinous dosage that are regularly efficient for other main stored merchandise beetle species.

Sagheer *et al*. (2014) examined that Acetone based seed ingredients of *Nigella sativa*, *Syzygium aromatiicum* and *Trachyspeirmum ammi* was assessed resistant to the stored infestations of processed goods, *Tribolium castaneum*. The Regular examination for the repellence, by filter paper with different concentrations (5, 10, 15%), was completed. Experiments displayed considerable repellent results as *T. ammi* (77.68%) accompanied by *S. aromatiicum* (75.53%) and N. sativa (63.34%). In general, the *T. ammi* ingredients were become much repellent accompanied by *S. aromaticum* and *N. sativa*. All the Results indicated that there were a secured probable of the normal ingredients toward troubling the ecology and incursion of stored commodity infestation red flour beetle. The experiments Results also showed exact probable of components in relation to integration of the components in pest supervision programs and to improved food security during using them as botanicals pesticides.

Asma *et al.* (2017) *Syzygium cumini*, *Momordica charentia*, *Eucalyptus globules,* Piper *nigrum and Callosobruchus chinensis* was infested cowpea grains throughout storeroom. There was different test used, one was the free selection and other no selection tests during the experiment. Botanical fine powders were entreated at dose of twenty-two (w/w). Affectivity of every one botanical powder was match by other series, eggs laying process, adult death and adult appearance of the heart beat beetle. The Result of plant fine powder on growing of seed was conjointly determined by germination take a look at. Leaf powder of M. *Syzygium cumini*, *Eucalyptus globules, Citrus limon*, *Momordica charantia* and *Piper* against *charantia* was found to be simpler whereas leaves powder of pure *S. cumini* that was obtained slightest efficient in adult death and egg laying anticipation.

Arthur *et al.* (2018) the khapra beetle, *Trogoderma granarium* was dangerous pest of stored products and the mainly warehouse pest that causes diseases reaction when this really is investigated in the USA. The youngone of *T. granarium* eaten up an extensive variety of wipe foodstuff of producer together with cereal of product, dehydrated fish, and gallery specimens. In the study, we concluded that the left over effectiveness of two pyrethroid insecticides,  deltamethrin also cyfluthrin ,usable on concrete, wood, finished  wood , vinyl flooring surface floors , and alloy outside exterior area making used of  minute and huge *T . granarium* larvae . Additional efficiency of two insect growth regulators (IGRs) methoprene and pyriproxyfen had been evaluated on concrete, steel, and unrefined wood surfaces. In both studies, larvae were obvious with stipulation of a food resource on the cured area of surfaces and residual assays were undertaken at a month, 1.0, 2.0, and 3.0 months promote treatment. In general, the two of the pyrethroids gave a maximum quantity of management and control of T*. granarium larvae*, though small youngone were more disposed than youngone. The IGRs were really a smaller amount successful with maximum larval endurance and adult appearance of obvious youngone compared with the pyrethroids. Residues activities of the pyrethroids chemical and IGRs were the majority of the relentless on the alloy steel shell. Consequences results were helpful to manage and erased damaging of *T. granarium* while they were located in North America.

BS Chandel*et al.* (2018) reported that *Callosobruchus chinensis Linn*. (Coleoptera: Bruchidae) was infesting on chickpea, *Cicer arietinum* L. ver. K 850 seed products. The selected herb materials viz; aerial elements *of Vitex negundo Linn., Withania somnifera Dun., Swertia chirayita Roxb., Tabernamontana devaricata Linn.*, ripe fruites of Jatropha curcus Linn., Nyctanthes arbortristis Linn., unripe fruits of Lantana camara Linn., *Momordica charantia Linn*., rhizomes of *Zingiber officinale Rosc*. and *Saussurea lappa* C.B. Clarke were used because of their insecticidal efficiency against early appearing of pulse beetle, *C. chinensis Linn*. in lab studies. The crude remove of each seed was decided on and analyzed by dried up film way of early raised beetles of *C. chinensis* on pulse grain. The information obtained from the results that among chosen bioactive crude place extracts maximum mean mortality was seen in *L. camara* (77.0) accompanied by *V. negundo* (75.40) and *W. somnifera* (71.14), respectively.

Kavallieratos *et al.* (2018) estimated the next six insecticides, cypermethrin, deltamethrin, pirimiphos-methyl smethoprene , silicoSec and spinosad, that are listed as grain to protected against young individuals of the khapra beetle, *Trogoderma granarium* Everts whole chickpea, maize ,wheat and hard rice. Only three dosages were analyzed the one partially of the tag medication dosage, the brand dosage and the dual sticky tag quantity dose for every pesticide and death rate was evaluated after 1.0, 3.0, 7.0 and 2.0 weeks post publicity. For parental adult pest, progeny creation was supposed later than yet another amount of 46 d of coverage. All analyzed insecticides could actually curb *T. granarium* individuals, even at the cheapest medication dosage. Pirimiphos- methyl and silicoSec were estimated to be mainly reliable than the all insecticides that used in the experiment, as they were the one ones that induced relevance led to 100% transience at the 7-day publicity period, at the 50 % label. On the other hand, a lot of the insecticides examined were provided the results to be inadequate against *T . granarium* larvae. There was 100% mortality rate due to the chemical Pirimiphos-methyl when all commodities examined and gave efficient results than the other insecticides. For male and female and larvae, death was usually maximum on entire wheat and barley as compared to grain and maize, for almost all of the combinations analyzed. Our conclusion revealed that the natural level individual’s larvae and the sort of contaminated goods should be really measured when insecticidal executive approach with cypermethrin, deltamethrin, pirimiphos-methyl, silicoSec, s-methoprene or spinosad are planned againts to Khapra beetle*.*

**IGRS**

Amos and Williams (1977) found that parental adult death changed into typically maximum on wheat handled with methoprene as compared treated with hydroprene and mortality turned into generally improved beneath unventilated situations. The efficiency of the three species changed into markedly decreased, in a few examples concealed in case of close situations. Toxicity of IGRs changed by the average percent IGR, the pest kinds and precise seeds (Daglish and Samson, 1990; Athanassiou *et al*., 2011a,b). The LD50 of methoprene for pests surpasses 34,400.0 mg/kg (Phillips and Throne, 2010), marketable JHAs, like methoprene, when put on juvenile pests, put off metamorphosis to the maximum age level, but did not usually destroy adult pests (Oberlander and Silhacek, 2000). There had been significant lab investigation because the 1970 on immediate level of toxicity of chemical methoprene on undeveloped pest (McGregor and Kramer, 1975; Loschiavo, 1976; Stockel and Edwards, 1981 Manzelli, 1982; Edwards *et al*., 1988; Samson *et al*., 1990; Nayar *et al*., 2002),

Mian and Mulla (1982), repoted that one limitation of methoprene use is more time taken to permeate from grains. Subsequently, it could have decreased effect on pest nourishing within grains such as *S. oryzae, R. dominica and Sitophilus granarius* (Edwards and Short, 1984; Athanassiou *et al.,* 2010). Commonly, methoprene is steady within a variety of conditions for a reasonably lengthy instance frame; no factor in the rest of the efficiency of methoprene is discovered between 24.0OC and 35OC for 6 month or at 65OC for 2 days when practical done on concrete or wood floors (Wijayaratne *et al*., 2012b). The particals residual effectiveness on *Triticum aestivum* looked after at 46.0 OC also will not drop for 2 days (Wijayaratne *et al*., 2012b).

White and Leesch (1996). Reported that The probable known logic for the decrease residual effectiveness on actual areas are their maximum priority boosting the infiltration of pesticide from the top, and maximum value of pH (about 9.5) which heightens breakdown of insecticides both occurrence of flour and there own exclusion through clean-up take action to adulterate particals of methoprene on concrete floors (Wijayaratne *et al*., 2012b). Similar studies have been mentioned with residual touch with insecticides, that occurrence of the flour noxious waste seriously compromises insecticidal efficiency (Arthur, 2012). On the other hand, the occurrence of flour will not decrease the residual effectiveness of methoprene on lumber (Wijayaratne *et al*., 2012b).

Johnson *el al*., (1997, 1998, 2002) tested that multiple-techniques of IGRs utility should improve saved-product pest management. IGRs and aerosols are not unusual techniques of IGRs chemical hired in lots of smaller storage centers, together with packaging devices and retail stores. Consisting of underneath storage units and shelves or close to packaged food. Pest may additionally breed or find refuges in places where spraying three. Saved-product pest control within the destiny will encompass greater incorporated techniques, in preference to strict reliance on chemical manage techniques. Such integrated tactics are receiving extra interest.

Oberlander and Silhacek, (2000) reported that IGRS word has been extended to further insect natural hormones or cognate that are choose to pests (Mondal and Parween, 2000). IGRs obstruct primarily with three only physiological operations, expansion and escalation of undeveloped pest, initiation of metamorphosis, or cell chitin production in the skin (Oberlander and Silhacek, 2000). Physiological results brought on by ecdysteroids comprise expansion inhibition (Silhacek *et al*., 1990) IGRs in charge of these three settings of action are specified as chitin synthesis inhibitors, juvenile hormone agonists and ecdysteroid agonists respectively (Oberlander *et al*., 1997).

Arthur (2004), reported that the methoprene was employed in blend with another pesticides, it showed results within an positive influence on insect mortality. Methoprene showed the impact when utilized in combination with diatomaceousearth. Methoprene is efficient when found in blend with different insect growth regulators i.e.with diflubenzuron, offspring development is low in Sitophilu oryzae (L.) and *Rhyzopertha dominica* the reduced grain borer (Daglish and Wallbank, 2005). IGRS Methoprene in blend by diatomaceous globe triggers enhance death in *R. dominica* on difficult grain (Arthur, 2004; Chanbang *et al*., 2007).

Bakr *et al*. (2008) seen that lufenuron effect on the inhibitory of the adult introduction in the grain after treatment of previous instar nymphs, whatever the timing of treatment.

Trostanetsky and kostyukovsky (2008) revealed that the egg originated by red flour beetlewas completely repressed later than 1 month because of the after cause of novaluron; however inhibition improved gradually to 67.1% above the 36.0 days test. Arthur *et al*. (2009) disclosed that hydroprene was established to be slightest consistent on solid material and slowly but surely the majority prolonged on steel. Pyriproxifen showed higher residual perseverance than hydroprene displaying comparable consequences at the treated surfaces.

Pedigo and Rice, (2009) reported that lately, common traditions of insect management by neurotoxic artificial chemicals attended under attack and inspection for their unwanted results on human health insurance and the surroundings ecology. As a result, original secure methods for insect control were under development. Among there some approaches that have enforced all over the world was the utilization of insect growth regulators (IGRs). 1GRs are also called biorationls insecticides due to their specific toxicity and not harmfull to the other insects, environmental security and their influence on the urinary tract of pests

Desmarchelier and Allen (2009) said that diflubenzuron, implemented to *Triticum aestivum* prevented growth of first generation (F1) young larvae of *S. oiyzae and S. granarius* species.The capability of IGRs as a subject to pest management method has garnered the eye of many investigators due to their non-poisonous features to non-target species inclusive of mammals. They’re advanced in numerous factor to the traditional first and second skill and technology pesticides.

Kavallieratos *et al*. (2012) discovered that the use of diflubenzuron, fenoxycarb, lufenuron , pyriproxifen, flufenoxuron, triflumuron and methoxyfeinozide as granule escorting associated with *Prostephanus truncatus* in the crop maize and lessor grain borer in whole wheat were quite efficient (89.15% repression of progeny). Experiments showed that pyriproxyfen led to considerable decrease in nymphs and parents when used as surface treatment for the management of *Liposcelis bostrychophila*, *Liposcelis paeta Pearman* and *Liposcelis decolor* (Pearman).

Wijayaratne *et al*. (2012a) explained that Methoprene also reduced offspring development by *T. castaneum* when uncovered at the larvae young level and afterward copulate at the mature level. The impact is sexual characteristics established males are usually high damaged as compared with females once *T. castaneum* were free to methoprene, their lenience was decreased. But, no such results have been diagnosed in *T. castaneum* young larvae (Wijayaratne and Domains, 2010). When high temperature allotment are thoroughly found in the manifestation of constructions and dispensation vegetation in foodstuff engineering as well as product disinfestations, togather warm allotment with the rest of the effectiveness of methoprene might be not increased overall expenditure related with high temperature technology in such treatments. Efficiency of methoprene useful on areas reduced as the time passes, based on composition of this material. Cement is an average floor covering outside of grain bins and also for flourmills and storeroom. Many reports explained that reduced effectiveness of insecticides on cement in comparison to another floors (Williams *et al*., 1983; White and Leesch, 1996; Hagstrum and Subramanyam, 2006; Arthur *et al*., 2009; Wijayaratne *et al*., 2012b)

 Tucker *et al*. (2014a,b ), reported that Taking care of of sub-lethal subjection was the probable of methoprene residues to be moved from cadavers for the duration of larval feeding on flour formulated with small larvae subjected directly to methoprene in that locations where those larval residues were came into connection without exposed young larvae. Their consequences results a less toxic impact that is recognized as a kind of straight shift inside a resident population. On this flat transfer, the consequences are varying, as proven in tests that methoprene has effect on khapra larvae.

Tucker *et al*., (2014b), tested that *Tribolium castaneum* young larvae subjected to fine flour with methoprene chemical treated new pupae indicated that reduced adult introduction in the flour, flour with larvae indicated superior degrees of larvae mortality for the reason that level, and new larvae subjected to methoprene treated individual often didn't appear as individuals or there were morphological defects when treated with surfaced.

The quantity of resistance to methoprene in the variety coleopteran and Dipterans (Hammock *et al*., 1977; Ashok *et al*., 1998; Cornel *et al*., 2002; Kristensen and Jespersien, 2003; Cetin *et al*., 2009) and Coleopterans (Benezet and Helms, 1994; Daglish, 2008) had been diagnosed. in recent times, methoprene has the level of resistance to *R. dominica* that was reported from country Australia, a resilient inhabitants exhibited a dosage for death of larvae and progeny development with entire inhibition of the offspring at 40.0 ppm (Daglish *et al*., 2013). Although the system by which pest became repellent to methoprene in the field up till now has been not properly elucidated (Palli, 2009).

Arthur (2015) reported that Methoprene mixed with grains offer cover for two years from red flour beetleand *R. dominica* while to safeguard from the Angoumois grain moth, would needed the adding together contect pesticide with insecticide.

**Chapter 3**

**Materials and Methods**

The material was comprised of stock of *Trogoderma granarium*, sterilized wheat flour, plastic jars, , rubber bands, muslin cloth, sieves, muslin cloth ,incubator ,fine hair brushes and electric grinder .

**3.1 Plant extracts:**

There are four different plant extracts e.g Neem (*Azadiractin indica*), Caster seed (*Ricinus communis*) Carrot grass (*Parthenium hysterophorus)* and Mangroes (*Conocarpus erectus).* Four different concentrations (5, 10, 15 and 20) of each extracts will be used.

**3.2 IGRS:**

Four IGRs (Lufenuron, Pyriproxyfen, Hydroprene and Methoprene) Four commercial formulations of different concentration 2.5, 5, 7.5 and 10 ppm for the treatment. Commercial acetone was used to making the stock solution. The insecticide assays were conducted with three replication .The prepared and Stocks solution was stored at 1OC when not in used.

**3.3 COLLECTION AND REARING OF INSECTS:**

Infested wheat grains will be collecting with adult Khapra beetle (*Trogoderma granarium*)from grain market of Faisalabad and Toba Tek singh. Insect culture was kept for rearing in glass jarsat laboratory conditions. Culture was reared until the homogeneous population. This homogenous culture was used for next experimental procedure. The insects culture was maintained at 28±2ºC and 65±5% R.H at laboratory condition and reared on the whole wheat flour sterilized at 60ºC for 60-90 minutes at uncontaminated glass jars.Fifty to fourty pairs *Trogoderma granarium* of were adding in the jars filled by 2 kg of wheat flour single female laid 50-90 cylindrical eggs with a number of spine-like projections. The eggs incubation period was 3-to 14 days. The Complete development from egg to adult cans occured from 26 to 220 days, depending upon temperature. Optimum temperature for development is 35°C. If the temperature falls below 25°C for a considerable period of time or if larvae are very crowded, they may enter diapause.

##### 3.4 PREPARATION OF PLANTS EXTRACTS:

##### There are four different plant extracts e.g Neem (*Azadiractin indica*), Caster seed (*Ricinus communis* ) Carrot grass(*Parthenium hysterophorus)* and Mangroes (*Conocarpus erectus)* was collected from different area of University of Agriculture Faisalabad and Toba Tek Singh. All Plants materials like leaves were washed with distilled water. The plant material dried under shade and not exposed to the sunlight. Plants leaves grinded with the help of electric grander to bring it into fine powdered form. The powder of plants material was kept in plastic jar so that there was no contamination with the powder, after those powders’s fine were sieved with a 40.0 -mesh sieve to attain a very fine powder with no contamination of debris or small soil particles. Acetone used as solvent for the extractions. The extractions were done using by adding 50 gram of powder and 100 ml of solvent (acetone). The flask mouth was closed with cotton plug and aluminum foil to keep away from evaporation of botanical mixture solution. The samples were loaded on rotary shaker at 220 rpm for 24 hours. Filtration was done with the help of Whatman filter paper, removed remaining material and obtained botanical solvent.

##### 3.5 CONTACT TOXICITY BIOASSAY OF PLANT EXTRACTS AND IGRS AGAINST *Trogoderma granarium*

##### From 100 % stock solution three dilutions of each extract (5, 10, 15 and 20%) were prepared in acetone. From 100 % stock reserve solution four dilutions of each extract (5, 10, 15 and 20%) were prepared in chemical acetone. The experiments were conducted using Completely Randomized Design and each treatment was replicated three times. The plastic Jars were used as exposure chamber. Aliquots of each dilution were applied on 40.0 grams of clean wheat with the aid of pipette while the control was treated with acetone. Each plastic jar was stunned instinctively for two minute to achieve homogeneous portion of extract. After acetone evaporation for one hour, 20 unsexed adults of *Trogoderma granarium* were introduced to each plastic jar. Plastic Jars were covered with a piece of muslin fabric cloth by the assist of rubber band to keep away from the run away of insects. Plastic Jars were placed in incubator under most favorable conditions of growth and development. Data of insect’s mortality were recorded after 24, 48, 72 and 96 hours. Mortality was corrected and calculated according to the Abott (1925) formula.

##### 3.5.1 IMPACT OF INSECT GROWTH REGULATOR (IGRS) ON THE SURVIVAL AND DEVELOPMENT OF LARVAL STAGE OF *T . GRANARIUM*:

##### The third instar larvae of *Trogoderma granarium* were sited into 250ml jars containing 50g IGRS of treated diet. There were three replication with four concentration (i.e. 2.5, 5, 7.5 and 10 ppm) and with untreated control. The entire glass jar was kept in 30±2 OC and 70±5% R.H. Data obtained after 7 and 14 days.

##### 3.6 GROWTH INHIBITION EFFECTS OF PLANT EXTRACTS AND IGRS ON *T. granarium*:

##### Growth inhibitory effect was checked to treat the broken grains with different concentration of plant extracts. Filter paper and grain was treated with plant extract. Thirthy beetles were introduced to complete the life cycle on the treated broken grains. Data was collected for pupae and adult inhibition in first final generation (F1 generation) after each day and process was continuing till the emergence of F1 adults.

##### IGRs were applied on wheat grains at rate of 2.5, 5.0 and 7.5 ppm concentration. Untreated grains (control unit) were replicated thrice. *T. granarium* larvae of 3rd instaar were released on treated grains and data regarding pupae adult inhibition was recorded periodically (7 days and 14 days) till the emergence of adults.

#####  Data analysis

After corrected mortality calculation using Abott formula,data collected was subjected to suitable statistical analysis for ANOVA calculation. Average Means of treatments were compared using Tucky-HSD at 5% significant level.

**CHAPTER NO. 4 RESULTS**

Present investigations were carried to find out the comparative insecticidal and growth inhibitory effects of carrot grass (*Parthenium hysterophorus* L.), neem (*Azadirachta indica*), Conocarpus (*Concarpus erectus*), castor bean (*Ricinus communis*) and three insect growth regulators (IGRs) (Pyriproxyfen, lufenuron, hydroprene, methoprene) against *Trogoderma granarium* (Everts) under controlled (laboratory) conditions.Experimentations were carried using Completely Randomized Design (CRD) and each treatment was replicated thrice along with control. Four different concentrations (5, 10, 15 and 20) of each extract and 2.5, 5, 7.5 and 10 ppm of IGRs were used. The data regaring mortality was recorded after 24, 48, 72 and 96 hr of the each treatment application. The growth inhibition experiment was also conducted at same application rate of each insecticide as well as in combination and data regarding larval, pupae and adults inhibition was observed after regular intervals of time.

**MORTALITY DATA AFTER EXPOSURE OF 24 HRS**

Table 4.1 revealed the analysis of variance (ANOVA) of data regarding percent mortality of *T. granarium* at different concentrations of carrot grass (*Parthenium hysterophorus* L.), *neem* (*Azadirachta indica*), *Conocarpus* (*Concarpus erectus*) andcastor bean (*Ricinus communis*). Data showed that main effects, plants (F=7.009; df=3: p<0.05) and concentration (F=8.599, df=3 p<0.05) were significant regarding mortality values of *T. castaneum* after 24 hours of the treatment application.

**Table 4.1. Analysis of variance (ANOVA) of the data regarding % mortality of *Trogoderma granarium* (Everts) using different plant extracts**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **Plant** | 3 | 607.470 | 202.490 | 7.0098\*\* |
| **Concentration** | 3 | 745.248 | 248.416 | 8.5997\*\* |
| **Plant\*Concentration** | 9 | 856.299 | 95.144 | 3.2937\*\* |
| **Error** | 32 | 924.370 | 28.887 |  |
| **Total** | 47 | 3133.387 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.2 Mean percentage mortality of *Trogoderma granarium* with application of different concentrations of plant extracts after 24 hrs**

| **Concentrations (%)** | **% Mean mortality ± SE** |
| --- | --- |
| **5** | 3.69±1.01 c |
| **10** | 10.55±3.15 b |
| **15** | 10.00±1.23 ab |
| **20** | 14.72±1.80 a |

The data in table (4.2) revealed lowest mean mortality was 3.69 % at 5% concentration, similiar results 10.55, 10.00% at 10 and 15% concentrations and highest values 14.72% was noticed at 15% concentration of plant extracts. From these findings we can determined that concentration effect was significant on percent mean percent mortality of *T. granarium*.

**4.3 Mean percentage mortality of *Trogoderma granarium* after exposure to different plant extracts**

| **Plants** | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* | 7.027±2.38 b |
| *Ricinus communis* | 6.66±1.08 b |
| *Concarpus erectus* | 15.55±3.13 a |
| *Azadirachta indica* | 9.72±1.56 ab |

Table 4.3 showed percent mean mortalities with application of different plant extracts at four concentrations. The data indicated showed that extracts of *Concarpus erectus* gave maximum mortality 15.55% of *T. granarium*, followed by 9.72 with *Azadirachta indica* extract, 7.027% by *Parthenium hysterophorus* and comparatively low 6.66% was obtained with the application of *Ricinus communis* extracts. From the results we concluded that the extract of *Concarpus erectus* proved more effective than others.

**4.4 Interaction between different plants and concentrations against percentage mortality of *Trogoderma granarium***

| **Plant extracts x Concentrations** | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* x 5 | 1.41**±**0.98c |
| *Parthenium hysterophorus* x 10 | 3.32**±**1.92c |
| *Parthenium hysterophorus* x 15 | 6.67**±**1.92bc |
| *Parthenium hysterophorus* x 20 | 16.65**±**3.53ab |
| *Ricinus communis* x 5 | 4.41**±**2.93c |
| *Ricinus communis* x 10 | 4.43**±**2.93c |
| *Ricinus communis* x 15 | 7.76**±**1.11bc |
| *Ricinus communis* x 20 | 11.10**±**1.92b |
| *Concarpus erectus* x 5 | 3.32**±**1.92c |
| *Concarpus erectus* x 10 | 15.56±1.11ab |
| *Concarpus erectus* x 15 | 15.56±1.11ab |
| *Concarpus erectus* x 20 | 27.76±2.77a |
| *Azadirachta indica* x 5 | 5.56**±**2.23c |
| *Azadirachta indica* x 10 | 7.76**±**1.92bc |
| *Azadirachta indica* x 15 | 10.02**±**1.92b |
| *Azadirachta indica* x 20 | 16.67**±**1.92ab |

Table 4.4 revealed highest mortality 27.76% at highest concentration 20% of *Concarpus erectus* after exposure period of 24 hr. The extract of *Azadirachta indica* and *Parthenium hysterophorus* proved effective with percentage mortality values of 16.67 and 16.65, accordingly. At 15% concentration, *Concarpus erectus* gave 15.56%, followed by *Azadirachta indica* (10.02%), *Ricinus communis* (7.76%) while lowest 6.67% was observed in case of *P.hysterophorus* extract at same concentration. Mean percentage mortality at 10% concentration was 15.56% followed by 7.76% as in case of *A*. *indica* extract, 4.43% with *R*. *communis* extract and comparatively low mortality3.32% was recorded with *P*. *hysterophorus*. Comparatively low mortality values were observed at lowest concentration 5% of each extract and highest percentage mortality 5.56% with application of *Azadirachta indica* extract while lowest1.41% was observed in case of *P.hysterophorus*. The mean mortality was found 5.56, 13.67% in case of *Azadirachta indica* and *Cymbopogon citratus* at 10% concentration of plant extract. From the outcomes we concluded that there was a steadily increase in mortality with increase in concentration of each plant extract.

**MORTALITY DATA AFTER EXPOSURE OF 48 HRS**

Table 4.5 illustrated the analysis of variance (ANOVA) of data related to percentage mortality of *Trogoderma granarium* at various concentrations of *Parthenium hysterophorus* L., *Azadirachta indica*, *Concarpus erectus* and *Ricinus communis*. Data revealed that main effects, plants (F=3.6585; df=3: p<0.05) and concentration (F=11.4821, df= 3, p<0.05) were significant regarding mortality values of *T. granarium* after exposure period of 48 hours.

**Table 4.5 Analysis of variance (ANOVA) of the data regarding % mortality of *Trogoderma granarium* (Everts) for different plant extracts**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **Plant** | 3 | 586.03 | 195.34 | 3.6585\* |
| **Concentration** | 3 | 1839.24 | 613.08 | 11.4821\*\* |
| **Plant\*Concentration** | 9 | 1349.35 | 149.93 | 2.8079\* |
| **Error** | 32 | 1708.62 | 53.39 |  |
| **Total** | 47 | 5483.24 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.6 Mean percentage mortality of *Trogoderma granarium* with application of different concentrations of plant extracts after 48 hrs**

| **Concentrations (%)** |  **% Mean mortality ± SE**  |
| --- | --- |
| **5** | 10.67± 1.32 b |
| **10** | 12.18±1.25 b |
| **15** | 16.80± 2.43 ab |
| **20** | 26.52±4.07 a |

Table 4.6 presented mortality 10.67% mean percentage mortality at lowest concentration (5%) and 26.52 % mortality was recorded at 20% concentration of the extracts. From the findings we can conclude that concentration were significant regarding percent mean percent mortality of *T. granarium*.

**4.7 Mean percentage mortality of *Trogoderma granarium* after exposure to different plant extracts**

| **Plants** | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* | 12.59±1.87 c |
| *Ricinus communis* | 14.13±2.68 ab |
| *Concarpus erectus* | 17.80±3.19 ab |
| *Azadirachta indica* | 21.63±4.01 a |

Table 4.7 showed percent mean mortality values of different plant extracts at different concentrations. Extracts of *Azadirachta indica* and *Concarpus erectus* gave comparatively more mortality values 21.63 and 17.80%, correspondly. While least value 12.59 % was given by extract of *Parthenium hysterophorus*.

**4.8 Interaction between different plants and concentrations against percentage mortality of *Trogoderma granarium* after 48 hrs**

| **Plant extracts x Concentrations**  | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* x 5 | 10.07**±**1.85c |
| *Parthenium hysterophorus* x 10 | 7.93**±**2.24c |
| *Parthenium hysterophorus* x 15 | 13.32**±**1.92bc |
| *Parthenium hysterophorus* x 20 | 19.04**±**3.48 ab |
| *Ricinus communis* x 5 | 7.32**±**1.57c |
| *Ricinus communis* x 10 | 11.30**±**2.86 bc |
| *Ricinus communis* x 15 | 14.59**±**2.91 bc |
| *Ricinus communis* x 20 | 23.32**±**3.38 ab |
| *Concarpus erectus* x 5 | 9.59**±**2.43c |
| *Concarpus erectus* x 10 | 13.63±0.15 bc |
| *Concarpus erectus* x 15 | 18.86±1.11 bc |
| *Concarpus erectus* x 20 | 29.11±3.50 ab |
| *Azadirachta indica* x 5 | 15.67**±**2.83 bc |
| *Azadirachta indica* x 10 | 15.85**±**2.06 bc |
| *Azadirachta indica* x 15 | 11.67**±**3.46 bc |
| *Azadirachta indica* x 20 | 43.32**±**3.32 a |

Table 4.8 illustrated that maximum mean mortality 43.32% was recorded at 20 % concentration of *Azadirachta indica* after exposure of 48 hr, followed by 29.11% by extract of *Concarpus erectus*. *Ricinus communis* and *Parthenium hysterophorus* gave 23.32and 19.04 % mortality values at same concentration. At 15% concentration, mean percentage mortality 18.86 % was recorded with application of *Concarpus erectus* extract, followed by 14.59% with *Ricinus communis*, 13.32% by *P*. *hysterophorus* and 11.67 % by *A. indica* extract. At 10% concentration, mortality values 15.85, 13.63, 11.30 and 7.93 was observed with *A. indica*, *C*. *erectus*, *R*. *communis* and *P*. *hysterophorus*, accordingly. Comparatively lower mean mortality values 15.67(*A. indica* extract), 10.07(with *P*. *hysterophorus*), 9.59 (*Concarpus erectus*) and 7.32 % (in *Ricinus communis*) was recorded at 5% concentration of plant extracts. The mean mortality outcomes showed that concentration level as well as type of plant was found significant and mortality was found increased with rise in concentration of the plant extracts indicating that both type of plant extract as well as concentration were significant in mortality bioassay against the *Trogoderma granarium*.

**MORTALITY DATA AFTER EXPOSURE OF 72 HRS**

Table 4.9 showed the analysis of variance (ANOVA) of data related to mean percentage mortality of *T. granarium* at various concentrations of *Parthenium hysterophorus* L*.*, *Azadirachta indica*, *Concarpus erectus* and *Ricinus communis*. Data showed that the main effects, plants (F=1800.41, df=3: p<0.05) and concentration (F= 608.85, df=3, p<0.05) were significant regarding mortality values of *T. granarium* after exposure period of 24 hours.

**Table 4.9 Analysis of variance (ANOVA) of the data concerning % mortality of *Tribolium castaneum* (Herbst) for different plant extracts**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **Plant** | 3 | 5401.24 | 1800.41 | 111.766\*\* |
| **Concentration** | 3 | 1826.56 | 608.85 |  37.796\*\* |
| **Plant\*Concentration** | 9 | 454.04 | 50.45 | 3.132\*\* |
| **Error** | 32 | 515.48 |  |  |
| **Total** | 47 | 8197.31 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.10 Mean percentage mortality of *Trogoderma granarium* with application of different concentrations of plant extracts after 72 hrs**

| **Concentrations (%)** | **(%) Mortality ± SE** |
| --- | --- |
| **5** | 22.98±2.25 |
| **10** | 28.35±3.19 |
| **15** | 33.22±4.14 |
| **20** | 39.72±3.96 |

Data presented in table 4.10 revealed that mortality 22.98 % percentage mortality was recorded at 5% concentration and 39.72 % mortality was observed at 20% concentration of the plant extracts. From results we can conclude that concentration has significant effect on percent mean percent mortality of *T. castaneum*.

| **Concentrations (%)** | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* | 17.95 ± 1.36 d |
| *Ricinus communis* | 24.12 ± 1.70 c |
| *Concarpus erectus* | 37.30 ± 2.31 b |
| *Azadirachta indica* | 44.89 ± 3.32 a |

**4.11 Mean percentage mortality of *Trogoderma granarium* after exposure to different**

**Plant extract**

Table 4.11 showed trend regarding percent mean mortality values of different plant extracts at various concentration levels. Extracts of *Azadirachta indica* and *Concarpus erectus* comparatively proved very effective and gave mortality values 44.89 and 37.30%, correspondly. While lowest mortality 17.95 % was given by extract of *Parthenium hysterophorus*.

**4.12 Interaction between different plants and concentrations against percentage mortality of *Trogoderma granarium* after 72 hrs**

| **Plant extracts x Concentrations**  | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* x 5 | 14.59**±**2.91g |
| *Parthenium hysterophorus* x 10 | 15.70**±**2.14 g |
| *Parthenium hysterophorus* x 15 | 18.19**±**1.25 fg |
| *Parthenium hysterophorus* x 20 | 23.21**±**1.92 efg |
| *Ricinus communis* x 5 | 19.04**±**2.79 fg |
| *Ricinus communis* x 10 | 22.49**±**1.26 efg |
| *Ricinus communis* x 15 | 22.75**±**1.37 efg |
| *Ricinus communis* x 20 | 32.22**±**2.22 cde |
| *Concarpus erectus* x 5 | 29.15**±**2.68 def |
| *Concarpus erectus* x 10 | 32.56±2.07 cde |
| *Concarpus erectus* x 15 | 40.84±2.91 bcd |
| *Concarpus erectus* x 20 | 46.65±1.92 ab |
| *Azadirachta indica* x 5 | 29.15**±**2.68 bc |
| *Azadirachta indica* x 10 | 42.64**±**2.54 bc ab |
| *Azadirachta indica* x 15 | 51.10**±**3.18 ab |
| *Azadirachta indica* x 20 | 56.67**±**1.92 a |

Data in table 4.12 showed that maximum mortality 56.67% was examined with 20 % *Azadirachta indica* at 20% concentration after exposure period of 72 hr, followed by 46.65 % with *Concarpus erectus* extract, 32.22% by *Ricinus communis* extract while comparatively low 23.21was observed in case of *Parthenium hysterophorus* extract. At 15% concentration, comparatively low mortality 51.10% was noticed in case of *A. indica* followed by 40.07% by *C. erectus*, 22.75% by *R.communis.* Extracts of *Concarpus erectus* and *Ricinus communis* gave 40.07and 22.75% at 15% concentrations. While 18.19% was observed in case of *P*.hysterophorus. Mean mortality values 42.64, 32.56, 22.49 and 15.70% were observed at 10% concentration of the plant extract. Comparatively low mean percentage mortality was observed at 5% concentration. Extracts of *Azadirachta indica* and *Concarpus erectus* were equally effective with value of 29.15 while 19.04 and 14.59% mean percentage mortality values were given by *Ricinus communis* and *Parthenium hysterophorus* at 5% concentration, respectively. From the experiment outcomes we concluded that there both plant type and concentration levels proved effective against *T. granarium*.

**MORTALITY DATA AFTER EXPOSURE OF 96 HRS**

Table 4.13 showed the analysis of variance (ANOVA) of data related to mean percentage mortality of *T . granarium* at various concentrations of *Parthenium hysterophorus* L*.*, *Azadirachta indica*, *Concarpus erectus* and *Ricinus communis*. Data showed that the main effects, plants (F=97.160, df=3: p<0.05) and concentration (F= 39.620, df=3, p<0.05) were significant regarding mortality values of *T. granarium* after exposure period of 24 hours.

**Table 4.13 Analysis of variance (ANOVA) of the data concerning % mortality of *Trogoderma granarium* for different plant extracts**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **Plant** | 3 | 9899.6 | 3299.9 | 97.160\*\* |
| **Concentration** | 3 | 4036.8 | 1345.6 | 39.620\*\* |
| **Plant\*Concentration** | 9 | 707.1 | 78.6 | 2.313\* |
| **Error** | 32 | 1086.8 | 34.0 | 97.160 |
| **Total** | 47 | 15730.3 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.14 Mean percentage mortality of *Trogoderma granarium* with application of different concentrations of plant extracts after 96 hrs**

| **Concentrations (%)** | **(%) Mean Mortality ± SE** |
| --- | --- |
| **5** | 38.68±3.88 c |
| **10** | 51.10±4.27 b |
| **15** | 55.60±3.67 b |
| **20** | 64.08±3.80 a |

Data presented in table 4.14 revealed that mortality 38.68% percentage mortality was recorded at 5% concentration while 55.60 and 64.08 % mortality was observed at 15 and 20% concentration of the plant extracts. From results we can conclude that concentration has significant effect on percent mean percent mortality of *T. castaneum*.

**4.15 Mean percentage mortality of *Trogoderma granarium* after exposure to different plant extracts**

| **Concentrations (%)** | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* | 33.64 ± 4.12 d |
| *Ricinus communis* | 47.50 ± 2.79 c |
| *Concarpus erectus* | 54.85 ± 3.71 b |
| *Azadirachta indica* | 73.45 ± 1.70 a |

Table 4.15 showed trend regarding percent mean mortality values of different plant extracts at various concentration levels. Extracts of *Azadirachta indica* and *Concarpus erectus* comparatively proved very effective and gave mortality values 44.89 and 37.30%, correspondly. While lowest mortality 17.95 % was given by extract of *Parthenium hysterophorus*.

**4.16 Interaction between different plants and concentrations against percentage mortality of *Trogoderma granarium* after 96 hrs**

| **Plant extracts x Concentrations**  | **(%) Mean Mortality ± SE** |
| --- | --- |
| *Parthenium hysterophorus* x 5 | 12.23**±**3.22 g |
| *Parthenium hysterophorus* x 10 | 33.67**±**3.17 g |
| *Parthenium hysterophorus* x 15 | 41.57**±**2.88 efg |
| *Parthenium hysterophorus* x 20 | 47.12**±**3.04 defg |
| *Ricinus communis* x 5 | 37.01**±**3.55 fg |
| *Ricinus communis* x 10 | 43.86**±**2.40 defg |
| *Ricinus communis* x 15 | 49.38**±**2.47 defg |
| *Ricinus communis* x 20 | 59.76**±**3.04 cde |
| *Concarpus erectus* x 5 | 38.16**±**4.26 fg |
| *Concarpus erectus* x 10 | 52.75±2.43 cdef |
| *Concarpus erectus* x 15 | 58.39±2.91 bcd |
| *Concarpus erectus* x 20 | 70.11±3.04 abc |
| *Azadirachta indica* x 5 | 57.35**±**3.26 bcd |
| *Azadirachta indica* x 10 | 74.09**±**3.20 bc ab |
| *Azadirachta indica* x 15 | 73.06**±**1.69 ab |
| *Azadirachta indica* x 20 | 79.31**±**1.99 a |

Data in table 4.16 showed that maximum mortality 79.31% was examined with 20 % concentration of *Azadirachta indica* extract after exposure period of 96 hr, followed by 70.11% with *Concarpus erectus* extract, 59.76% by *Ricinus communis* extract while comparatively low 47.12% was observed in case of *Parthenium hysterophorus* extract. At 15% concentration, mortality values were 73.06, 58.39, 49.38 and 41.57, accordingly*.* Mean mortality values 74.09, 52.75, 43.86 and 33.67% were observed at 10% concentration of the plant extract. Comparatively low mean percentage mortality was observed at 5% concentration. Extracts of *Azadirachta indica* gave 57.35% followed by *Concarpus erectus* 38.16% and 37.01% with *Ricinus communis* (both extracs were equally effective) while lowest mean percent mortlity 12.23% was observed in *P. hysterophorus* extract at 5% concentration. From the experiment findings we concluded there was a gradual increase in mortality response of test insect with rise in concentration of plant extracts as well as exposure period of the treatment. Furthurmore, mortality was also influenced by type of plant extract, used in mortality bioassay.

**MORTALITY DATA WITH INSECT GROWTH REGULATORS (IGRs) AGAISNT *Trogoderma granarium* AFTER 7 DAYS**

Table 4.17 revealed that the analysis of variance (ANOVA) of data regarding mean percentage mortality of *T . granarium* three insect growth regulators (IGRs) (Pyriproxyfen, lufenuron, hydroprene, methoprene). Data showed that main effects, IGRs (F=19.678; df=3: p<0.05) and concentration (F=55.230, df=3 p<0.05) were found significant concerning mortality response of *T . granarium*.

**Table 4.17 Analysis of variance (ANOVA) of the data concerning % mortality of *Trogoderma granarium* (Everst) for different concentrations of IGRs**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **IGRs** | 3 | 1841.38 | 613.79 | 19.678\*\* |
| **Concentration** | 3 | 5168.23 | 1722.74 | 55.230\*\* |
| **IGRs \*Concentration** | 9 | 671.35 | 74.59 | 2.391\* |
| **Error** | 32 | 998.15 | 31.19 |  |
| **Total** | 47 | 8679.11 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01

**Table 4.18 Comparison of percentage mortality of *Trogoderma granarium* after exposure to various concentrations of Insect growth regulators**

| **Concentrations (ppm)** | **(%) Mean mortality ± SE** |
| --- | --- |
| **2.25** | 15.29 ± 2.07 b |
| **5.0** | 27.76 ± 2.36 b |
| **7.5** | 33.61 ± 2.68 a |
| **10** | 44.43 ± 3.07 a |

Data table 4.18 illustrated that 15.29 % mean percentage mortality was recorded at 2.25% concentration and 44.43 % mortality was observed at 10 ppm concentration of the IGRs. While 33.61 % mortality was noticed at 7.5 ppm. From results we can conclude that concentration was found very effective against mean percent mortality of *T. granarium*.

**4.19 Mean percentage mortality of *Trogoderma granarium* after exposure to 5 days**

| **IGRs** | **(%) Mean Mortality ± SE** |
| --- | --- |
| Pyriproxyfen | 37.50 ± 1.68 a |
| Lufenuron | 35.56 ± 3.11 a |
| Methoprene | 24.72 ± 2.98 b |
| Hydroprene | 22.75 ± 2.98 b |

Table 4.19 indicated percent mean mortality values after 5 days exposure period. Maximum mean percentage mortality 37.50 %was observed in Pyriproxyfen followed by 35.56 with Lufenuron, 24.72 % by methoprene while lowest 22.75 % was observed in case of Hydroprene. From data we conclude that pyriproxyfen and Lufenuron were found effective in mortality experiment.

**4.20 Interaction effect (IGRs × Concentration) for percentage mortality of *Trogoderma granarium***

| **IGRs × Concentration** | **(%) Mean Mortality ± SE** |
| --- | --- |
| Pyriproxyfen x2.25 | 15.07**±**3.30 f |
| Pyriproxyfen x 5.0 | 35.56**±**2.93de |
| Pyriproxyfen x 7.5 | 41.67**±**2.22 abc |
| Pyriproxyfen x10 | 55.76**±**2.22 a |
| Lufenuron x2.25 | 18.87**±**3.84 cd |
| Lufenuron x 5.0 | 33.32**±**1.92 bc |
| Lufenuron x 7.5 | 40.10**±**1.11 abcd |
| Lufenuron x10 | 48.87**±**1.11 ab |
| Methoprene x2.25 | 14.54**±**4.42 a |
| Methoprene x 5.0 | 17.76**±**1.11 |
| Methoprene x 7.5 | 28.87**±**1.11 |
| Methoprene x10 | 36.67**±**1.92 |
| Hydroprene x2.25 | 12.33**±**1.92 |
| Hydroprene x 5.0 | 24.43**±**2.93 |
| Hydroprene x 7.5 | 22.76**±**4.33 |
| Hydroprene x10 | 34.43**±**2.89 |

Table 4.20 reveaed that maximum mortality 55.76 % was noticed at 10 ppm concentration of pyriproxyfen after exposure of 7 days followed by 48.87% with lufenuron, 36.67% by methoprene while lower 34.43% was recorded in 10 ppm concentration of Hydroprene. Almost equal mortality results 41.67 and 40.10 were recorded with Pyriproxyfen and lufenuron at 7.5 ppm concentrations, accordingly. Mortality values 28.87 and 22.76% wer observed in Methoprene and Hydroprene, respectively with same concentration. At 5.0 ppm mortality values of 35.56 with pyriproxyfen, 33.32% in lufenurone, 24.43 hydroprene and 17.76% in methoprene was recorded. Comparatively low mortality values 18.87, 15.07, 14.54 and 12.33% were recorded with lufenuron, pyriproxyfen, methoprene and hydroprene, accordingly. It was found that at lowest concentration, all the IGRs gave comparatively low and close results compared to that of higher concentrations indicating that concentration levels significantly affected the mortality values. Overall, pyriproxyfen was found comparatively more effective, then the lufenuron, methoprene and hydroprene was found least effective in mortality bioassay. This revealed that type of IGRs also found significant in bioassay. From results we concluded that almost all concentration and were IGRs were significant and there was a gradually increase in mortality values with increase in concentration of IGRs.

**MORTALITY DATA WITH INSECT GROWTH REGULATORS (IGRs) AGAISNT *Trogoderma granarium* AFTER 14 DAYS**

Table 4.21 revealed that the analysis of variance (ANOVA) of data regarding mean percentage mortality of *T. granarium* three insect growth regulators (IGRs) (Pyriproxyfen, lufenuron, hydroprene, methoprene). Data showed that main effects, IGRs (F=14.870; df=3: p<0.05) and concentration (F=62.119, df=3 p<0.05) were found significant concerning mortality response of *T. granarium*.

**Table 4.21 Analysis of variance (ANOVA) of the data concerning % mortality of *Trogoderma granarium* (Everst) for different concentrations of IGRs**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **IGRs** | 3 | 1208.41 | 402.80 | 14.870 \*\* |
| **Concentration** | 3 | 5048.02 | 1682.67 | 62.119 \*\* |
| **IGRs \*Concentration** | 9 | 558.87 | 62.10 | 2.292 \* |
| **Error** | 32 | 866.81 | 27.09 |  |
| **Total** | 47 | 7682.11 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.22 Comparison of percentage mortality of *Trogoderma granarium*  after exposure to various concentrations of Insect growth regulators**

| **Concentrations (ppm)** | **(%) Mean mortality ± SE** |
| --- | --- |
| **2.25** | 22.76 ± 2.83 b |
| **5.0** | 35.87 ± 2.50 b |
| **7.5** | 44.41 ± 1.55 a |
| **10** | 49.97 ± 1.79 a |

Data present in table 4.22 revealed that 22.76 % mean percentage mortality was recorded at 2.25% concentration and 49.97 % mortality was observed at 10 ppm concentration of the IGRs. While 44.41 % mortality was noticed at 7.5 ppm. From results we can determined that concentration was found very effective against mean percent mortality of *T. granarium*.

**4.23 Mean percentage mortality of *Trogoderma granarium* after exposure to 14 days**

| **IGRs** | **(%) Mean Mortality ± SE** |
| --- | --- |
| Pyriproxyfen | 45.56 ± 2.88 a |
| Lufenuron | 40.01 ± 3.95 a |
| Methoprene | 35.07 ± 3.01 b |
| Hydroprene | 32.44 ± 3.37 b |

Tabulated data 4.23 indicated percent mean mortality values after 14 days exposure period. Maximum mean percentage mortality 45.56 %was observed in Pyriproxyfen followed by 40.01 with Lufenuron, 35.07 % by methoprene while lowest 32.44 % was observed in case of Hydroprene. From data we conclude that pyriproxyfen was comparatively found more effective in mortality experiment.

**4.24 Interaction effect (IGRs × Concentration) for percentage mortality of *Trogoderma granarium***

| **IGRs × Concentration** | **(%) Mean Mortality ± SE** |
| --- | --- |
| Pyriproxyfen x2.25 | 33.32**±**3.84 f |
| Pyriproxyfen x 5.0 | 42.23**±**2.93de |
| Pyriproxyfen x 7.5 | 50.17**±**1.92 abc |
| Pyriproxyfen x10 | 56.65**±**1.92 a |
| Lufenuron x2.25 | 17.76**±**3.77 cd |
| Lufenuron x 5.0 | 40.02**±**1.92 bc |
| Lufenuron x 7.5 | 47.75**±**1.11 abcd |
| Lufenuron x10 | 53.44**±**1.11 ab |
| Methoprene x2.25 | 20.04**±**3.09 a |
| Methoprene x 5.0 | 37.76**±**1.11 |
| Methoprene x 7.5 | 37.76**±**2.21 |
| Methoprene x10 | 44.43**±**1.11 |
| Hydroprene x2.25 | 18.13**±**1.42 |
| Hydroprene x 5.0 | 23.32**±**3.33 |
| Hydroprene x 7.5 | 42.11**±**1.05 |
| Hydroprene x10 | 44.32**±**1.17 |

Table 4.24 reveaed that maximum mortality 56.65% was noticed at 10 ppm concentration of pyriproxyfen after exposure of 14 days followed by 53.44% with lufenuron while methoprene and hydroprene proved equally effective with mean percentage values of 44.43 and 44.32 %, accordingly at the same concentration. At 7.5 ppm, maximum mortality of 50.17% with pyriproxyfen, 47.75 in lufenuron, 42.11% in hydroprene. Methoprene gave 37.76% at both 7.5 and 5 ppm concentrations while 42.23, 40.02 and 23.32 mortality were recorded with Pyriproxyfen, lufenuron and hydroprene at 5.0 ppm concentration, accordingly. The lowest concentration of IGRs proved least effcive and comparatively low mortality values 33.32 was recorded by proxyfen, 20.04 in methoprene, 18.13 as with hydroprene and 17.76 % were recorded with lufenurone. Frome these findings we conclude that higher levels significantly affected the mortality values. Overall results indicated that, pyriproxyfen was found comparatively more effective, then the lufenuron, methoprene and hydroprene was found least effective in mortality bioassay. This revealed that type of IGRs also found significant in bioassay. From results we concluded that almost all concentration and were IGRs were significant and there was a gradually increase in mortality values with increase in concentration of IGRs.

**GROWTH INHIBITION DATA OF PLANT EXTRACTS**

Table 4.25 reveals the analysis of variance (ANOVA) of data regarding pupae inhibition of *Trogoderma granarium* with various concentrations of *Parthenium hysterophorus* L*.*, *Azadirachta indica*, *Concarpus erectus* and *Ricinus communis* that main effects, plants (F= 3.43, df=3, p<0.05) and concentration (F=153.91, df=2 p<0.05) were significant regarding mortality values of *T . Granarium*

**Table 4.25 Analysis of variance (ANOVA) of the data regarding % pupae inhibition of *Trogoderma granarium* (Everts) for different concentrations of plant extracts**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **Plant**  | 3 | 349.77 | 116.59 | 3.43\* |
| **Conc.** | 2 | 10436.79 | 5218.39 | 153.91\*\* |
| **Plant\* Conc.** | 6 | 590.00 | 98.33 | 2.90\* |
| **Error** | 23 | 779.80 | 33.90 |  |
| **Total** | 34 | 12731.57 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.26 Percent pupae inhibition effects of plant extracts against of *Trogoderma granarium***

| **Plants** | **(%) Pupal inhibition ± SE** |
| --- | --- |
| *Parthenium hysterophorus* | 30.17 ± 3.30 ab |
| *Ricinus communis* | 25.86 ± 2.88 c |
| *Concarpus erectus* | 36.51 ± 3.05 a |
| *Azadirachta indica* | 30.45 ± 3.60 ab |

Data in table 4.26 showed that pupae inhibition was 36.51 % was observed with *Concarpus erectus*. Inhibtion values were 30.45 and 30.17 % almost equal with *Azadirachta indica* and *Parthenium hysterophorus*. While lowest inhibition 25.86 % was given by extract of *Ricinus communis*. From the results we can conclude that extract of *C. erectus* and *A. indica* comparatively more effective than other two extracts against *T. granarium*.

**Table 4.27 Pupae inhibition effects of different concentrations of plant extracts against *Trogoderma granarium***

| **Concentration (%)** | **(%) Pupae inhibition ± SE** |
| --- | --- |
| **5** | 10.75± 1.39 c |
| **10** | 29.34± 2.06 b |
| **15** | 50.54± 2.83 a |

Table 4.27 revealed pupae inhibition values after application of different concentrations of plant extracts. Maximum mean percentage inhibition 50.54 % was observed at 15% concentration while lowest 10.75 % at lowest concentration. From the findings we conclude that concentration level was found effective in inhibition bioassay against *T . granarium*.

**4.28 Comparison of the pupae inhibition of *Trogoderma granarium* by different plants and concentrations**

| **Plants x Concentrations** | **(%) Pupae inhibition ± SE** |
| --- | --- |
| *Parthenium hysterophorus* x 5 | 12.03**±**3.12 cd |
| *Parthenium hysterophorus* x 10 | 30.86**±**1.23 bc |
| *Parthenium hysterophorus* x 15 | 47.61**±**3.14 ab |
| *Ricinus communis* x 5 | 7.38 **±**1.36 d |
| *Ricinus communis* x 10 | 31.27**±**3.40 bc |
| *Ricinus communis* x 15 | 44.42**±**3.40 ab |
| *Concarpus erectus* x 5 | 13.98**±**4.02 d |
| *Concarpus erectus* x 10 | 35.32**±**3.41 bc |
| *Concarpus erectus* x 15 | 63.21**±**3.06 a |
| *Azadirachta indica* | 10.61**±**2.33 d |
| *Azadirachta indica* | 22.21**±**2.18 d |
| *Azadirachta indica* | 59.52**±**2.91 a |

Table 4.28 showed that maximum pupae inhibition 63.21 % was observed at 15% concentration of *Concarpus erectus*, followed by 59.52 % in *Azadirachta indica* extract, 47.61 with *Parthenium hysterophorus* and 44.42 % in *Ricinus communis*. Inhibition values were 35.32, 31.27, 30.86 and 22.21% at 10% concentration in *C. erectus*, *R*. *communis*, *P*. *hysterophorus* and *A. indica*, respectively. At lowest concentration (5%), comparatively low inhibition values 13.98% with *C. erectus*, 12.03% in *P*. *hysterophorus*, 10.61 with *A. indica* and 7.38 % in *R*. *communis*, was recorded. From results we concluded that extracts were found effective especially *C. erectus* and *A. indica* which gave comparatively more pupae inhibition values than *R*. *communis* and *P*. *hysterophorus.* Relatively low inhibition values were observed at lower concentrations of all plant extract showing that concentration level was significant. An increased in inhibition response was recorded at increased concentration.

**ADULT INHIBITION DATA OF *TROGODERMA GRANARIUM* BY PLANT EXTRACTS**

Table 4.29 showed the analysis of variance (ANOVA) of data regarding adult inhibition of *Trogoderma granarium* with various concentrations of *Parthenium hysterophorus* L*.*, *Azadirachta indica*, *Concarpus erectus* and *Ricinus communis* that main effects, Plants (F=3.928, df=3: p<0.05) and concentration (F=159.985 df=2 p<0.05) were significant regarding mortality values of *T . granarium*

**Table 4.29 Analysis of variance (ANOVA) of the data regarding % adult inhibition of *Trogoderma granarium* (Everts) for different concentrations of plant extracts**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **Plant**  | 3 | 372.91 | 124.30 | 3.928 \* |
| **Conc.** | 2 | 10126.13 | 5063.06 | 159.985 \*\* |
| **Plant\* Conc.** | 6 | 680.88 | 113.48 | 3.586 \* |
| **Error** | 23 | 727.88 | 31.65 |  |
| **Total** | 34 | 12443.79 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.30 Percent adult inhibition effects of plant extracts against of *Trogoderma granarium***

| **Plants** | **(%) Adult inhibition ± SE** |
| --- | --- |
| *Parthenium hysterophorus* | 29.32 ± 4.19 c |
| *Ricinus communis* | 23.82 ± 2.88 c |
| *Concarpus erectus* | 36.51 ± 3.14 ab |
| *Azadirachta indica* | 40.24 ± 3.66 a |

Data in table 4.30 showed that maximum adult inhibition was 40.24 % was observed with *Azadirachta indica* extract. Inhibtion values were 30.45 and 29.32 % with *Concarpus erectus* and *Parthenium hysterophorus* while relatively low inhibition 23.82 % was observed in case of *Ricinus communis* extract. From the outcomes of the adult inhibition bioassay we can conclude that extract of *A. indica* and *C. erectus* were found comparatively more effective than other two extracts against *T . granarium*.

**Table 4.31 Adult inhibition effects of different concentrations of plant extracts against *Trogoderma granarium***

| **Concentration (%)** | **(%) Adult inhibition ± SE** |
| --- | --- |
| **5** | 10.75± 1.39 c |
| **10** | 27.24± 2.06 b |
| **15** | 53.85± 2.83 a |

 Table 4.31 revealed adult inhibition values after application of different concentrations of plant extracts. Maximum mean percentage inhibition 53.85% was observed at 15% concentration while lowest 10.75 % at lowest concentration. From the findings we conclude that concentration level was found effective in inhibition bioassay against *T . granarium*.

**4.32 Comparison of the adult inhibition inhibition of *Trogoderma granarium* by different plants and concentrations**

| **Plants x Concentrations** | **(%) Adult inhibition ± SE** |
| --- | --- |
| *Parthenium hysterophorus* x 5 | 15.63**±**1.43 d |
| *Parthenium hysterophorus* x 10 | 29.96**±**1.85 cd |
| *Parthenium hysterophorus* x 15 | 38.46 **±**2.23 bcd |
| *Ricinus communis* x 5 | 8.34 **±**2.39 d |
| *Ricinus communis* x 10 | 31.27**±**3.40 bcd |
| *Ricinus communis* x 15 | 41.44**±**3.28bc |
| *Concarpus erectus* x 5 | 13.12**±**4.14 d |
| *Concarpus erectus* x 10 | 33.31**±**3.41 cd |
| *Concarpus erectus* x 15 | 46.42**±**3.24 ab |
| *Azadirachta indica* | 12.08**±**2.47 cd |
| *Azadirachta indica* | 30.42**±**4.15 bc |
| *Azadirachta indica* | 56.42**±**2.91 a |

Table 4.32 showed that maximum adult inhibition 56.42 % was observed at 15% concentration of *Azadirachta indica*, followed by 46.42% in *Concarpus erectus* extract, 41.44with *Ricinus communis* and 38.46 % in *Parthenium hysterophorus*. Inhibition values were 33.31, 31.27, 30.42 and 29.96 % at 10% concentration in *C. erectus*, *R*. *communis*, *A. indica* and *P*. *hysterophorus*, respectively. At lowest concentration (5%), comparatively low inhibition values 15.63 % in *P*. *hysterophorus*, 13.12 with *C*. *erectus*,12.08 and 8.34 % in *R*. *communis*, was recorded. From results we concluded that extracts were found effective especially *A. indica* and *C. erectus* which gave comparatively more adult inhibition values than *R*. *communis* and *P*. *hysterophorus.* Relatively low inhibition values were observed at lower concentrations of all plant extract showing that concentration level was significant. An increased in inhibition response was recorded at increased concentration. Morover plant factor also found significant.

**GROWTH INHIBITION DATA OF INSECT GROWTH REGULATORS**

Table 4.33 reveals the analysis of variance (ANOVA) of data regarding pupae inhibition of *Trogoderma granarium* with various concentrations of Pyriproxyfen, Lufenuron, Methoprene, Hydroprene.Thethat main effects, IGRs (F= 14.739, df=3, p<0.05) and concentration (F=81.687, df=2 p<0.05) were significant regarding mortality values of *T . granarium*

**Table 4.33 Analysis of variance (ANOVA) of the data regarding % pupae inhibition of *Trogoderma granarium* (Everts) for different concentrations of IGRs after 7 days**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **IGRs** | 3 | 500.99 | 167.00 | 14.739 \*\* |
| **Conc.** | 2 | 1851.11 | 925.56 | 81.687 \*\* |
| **Plant\* Conc.** | 6 | 94.07 | 15.68 | 1.384 Ns |
| **Error** | 24 | 271.93 | 11.33 |  |
| **Total** | 35 | 2718.11 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.34 Percent pupae inhibition effects of insect growth regulators (IGRs) against of *Trogoderma granarium***

| **Plants** | **(%) Pupal inhibition ± SE** |
| --- | --- |
| Pyriproxyfen | 40.87 ± 3.32 ab |
| Lufenuron | 38.28 ± 1.73 c |
| Methoprene | 34.61 ± 2.72 a |
| Hydroprene | 30.18 ± 3.60 ab |

Data in table 4.34 revealed that pupae inhibition was 40.87 % was observed withPyriproxyfen. Inhibtion values were 38.28 and 34.61 % withLufenuron andMethoprene, accordingly. While lowest inhibition 30.18 % was given by extract of Hydroprene. From the results we can conclude that extract of Pyriproxyfen and Lufenuron were comparatively more effective than other two IGRs against *T . granarium*.

**Table 4.35 Pupae inhibition effects of different concentrations of insect growth regulators against *Trogoderma granarium***

| **Concentration (ppm)** | **(%) Pupae inhibition ± SE** |
| --- | --- |
| **2.5** | 27.08±1.65 c |
| **5.0** | 35.49±1.54 b |
| **7.5** | 44.64±1.20 a |

Table 4.35 revealed pupae inhibition values after application of different concentrations of IGRs. Maximum mean percentage inhibition 44.64 % was observed at 7.5 % concentration while lowest 27.08% at lowest concentration. From the findings we conclude that concentration level was found effective in inhibition bioassay against *T . granarium*.

**PUPAE INHIBITION DATA OF INSECT GROWTH REGULATORS AFTER 14 DAYS**

Table 4.36 reveals the analysis of variance (ANOVA) of data regarding pupae inhibition of *Trogoderma granarium* with various concentrations of Pyriproxyfen, Lufenuron, Methoprene, Hydroprene.Thethat main effects, IGRs (F= 20.980, df=3, p<0.05) and concentration (F=32.879, df=2 p<0.05) were significant regarding mortality values of *T . granarium*

**Table 4.36 Analysis of variance (ANOVA) of the data regarding % pupae inhibition of *Trogoderma granarium* (Everts) for different concentrations of IGRs after 14 days**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **IGRs** | 3 | 796.41 | 265.47 | 20.980 \*\* |
| **Conc.** | 2 | 832.06 | 416.03 | 32.879 \*\* |
| **Plant\* Conc.** | 6 | 224.49 | 37.42 | 2.957 \* |
| **Error** | 24 | 303.68 |  |  |
| **Total** | 35 | 2156.65 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.37 Percent pupae inhibition effects of insect growth regulators (IGRs) against of *Trogoderma granarium***

| **Plants** | **(%) Pupal inhibition ± SE** |
| --- | --- |
| Pyriproxyfen | 46.76 ± 3.48 a |
| Lufenuron | 45.32 ± 1.82 a |
| Methoprene | 39.90 ± 1.38 b |
| Hydroprene | 35.46 ± 1.22 b |

Data in table 4.37 revealed that pupae inhibition was 46.76 % was observed withPyriproxyfen. Inhibtion values were 45.32 and 39.90 % withLufenuron andMethoprene, accordingly. While lowest inhibition 35.46 % was given by Hydroprene. From the results we can conclude that Pyriproxyfen and Lufenuron were comparatively more effective than other two IGRs against *T . granarium*.

**Table 4.38 Pupae inhibition effects of different concentrations of insect growth**

**regulators against *Trogoderma granarium***

| **Concentration (ppm)** | **(%) Pupae inhibition ± SE** |
| --- | --- |
| **2.5** | 36.14±1.51 c |
| **5.0** | 42.28±1.79 b |
| **7.5** | 47.91±2.12 a |

Table 4.38 revealed pupae inhibition values after application of different concentrations of IGRs. Maximum mean percentage inhibition 47.91 % was observed at 7.5 % concentration while lowest 36.14 % at lowest concentration. From the findings we conclude that concentration level was found effective in inhibition bioassay against *T . granarium*.

**4.39 Comparison of the pupae inhibition inhibition of *Trogoderma granarium* by different inset growth regulars and concentrations**

| **Plants x Concentrations** | **(%) Pupae inhibition ± SE** |
| --- | --- |
| Pyriproxyfen x 2.5 | 34.96**±**4.25 d |
| Pyriproxyfen x 5.0 | 49.38**±**1.23 cd |
| Pyriproxyfen x 7.5 | 54.95 **±**1.19 bcd |
| Lufenuron x 2.5 | 40.91**±**1.94 d |
| Lufenuron x 5.0 | 45.67**±**1.23 bcd |
| Lufenuron x 7.5 | 51.38**±**2.19bc |
| Methoprene x 2.5 | 36.15**±**0.44 d |
| Methoprene x 5.0 | 39.50**±**1.23 cd |
| Methoprene x 7.5 | 43.44**±**2.38 ab |
| Hydroprene x 2.5 | 32.**±**0.39 cd |
| Hydroprene x 5.0 | 34.56**±**1.23 bc |
| Hydroprene x 7.5 | 39.28**±**2.06 a |

Table 4.39 showed that maximum pupae inhibition 54.95 % was observed at 7.5 ppm concentration of Pyriproxyfen, followed by 51.38 % in Lufenuron, 43.44% with Methoprene and 39.28% in Hydroprene. Inhibition values were 49.38, 45.67, 39.50 and 34.56 % at 5.0 ppm, respectively. At lowest concentration (2.5 ppm), comparatively low inhibition values 40.91% in Lufenuron, 36.15% with Methoprene,34.96 by pyriproxyfen and 32.53 in Hydroprene, was recorded. From results we concluded that IGRs were found effective especially Pyriproxyfen and Lufenuron which gave comparatively more adult inhibition values than Methoprene and Hydroprene*.* Relatively low inhibition values were observed at lower concentrations of all IGRs showing that concentration level was significant. An increased in inhibition response was recorded at increased concentration

**ADULT INHIBITION DATA OF INSECT GROWTH REGULATORS AFTER 7 DAYS**

Table 4.40 reveals the analysis of variance (ANOVA) of data regarding pupae inhibition of *Trogoderma granarium* with various concentrations of Pyriproxyfen, Lufenuron, Methoprene, Hydroprene.Thethat main effects, IGRs (F= 44.140, df=3, p<0.05) and concentration (F=78.441, df=2 p<0.05) were significant regarding mortality values of *T . granarium*

**Table 4.40 Analysis of variance (ANOVA) of the data regarding % adult inhibition of *Trogoderma granarium* (Everts) for different concentrations of IGRs after 7 days**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **IGRs** | 3 | 1150.22 | 383.41 | 44.140 \*\* |
| **Conc.** | 2 | 1362.70 | 681.35 | 78.441 \*\* |
| **Plant\* Conc.** | 6 | 20.09 | 3.35 | 0.385 NS |
| **Error** | 24 | 208.47 | 8.69 |  |
| **Total** | 35 | 2741.47 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.41 Percent adult inhibition effects of insect growth regulators (IGRs) against of *Trogoderma granarium***

| **Plants** | **(%) Adult inhibition ± SE** |
| --- | --- |
| Pyriproxyfen | 50.14 ± 2.49 a |
| Lufenuron | 46.95 ± 2.46 a |
| Methoprene | 39.32 ± 2.13 b |
| Hydroprene | 29.09 ± 2.29 c |

Data in table 4.41 revealed that adult inhibition was 50.14 % was observed withPyriproxyfen. Inhibtion values were 46.95 and 39.32 % withLufenuron andMethoprene, accordingly. While lowest inhibition 29.09 % was given by Hydroprene. From the results we can conclude that Pyriproxyfen and Lufenuron were comparatively more effective than other two IGRs against *T . granarium*.

**Table 4.42 Adult inhibition effects of different concentrations of insect growth regulators against *Trogoderma granarium***

| **Concentration (ppm)** | **(%) Adult inhibition ± SE** |
| --- | --- |
| **2.5** | 34.52±1.72 c |
| **5.0** | 43.27±1.85 b |
| **7.5** | 51.59±2.00 a |

Table 4.42 revealedadult inhibition values after application of different concentrations of IGRs. Maximum mean percentage inhibition 51.59% was observed at 7.5 % concentration while lowest 34.52% at lowest concentration. From the findings we conclude that concentration level was found effective in inhibition bioassay against *T . granarium*.

**ADULT INHIBITION DATA OF INSECT GROWTH REGULATORS AFTER 14 DAYS**

Table 4.43 reveals the analysis of variance (ANOVA) of data regarding pupae inhibition of *Trogoderma granarium* with various concentrations of Pyriproxyfen, Lufenuron, Methoprene, Hydroprene.Thethat main effects, IGRs (F= 44.140, df=3, p<0.05) and concentration (F=78.441, df=2 p<0.05) were significant regarding mortality values of *T . granarium*

**Table 4.43 Analysis of variance (ANOVA) of the data regarding % adult inhibition of *Trogoderma granarium* (Everts) for different concentrations of IGRs after 14 days**

| **S.O.V** | **DF** | **SS** | **MSS** | **F value** |
| --- | --- | --- | --- | --- |
| **IGRs** | 3 | 1179.09 | 393.03 | 48.57 \* |
| **Conc.** | 2 | 859.81 | 429.91 | 53.13\*\* |
| **Plant\* Conc.** | 6 | 78.63 | 13.10 | 1.62 NS |
| **Error** | 24 | 194.21 |  |  |
| **Total** | 35 | 2311.75 |  |  |

NS = Non-significant (P>0.05);\* = Significant (P<0.05); \*\* = Highly significant (P<0.01)

**Table 4.44 Percent adult inhibition effects of insect growth regulators (IGRs) against of *Trogoderma granarium***

| **Plants** | **(%) Adult inhibition ± SE** |
| --- | --- |
| Pyriproxyfen | 56.98 ± 1.90 a |
| Lufenuron | 53.17 ± 2.24 a |
| Methoprene | 44.97 ± 1.87 b |
| Hydroprene | 42.72± 1.87 c |

Data presented in table 4.44 revealed that adult inhibition was 56.98 % was observed withPyriproxyfen. Inhibtion values were 53.17 and 44.97 % withLufenuron andMethoprene, accordingly. While comparatively low inhibition 42.72% was given by Hydroprene. From the results we can conclude that Pyriproxyfen and Lufenuron were comparatively more effective than other two IGRs against *T . granarium*.

**Table 4.45 Adult inhibition effects of different concentrations of insect growth regulators against *Trogoderma granarium***

| **Concentration (ppm)** | **(%) Adult inhibition ± SE** |
| --- | --- |
| 2.25 | 50.14 ± 2.49 a |
| 5.0 | 46.95 ± 2.46 a |
| 7.5 | 39.32 ± 2.13 b |

Table 4.38 revealed adult inhibition values after application of different concentrations of IGRs. Maximum mean percentage inhibition 50.14 % was observed at 7.5 % concentration while lowest 39.32 % at lowest concentration. From the findings we conclude that concentration level was found effective in inhibition bioassay against *T . granarium*.

**CHAPTER 5 DISCUSSION**

**5.1. Mortality effects of plant extracts against *Trogoderma granarium* (Everst) at different concentration and time periods**

Present investigations were carried to find out the comparative insecticidal and growth inhibitory effects of carrot grass (*Parthenium hysterophorus* L.), neem (*Azadirachta indica*), Conocarpus (*Concarpus erectus*), castor bean (*Ricinus communis*) and three insect growth regulators (IGRs) (Pyriproxyfen, lufenuron, hydroprene, methoprene) against *Trogoderma granarium* (Everts) under controlled (laboratory) conditions.Experimentations were carried using Completely Randomized Design (CRD) and each treatment was replicated thrice along with control. Four different concentrations (5, 10, 15 and 20) of each extract and 2.5, 5, 7.5 and 10 ppm of IGRs were used. The data regarding mortality was recorded after 24, 48, 72 and 96 hr of the each treatment application. The growth inhibition experiment was also conducted at same application rate of each insecticide as well as in combination and data regarding larval, pupae and adults inhibition was observed after regular intervals of time.

 The projected study disclosed that maximum mortality 79.31% was examined with 20 % concentration of *Azadirachta indica* extract after exposure period of 96 hr, followed by 70.11% with *Concarpus erectus* extract, 59.76% by *Ricinus communis* extract while comparatively low 47.12% was observed in case of *Parthenium hysterophorus* extract. At 15% concentration, mortality values were 73.06, 58.39, 49.38 and 41.57, accordingly*.* Mean mortaliy values 74.09, 52.75, 43.86 and 33.67% were observed at 10% concentration of the plant extract. Comparatively low mean percentage mortality was observed at 5% concentration.

After exposure period of 72 hr Extracts of *Azadirachta indica* gave 57.35% followed by *Concarpus erectus* 38.16% and 37.01% with *Ricinus communis* (both extracs were equally effective) while lowest mean percent mortlity 12.23% was observed in *P. hysterophorus* extract at 5% concentration. Showed that maximum mortality 56.67% was examined with 20 % *Azadirachta indica* at 20% concentration, followed by 46.65 % with *Concarpus erectus* extract, 32.22% by *Ricinus communis* extract while comparatively low 23.21was observed in case of *Parthenium hysterophorus* extract. At 15% concentration, comparatively low mortality 51.10% was noticed in case of *A. indica* followed by 40.07% by *C. erectus*, 22.75% by *R.communis.* Extracts of *Concarpus erectus* and *Ricinus communis* gave 40.07 and 22.75% at 15% concentrations. While 18.19% was observed in case of *P*.hysterophorus. Mean mortality values 42.64, 32.56, 22.49 and 15.70% were observed at 10% concentration of the plant extract.

After 48 hr, maximum mean mortality 43.32% was recorded at 20 % concentration of *Azadirachta indica* after exposure of 48 hr, followed by 29.11% by extract of *Concarpus erectus*. *Ricinus communis* and *Parthenium hysterophorus* gave 23.32and 19.04 % mortality values at same concentration. At 15% concentration, mean percentage mortality 18.86 % was recorded with application of *Concarpus erectus* extract, followed by 14.59% with *Ricinus communis*, 13.32% by *P*. *hysterophorus* and 11.67 % by *A. indica* extract. At 10% concentration, mortality values 15.85, 13.63, 11.30 and 7.93 was observed with *A. indica*, *C*. *erectus*, *R*. *communis* and *P*. *hysterophorus*, accordingly. Comparatively lower mean mortality values 15.67(*A. indica* extract), 10.07(with *P*. *hysterophorus*), 9.59 (*Concarpus erectus*) and 7.32 % (in *Ricinus communis*) was recorded at 5% concentration of plant extracts.

With exposure period of highest mortality 27.76% at highest concentration 20% of *Concarpus erectus* after exposure period of 24 hr. The extract of *Azadirachta indica* and *Parthenium hysterophorus* proved effective with percentage mortality values of 16.67 and 16.65, accordingly. At 15% concentration, *Concarpus erectus* gave 15.56%, followed by *Azadirachta indica* (10.02%), *Ricinus communis* (7.76%) while lowest 6.67% was observed in case of *P.hysterophorus* extract at same concentration. Mean percentage mortality at 10% concentration was 15.56% followed by 7.76% as in case of *A*. *indica* extract, 4.43% with *R*. *communis* extract and comparatively low mortality3.32% was recorded with *P*. *hysterophorus*. Comparatively low mortality values were observed at lowest concentration 5% of each extract and highest percentage mortality 5.56% with application of *Azadirachta indica* extract while lowest1.41% was observed in case of *P.hysterophorus*.

The findings of our (current) study are close toMuntaha *et al*., 2017 who recorded increased mortality at increased concentrations of the plant extracts. The mortality results of current (our) study are also in accordance with Ali *et al*. (2017) who used plant extracts against *Rhyzopertha dominica* and observed increased mortality at high concentration. Dwivedi and Shekhawat, 2004 used some plant extracts against *T. granarium* and found increased mortality at increased concentration of plant extracts similar to our study. Our results are in accordance with the Hameed *et al*. (2012) checked the toxicity of a bio-derived insecticide Spinosad and two extracts; A. indica Nerium oleander were evaluated against T. castaneum (Hbst). Mortality values of T.castaneum up to 50% were obtained with neem and kanair close to our results of study. Mortality was found high at increased concentrations. A slight difference may be due to different plant extracts and insect species, used. Mortality trend in our study was similar to Hassan *et al*., 2005 who evaluated the comparative ethanolic extracts of *Amaranthus viridis* l. and *Salsola baryosma* (schultes) and Cypermethrin against *Trogoderma granarium* (everts) and recorded increased mortality at increased concentration of plant extracts.

Mondal and Khalequzaman (2006) evaluated the insecticidal effect of *Elletraria cardamomum*, *Syzgium aromaticum* and *Cinnamomum aromaticum* against the *T. castaneum* under controlled (laboratory) conditions. The outcomes revealed that Cinnamon oil and Cardamom gave significant results in mortality bioassay about the test insect pest of stored commodities quit close with results of our study. With the increase in plant extract concentration the mortality of insect pests increased same trend was observed in our study.

The results of our study were similar with Hasan *et al.* (2005) who concluded that mortality of test insect increases with increase in plant extract concentration and exposure period. Two plant extracts *Salsola baryosma* and *Amaranthus vitidis* were evaluated for mortality against *Trogoderma granarium*. These extracts showed different mortality trend against the target insects, when different concentration were used then various data about mortality obtained. By increasing the plant extract concentration the mortality of insect pests increased similar trend was observed in our study.

After the valuating the efficacy of *Salsola baryosma* and *Amaranthus vitidis*, Sagheer *et al.* (2013) reported about the effect of five indigenous plant extracts (*Azadirachta indica, Murraya exotica, Eucalyptus comeldulensis*, *Trachspermum ammi* and *Teminalia chebula*) at a rate of 5, 10 and 15 % concentrations against the *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). The mortality responseof tested insect was recorded increased at increased concentration. The mortality trend was found similar to our study, increased mortality was found at increased concentrations in present study.

Musa, 2013 evaluated toxic potential of plant powders against the Adults and larvae of Khapra beetle, *Trogoderma granarium* Everts (Coleoptera: Dermestidae) using groundnut treated with plant extracts and recorded increased mortality at high concentration similar to our study.

Our results are in accordance with Khan *et al*.(2013) who evaluated the laboratory experimentations were conducted for the evaluation of contact and repellent activities of acetone based plant extracts of *Allium sativum* (Garlic), *Azadirachta indica* (Neem), *Citrus limon* (Lemon) and *Eucalyptus globules* (Safaida) against the insect pest of stored grain commodities, *Tribolium castaneum*. Various concentrations (5, 10 and 15%) of the plant extracts were applied on the filter papers in the bioassay experiments and after the release of 15d old beetles, mortality was evaluated after fixed intervals (24, 48, 72, 96, 120, 144 and 168h). Increased mortality was found at increased concentrations of plants.

Plant extracts and concentration interaction results for most of the treatments remained significant. The overall results showed increased mortality with increase in concentration and exposure period.

**5.1.2 GROWTH INHIBITION DATA OF PLANT EXTRACTS**

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In pupal inhibition bioassay, maximum pupae inhibition 63.21 % was observed at 15% concentration of *Concarpus erectus*, followed by 59.52 % in *Azadirachta indica* extract, 47.61 with *Parthenium hysterophorus* and 44.42 % in *Ricinus communis*. Inhibition values were 35.32, 31.27, 30.86 and 22.21% at 10% concentration in *C. erectus*, *R*. *communis*, *P*. *hysterophorus* and *A. indica*, respectively. At lowest concentration (5%), comparatively low inhibition values 13.98% with *C. erectus*, 12.03% in *P*. *hysterophorus*, 10.61 with *A. indica* and 7.38 % in *R*. *communis*, was recorded.

In case of adult inhibition, maximum adult inhibition 56.42 % was observed at 15% concentration of *Azadirachta indica*, followed by 46.42% in *Concarpus erectus* extract, 41.44with *Ricinus communis* and 38.46 % in *Parthenium hysterophorus*. Inhibition values were 33.31, 31.27, 30.42 and 29.96 % at 10% concentration in *C. erectus*, *R*. *communis*, *A. indica* and *P*. *hysterophorus*, respectively. At lowest concentration (5%), comparatively low inhibition values 15.63 % in *P*. *hysterophorus*, 13.12 with *C*. *erectus*,12.08 and 8.34 % in *R*. *communis*, was recorded. From results we concluded that extracts were found effective especially *A. indica* and *C. erectus* which gave comparatively more adult inhibition values than *R*. *communis* and *P*. *hysterophorus*

**5.1.3 MORTALITY WITH IGRs**

Maximum mortality 55.76 % was noticed at 10 ppm concentration of pyriproxyfen after exposure of 7 days followed by 48.87% with lufenuron, 36.67% by methoprene while lower 34.43% was recorded in 10 ppm concentration of Hydroprene. Almost equal mortality results 41.67 and 40.10 were recorded with Pyriproxyfen and lufenuron at 7.5 ppm concentrations, accordingly. Mortality values 28.87 and 22.76% wer observed in Methoprene and Hydroprene, respectively with same concentration. At 5.0 ppm mortality values of 35.56 with pyriproxyfen, 33.32% in lufenurone, 24.43 hydroprene and 17.76% in methoprene was recorded. Comparatively low mortality values 18.87, 15.07, 14.54 and 12.33% were recorded with lufenuron, pyriproxyfen, methoprene and hydroprene, accordingly.

With exposure period of 14 days, maximum mortality 56.65% was noticed at 10 ppm concentration of pyriproxyfen after exposure of 14 days followed by 53.44% with lufenuron while methoprene and hydroprene proved equally effective with mean percentage values of 44.43 and 44.32 %, accordingly at the same concentration. At 7.5 ppm, maximum mortality of 50.17% with pyriproxyfen, 47.75 in lufenuron, 42.11% in hydroprene. Our findings of mortality against *Trogoderma granarium* are close to Nayar *et al*., 2002 who checked the effectiveness and comparison of granular formulations of insect growth regulators pyriproxyfen and s-methoprene against Florida mosquitoes and recorded increased mortality trend at high concentration similar to our trend of study. Findings of our study are close to Arthur *et al*. (2018) who found comparative toxic effect of *Beauveria bassiana* and IGRs for *T*. *castaneum* (Herbst) and *T. granarium* (Everts) and noticed increased mortality at increased concentration similar to our study. The findings of current study are in accordance with Bilal *et al*. (2017) who evaluated the comparative efficacy of *B. bassiana* and Pyriproxyfen and recorded increased mortality at high mortality similiar trend as in our study

**5.1.4 GROWTH IHIBITION DATA WITH IGRs**

In case of pupal inhibition after 7 days, pupae inhibition was 40.87 % was observed withPyriproxyfen. Inhibtion values were 38.28 and 34.61 % withLufenuron andMethoprene, accordingly. While lowest inhibition 30.18 % was given by extract of Hydroprene

In case of pupae inhibition after 14 days, maximum pupae inhibition 54.95 % was observed at 7.5 ppm concentration of Pyriproxyfen, followed by 51.38 % in Lufenuron, 43.44% with Methoprene and 39.28% in Hydroprene. Inhibition values were 49.38, 45.67, 39.50 and 34.56 % at 5.0 ppm, respectively. At lowest concentration (2.5 ppm), comparatively low inhibition values 40.91% in Lufenuron, 36.15% with Methoprene,34.96 by pyriproxyfen and 32.53 in Hydroprene, was recorded.

After 14 days, maximum mean percentage adult inhibition 50.14 % was observed at 7.5 % concentration while lowest 39.32 % at lowest concentration.

**Chapter 6**

**SUMMARY**

Present investigations were carried to find out the comparative insecticidal and growth inhibitory effects of carrot grass (*Parthenium hysterophorus* L.), neem (*Azadirachta indica*), Conocarpus (*Concarpus erectus*), castor bean (*Ricinus communis*) and three insect growth regulators (IGRs) (Pyriproxyfen, lufenuron, hydroprene, methoprene) against *Trogoderma granarium* (Everts) under controlled (laboratory) conditions.Experimentations were carried using Completely Randomized Design (CRD) and each treatment was replicated thrice along with control. Four different concentrations (5, 10, 15 and 20) of each extract and 2.5, 5, 7.5 and 10 ppm of IGRs were used. The data regaring mortality was recorded after 24, 48, 72 and 96 hr of the each treatment application. The growth inhibition experiment was also conducted at same application rate of each insecticide as well as in combination and data regarding larval, pupae and adults inhibition was observed after regular intervals of time. In maximum mortality bioassay, 79.31% was examined with 20 % concentration of *Azadirachta indica* extract after exposure period of 96 hr while lowest was observed after 24 hr of exposure period and extract of Conocarpus erctus and Azadirachta were found comparatively more better than other two extracts.In growth inhibition bioassay, maximum pupae inhibition 63.21 % was observed at 15% concentration of *Concarpus erectus*, followed by 59.52 % in *Azadirachta indica* extract. In case of adult inhibition, maximum adult inhibition 56.42 % was observed at 15% concentration of *Azadirachta indica*, followed by 46.42% in *Concarpus erectus* extract, 41.44 with *Ricinus communis* and 38.46 % in *Parthenium hysterophorus*. Inhibition values were 33.31, 31.27, 30.42 and 29.96 % at 10% concentration in *C. erectus*, *R*. *communis*, *A. indica* and *P*. *hysterophorus*, respectively. At lowest concentration (5%), comparatively low inhibition values 15.63 % in *P*. *hysterophorus*, 13.12 with *C*. *erectus*,12.08 and 8.34 % in *R*. *communis*, was recorded. From results we concluded that extracts were found effective especially *A. indica* and *C. erectus* which gave comparatively more adult inhibition values than *R*. *communis* and *P*. *hysterophorus*. In case of IGRs, Maximum mortality 55.76 % was noticed at 10 ppm concentration of pyriproxyfen after exposure of 7 days followed by 48.87% with lufenuron. At 5.0 ppm mortality values of 35.56 with pyriproxyfen, 33.32% in lufenurone, 24.43 hydroprene and 17.76% in methoprene was recorded. In case of pupal inhibition after 7 days, pupae inhibition was 40.87 % was observed withPyriproxyfen. Inhibtion values were 38.28 and 34.61 % withLufenuron andMethoprene, accordingly. In case of pupae inhibition after 14 days, maximum pupae inhibition 54.95 % was observed at 7.5 ppm concentration of Pyriproxyfen, followed by 51.38 % in Lufenuron, 43.44% with Methoprene and 39.28% in Hydroprene. Inhibition values were 49.38, 45.67, 39.50 and 34.56 % at 5.0 ppm, respectively. At lowest concentration (2.5 ppm), comparatively low inhibition values 40.91% in Lufenuron, 36.15% with Methoprene,34.96 by pyriproxyfen and 32.53 in Hydroprene, was recorded.

From the results of our study we conclude that bBoth these tactics IGRs especially Lufenuron and Pyriproxyfen comparatively proved more effective effective in mortality as well as growth inhibition bioassays as compared to the other two IGRs. In case of plant extracts, extracts of *Azadirachta indica* and *Conocarpus erectus* gave relatively more effective results than the other two extracts. Concentration of IGRs and plant extracts were also found significant. Exposure time was alo found siginificant regarding all mentioned bioassays of the test insect, especially longest exposure (96 hr) which gave comparatively better results. So, from above discussion we can conclude that both IGRs and plant extracts are effective insect pest management tools that can be used in an integrated manner for efficient management of stored grain insect pests.

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