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Biopotency of *Acorus calamus*, *Wthania somnifera* and *Azadirachta indica* in suppressing oviposition and adult emergence, caused by of *Callasobruchus chinensis* (L) infesting stored chickpea seeds in U.P.

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Abstract
Experiments were conducted in Biopesticides and Toxicological Laboratory, Department of Zoology, D.B.S. College, affiliated to CSJM University Kanpur, India. In the present investigation ten naturally indigenous plant parts viz; aerial parts of *Adhatoda vasica* Nees., *Cassia tora* Linn., *Vitex negundo* Linn., *Withania somnifera* Dun., unripe fruits of *Lantana camara* Linn., *Momordica charantia* Linn., ripe seeds of *Azadirachta indica* A.Juss, *Gynendropsis pentaphylla* L., rhizomes of *Acorus calamus* Linn, *Alpinia galanga* (Linn.) Willd. extracts have been used for their biological efficacy against *Callosobruchus chinensis* L. (pulse beetle) on stored gram, chickpea *Cicer arietinum* L. ver. Kabuli (Fabales: Fabaceae) was used for oviposition deterrent and adult emergence trial under laboratory condition. Three concentrations viz. 0.5, 1.0 and 2.0 per cent of each plant extract were selected and tested by dry film technique for early emerge beetles of *C. chinensis* on pulse grains. The data depicted from results that maximum number of eggs laid per hundred grains are as*: A. calamus* (12.67) followed by *L.camara* (15.01) > *W. somnifera* (15.02) and *A. indica* (15.26), respectively. Minimum number of eggs bearing seeds / per hundred seeds was observed *A. calamus (*11.33) followed by *M. charantia* (12.42) > *L. camara* (15.01) > *W. somnifera* (15.02) and *A. indica* (15.26), respectively. The data depicted in results indicated that extracts of *A.calamus* registered highest resistance to adults emergence (22.67%), when compared to other extracts have registered encouraging results as: *M. charantia* (36.67) followed by *A. indica* & *L. camara* (42.67) and *W. somnifera* (42.70), respectively.

Keywords: *callosobruchus chinensis*, *acorus calamus*, *lantana camara* and *withania somnifera*

Introduction

Pulse beetle, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae) is most destructive pest of stored pulses and cause both qualitative and quantitative losses in legumes. (Dwivedi and Maheswari, 1997; El-Nahal *et al.* 1989; Kachare *et al.* 1995; Khaire *et al.* 1992; 2017) [18, 19, 25, 26, 7]. The *C. chinensis* is infested on economically important leguminous grains such as chickpea, cowpea, green gram, lentil and black gram, (Khan and Borle, 1985, Kurnar *et al.* 1990, Kumari, *et al.* 1988, Pandey *et al.* 1976 & 1986) [27, 29, 30, 39, 40]. It is a pest of stored pulses in Asia and Africa (Maredia *et al*. 1992, Uvah and Ishaya, 1993, Rehman *et al*. 2009, Sangappa, 1977, Schmutterer, 1990, Seck, 1993) [33, 52, 42, 45, 46, 47]. *Callosobruchus* spp. cause 12-13% loss by feeding the protein contents of grains (Agarwal, *et al.* 1988, Su, 1991; Wada and Munakata, 1955) [2, 49, 55]. *C. chinensis* causes up to 10% damage to stored chick pea Chandel and Bhadauria,2015, Chandel and Singh, 2016) [7, 8, 9, 10, 11] and up to 90% loss to stored gram Richa *et al.* 1995 [44]. In order to manage the deterioration, more and more synthetic fumigants are being used, but unfortunately they posed various side effects on human health like carcinogenicity and hormonal imbalance etc. (Das, 1986; Shifa *et al*. 2010) [15, 43, 48]. With the limitations on the use of current pest control methods, there is scope for the discovery of safe, non-polluting, bio-rational pest management technologies for stored products. (Negi *et al*. 1997; Pajni, *et al*. 1996; Teotia and Pandey, 1979; Varma and Pandey, 1978; Wilson, 1988 and Yadav and Bhatnagar, 1987) [35, 38, 51, 53, 56, 57]. In view to combat the above problem of ill effect of synthetic insecticides on pulses in storage under the varied ecological conditions, an attempt has therefore, been made to evaluate relative oviposition deterrence and adult emergence effect of different formulations of ten naturally occurring indigenous plant extract against early emerged pulse beetle, *Callosobruchus chinensis* Linn.

Materials and method

Procurement of raw plant materials

After preliminary experiment of aqueous extract on different aspects mention already in first report, the regular experiments of selected 10 botanical soxhlet extractives regarding oviposition deterrent and adult emergence bioefficacy were conducted under laboratory conditions. The plants parts used for extracts were collected mainly from wasteland and wild areas and some plants were collected from cultivated fields of the farmers. The investigations on the screening of various available indigenous naturally occurring plant extracts on one hand viz., aerial parts of *Adhatoda vasica* Nees., *Cassia tora* Linn., *Vitex negundo* Linn., *Withania somnifera* Dun., unripe fruits of *Lantana camara* Linn., *Momordica charantia* Linn., ripe seeds of *Azadirachta indica* A.Juss, *Gynendropsis pentaphylla* L., rhizomes of *Acorus calamus* Linn, *Alpinia galanga* (Linn.) Will were screened for their bioefficacy insecticidal against pulse beetle, *Callosobruchus chinensis* Linn. In laboratory.

Preparation of powder
Fresh collected green plant parts (leaves, Flowers and seeds, rhizomes etc.) were washed with distilled water and kept in the laboratory for 7 days for air drying followed by one day sun drying before making powder. Electric grinder was used to have coarse powder then these were passed through a 60-mesh sieve to get fine powder. Powders were kept in polythene bags at room temperature and properly sealed to prevent quality loss (Chandel and Singh, 2016).

Preparation of botanical extracts
For the extraction, Soxhlet Apparatus was used; about 20g powder of each category of powder were extracted with 300 ml of different solvents (n-hexane, acetone, methanol, petroleum ether and distilled water). Extraction of each category of powder were done in about 12 hrs. After soxhlet extraction, the material was run on rotary evaporator. The extracts were concentrated on rotary evaporator by removing the excess solvent under vacuum. After evaporation of solvent with rotary evaporator the remaining extracted material was kept on water bath for removing remaining solvent from the extracts. The extracts were stored at 4°C prior to application.

Apparatus used for experiment
Small plastic jars (capacity 50 ml) were used for the experiment; there was one set of two jars joined by clear plastic pipe of 1cm diameter at an angle of 180 degree for each replication. One jar of each set was provided with 10 g of grains given the name ‘A’ while the other jar was kept empty and given the name ‘B’. In jar ‘A’, the grains treated with extracts were placed, while the jar B remained empty. The jars used for experiment were disinfected with alcohol.

Preparation of Stock Solution and Insecticidal formulations
For stock solution, 50ml. extract in each case was taken into reagent bottles and 50ml. benzene was added in it to dissolve the constituents of the materials. The mouth of the bottles were stopper with airtight corks after which, these bottles containing the solutions were kept in refrigerator. Five concentrations (0.5, 1.0, 2.0 percent) were used for experiments on insecticidal and repellent tests in the laboratory conditions. However, only three concentrations (0.5, 1.0 and 2.0 percent)were used for insecticidal test in the laboratory and contact test in the field experiment. The different concentrations of the herbal extracts were prepared from the stock solution using benzene as solvent and Triton X-100 as emulsifier. The level of solvent and emulsifier were kept constant.

Experimental Protocol
Oviposition Deterrent and adult Emergence Bioassay
Fifty gram of healthy chickpea seeds were taken in a plastic container (300 ml) and mixed with 2.0% of each tested extract (v/w) and then air dried for 30 minutes. Five pairs of newly emerged one day old adult beetles were released in each plastic container and the mouth was closed with its lid. Each treatment was replicated thrice including control. All treated containers were kept at ambient room temperature (27-30ºC) in the laboratory for oviposition. After 7 days, dead and alive beetles were removed from each container and seeds along with eggs were kept in the laboratory for further development of the insect. The efficacy of plant materials as protectant of chickpea seeds against *C. chinensis* was assessed considering oviposition, adult’s emergence done. The da
For the experimentation and observation of oviposition of the pulse beetle, *C. chinensis*, one hundred (100) seeds were collected randomly from each plastic container of each treatment and examined under 10x magnifying glass and the number of seeds along with eggs (egg bearing seeds) and the number of eggs deposited were counted. After each observation, the grains were returned to the respective containers for the further development of the beetle. The adults were counted and removed daily from each plastic container and the data were recorded It is obvious from Table-1 and figure-1 that maximum number of eggs laid per hundred grains *are as: Mantisalca duriaei* (257.00) > *Inula racemosa* (69.00) > *Scorzonera undulate* (51.33) > *Rhaponticum acaule* (48.33) > *Spilanthes paniculata* (48.33) > *Cichorium intybus* (40.67) > *Reichardia tingitana* (40.33) > *Chrysanthemum cinerariaefolium* (34.00) > *Tagetes minuta* (26.67) > *Chromolaena odorata* (23.00), respectively.

Table 1: Potential of plant extracts on oviposition inhibition and adult emergence of pulse beetle, *C. chinensis* on chickpea seeds

Plant Extracts	No. of eggs/100 seeds	TB	No. of eggs bearing seeds /100 seeds	TB	No. of adults Emergence	TB
A. calamus	12.67	1.09	11.33	1.04	22.67	1.35
A. indica	26.00	1.40	24.67	1.38	42.67	1.62
A. vasica	33.00	1.49	28.67	1.14	57.00	1.47
G. pentaphylla	76.33	1.87	64.33	1.80	148.00	2.17
J. curcus	54.67	1.74	48.33	1.68	109.67	2.04
L. camara	18.33	1.25	16.67	1.21	42.67	1.63
M. charantia	31.00	1.48	27.33	1.43	36.67	1.57
V. negundo	63.00	1.80	51.67	1.71	113.00	2.05
W. somnifera	18.35	1.27	16.69	1.23	42.70	1.66
Z. officinale	54.33	1.73	45.00	1.65	112.00	2.04
Control	94.33	1.97	77.67	1.89	190.00	2.28

Results and Discussion
The bioassay test were carried out by following standard protocol which revealed that number of eggs per hundred cowpea seeds was observed significantly at various extractives. The data depicted in results indicated that soxhlet extracts of *A. calamus* registered highest resistance number of egg per hundred seeds to cowpea seed (12.67), when compared to other extracts have registered encouraging results

having number go egg laying per 100 cowpea seeds. as: *L. camara* (15.01) > *W. somnifera* (15.02) > *A. indica* (15.26) > *A. vasica* (20.03) > *Z. officinale* (31.53) > *V. negundo* (35.01) > *J. curcus* (35.25) > *G. pentaphylla* (48.26) > control (94.33), respectively.

Similarly, the bioassay test were carried out by following standard protocol which revealed number of eggs bearing seeds per 100 seeds of cowpea significantly at various extractives. The data depicted in results indicated that soxhlet extracts of *A.calamus* registered highest resistance to cowpea eggs bearing seeds (11.33%) when compared to other extracts have registered encouraging results as: *M. charantia* (12.42) > *L. camara* (15.01) > *W. somnifera* (15.02) > *A. indica* (15.26) > *A. vasica* (20.03) > *Z. officinale* (31.53) > *V. negundo* (35.01) > *J. curcus* (35.25) > *G. pentaphylla* (48.26) > Contro (77.67), respectively. In continuation of above findings the bioassay test were carried out by following standard protocol which revealed that number of adults beetle *C.chinensis* emerged from seeds significantly at treated with various extractives. The data depicted in results indicated that soxhlet extracts of *A.calamus* registered highest resistance to for adults emergence in *A. calamus* (22.67%) when compared to other extracts have registered encouraging results as: *M. charantia* (36.67) > *A. indica* & *L. camara* (42.67) > *W. somnifera* (42.70) > *A. vasica* (57.00) > *J. curcus* (109.67) > *Z. officinale* (112.00) > *V. negundo* (113.00) > *G. pentaphylla* (148.00)> Control (190.00), respectively.

In the present experiment, it was also observed that the number of insects emerged was proportional to the number of eggs deposited on the grains within a period of one week. Agarwal *et al.* (1973) [3] have observed this type of reduction in adult emergence of *C. chinensis* from grains treated with extract of *Acorus calamus*. Besides above, many workers also reported effective ovipositional biopotency of *A.calmus* against stored grain pest. (Chandel *et al.* 2000, Imam, *et al.* 2013, Jilani *et al.* 1988) [6, 22, 24]. Remarkable decrease in the adult emergence of *C. chinensis* with increase in concentration of *Lantana camara* extracts was also reported by Dua *et al*, 2010, Ling and Zhang, 2005; Ogendo *et al*, 2003; Rajashekar and Bakthavatsalam) [17, 32, 36, 43]. Khan and Marwat (2004) [28] reported the effects of *Azadirachta indica* extracts on adult emergence against lesser grain borer, *Rhyzopertha dominica* F. Similarly, effect of *Azadirachta indica* was also reported as protectants to stored product pest (Pradhan *et al.*1963; Zanno *et al.* 1975; Yadav, 1985; Das, 1986; Ivbijaro, 1990; Dharmasena *et al.* 1998, Lale and Abdulrahman, 1999) [41, 59, 57, 15, 23, 16, 31]. Their studies revealed that there was a significant reduction in adult emergence with increased exposure period and concentration of the extract. (Chander *et al.* 1997; Chavan *et al.* 1997 and Haridasan and Gokuldas, 2009) [12, 13, 20] reported the effects of *Vitex negundo* leaf extracts on adult emergence of the stored product pest, *Tribolium castaneum*. Their studies revealed that there was a significant reduction in adult emergence with increased exposure period and concentration of the extract. Considerable reduction in adult emergence was found in different concentrations. The results thus are in agreement with the earlier studies thus suggesting that adult emergence was greatly reduced in treated seeds than control seeds.

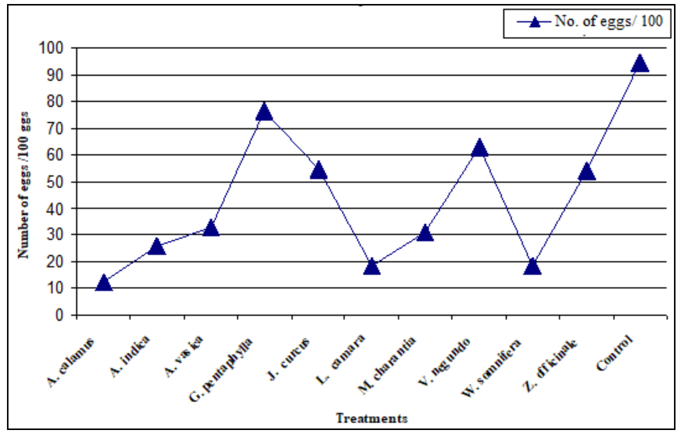

Fig 1: Bioefficacy of Certain Plant extracts showing number of *C. chinensis* eggs laid/100 chickpea seeds

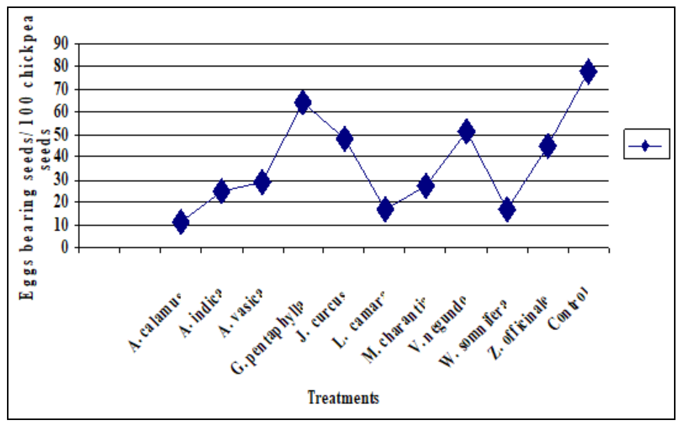

Fig 2: Bioefficacy of certain plant extracts showing number of *C. chinensis* eggs bearing seeds/100 chickpea seeds

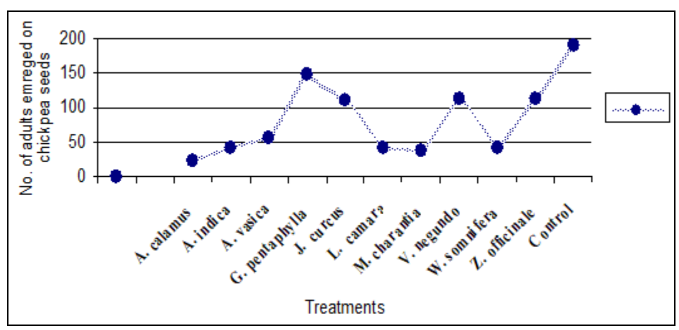

Fig 3: Bioefficacy of extracts showing number of *C. chinensis* adults emergence on chickpea seeds

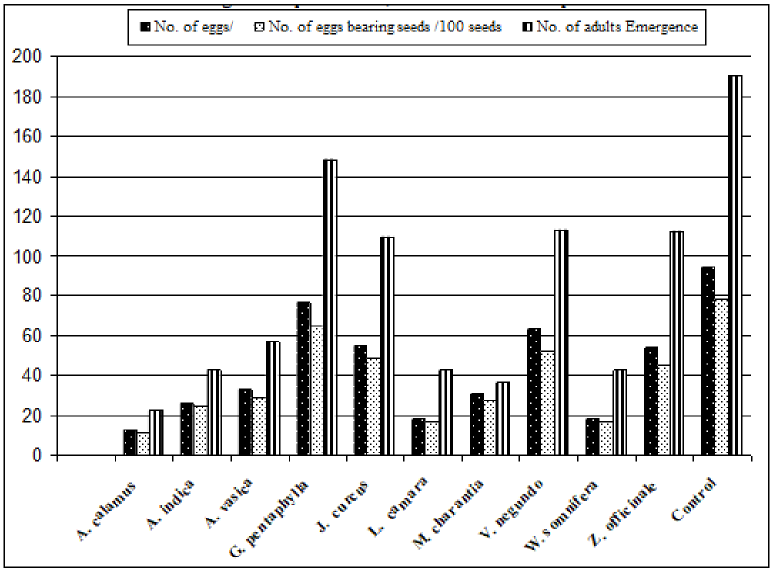

Fig 4: Comparative bipotential of plant extracts on oviposition inhibition and adult emergence of pulse beetle, *C. chinensis* on chickpea seeds

Conclusion

Conclusively, the present investigation revealed that there appears prospects in selected botanicals *Acorus calamus, Lantana camara, Withamnia somnifera* and *zadirachta indica* registered promising egg laying inhibiting capacity (1.00 to 15.26%) to the *C. chinensis,* when compared to other extracts and control. The number of eggs bearing seeds per 100 seeds of cowpea significantly at various extractives. The data depicted in results indicated that soxhlet extracts of *A.calamus* registered highest resistance to cowpea eggs bearing seeds (11.33%) when compared to other extracts have registered encouraging results as: *Momordica charantia* >*Lantana camara* > *Withanmia somnifera* > *Azedirachta indica* (1.00 to 15.26%) of treated seed done by selected extractives.The data depicted in results indicated that soxhlet extracts of *A.calamus* registered highest resistance to for adult's emergence in *A. calamus* (22.67%) when compared to other extracts have registered encouraging results as: *M. charantia*, *A. indica*, *L. camara,* and *W. somnifera* (36.67 to 42.70), respectively.

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References

1. Abbott WS. A method of computing the effectiveness of insecticides. Journal of Economic Entomology, 1925; 18:265-267.
2. Agarwal A, Lal S, Gupta KC. Natural products as protectants of pulses against pulse beetles. Bulletin of Grain Technology, 1988; 26:154-164.
3. Agarwal DC, Deshpande RS, Tipnis HP. Insecticidal activity of Acorus calamus on stored grain insects. J. Pesticides, 1973; 7:21-22.
4. Ali SIG, Singh OP, Mishra US. Effectiveness of plant oils against pulse beetle, Callosobruchus chinensis. Indian J. Ent., 1983; 45:6-9.
5. Bhatnagar A, Sharma VK, Bhatnagar A. Studies on the ovicidal action of non-edible oils against maize stem borer, Chilo partellus. J Insect Sci., 1996; 8:217-219.
6. Chandel, BS, Chauhan RRS, Alok Kumar. Phagodeterrent efficacy of rhizome extract of sweetflag, Acorus calamus against Tribolium castaneum. Ind. J. Ent., 2000; 63:8-10.
7. Chandel BS, Bhadauria DS. Impact of bio-chemical parameters on pigeonpea varieties against egg laying, fecundity and viability of pulse beetle, Callosobruchus chinensis Linn. Journal of Entomology and Zoology Studies. 2015; 3(2):109-117.
8. Chandel BS, Bhadauria DS. Assessment of resistance to the attack of pulse beetle, Callosobruchus chinensis L. in chickpea genotypes on the basis of various physical parameters during storage. Journal of Entomology and Zoology Studies. 2015; 3(2):160-165.
9. Chandel BS, Arti Singh. Exploration of Chromolaena odorata, Spilanthes paniculata, Tagetes minuta, Scorzonera undulata and Mantisalca duriaeri as Insecticides against Callosobruchus chinensis Linn. Coleoptera: Bruchidae. Life Science Bulletin. 2016; 13(2):193-196.
10. Chandel BS, Arti Singh. Phagodeterrent bioefficacy of Acorus calamus, Withania somnifera and Momordica charantia against chickpea bruchids, Callosobruchus chinensis Linn. Coleoptera: Bruchidae, Journal of Entomology and Zoology Studies. 2017; 5(6):935-939.
11. Chandel BS, Arti Singh. Entomotoxicity of Chromolaena odorata, Tagetes minuta and Reichardia tingitana in suppressing oviposition and adult emergence of Callasobruchus chinensis L infesting stored chickpea seeds in UP International Journal of Zoology Studies. 2017; 2(6):38-44.
12. Chander H, Kulkarni SG, Berry SK. Acorus calamus

rhizomes as a protectant of milled rice against Sitophilus oryzae and Tribolium castaneum. J. Food Sci. Tech., 1990; 27:171-174.
13. Chavan PD, Singh Y, Singh SP, Singh Y. Ovipositional preference of Callosobruchus chinensis for cowpea lines. Indian J. Ent., 1997; 59:295-303.
14. Chiranjeevi CH, Sudhakar TR. Effect of indigenous plant materials on the fecundity, adult emergence and development of pulse beetle, Callosobruchus chinensis in black gram. J. of Research. APAU, 1996; 24:57-6 1.
15. Das GP. Effect of different concentrations of neem oil on the adult mortality and oviposition of Callosobruchus chinensis L. Bruchidae: Coleoptera. Indian J Agri. Sci. 1986; 56:743-744
16. Dharmasena CMD, Simmonds SMJ, Blancy WM. Insecticidal activity of eight plant species on egg laying, larval development and adult emergence of Callosobruchus maculatus F. in cowpea. Tropical Agric. Res. and Extension, 1998; 1:67-69.
17. Dua VK, Pandey AC, Dash AP. Adulticidal activity of essential oil of Lantana camara leaves against mosquitoes. Indian J Med Res., 2010; 131:434-439.
18. Dwivedi SC, Maheswari HK. Screening of some plant extracts for their oviposition deterrent properties against the pulse beetle, Callosobruchus chinensis L. Uttar Pradesh J Zool, 1997; 17:30-37.
19. El-Nahal AKM, Schmidt GH, Risha EM. Vapour of Acorus calamus oil on the reproductivity of some stored product insects. J. Stored Prod. Res., 1989; 25(21):1-216.
20. Haridasan P, Gokuldas M. Effects of Vitex negundo leaf extracts on adult emergence of the stored product pest, Tribolium castaneum H. Coleoptera: Tenebrionidae J Ent, Res., 2009; 33:343-347.
21. Howe RW, Currie JE. Some laboratory observations on the rate of development, mortality and oviposition of several species of Bruchldae breeding in stored pulses. Bull. Ent, Res, 1964; 55:437-477.
22. Imam H, Riaz Z, Azhar M, Sofi G, Hussain Azad. Sweet flag Acorus calamus Linn. An incredible medicinal herb, International Journal of Green Pharmacy, 2013; 2:288-296.
23. Ivbijaro MF. The efficacy of seed oils of Azadirachta indica Juss. And Piper guineese on the Callosobruchus maculatus FJ Insect Sci., 1990; 11:149-152.
24. Jilani G, Saxena RC, Rueda BP. Repellent and growth inhibiting effects of turmeric oil, sweetflag oil, Neem oil and Margosan oil on red flour beetle Coleoptera: Tenebrionidae. Jour. Econ. Ent., 1988; 81(4):1226-1230.
25. Kachare BV, Khaire VM, Mote UN. Efficacy of different vegetable oils as seed treatment in increasing storage ability of pigeonpea seed against Callosobruchus chinensis. Indian J Ent., 1994; 56:58-62.
26. Khaire VM, Kachare BV, Mote UN. Efficacy of different Vegetable oils as grain protectants against pulse beetle, Callosobruchus chinensis L. in increasing storability of pigeon pea. J Stored Prod Res., 1992; 28:153-156.
27. Khan MI, Borle MN. Efficacy of some safer grain protectants against the pulse beetle, Callosobruchus chinensis Infesting stored Bengal gram Cicer arietinum. Punjabrao Krishi Vidyapeeth Res. J, 1985; 9:53-55.
28. Khan SM, Marwat AA. Effect of bakain Melia azadarach and Ak Calatropis procera against lesser grain borer Rhyzopertha dominica FJ Res. Sci., 2004; 15:319-324.
29. Kurnar K, Singh MM, Metha DN, Hammed SF. Effect of some vegetable oil as protectant against pulse beetle, Callosobruchus chinensis L Bull. Grain Tech., 1990; 28:58-60.
30. Kumari P, Kumar D, Kumari P, Kumar D. Effect of mixture of tobacco leaf and neem seed powder on Callosobruchus chinensis L. infesting pulse grains. J. Ecotoxic and Environ. Monitoring, 1988; 8:229-232.
31. Lale NES, Abdulrahman HT. Evaluation of neem Azadirachtaindica seed oil obtained by different methods and neem powder for the management of Callosobruchus maculatus in stored cowpea. J Stoed Prod. Res., 1999; 35:135-143.
32. Ling RZ, Zhang M. Oviposition deterrence and antifeeding effects of extract from Lantana camara on Liriomyza sativae adult, 2005; 61(1):53-55.
33. Maredia KM, Segura OL, Mihm JA. Effects of neem, Azadirachata indica, on six species of maize insect pests. Tropical Pest Management. 1992; 38(2):190-195.
34. Mukherjee TD, Govind R. A Plant Insecticide- Acorus calamus.Indian J. Ent., 1959; 21:194.
35. Negi RS, Srivasthava M, Saxena MM. Egg laying and adult emergence of Callosobruchus chinensis on green gram Vigna radiata treated with Pongam oil. Indian. J Ent., 1997; 59:170-172.
36. Ogendo JO, Belmain SR, Deng AL, Walker DJ. Comparision of toxic and repellent effects of Lantana camara L. with Tephrosia vogelii Hook and a synthetic pesticide against Sitophilus zeamais Motschulsky Coleoptera: Curculionidae in stored maize grain. Insect Sci. Appl. 2003; 23(2):127-135.
37. Ofuya, TI. Oviposition deterrence and ovicidal properties of some plant powder against Callosobruchus maculatus in stored cowpea fignuunguiculata seed. J. Agric. Sci. 1990; 115:343-345.
38. Pajni HR, Talwar N, Sahnan S, Talwar N, Sahnan S. Use of new pesticides of plant origin-asarone and its derivatives for the control of bruchids. J. Annals of Ent., 1996; 13:59-63.
39. Pandey ND, Mathur KK, Pandey S, Tripathi RA. Effect of some plant extracts against pulse beetle, Callosobruchus chinensis L. Ind. J Ent. 1986; 48:85-90.
40. Pandey ND, Singh SR, Tiwari GC. Use of some plant powders, oils and extracts as protectant against pulse beetle Callosobruchus chinensis. Indian J Ent., 1976; 38:110-1 13.
41. Pradhan S, Jotwani MG, Rai BK. The neem seed deterrent to locusts. Indian J. Ent., 1963; 12:7-11.
42. Rehman JU, Jilani G, Khan MA, Masih R, Kanvil S. Repellent and Oviposition Deterrent Effects of Indigenous Plant Extracts to Peach Fruit Fly, Bactrocera zonata Saunders Diptera: Tephritidae. Pakistan J Zool., 2009; 41(2):101-108.
43. Rajashekar YKV, Bakthavatsalam N. Leaves of Lantana camara Linn. Verbenaceae as a potential insecticide for the management of three species of stored grain insect pests, Food Sci Technol ogy. 2014; 51(11):3494-3499.

44. Richa EM, Rashem MY, Rabie M. Use of some essential oils as protectant against the pulse beetle, CalIosobruchus chinensis L. Bull. Entomological Society of Egypt-Economic Series. 1995; 20(15):1-159.
45. Sangappa HK. Effectiveness of oils as surface protectant against the bruchids, Callosobruchus chinensis L. infestation on red gram. Mysore Agric. Sci., 1977; 11:291-397.
46. Schmutterer H. Properties and potential of natural pesticides from the neem tree, Azhadirachta indica. Annual Rev. of Ent., 1990; 35:271-297.
47. Seck D. Economic importance and development of an integrated control approach against insect pests of stores of maize, millet and cowpea in farming areas. J. Sahel. Pv. Info, 1993; 33:15-20.
48. Shifa VJ, Padmalatha C, Ranjith Singh AJA, Sudhakar IS. Efficacy of selected plant extracts on the oviposition deterrent and adult emergence activity of Callosobruchus maculatus F Bruchidae: Coleoptera. Global j. of Sci. Frontier Res., 2010; 10:12-14.
49. Su HCF. Laboratory evaluation of toxicity in Calamus oil against four species of stored product insects. J. Ent. Sci., 1991; 26:76-80.
50. Subramanium TV. Sweet flag, Acorus calamus: A potential source of valuable insecticide, Jour. Bombay Nat. Hist. Soc., 1949; 48(2):338-341.
51. Teotia PS, Pandey GP. Insecticidal properties of rhizome of sweet flag, Acorus calamus against rice weevil. Indian J. Ent., 1979; 41:91-94.
52. Uvah II, Ishaya AT. Effect of vegetable oils on emergence, oviposition and longevity of the bean weevil, Callosobruchus maculatus FJ. Tropical Pest Management, 1993; 38:257-260.
53. Varma BK, Pandey GP. Treatment of stored greengram seed with edible oils for protection from Callosobruchus maculatus F. Indian J Agric Sci., 1978; 48:72-75.
54. Venkateshwarlu P, Sharma CM, Saikishan Singh RS. Effect of neem oil on growth and development of mustard aphid, Lipaphis clysimiKalt. Homoptera: Aphadidae. J. Bioved. 1993; 4(13):9-142.
55. Wada K, Munakata K. Insect-feeding deterrents in plants. Feeding inhibiting activity of terpenoids in plants. J. Agric. Biol. Chem. 1971; 35:115-118.
56. Wilson K. Egg laying decision by the bean weevil Callosobruchus maculatus. J. Ecol. Ent., 1988; 13:107-117.
57. Yadav SRS, Bhatnagar KN. A preliminary study on the protection of stored cowpea grains against pulse beetle by indigenous plant products J Pesticides, 1987; 21:25-29.
58. Yadav TD. Anti-ovipositional and ovicidal toxicity of neem Azadirachta indica oil against three species of Callosobruchus. Neem News Letter, 1985; 2:5-6.
59. Zanno PR, Miura I, Nakanishi K, Elder DL. Structure of insect phagodeterrent azadirachtin. J. Am. Chem. Soc., 1975; 97:1975-1977.