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RESEARCH ARTICLE

IMPROVED QUALITY OF FABA BEANS (*VICIA FABA L.*) CROP WITH BIO-CONTROL AGAINST BRUCHID BEETLE (*BRUCHUS RUFIMANUS*)

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ABSTRACT

The faba bean crop is facing different biotic and abiotic factors that ultimately lower its production. One of the serious threats to faba beans production is the bruchid beetle (*Bruchu rufimanus*). The crop acts as a host plant, and the life cycle of bruchid beetles (*Bruchus rufimanus*) is based on faba bean crop. Studies reveal that there is a significant impact of different organic extracts on faba bean (*Vicia faba L.*) Production against the bruchid beetle, furthermore, essential oils and organic extracts bearing insecticidal compounds that counter the bruchid beetle infestation to an appropriate level. Globally, crops bear unstable yield which leads to an inadequate area under production and limited farmer expertise in relation to faba bean crop production. The ultimate result is inadequate experience and expertise of its management practices. Use of chemical insecticides has an adverse impact on the natural ecosystem and non-target insect pests. The review is based on different biological approaches that may counter the bruchid beetle (*Bruchus rufimanus*) infestation. There is a need to limit its attack at pre harvest stage to obtain quality seed and to boost the yield potential. There is very less literature available on pre harvest control of bruchid beetles (*Bruchus rufimanus*). Different plant based essential oil and extracts having insect repellent tendency with insecticidal compounds. Innovative approaches like Semiochemical based insect trap and nanosilica coating will prove a breakthrough to counter bruchid beetle (*Bruchus rufimanus*) infestation. This review paper represents the summary and overview related to the improved quality of faba beans (*Vicia faba L.*) crop with bio-control against bruchid beetle (*Bruchus rufimanus*). The data reveals the combined exposure of research papers and other literature that is available in terms of related aspects. This may lead to literature overview from previous research and present findings in a combined form. Further work is needed to counter bruchid beetle (*Bruchus rufimanus*) attack at pre harvest stage by using biological approaches.

KEYWORDS

Faba Bean, Bruchid Beetle, *Bruchus rufimanus,* Bio control.

1. INTRODUCTION

1.1 Importance of Faba Bean (*Vicia faba*)

Faba beans are characterized among the ancient crops worldwide. The importance and popularity of this crop exist globally as third among the feed grains. The crop is globally cultivated in around 58 countries. Faba beans crop have the ability to withstand different climatic conditions that makes it more popular, furthermore according to current global warming and adverse climatic conditions the crop have ability to bear severe climatic conditions with multiple soil types (Singh et al., 2013). China is a world leading country in terms of faba beans production. Due to dietary importance as a food and feed the progress is made in nutritional value, improved crop quality, and an increase in production. In terms of nutritional content the crop is the best source of lysine rich protein, a number of bioactive compounds, carbohydrates, vitamins and minerals (Dhull et al., 2021). Beans are enrich in protein with low oil content, having 28 to 32% of protein as compared to field peas with 24% of protein. Faba beans are processed at industrial scale into starch, fiber and protein. In recent years there is an unusual difference in faba bean cultivation production and consumption. The crop has importance in crop rotation with a hardy nature (Merga et al., 2019). Faba bean crop is leguminous in nature with ability to fix nitrogen, intercropping with other crops will increase the soil productivity with an increase in yield resulting in an increase in income of 50% (Isabirye et al., 2012). According to the current food security and malnutrition scenario the researchers predict a rapid increase in the production of faba beans over the coming five years. The crop is a popular source of plant-based protein with an increase in demand globally. According to a survey within ten years the crop has potential to reach 400,000 ha, and most of its consumption as an ingredient (Khazaei et al., 2021).

1.2 Global Production of Faba Bean (*Vicia faba*)

Global faba bean production during 2017 was 4.8 million metric tons. China is among the largest producers with 1.8 metric tons followed by Ethiopia with average production of 0.93 metric tons and Australia 0.37 metric tons. As compared to other crops the area under production of faba beans unfortunately has not increased, the only reason is fluctuation in its yield. Different biotic and abiotic stress and other a number of plant phenology and morphology factors lead to yield instability (Alharbi and Adhikari, 2020). Faba beans are used globally as livestock feed due to being rich in protein. In livestock production the better growth and

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production of animals are achieved through raw faba beans seed consumption (Meng et al., 2021). In terms of total production of faba beans the majority of the portion is related to Asia, Africa and the European Union (FAO, 2020). Annual production reached 5.43 million metric tons according to statistics of 2019. Asia encompasses 33.55% of total world production of Faba beans followed by the European Union with 29.36% and Africa with 27.04%proportion (FAO, 2020).

Graphical representation in the form of Figures 1, 2 and 3 illustrate the world prominent countries of faba beans as producer, exporter and importers. Around half of the world production of faba beans is encompassed by China and Ethiopia. During 2019 Australia ranked first in terms of top exporter with 265,543 Mt. Egypt ranked first in terms of major importers of faba beans with 309,355 Mt approximately 40.48% of total world production (FAO, 2020).

Table 1: Top Leading Faba Beans Producing Countries Globally

World leading Faba beans producing countries	
Countries	**Quantity (metric tons)**
China	1,740,945
Ethiopia	1,006,752
United Kingdom	547,800
Australia	327,000
France	177,380

Source: FAO (2020)

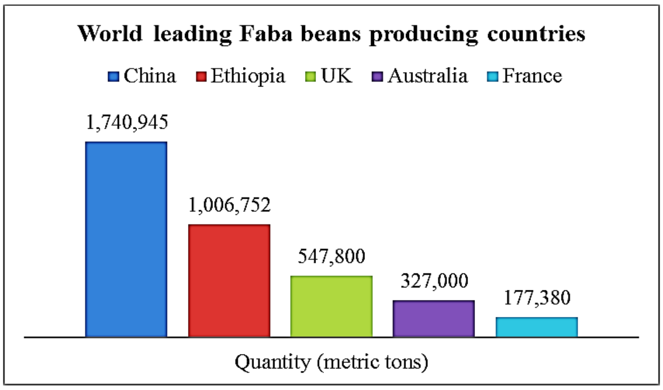

Figure 1: World Leading countries in Faba beans production (Source: FAO, 2020)

Table 2: Leading Exporting Countries of Faba Beans Globally

Prominent Faba beans exporting countries	
Countries	**Quantity (metric tons)**
Australia	265,543
United Kingdom	119,071
Lithuania	92,445
Egypt	71,022
Latvia	66,860

Source: FAO, 2020

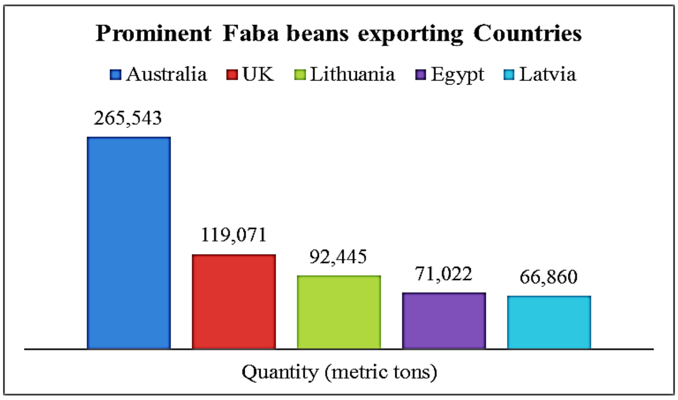

Figure 2: Prominent Faba beans exporting countries (Source: FAO, 2020)

Table 3: Leading Importing Countries of Faba Beans Globally

Prominent Faba beans importing countries	
Countries	**Quantity (metric tons)**
Egypt	309,355
Norway	56,437
Germany	46,707
Saudi Arabia	43,397
France	30,396

Source: FAO, 2020

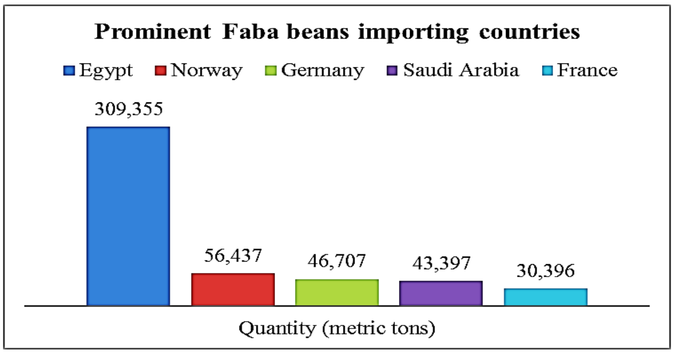

Figure 3: Prominent Faba beans importing countries (Source: FAO, 2020)

1.3 Bruchid Beetle (*Bruchus Rufimanus*)

Cultivation of faba bean crops within the European Union will facilitate sustainability in relation to providing an enriched source of protein as food and animal feed. Furthermore, there is a need to introduce the technology and techniques to counter the impact of Bruchid beetle against its destructive impact. Bruchid beetles significantly devalue the faba bean seed by concentrating post embryonic growth inside the seed. Unfortunately a lot of research work is taking place on different control measures of bruchid beetles but still there is an unavailability of proper control strategy (Segers et al., 2021). Faba beans having multiple dietary importances acts as a host plant of bruchid beetles. During the life cycle of bruchid beetles the adult sustains on pollen and when the pods are at vegetative stage the female lays eggs on pods and then larvae penetrate inside the seeds. Sowing dates have a significant impact to counter the attack of bruchid beetles, in relation with delayed bloom the adult feed on other flowering plants. In view of sowing dates there should be less or more effect of bruchid beetle on faba bean production (Hamidi et al., 2021). The egg laying process lasts from 4 to 5 weeks during the vegetative development of pods.

In case of serious infestation, the egg laying capacity increases and per pod approximately 34 eggs were estimated. Higher Yield losses would be estimated in relation to the average number of eggs (Gailis et al., 2022). Studies reveal that the attack of bruchid beetle on faba ban seeds resulting in poor seed germination beside this water also facilitates the weevil emergence after the sowing seed. In conclusion the seed infestation results in lowering the germination percentage with a prospect of future infestation of the coming cropping cycle (Khelfane-Goucem and Medjdoub-Bensaad, 2016). The development rate of bruchid beetles differs in relation to the type of crop varieties. Mortality rates on different stages of development (Eggs, Larvae, and Pupas) are significantly higher on commonly grown varieties. Studies reveal that about 64 to 99% mortality rates were estimated among larvae development within seed. Some of the faba bean varieties have pod formation that remains a hurdle for larvae penetration. A bio control strategy is significantly successful of lowering the adult ratio by using the *Triaspis thoracicus* (Seidenglanz and Huňady, 2016).

1.4 Life cycle of Bruchid Beetle (*Bruchus rufimanus*)

During the month of February termination of bruchid beetle diapauses takes place and the adults start to colonize. Male of bruchid beetles began to colonize during the February after diapause termination, furthermore during the month of March the female ready to colonize after feeding of pollen and nectar of faba bean flowers. The degree of abundance of adults is directly related to the availability of trophic sources at its earlier stage of development. Ovipositor takes place as the female of a bruchid beetle appeared on young pods until its maturation. Larvae maturation takes place inside the mature seed of faba bean when the pods where green. Pupae development takes place during the seed storage inside the dry seed (Medjdoub-Bensaad et al., 2007).

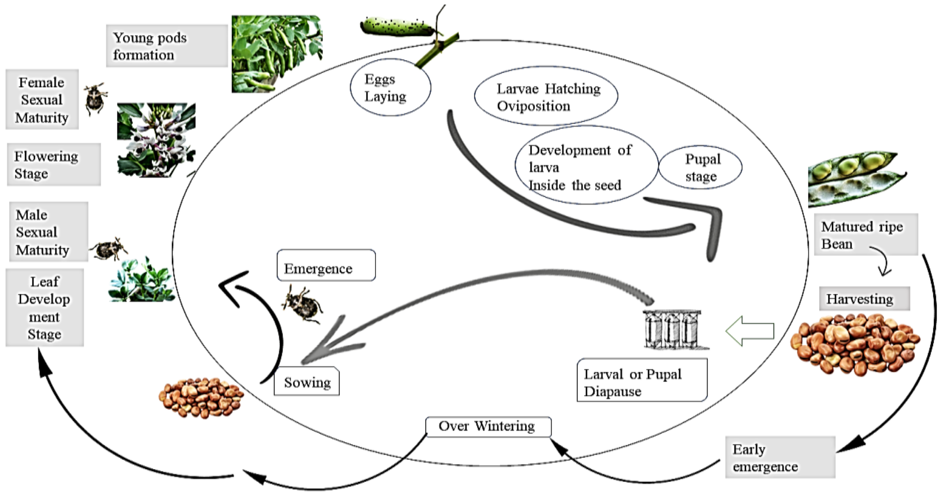

Figure 4: Life Cycle of Bruchid Beetle (*Bruchus rufimanus*)

2. Use of Chemical Against *Bruchus Rufimanus*

To counter the destructive impact of bruchid beetles a large number of chemical pesticides have been used. The adverse impact of these chemical pesticides is not only on plant health but it may also affect the environment as well as non target insect populations. Many of the chemical pesticides have been banned due to the hazard impact on the ecosystem. Many of the hazardous chemicals leached down with rain water and polluted the underwater reservoirs. Post harvest treatment is significantly lowering the insect infestation but there is a need to limit the insect infestation at an earlier stage. Biological control is a key to achieve sustainability and eco friendly approaches to counter the insect infestation.

3. Impact of Bio Rational Control Strategy Against *Bruchus Rufimanus*

Studies reveal that insecticidal impact of Eucalyptus and Artemisia, both genera can be used as fumigant and insect repellant. 1,8 cineole, and α-pinene the essential bio active compound derived from Eucalyptus and β-thujone and Camphor derived from Artemisia significantly proven as bio insecticides (Ben, 2014). Like bruchid beetles, many of the insects attack on pods in leguminous crops. The studies stated that use of bio insecticides Tephrosia, Tagetes and Tobacco extract have ability to decrease the insect population during pod development stages (Kawuki et al., 2005). Artemisia essential oil has insecticidal and repellent ability in combination with essential oil derived from *Cinnamomum camphora (L.)* seeds against the bruchid beetle. There is also an antagonistic impact of combined mixture of Artemisia essential oil and *Cinnamomum camphora (L.)* seeds oil on seed germination of bean crop against the insect infestation (Liu et al., 2006).

Application of microbial agents also counters the bruchid beetle losses in the field in relation with application of some essential oils. A field experiment was conducted to analyze the impact of microbial agents in combination with essential oils. Results derived from the experiment states that application of *Beauveria bassiana*, *Metarhaizum anisopliae* fungusand essential oil derived from Nigella and Mustard shows significant impact to lower the bruchid beetle infestation (Sabbour and E-Abd-El-Aziz, 2007). Beside the essential oil some plant based organic extracts also proven insect repellent ability. Application of *Vernonia lasiopus* and *Tithonia diversifolia* leaf extract have repellency tendency. The extract is analyzed using GC-MS technique and it is concluded that both extract have bio active compound against the weevils repellency (Gitahi et al., 2021).

Studies reveal that *Azadirachta indica* oil significantly manifest a powerful insecticide with 100% mortality rate within two day against *Callosobruchus maculatus F*. Beside this *Acorus calamus*, rice husk and mustard oil also has insect killing properties against pulse beetle (Paneru and Shivakoti, 1970). Essential oil derived from *Zea mays*, *Arachis hypogaea*, *Helianthus annuus*, and *Sesamum indicum* were tested against the three species of pulse beetle i.e *Callosobruchus rhodesianus*, *Callosobruchus chinensis*, *Callosobruchus maculatus*. Findings illustrate that there was a significant reduction in ovipositor of all species tested when applied at a concentration of 10ml/kg. It is also concluded that a significant decrease in longevity of adults of *Callosobruchus maculatus* and *Callosobruchus chinensis* may also be recorded (Rajapakse and Van Emden, 1997).

4. Semiochemical Based Traps Against *Bruchus Rufimanus*

Semiochemical based traps are emerging technology to counter the insect attack. They consist of a volatile compound that attracts the insects and captures them. *Bruchus rufimanus* mature male are attracted by the bloom of faba beans. Meanwhile the female of *Bruchus rufimanus* may also be attracted by bloom volatile in the presence of mature male. Volatile compounds extracted from faba bean bloom are used as semiochemical traps during the colonization of female and male adults. These traps are significantly beneficial to lowering the insect population when used before ovipositor by targeting fertilized females (Bruce et al., 2011).

5. Impact of Different Sowing Dates Against *Bruchus Rufimanus*

Sowing dates may also be a strong counter strategy against the *Bruchus rufimanus*. *Bruchus rufimanus* population significantly affects female biobehavioral synchrony to the young pods. It is estimated that a crop with early flowering and pods long diversification distinct the *Bruchus rufimanus* to winter sown crops. In case of delayed flowering it will facilitate the beetle to feed on other crops instead of the main crop. Elimination of bloom availability by surrounding crops in relation with pods long diversification varieties will facilitate the low infestation (Hamidi et al., 2021). In the view of the life cycle of *Bruchus rufimanus*, it is stated that faba bean crop sown during late March and Early April results in lower insect infestation. Delayed sowing may also lower the yield. Studies should be needed to improve the yield by delayed sowing (Ward, 2018).

6. Post-Harvest Treatment Against *Bruchus Rufimanus*

In order to protect stored grain the post harvest treatment is essential. Essential oil derived from plants in combination with parasitoids significantly reduces the insect infestation during storage period. For this purpose essential oil derived from *Artemisia absinthium*, *Artemisia herba-alba*, and *Artemisia campestris* were analysed using GCeMS and GC techniques and applied in combination with parasitoids to manifest the impact against *Bruchus rufimanus*. Significant reductions in insect's infestation were recorded with the application of *Artemisia campestris* along with natural enemies. *Triaspis luteipes* and *Dinarmus basalis* used as natural enemies on target insect.

Application of essential oil of *Artemisia campestris* along with release of above mentioned parasitoids, were results in significantly decrease in insect infestation in stored grain (Titouhi et al., 2017). *Moringa oleifera* is characterized as a powerful insecticide with insect repellent abilities widely utilized. In order to analyze its bio-insecticidal properties, powder derived from different plant parts (flower, Leaf, Stem, Root) were analyzed against *Bruchus rufimanus* infestation in cowpea seed. The impacts were analyzed by targeting virgin adults, and findings reveal that moringa bloom powder when applied at a concentration of 0.5 g results in a significant reduction in egg laying capacity. Finding manifest that the *Moringa oleifera* bloom have insecticidal properties and used as bio insecticide against bruchid beetle (Adenekan, et al., 2013).

Storage grain of leguminous crops is susceptible to bruchid beetle infestation, a physical method of post harvest treatment using hot and cold Salt water, application of essential oil derived from *Sesamum indicum* and

Azadirachta indica seed powder were tested. During the analyses period of five months a significant decrease is manifest in insect infestation. Most appropriate treatment was application of essential oil of *Sesamum indicum* when using 5 drop/250g grain followed by *Azadirachta indica* seed powder 10g/250 g grain and hot salt water 50g/250g grain (Ahmad et al., 2015). A limited but emerging technology is nano silica coating. Limited work is undergone but the potential is wide. The current literature states that it's the first ever attempt to establish nano based silica coating materials to protect stored grain from insect and pest infestation.

Furthermore, it is stated that a significant dosage of nano silica is used by utilizing its minimum concentration as a coating material against pulses seed. Results manifest the efficiency any accuracy of nano silica based coating against insect infestation (Arumugam et al., 2016). Much of the literature demonstrates the insecticidal properties of rice husk ash. It is stated that before grain storage the application of rice husk ash at a concentration of 1% thoroughly mixed with grains will results an effective control against insect infestation (Naito, 1988). A significant cultural practice to control bruchid beetles during storage is neglected nowadays. Sunning and sieving S&S is a strong technique to eliminate the egg, larvae and adults from beans (Huis 1991). There are a number of advantages by adopting this approach, seed germination and grain appearance would not be affected. It is concluded that the application of this technique is analyzed on farms and results declared that it is suitable and beneficial as the application of a substance having insecticidal properties. The approach is familiar to farmers because of its low cast, and well grain maintenance (Songa and Rono, 1998).

7. Conclusion

Plant proteins are the prominent alternatives in the current scenario of food security and malnutrition. Faba beans crop is a significant source of nitrogen fixation among the leguminous crops. The dietary importance of crops is well known and also withstand in a diverse type of climatic region and soil type. There is a need to boost the production and yield of faba beans to meet future generation dietary needs. Use of plant derived essential oil and extract as biocontrol against bruchid beetle infestation is significantly improving the crop productivity.

The essential oil and extract have not only insect repellant ability but may also act as insecticides. It is more significant to limit the infestation before larvae penetrates into young pods; because once it penetrates into pod it's very hard to counter its attack at pre harvest stage. Post-harvest treatment may also effective against bruchid beetle infestation but it's more difficult and not economical. To limit bruchid beetle attack it is crucial to understand its life cycle. Sowing dates may also a significant impact to counter its attack but ultimately late or pre sowing may have adverse effect on crop yield. Chemical insecticides are dominant to control bruchid beetle but they have hazard impact on crop and environment. There is a need to more focus on pre harvest control of bruchid beetle with more innovative and sustainable approaches. Very less work has been published in terms of biological control of faba beans at pre harvest stage.

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