CURRENT METHODS OF INTEGRATED PEST PREVENTION AND CONTROL IN BEAN CULTURE IN THE CONTEXT OF CLIMATE CHANGE

*Chiriloaie - Palade Andrei**, *Petrișor Cristina*
Research and Development Institute for Plant Protection, Bucharest, Romania

*Correspondig author
Research-Development Institute for Plant Protection Bucharest
8 Ion Ionescu de la Brad, 013813, Bucharest, Romania
Tel.:004-021-2693231
Fax: 004-021-2693239
E-mail: chiriloaie.andrei@icdpp.ro

Abstract: Currently, as a result of anthropogenic activities such as uncontrolled deforestation, industrialization, water pollution, soil, major climate change takes place. Agricultural production will certainly be one of the most affected industries over the next decade. Bean culture is a relatively easy product, versatile, an important source of protein, carbohydrates, some vitamins and micronutrients. In view of these beneficial effects and the high economic value (occupying the third place after soybeans and peanuts for oilseeds), contemporary research sought methods of integrated pest control against bean crops, most notably the bean beetle, *Acanthoscelides obtectus*. This paper is a review of integrated pest management methods for bean culture in the context of climate change.

Keywords: *agriculture, climat changes, beans, Acanthoscelides obtectus*

INTRODUCTION

Climate change, also known as global warming, refers to the increase in average temperatures on the Earth's surface. Much of the scientific community argues that climate change is primarily due to people using fossil fuels, which emit carbon dioxide and other greenhouse gases into the atmosphere. These gases capture heat in the atmosphere, giving rise to a series of severe meteorological events, affecting ecosystems, sea level, significant amounts of water or long droughts.

With the rise in spring temperatures, soils will warm up sooner, combined with increased rainfall, will greatly benefit seed germination (Peet & Wolfe, 2000). Long-term rainfall could, however, delay some production steps, sowing or harvesting, making muddy and inaccessible soils for agricultural machinery, leading to non-marketable crops. Growth conditions and stress factors do not only affect the quality of vegetables at harvest, but also have a strong influence on storage life (Arun & Venkateswarlu, 2011).

Therefore, higher temperatures and rainfall will only be beneficial in the absence of extreme weather conditions that can prevent production steps, germination of seeds and damage to delicate planting material.

Gentle winters will be characterized by higher temperatures that shorten the frost period, precipitations mainly being expressed as rain rather than snow (Massignam et al., 2017). In view of this situation, the best planting date is that which facilitates culture to reach its vegetative cycle by meeting physiological needs despite the critical (water deficit) and yielding period.

Agriculture is an important sector of the Romanian economy. Crops, animals and fruits produced in Romania account for 6% of its GDP (gross domestic product). Cultures need adequate soil, water, sunlight and heat to grow. Warmer air temperatures have already affected the growing season of large-scale plants in Europe. The flowering and harvesting period for crops has faded a few days ago, in some areas by months, and the trend is to continue. It is also estimated that crop yields will vary more and more from year to year due to extreme weather phenomena.

Changes in temperatures and growing seasons could also affect the proliferation and spread of certain species, such as insects, invasive weeds or diseases, all of which can affect crop yields. In line with the estimated population growth and changes in eating habits in favor of higher consumption, global food demand is expected to grow by as much as 70% over the coming decades. Agriculture is already one of the economic sectors with the greatest environmental impact. This substantial increase in demand will undoubtedly create additional pressure. The yields of crops are affected by various issues, including drought that can generate losses between 10% and 100%. Approximately 60% of the bean production areas have long droughts, being the second cause of disease loss after disease (Thung & Rao, 1999).

Impact on vegetable crops. The beans belongs to the family Phabaceae, the genus *Phaseolus* comprising about 20 species of American or Asian origin (Muntean et al., 2008). The common bean, *Phaseolus vulgaris* (L.) Savi. is the most common species of South American origin, is a short cycle culture, therefore more sensitive to climate change (Hoffmann et al., 2007). Generally, precipitation, air temperature and solar radiation are climatic factors that influence its yield (Didonet & Silva, 2004). Like other legumes, beans are a rich source of protein containing about 20% more energy than bread; rich in vitamins A and C (Norman, 1999). Common beans have reduced drought tolerance due to anatomical and physiological limitations, as well as reduced resistance to water deficiency conditions (Fancelli & Dourado, 2005). The minimum germination temperature of seeds is 15°C, when rising takes place in 10-14 days. The optimal temperature is 20-27°C, when rising occurs in 4-8 days. During vegetation, the optimal temperature is 20-25°C, minimum 10-12°C, and maximum 30-35°C. At temperatures below 10°C, the growth ceases and at - 0.5°C the plants die. The root system of the pivoting bean is less developed than in other legumes, most of the roots being located up to 25 cm deep in the arable soil layer. The soils indicated for beans are medium-textured, fertile, loose, aerated, that is heated easily, neutral (pH = 6-7.5), well supplied with water and nutrients. It can also be grown on lightly textured brown soils on the southern exhibition. It can also capitalize soils with a thin arable layer if the necessary humidity is ensured. Not suitable clay, compact, excessively moist, cold, salinized or sandy soils, podzolic, acidic soils. It is anticipated that global warming will increase in the future both the average temperature and the extreme temperatures, thus changing the conditions for their growth. Higher air temperatures during the flowering period decrease the production and viability of the pollen, the number of pods per plant, seeds on the pod, all negatively affecting the yield of cereals (Massignam & Dittrich, 1998). In beans, the temperature during plant vegetation greatly influences the length of the vegetation period of the varieties in the sense that at lower temperatures the vegetation duration is extended.

Tehnology. Changes associated with global warming (high temperatures, unequal rainfall, elevated CO^2, drought, etc.) can affect the severity of pest and pathogen attack on plants. First, higher temperatures exponentially increase insect metabolism. Secondly, warmer temperatures will increase the rate of insect breeding. Climate fluctuations affect post-harvest quality and cause serious losses during storage. Pest management typically involves the integration of several agrofitotechnical practices, phytosanitary quarantine, healthy seed, crop rotation, cultivation in strips, sowing with resistant varieties, use of plant protection products and biological control means. In the field, many pests attack all parts of the bean during the growing stages, from seedling to storage. Their economic importance varies from one area to another, but researchers generally agree that the bean weevil, *Acanthoscelides obtectus* Say 1831) is one of the most important bean pests both in the field and in the stored products. Other pests include aphids, mites and some flyes.

Pests. The bean weevil, *A. obtectus* is the most important bean pest. Adults lay eggs onto seed pods in the field, and the larvae penetrate the incompletely developed bean beans. It is very difficult to distinguish between males and females of this species, because their size and color are the same. After hatching the eggs, the larvae penetrate the beans and develop inside them, forming a cell. This way they get into the warehouse. In the stored area they feed on the beans, destroying the embryo. The beans can no longer be consumed and lose their germination. In the last larvae stage, the adult chews an exit hole through the seed coat. Shortly afterwards, mating occurs and a new egg deposit begins. At temperatures below 14°C, the reproduction is stagnating. Bean weevil has 2 - 3 generations in the field and 1 - 2 generations in storehouses. The treatment will be accomplished by applying three foliar treatments with specific insecticides in the field; application of specific insecticides for the disinfection of deposited and stored seeds; keeping beans at low temperatures (<3°C) preventing pest development. Where low temperatures can not be used, it is possible to apply edible oils (cotton seed oil, soybean oil, corn oil, peanut oil) (Papachristos & Stamopoulos, 2002). Oils penetrate the eggs and destroy them.

Many essential plant extracts and oils are known to have ovicidal and repellent effects against various insects of stored products. The relevant literature presents the plant oils of *Gomortega keule*, *Laurelia sempervirens*, *Eucalyptus globulus*, *Origanum vulgare*, *Thymus vulgaris* and *Terpenes* with a repellent effect of the pest during the storage period (Magalisl et al., 2008). Treating beans immediately after harvest with Delicia Gastoxin -30 gr/t and Phostoxin -10 tablets/t, is also used against adults. These are only used in storage areas that can be tightly sealed and do not allow gas to pass. Early harvesting and seed treatment immediately to remove eggs and insects that have come from the field.

Biological control techniques can be used in warehouses using the parasitoid *Dinarmus basalis* Rondani, 1877 (Hymenoptera: Pteromalidae). Succes of this practice depends on the level of initial infestation and the stage of larval growth of *A. obtectus* at the time of harvesting. A rapid harvesting is therefore crucial to reducing the time when the bean is exposed to the pest attack (Schmale et al., 2006). For subsistence and semi-subsistence farms, an inexpensive method would require beans to be fill up to 75% volume in cylindrical containers and to rotate regularly each morning and evening. This mechanical effect has been found to lead to deterioration of the stern stage within beans (Quentin et al., 1991).

One of the promising alternatives for harvested crop protection is the use of inert powders from diatomite sediments. Diatomite is perhaps the most effective insecticide of inert powders (Korunic, 1998). This acts on the exoskeleton of the insects, causing desication and death by the loss of water. Insecticides in this category are non-toxic for mammals (DL50> 5000 mg/kg). In the protection of stored cereals, methods of application of these products are similar to other traditional protectors (silicagel, bentonite, tricalcium phosphate) (Athanassiou et al., 2005). In addition, as inert materials, it does not affect the environment. Inert powders (diatomaceous earth) persist in treated substrates, providing long-lasting protection against pests. The efficacy of diatomaceous earth as an insecticide varies according to composition, geological and geographical origin, chemical characteristics such as SiO_2 content, pH (Korunic, 1997).

Other important pest for common beans is the pea leaf weevil, *Sitona lineatus* L 1758 (Coleoptera: Curculionidae). In spring, when temperatures rise to 14-15°C, they leave their wintering place and climb to the surface of the soil. This species has 1 generation per year. The adults feed on leaves, making semicircular holes around the foliage. The attack continues inside the roots where they dig the galleries. Indirect damages of the pea weevil refer to virus's transmission. The pest control will be achieved through foliar insecticides based on pyrethrum - natural and synthetic pyrethroids and seed treatment (Smart et al., 1994). The use of pheromone conical traps has potential for both monitoring and mass capture programs (Nielsen & Jensen, 1993). Resistant bean varieties are a more sustainable management option for *S. lineatus*.

Red spider mite *Tetranychus urticae* Koch 1836 (Trombidiformes:Tetranychidae) has 6-10 generations per year and overwinters in the adult female stage under the exfoliated bark of the trees, under the leaves left in the field or in the vicinity (forest, screen of trees). The rapid growth and multiplication of populations is favored by high temperatures and low relative humidity in the air. *T. urticae* feeds on leaves and flowers. As a result of the attack, there is a stoppage of shoots growth. Preventive measures are destruction of plant debris, autumn plowing, and destruction of weeds that are host plants. During vegetative season, *T. urticae* may be controled with specific acaricides are necessary.

Greenhouse whitefly *Trialeurodes vaporariorum* Westwood 1856 (Hemiptera: Aleyrodidae) is a polyphagous insect encountered in fields of bean crops, where adults and larvae colonize the leaves and shoots, from which they suck the cellular contents. After the attack, the leaves turn yellow, dry and fall. The attacked plants are covered by insect debris which promotes the development of fungus. Detection can be done easily with the sticky yellow traps. The control of this pest is based mainly on insecticidal treatments with systemic action and synthesis pyrethroids.

Bean seed fly *Delia platura* Meigen 1826 (Diptera: Anthomyiidae) is a polyphagous pest attacking more than 40 species of plants. It has 2-3 generations per year, and the attack occurs from the seed stage in the fields. Organic decomposing matter attracts females to lay their eggs. The larvae attack the seed blooms, and then they get inside the plants. The attack continues on seedlings plants. The control measures are: reducing the use of organic matter, treatment of weeds and seed treatment with insecticides, insecticides against both adults and larvae. Adult flight time is identified with yellow sticky traps.

Aphids affect also the common bean crops in the field. They develop massive conies on the lower part of the leaves, on flowers or inflorescences and on young shoots. Insects are sucking the cell juice causing a stress to the plant. At severe attacks the plants die (Vickerman & Wratten, 1979). Black bean aphid *Aphis fabae* Sulz. 1776 (Homoptera: Aphididae) couses direct damage and indirect damages by its ability to transmit the common bean mosaic virus. Presence of pest can be done with yellow stiky traps. Chemical treatments with systemic insecticides applied before and after flowering when the pest colonies appered. Encouraging of entomofagous species as *Coccinella* sp. and *Syrphus* sp. by Umbelifera cultures near bean cultures is a well known practice.

Cotton bollworm *Helicoverpa armigera* Hüb. 1808 (Lepidoptera: Noctuidae) is an extremely polyphagous pest on 60 plant species and has about 67 wild hosts in 39 families. It feeds on leaves and stems but has a strong preference for reproductive organs such as buds, inflorescences, beans, pods, capsules. Larvae (caterpillars) of first and second age attack the young parts of the plant, the apical growth points and the axillary buds, thus compromising the plant's ability to compensate for damage especially leaf epidermis; third-age larvae attack the fruit. As a side effect, infections caused by fungus and bacteria lead to rotting fruit. *H. armigera* has 2 generations per year in the climatic conditions in our country (May-June, July-September). It is overwinters as nympha in the ground. The males are yellow-brown butterflies and the orange-brown-brown females, mostly active at night. The larvae are pale green but later they are very variable in color (yellow-green to dark brown). Cultures should be closely monitored from emergence to maturity, from budding/flowering to maturity for eggs and larvae. Eggs are distributed on all parts of plants, including inflorescences and fruits. Traps (pheromone, light) are used to monitor the presence of adults and the application of treatments when the presence is confirmed. The first and second age larvae are most susceptible to insecticide. The number of populations is influenced by area, climatic conditions, attacked crop types, weed management around crops and the ability to use trap crops (in castor, ricin, cotton, chickpea) sown early spring to attract butterflies to pond, after which plants are eliminated and destroyed (Rogers &Brier, 2010).

Painted lady *Vanessa cardui* L. 1758 (Lepidoptera: Nymphalidae) is a polyphagous pest on over 300 host plants. Adults are big day butterflies (Orsak, 1977) feed on flower nectar and honey dew produced by aphids. The eggs are deposited solitary on the top of the plant leaves that will serve as a source of food. After hatching, the larvae feed on the cuticle of the leaves, leaving only the ribs and building silk tents on the host plant for protection. The insect presents 3 generations/year. It overwinters as pupae stage (Ștefanescu et al., 2012). Larvae are distroyed with insecticide specific to Lepidopteran as soon as the attack has been reported. Products based on the *Bacillus thuringiensis* fungus are used in biological control.

Field slug *Deroceras agreste* L. 1758 (Gastropoda: Agriolimacidae) is a polyphagous species feeding on flowers, trees, ornamental plants, vegetables. It overwinters in the egg stage in the soil at 20 - 30 cm; can develop 3-4 generations/year. Gentle winters, warm winters with wet and cool summers lead to a strong attack on young plants in the crop at the level of the roots or leaves by making holes in them (the leaves dry, rotting roots) and in the soil attacking germinating seeds and tuberous roots. Preventive measures consist of respecting the culture tehnologies, observing planting density and soil mobilization at 14-20 cm. The use of floral strips with *Calendula officinalis* reduces the field slug attack. Biological combat can be achieved by sowing 300-500 thousand nematodes/m2 of *Phasmarhabditis hermaphrodita* Schneider species, together with the bacterium associated with *Moraxella osloensis* Bovre, which causes inhibition of the limax feeding process (Roşca & Iacomi, 2012).

Other technologies. Growing in strips. Beans is a resistant species to atmospheric drought than drought in the ground, hot and dry winds being very damaging. That is why, in drier areas, the intercalated bean culture among maize produces a more favorable microclimate that results in a better binding of bean flowers than in pure crops. Bean seeds intended for sowing must be healthy from crops, not infected with diseases, have a minimum purity of 98% and a germination degree of at least 80%, at the same time seed treatment should be used.

Rotation of crops. The bean crops are not pretentious to precursor crops, but with poorly developed root system (spread in the superficial soil layer), it is good to cultivate plants that are not depleting the soil in water and nutrients and allow good ground preparation for sowing. The land must be worked from autumn, deep, deeply drained, well drained, and weed-free, without vegetal remains. It can be cultivated with good results after grain cereals, especially wheat and barley which releases the land early, potato, sugar beet, tobacco, corn. Sunflower, rape and legume crops are not recommended as a precursor because of common diseases. After these cultures, beans should not come back earlier than four years (Samuil, 2007). Although it is self-supporting, repeated culture is not recommended due to disease multiplication (anthracnose, bacteriosis, grey mould, rust) and especially because beans are a very good pre-plant for most cultures and an excellent precursor plant for autumn wheat, leaving the land rich in nitrogen and pure of weeds. Since the areas occupied by pure bean are relatively low compared to others cultures, rotating it after the best precursors is not a special problem. It is necessary to grow beans in crops of 3-5 years.

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