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SUSTAINABLE AGRICULTURE: CONCEPTUALIZATION AND TENDENCY

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Sustainable agriculture is an activity that aims to produce an adequate amount of food to satisfy the current and future demand with emphasis on the efficient use of natural resources to generate incomes for the farmer and with less impact to the environment. Sustainable management of agricultural production would be defined by a balanced combination of technologies, policies and activities; all based on economic principles and environmental considerations, to maintain or increase agricultural production in the levels demanded by the growing world population. The agricultural sector must produce more food per unit area. It is estimated that the world population in 2025 will reach to 8,000 million of people; this is a 33% increase since the year 2000. Despite this population growth, it is expected that there will not be a considerable increase in the amount of land available for food production, in fact, arable land per capita in the world continues to decline. According to predictions, it is estimated a decrease of less than a quarter hectare for cultivation by the year 2025. In Ecuador, there are some initiatives that attempt to advance the construction of sustainable agriculture. These projects have been initially focused on the use of production technologies with lower impact on ecosystems; however it should not result in an economic fact for the farmer, as happened with the green revolution. The initial idea was to develop an alternative agriculture to face the economic and ecological crisis that affects the Ecuadorian agricultural sector, which mainly affects small farmers. Despite efforts to build a sustainable agriculture, a key to the success of these projects is to find a market for the products produced. For example, the domestic market for organic products is small and limited, thus organic products, also called "clean", have high demand in specific sites of the international market. It has to be taking into consideration that for the Ecuadorian farmer to access to these markets is extremely difficult due to the low quality of products and poor processing; in addition, there are not enough production volumes for exportation which limit the opportunities to open new markets. However, sustainable agriculture is an alternative to reduce environmental impacts and improve the income of farmers in terms of an efficient and competitive production.

Key words: agriculture, sustainable, alternative, tendency.

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REGULATION FOR REGISTRATION OF BIOPRODUCTS IN ECUADOR

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The objective of the Inter-American Institute for Cooperation on Agricultural (IICA) is to encourage and support the efforts of Member States to achieve their agricultural development and rural welfare through international technical cooperation. IICA has been working for about 4 years ago in the regulation for registration of bioproducts, supporting countries like Argentina, Chile, Nicaragua and Costa Rica in the harmonization of concepts and preparation of legislation. In Ecuador, it has been working on this issue since 2014, beginning with the organization of a workshop to address the topic of the regulations, this activity was carried out jointly AGROCALIDAD which is the official organization related to registration in Ecuador. There is not a specific legislation for bioproducts and their registration in the country; however by 2016, there are data about 2323 chemical pesticides and 46 bioproducts which are being commercialized in Ecuador. Currently IICA continues supporting the development of this regulation for the registration and control of biological control agents, plant extracts, prepared minerals and semiochemicals used in agriculture, as well as the elaboration of the Procedural Manual of the Normative, which are expected to be ready, socialized and validated at the end of 2016. In addition, IICA is working to AGRESEARCH and INIAP in the development of a project that allows strengthen the capacities of technicians in our country, generate protocols for the quality control of the bioproducts and their apllication in field crops, mainly in blackberry and banana.

Key words: normative, legislation, registration, bioproduct.

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FRUIT SUSTAINABLE PRODUCTION IN THE ECUADORIAN HIGHLAND

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Ecuador for its geographical position presents a variety of microclimates that allow the cultivation of distinct fruit throughout the year. The fruit sector covers mostly farmers who have small areas of production (0.5 ha). In the Ecuadorian Highlands are cultivated temperate fruit and also subtropical fruit (andean valleys and foothills of the Andean mountains) that are commercialized mainly in the local market and generate income for the small farmers. The focus of sustainable fruit production covers various application fields such as plant breeding, integrated pest management and agronomic crop management. The Fruit Program of the National Institute of Agricultural Research (INIAP) has been researching into different components that allow reducing agrochemical use and promote non-contaminant agronomic practices to improve the productivity of various fruit in the Ecuadorian Highlands. It has been identified wild Solanaceae such as *Nicotiana glauca*, Solanum hispidum and *Solanum auriculatum* to be used as rootstocks in tree tomato (*S. betaceum*)to avoid the attack of Fusarium and nematodes; while in naranjilla (*S. quitoense*) the rotstocks identified have been *S. hirtum* and *S. arboruem*. It is evaluated progeny from the crossing *S. uniloba* X *S. betaceum* to look for individuals showing fruit quality (up to 13 Brix degrees) and resistance / tolerance to anthracnose (*Colletotrichum acutatum*). Individuals selected from the interspecific cross between *S. sessiliflorum* X *S. quitoense* show genotypes with good quality fruit (green pulp, about 130 g in weight and 10 Brix degrees) to avoid the application of 2,4-D for fruit growing, such as hybrid Puyo (naranjilla). The use of mycorrhizae in cherimoya (*Annona cherimola*) and avocado (*Persea americana*) nurseries has generated that seedlings absorb 40% more phosphorus than non-inoculated seedlings and dry matter increase by 20%. It has been identified parasitodes of the genera *Bracon* sp. and *Copidosoma* sp. to control *Neoleucinoides elegantalis* (fruit borer of naranjilla). It is inoculated *Trichoderma* sp. (concentration of 1 x 109 spores) in soils of blackberry (*Rubus glaucus*) plantations in order to establish the microorganisms in the soil and produce beneficial results such as antagonism against pathogens and generating greater root mass. It has been developed a methodology for manual pollination on cherimoya that reaches up to 70% for fruit set which significantly improves yield, because the orchards that are not pollinated present only 2% of fruit set. This research will allow generating an integrated fruit production in Ecuador thereby to increase the cultivated area and promote the development of the fruit sector.

Key words: fruit, sustainable, Ecuador.

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BLACKBERRY (*Rubus glaucus* Benth.) PRODUCTION SYSTEMS IN THE ECUADORIAN ANDES

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The blackberry (*Rubus glaucus* Benth.) is a perennial Andean crop, grown by small farmers in the Andes (2600-3200 masl). The high demand of the crop is given by its taste, chemical composition and nutritional value; as well as the permanent income for the farmer in small cultivation areas (<1 ha). However, this fruit is susceptible to foliage diseases such as Oidium (78 %), fruit disease like Botrytis (90 %), and root system infection causing plant wilting (15 %). The research was conducted at fields of Pichincha and Tungurahua (2600 and 3100 masl). The objective was to evaluate the incidence of diseases affecting leaves, flowering buds, fruit and root system under three production systems: 1) integrated crop management, characterized by minimal use of (soft) synthetic, biological and natural products which have low toxicity and generate a minimal residual chemicals; 2) traditional crop management which considers the use of synthetic pesticides based on the tradition and the farmer´s expertise, without considering the problem of pesticides residues on fruit; 3) organic crop management using only certified pesticides permitted for organic production. The crop was monitored for six months with regular assessment of disease status. According to the results, the presence of foliar diseases such as *Oidium* spp. had lower incidence and severity in the integrated crop management system (5.3 %) compared to 12.3 % and 17.1 % observed in the traditional and organic productions systems, respectively. Regarding the incidence of *Botrytis* sp., the traditional system had a greater control (2.03%) compared to 2.49% and 2.92% of the integrated and organic productions systems. In terms of plant wilting caused by soil fungi affecting the root system, it was determined that plants under integrated management system were the least affected (1.17%) compared to the organic (1.29 %) and traditional (1.36%) systems. These results suggested that it is possible to control blackberry plant diseases using conventional and organic production systems, ensuring the quality of the fruit without residual pesticides or containing quantities that are in the threshold considered to warranty consumers' health.

Key words: blackberry, systems, pesticides, diseases**.**

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FROM INSECTICIDES TO BIOLOGICAL CONTROL: THE NEW ZEALAND FRUIT INDUSTRY EXPERIENCE

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Fruit crops in New Zealand are attacked by 117 different pest species, which are in turn attacked by ~135 species of natural enemies. While geographic isolation and effective quarantine have helped to protect New Zealand (e.g. free of tephritid fruit flies), 85% of the fruit pests (100 species) have arrived during 170 years of European colonisation. Almost 50% of the pests are Homoptera, mostly exotic species including many cosmopolitan scale insects. About 20% of the pests are Lepidoptera but most of these are endemic species, especially the highly polyphagous tortricid leafrollers. Almost 70% of the natural enemies (92 species) of fruit pests in New Zealand also arrived accidentally; there has been just 26 species established from various attempts to introduce new biological control agents. Pre-1940 was a key period for biological control introductions and, for apple crops, these mainly targeted host-specific pests, including codling moth, woolly apple aphid and apple leafcurling midge. Early interest in biological control was largely overshadowed by increasingly effective insecticides from the 1950s until insecticide-resistant leafrollers evolved in the mid-1960s. By then leafrollers had become major pests of apples so several less host-specific parasitoids for leafrollers were introduced in the late 1960s and 1970s as part of a new IPM research programme. Use of broad-spectrum organophosphate (OP) insecticides from the 1970s provided acceptable leafroller control but probably prevented the newly-introduced natural enemies from contributing fully to leafroller biological control. The OP insecticides also disrupted biological control of some previously minor pests (especially mealybugs, woolly apple aphid, leafhoppers and mites) raising their status to significant apple pests. Implementation of an Integrated Fruit Production (IFP) programme in the mid-1990s allowed new selective insecticides to preserve natural enemies and this provided a new focus for growers on biological control and IPM. These changes increased natural enemy activity resulting in effective biological control of some previously important pests while also decreasing pesticide use. Integrated control of pest mites was an early biological control success; control of plant feeding mites by predaceous phytoseiid mites reduced average miticide use from ~3.5 sprays per season in the 1980s to 0.03 in 2014. Following the widespread adoption of IFP, insecticides applied for the control of mealybugs and leafhoppers decreased from 3.9 sprays per season in 1996 to 1.0 in 2014. Similarly use of aphicides for the control of woolly apple aphid declined from 1.4 sprays per season in 1996 to 0.02 in 2014. All of these reductions occurred because restricted use of selective pesticides allowed natural enemies to exert their full contribution towards biological control. An even more impressive biological control outcome was the reduction of leafrollers as the primary pests of apple production in New Zealand. The leafroller pest complex consists of one exotic species (lightbrown apple moth, LBAM) and for endemic species (greenheaded leafrollers and brownheaded leafrollers); they are highly polyphagous and immigrant moth activity contributes to larval damage in export apple crops. The 1970s introduction of leafroller parasitoids, followed by the later implementation of selective pest management, brought about a dramatic reduction in leafroller damage in apple crops, from about 40% damage in unsprayed apples in the mid-1980s to 0-2% damage today At the same time, insecticide use for leafroller control in export apple crops has declined from ~8 applications per year in 1990 to 1-3 applications in 2014. The introduction of selective pest management has greatly increased the contribution of biological control and since the mid-1990s has reduced insecticide use by ~90% in New Zealand's export apple crops. However while the leafroller parasitoids released in the 1960s and 1970s improved biological control of LBAM, they also added to the parasitism of native leafroller species and greatly reduced their abundance throughout northern and central New Zealand. Such introductions would not be possible under current New Zealand legislation which is designed to protect our native species.
Key words: pest, natural enemy, parasitoid, biological control.

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MATERIALS USED FOR SHEATHED OF CHERIMOYA FRUIT (A*nnona cherimola* Mill.) TO CONTROL FRUIT FLY (*Anastrepha* spp.)

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Cherimoya (*Annona cherimola*) is a fruit cultivated in different provinces of Ecuador such as Imbabura, Pichincha, Azuay y Loja. This is a fruit which has good acceptation by the consumers because of its sweetness. One of the limitations of cherimoya crop is the attack of fruit flies, mainly *Anastrepha fraterculus*, which is a pest that can infest over 65% of production and cause great economic losses, as well as restrictions for the export of this fruit. This research was carried out to evaluate five materials (kraft paper bags, wax paper, polyphane plastic, canvas and pelón) to cover the cherimoya fruit and control fruit fly. Fruits were sheathed 60 days after fruit set, when they showed a diameter among 3.5 to 4 cm; while the absolute control was not sheathed. According to the results, it was determined that the control without sheathed showed 100% of infested fruit fly; whereas fruit sheathed with different treatments showed no fly attack. Brix degrees were not affected by the assessed treatments. In addition, the incidence of anthracnose (*Colletotrichum* sp.) in sheathed fruit was reduced; however there was presence of white cochineal (*Pseudococcus* sp.) in the sheathed fruit. It is concluded that the use of a physical barrier to control fruit fly as the kraft paper bags is an alternative for the integrated management of this pest.

Key words: cherimoya, fruit fly, integrated pest management.

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EVALUATION OF SUBSTRATES FOR AVOCADO (*Persea americana* Mill.) SEED GERMINATION

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The success of a good yield of fruit in adult plants depends on the quality and health of the seedlings used for planting. The nursery stage in the production of fruit plants plays a key role in the process of these crops. Among the aspects to consider propagating plants in nurseries, the selection of the substrate for seedbeds is one of the most important because it is involve in the development of the root system, essential for healthy plant growth. In this research, it was evaluated three substrates: 1) 100% pomina, 2) black soil + pomina + compost (2: 1: 1) and 3) 100% river sand. A number of 132 seeds per treatment where sown to measure the speed (days for germination) and the germination percentage. It was determined that the germination started at 24 days after planting; however the germination range for mostly seeds was between 33 and 38 days. The substrate composed of river sand is more compact thus significantly retards the speed of germination of the seed. The highest percentage of germination (84 %) was obtained in black soil + pomina + compost; followed by pomina with 79 %, and finally the river sand with 42 % whereby the latter cannot be considered as a comercial substrate in nursery. In conclusion, the substrate (black soil + pomina + compost (2: 1: 1)) is the best for nursery because it has all the components that give a good structure to the soil. Nevertheless, pomina could be considered as an alternative for substrate in seedbeds because it obtained an acceptable percentage of germination and also helps to eliminate water excess and has less cost.

Key words: avocado, seedbeds, germination, substrate.

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GENERATION OF AGRICULTURAL TECHNOLOGY WITH ADDED VALUE FOR THEIR IMPACT IN ECUADOR

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Postharvest fungal infections of fruits, during postharvest period, represent the majority of losses during export period. Synthetic fungicides are the main mean of control, but the constraints associated with the use of these kind of products, like the appearance of resistant strains, have led to search alternative methods to reduce fungal infections. Study of non-conventional methods to control postharvest decay has been developed over several decades, along with the demand for safer storage methods. Natural antimicrobials, such salts, chitosan, plant extracts and essential oils have demonstrated good results and often have been applied in various scales. Several GRAS-classified sanitizers have been tested to extend postharvest storage of fruits including sodium bicarbonate, acetic acid and methyl-jasmonate. Physical technologies involving variations in temperature, UV-C irradiation, gamma irradiation or changing atmospheric composition. Furthermore, several postharvest diseases can now be controlled by microbial antagonists. Although the mechanisms by which biocontrol agents suppress the postharvest diseases is still unknown, competition for nutrients and space is most widely accepted mechanisms of their action. In addition, production of antibiotics, direct parasitism, and possibly deduced resistant in the harvested commodity are other of their actions by which they suppress the activity of postharvest pathogens in fruits and vegetables. Production and formulation of these biological agents are very important in order to increase or decrease their action spectrum and effectiveness depending on the concentration of product and the duration of exposure to the treatment. However, application of these alternatives by themselves may not always provide a commercially acceptable level of control of postharvest diseases comparable to that obtained with synthetic fungicides. Therefore, mixed of the microbial antagonists or mixed several alternative methods appear to provide better control of postharvest diseases.

Key words: alternative methods, fungicide, GRAS, natural compounds, microbial antagonists.

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THE NEW ZEALAND/ECUADOR BIOCONTROL PROJECT – A STRATEGY FOR SUSTAINABLE AGRICULTURE

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The New Zealand/Ecuador biocontrol project is a partnership between AgResearch, New Zealand, and INIAP, Ecuador, to promote Agricultura Limpia – a goal of "clean, green agriculture for food safety and a pure environment to underpin better health, higher value agricultural products and economic advancement". The project is focussed on fruit production using biological control to reduce the need for pesticide use. It implements the strategy of bioprotection to maximize the impact of natural enemies and antagonists of plant pests and diseases, within the context of integrated pest management, to produce safe, high quality, agricultural products in a way that protects and improves the natural environment. Microbes are one component of the natural enemy complex and can be manipulated for crop protection. By production and formulation, beneficial microbes can be used to produce biopesticides or bioinoculants for the control of pests and diseases, but their successful use will depend on selection of stable, effective strains of microbes and development of efficient production systems and application strategies based on the characteristics of the pest and the host/pathogen interaction. The project will bring experts from New Zealand and other countries to assist INIAP and Ecuadorean collaborators in development and implementation of biocontrol in key fruit crops. In all cases, microbial controls must be economical for the user and amenable to large scale production to provide viable alternatives to chemical pesticides. The project has three components – Assisting development of a regulatory framework for biocontrol products, training of technicians in biocontrol research and development and implementation of bioprotection systems for key crops in pilot projects. The project will concentrate on smallholder farmers who are confronted by a wide range of pests and diseases while growing fruits. Microbial controls can be a safe and economic option for these growers, with beneficial microbes ranging from fungal colonisers of the soil for control of root pests and diseases to bacterial biopesticides for control of leaf feeding insects.
The project aims to improve the economic, social and environmental sustainability of the Ecuadorean fruit industry. The successful use of microbial agents in biological control will require a strong and effective partnership between researchers, microbial producers and the farmer users. For this reason, the project works right through the fruit value chain, including experts in biocontrol, implementation of fruit management systems and agribusiness, to achieve safer environments and a sustainable agriculture for the future.

Key words: integrated fruit production, organic, biological, residues.

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NEW STRATEGIES FOR USING ENTOMOPATHOGENIC FUNGI TO BENEFIT AGRICULTURE

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The use of entomopathogenic fungi — *Beauveria* spp., *Metarhizium* spp., *Isaria* spp. — is increasing in the U.S. and Europe because of the growing concern about environmental effects of chemical pesticides. Worldwide, there are about 200 products currently registered in countries that have organized regulatory systems, and more in other countries. In the U.S., one registered fungus had 2014 sales of over $2,000,000. In almost all cases these fungi are used as biological insecticides rather than true biocontrol agents. There is user dissatisfaction about the speed and extent of control causing historical complaints about these fungi. A fundamental challenge is that delivery of fungus spores to the insects is very inefficient, requiring large numbers of spores per hectare of crop. The perceived deficiencies are being addressed in a number of ways. Goals have been identified to deliver the fungi more efficiently; make them more persistent through formulations, some quite novel; or make them more virulent either with synergistic additives or genetic manipulation. More innovative approaches include bringing the insect to the fungus using attractants; using the insect to vector a fungus to its kin; using another insect to transfer the fungus to the microarena of the target, e.g., honeybees vectoring Beauveria to flowers; and taking advantage of insect normal behavior to increase transfer efficiency. The relatively recent discovery of Metarhizium and Beauveria as endophytes in more and more plants has opened the possibility of this approach to attack target insects, both directly, and indirectly via induced systemic resistance. In a wider sense, several enterprises are investigating the many other fungal endophytes in plants and how they could be leveraged into plant probiotics to combat disease as well as pests. A fundamental concept that is too often forgotten is that the fungi should be used as one tool in an integrated pest management program (IPM), complementing other approaches, but recent work is remediating this deficiency as biologically based IPM is being increasingly refined.

Key words: biocontrol agents, pest managment, entomopathogenic.

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DEVELOPMENT OF NEW BIOLOGICAL CONTROL AGENTS: FINDING YOUR AGENT IS JUST THE BEGINNING!

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To develop a new biological control program for a pest, the first step is to identify a potential agent. But identification alone is not enough to make biological control work. How effective is the agent against the target pest? What factors could change the agent's response to the target pest? Two examples, one parasitoid and one predator, demonstrate ways to address these questions in different agroecosystems. The first example looks at physiological and ecological host range in a species of Trichogramma that is native to California. The egg parasitoid, *Trichogramma platneri* (Hymenoptera: Trichogrammatidae) attacks the codling moth, *Cydia pomonella*, which is an exotic pest in California on apples, pears and walnuts. When offered a series of different host species in laboratory host range tests, *T. platneri* attacked several non-target hosts, including eggs of the green lacewing, *Chyrsoperla carnea*, and demonstrated a preference for larger host eggs, although it also showed some preference for the target host, *C. pomonella*. In a field experiment in a walnut orchard, *T. platneri* attacked all available host species at similar rates. This demonstrates a potential risk for the predator, *C. carnea*, a species that contributes to control of aphid pests in walnut orchards. It also shows that the physiological host range for this species did not match entirely with the ecological host range. A thorough understanding of host preferences in Trichogramma parasitoids is important for effective biological control. The second example compares the frequency of predation and scavenging events on the pest *Lygus hesperus* (Hemiptera: Miridae) by three insect predators: *C. carnea*, *Hippodamia convergens* (Coleoptera: Coccinellidae) and *Collops vittatus* (Coleoptera: Melyridae). Many predators will scavenge on dead 'prey' as well as capturing live prey, making it hard to measure predation accurately. One method is to release marked prey into the environment then collect predators and analyze their gut contents for presence of the marker. If two different markers are used to identify live and dead prey of the same species, you can quantify the number of predation and scavenging events. For these three predators in cage experiments on cotton plants, scavenging occurred more frequently than predation and all three species engaged in facultative scavenging. It is very important to distinguish between predation and scavenging events to avoid overestimating the impact of insect predators as biological control agents.

Key words: biological control, microorganism, parasitoid, predator.

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FORMULATION AND QUALITY CONTROL OF BENEFICIAL MICROBES

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Biopesticide formulations are prepared using active ingredients based on microorganisms such as bacteria, fungi, viruses, nematodes and naturally-occurring substances including plant extracts and semiochemicals. A range of formulations can be prepared using the microbes including liquids, granules, water dispersible prills, wettable powders, baits, and seed coatings. A large number of factors can potentially affect the economical feasibility of any given biological control product. These include the cost of production and a number of technological challenges during fermentation, formulation and delivery systems. Some of factors that might have a direct influence on the robustness of the microbial formulation are quality of raw ingredients, heat, desiccation, UV radiation, moisture, impact of excipients and substrate. Selection of appropriate formulation is critical for improving the product stability and efficacy of delivery. For example, a granular formulation prepared with the Gram- negative bacteria *Serratia entomophila* was stable at 20°C for more than 3 months and retained efficacy on delivery compared with rapid decline of viability in the original liquid broth. Similar results were obtained when *Trichoderma* spp. spores were coated onto wheat seeds. For any formulation to be successful it is of paramount importance to maintain the quality of the formulation during fermentation, production, storage and transport. Some of the quality control parameters to be periodically assessed are purity of the strains, cell/spore loading, moisture content, water activity and presence of contaminants. Any negative effect on these parameters will be deleterious to the formulation quality. Good quality microbial control products can be incorporated into pest management systems to produce high quality agricultural produce without chemical residues or environmental contamination thus delivering "green technologies". Users must understand the characteristics of the microbial control agent to successfully integrate the technology into their production systems. Economic return and efficacy of a product will be directly related to formulation and quality control.

Key words: microorganisms, ingredient, formulation, quality.

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EXPERIENCES AND RESULTS OF THE BIOLOGICAL CONTROL RESEARCH IN ECUADOR

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Research related to the use of biological control in Ecuador had its beginnings in the National Plant Protection Department from the National Institute of Agricultural Research (INIAP) in the 90's, when there was a prospection of entomopathogenic virus (Baculovirus) to control potato moths. Among the years 2003 and 2010, different activities related to prospection, bioassays and multiplication of biological control agents have been carried out. Fungi, nematodes and parasitoids, especially for controlling pests such as white potato worm (*Premnotrypes vorax*), potato tuber moths (*Tecia solanivora*, *Symmetrischema tangolias, Phthorimaea operculella*) naranjilla fruit borer (*Neoleucinodes elegantalis*), corn beetle (*Macrodactylus* spp.) and soil larvae (Scarabeidos) have been the principal targets in the biological control research. The Biological Control Laboratory of INIAP, which was established in 2011, maintains a ceparium of 104 isolates from fungi of the genera *Beauveria*, *Metarhizium* and *Trichoderma*, as well as 10 isolates of entomopathogenic nematodes. INIAP jointly with scientists form AgResearch (New Zealand), has developed formulation techniques using beneficial fungi to provide Ecuadorian farmers with innovative technologies for clean and organic management of Andean crops such as potato (*Solanum tuberosum*) and blackberry (*Rubus glaucus*). *Beauveria* sp. has showed high specificity for control *P. vorax*, reaching above 90% of mortality. In addition, it showed a production capacity between 2-3 x 10^9 spores/gram of substrate; and a survival up to 96 days without decrease its concentration. Formulations developed included soluble granules, granules covered, gels and others. *Beauveria* sp. were formulated as soluble granules which showed 100% of spore survival after formulation. The laboratory had also evaluated the quality of 20 bioproducts; the results showed that the fungi *Trichoderma* sp. and *Beauveria* sp. showed survival when their water activity (aw) was less than 0.600 on solid substrates. In wettable powder formulations, microorganisms showed higher survival of spores with water activity values near of 0.300. Additionally, *Trichoderma* sp. showed higher survival than *Beauveria* sp. in liquid formulations, as long as the product was stored under refrigeration.

Key words: entomopathogen, pest, granules, survival, concentration.

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