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Impact of the Use of Agrochemicals and Organic Fertilizers in the Creating of Agrobiodiversity in the Aymara Communities of Puno

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Abstract

The research is about the use of agrochemicals and organic fertilizers in the breeding of crops in the Aymara communities of Puno. The objective of the research is to describe and explain the practices and perceptions of farmers on the use of chemical and natural fertilizers in the production of various crops such as: tubers and grains, the characteristics of use and damage caused. For this, the qualitative-ethnographic methodology was used, with the help of techniques such as the interview, participant observation, theorical and practical experience and life stories, it allowed us to glimpse the context of the Aymara farmer. With the result of the research, a practice is perceived, that farmers combine agrochemical and natural fertilizers, in order to control pests and obtain better yields in production, they also show negative effects of the use of agrochemicals in production and human consumption, For this reason, some families are reoriented to invigorate in the communal and family organization on the traditional knowledge of the use of organic inputs in agriculture.

Keywords: *Natural Fertilizers, Agrochemicals, Farmers, Breeding, Crops.*

Introduction

The research alludes to the use of agrochemicals and natural fertilizers in the breeding of agrobiodiversity (Apaza, 2018), among the inhabitants of the Aymara peasant communities of the Puno region. This ecozone is located to the east of the region of the same name; however, its territory ranges from the flat zone (3,850 m.a.s.l.) to the upper part (3,926 m.a.s.l.) (Apaza *et al.*, 2019). The geographical context of Puno is part of the great Peruvian-Bolivian highland plateau (Pulgar, 2014) and constitutes one of the richest genocenters in the world in terms of the cultivation of potatoes (Solanum tuberosum), oca (Oxalis tuberosa), izaño (Tropdeolum tuberosum), olluco (Ullucus tuberosum), quinoa (Chinopodium quinoa), barley (Hordeum vulgare) and broad beans (Vicia faba) (Valladolid, 2005). A large number of species, varieties, ecotypes and races of food and medicinal plants are cultivated, depending on the different existing ecological levels and the unique climatic and soil conditions, which vary greatly throughout the year (Zárate and Miranda, 2016).

The research focuses on the use of agrochemicals and natural fertilizers in the breeding of agrobiodiversity in the Aymara context. According to farmer Máximo Apaza, 83, he knows and uses the following: "*Chemical fertilizers: urea, superphosphate and ammonium nitrate, for pest control: karate, sherpa, furadan and super cytogeel*" (personal communication September 8, 2020), are used in the agricultural campaign and nuanced with natural fertilizers: *mataje* (island guano), sheep manure, ash from natural plants, and bitter plants for pest control. In recent agricultural seasons it has a credit in the knowledge and traditional practices of use of organic fertilizers. Organic fertilizers are of great economic, social, and environmental importance by reducing the production costs of different crops, ensuring good quality production for the population, and mitigating the pollution of natural resources in general (Sarmiento *et al.*, 2019). In some young families, it leads to dependence on agrochemicals, due to their need to produce a little more for the local market and their survival when they see that the land already requires these chemical inputs. Ecological activity such as

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crop rotation (Alanoca & Apaza, 2018), this ancestral practice has been lost in some communities, potato cultivation requires turning and natural fertilizers so as not to be affected by Andean weevils (Escobar *et al.*, 2015).

Farmers assert that when the soil does not rest due to the constancy of planting in each agricultural season, these plots require more chemical inputs in each agricultural season and this fact generates soil sterility, soil microorganisms are more affected by agrochemicals, with reductions in abundance (Chaves *et al.*, 2013). In addition, crops with greater application of agrochemicals are more prone to natural phenomena such as frost, hail, and floods (Alanoca and Apaza, 2018). The Aymara experienced these collateral effects of agrochemical use, which is why in recent years farmers have once again invigorated the practices of using natural fertilizers, even nuanced with some chemical inputs in the breeding of agrobiodiversity at different times such as: planting, cultural work and harvesting.

It is important to point out that the use of agrochemicals in the context of peasant communities has been occurring since the 1950s, with the green revolution, due to the facilities it represents for the peasant farmer in combating the pest and fertilizing the land (Vallejo & Cárdenas, 2016). Agriculture was based on the use of agrochemicals, such as insecticides and herbicides, among others (Cruz *et al.*, 2011). This leads to greater production in the first years and satisfies the subsistence requirements of the peasants. However, due importance was given to the impact of these chemicals on soil, agricultural production and the environment. The use of these products has generated high levels of pollution, affecting the health of consumers and producers due to their use (Cruz *et al.*, 2011). In the long term, these cause environmental deterioration, greater soil degradation and the loss of fertility of land used for agriculture (Alanoca and Apaza, 2018). It has been observed that there is a lack of knowledge about the use (dose) in the application. In addition, the informants declare that they do not have scientific information on the effects of agrochemicals, only with their experiences can they examine the damage they cause to the soil, crops and generates the resistance of pests, which can no longer be effectively combated, these experts are contemplated in the testimonies of the farmers.

In this way, we present the use of agrochemicals in crop breeding and mixed with a traditional heritage of ethnoknowledge, which are amalgamated with the practices and knowledge of modern agriculture. The use of the various environmental protection strategies still in force, despite the efforts of the different development programs and academia to homogenize cultural practices of environmental protection (Alanoca and Apaza, 2018). We also present the different actions in the agricultural process that they have adopted to improve production and know the opinion that the use provokes in them, as well as the effects of agrochemicals on the various crops, this is essential to develop and propose strategies to support agriculture and sustainable development of peasant communities.

In the fieldwork, we have been inspired by those who say that the process of knowledge of a reality is not only intellectual, but also emotional and moral. The fieldwork has been developed, consequently, interviewing and meticulously observing every detail of the use of agrochemicals and natural fertilizers in breeding, but also dialoguing, sharing and living as Aymaras, the reality of the object of study. The results of the research are that for farmers the use of agrochemicals is important, because based on them production of various crops such as tubers and grains is obtained. This practice at the same time brings negative damages such as defertilization and the loss of soil microorganisms, the products lose flavor, they are tasteless.

Literature Review

Agrobiodiversity, defined as the variety of species cultivated and their ecological environment, is central to traditional agriculture and the sustainability of rural communities. The Aymara communities of Puno, located in the Peruvian Andes, have historically maintained a rich agrobiodiversity that has been adapted to the extreme climatic conditions and geography of the region. However, in recent decades, the introduction of **agrochemicals** and the return to the use of **organic fertilizers** have significantly impacted agrobiodiversity and agricultural production systems in these communities (Mamani-Flores *et al.*, 2022).

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Indigenous communities, such as the Aymara, rely heavily on agrobiodiversity for their food security and resilience to climate change. According to Altieri (1999), agrobiodiversity in traditional agricultural systems acts as a mechanism to reduce vulnerability to pests, diseases, and droughts. Crop diversification also plays an important role in adapting to different environmental conditions and in conserving the genetic resources of local species (Perales et al., 2005). For Aymara communities, agrobiodiversity breeding is intimately linked to their cultural traditions, so any change in agricultural practices has profound effects not only on the ecology, but also on the social and cultural structure.

The use of agrochemicals, such as pesticides and synthetic fertilizers, has been driven by the desire to increase agricultural yields in the short term. However, numerous studies have shown the adverse effects of these products on agrobiodiversity. According to Tilman et al. (2001), the intensive use of agrochemicals degrades soil health by killing beneficial microorganisms and promoting erosion, which reduces the capacity of agricultural ecosystems to sustain a diversity of crops. In Aymara communities, the use of agrochemicals has resulted in the loss of local crop varieties and has altered traditional ecological balances, affecting soil and water quality (Altieri & Nicholls, 2003).

In addition, the use of agrochemicals can have detrimental effects on human health and the environment. Pesticide residues can contaminate water and food, posing a health risk to farmers and local communities (Matson et al., 1997). Despite these risks, many Aymara farmers have adopted the use of agrochemicals due to market pressure and the need to increase productivity, which poses challenges for agrobiodiversity conservation.

In contrast to agrochemicals, organic fertilizers, such as manure and compost, have traditionally been used in Aymara agriculture. These fertilizers improve soil fertility by increasing organic matter and encouraging microbial activity, which contributes to the conservation of agrobiodiversity (Drinkwater et al., 1998). Organic fertilizers not only restore nutrients to the soil, but also promote more sustainable agriculture, reducing dependence on external inputs and protecting the environment.

The use of organic fertilizers has been identified as a key strategy to improve **sustainable agriculture** in indigenous communities. Badgley et al. (2007) point out that organic farming systems can be as productive as conventional systems, especially in rural regions where financial and technological resources are limited. In addition, organic agriculture supports crop diversification, which is crucial for the resilience of local farming systems and the food security of communities.

Several studies have compared the long-term effects of the use of agrochemicals and organic fertilizers on agricultural biodiversity. Matson et al. (1997) argue that although agrochemicals may increase productivity in the short term, in the long term they cause biodiversity loss and degrade natural resources essential to agriculture. In contrast, production systems based on organic fertilizers tend to improve soil fertility over time and promote greater diversity of crops and beneficial species.

In Aymara communities, the transition to greater use of organic fertilizers can contribute to restoring the agrobiodiversity that has been affected by the introduction of agrochemicals. However, the shift towards more sustainable agricultural practices requires adequate technical and financial support, as well as the implementation of policies that encourage the use of organic methods and respect for traditional crop management practices (Swinton et al., 2007).

The preservation of agrobiodiversity in Aymara communities faces several challenges, including lack of access to markets for organic products and pressure to adopt intensive agricultural practices. Toledo and Barrera-Bassols (2008) suggest that the integration of traditional knowledge with innovations in sustainable agriculture can be key to solving these problems. Policies that promote organic agriculture and support fair trade can help maintain agrobiodiversity and improve the quality of life for indigenous communities.

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Material and Method

The research method is based on qualitative methodology and comprehensive interpretative analysis of the objective meaning of the use of agrochemicals and natural fertilizers in the production of various crops in the Aymara communities of Puno. In this study, the main instruments have been used, the information has been obtained mainly through participant observation, interviews and performative, based on the experience of the researchers for having been born and lived in these communities. Ethnography aims to describe and analyze ideas, beliefs, meanings, knowledge, and practices of groups, cultures, and communities (Hernández, 2010). The data has been systematized under the following steps: organization and structuring of the categories and subcategories. In this way, it has been possible to describe the current forms of ancestral knowledge (Alanoca & Apaza, 2018), on the use of natural fertilizers and agrochemicals in crop breeding. The research areas are the provinces of Puno, El Collao-Ilave, Chucuito-Juli, Yunguyo and Moho, which are geographically located in the department of Puno. According to the census (2017), the department of Puno, located in the south-eastern part of Peru, is the ninth most populous in the country, home to 1,172,697 people (INEI, 2018) and the province of El Collao has 63,878 inhabitants (Apaza *et al.*, 2019). In this work, 4 families from each province have been taken as informants due to their characteristics as breeders of agrobiodiversity and a total of 20 families, with whom we have lived in order to obtain information on the use of fertilizers in the process of raising crops and it is also pertinent to point out that the protagonists have complementary pluriactivities.

Results and Discussion

Agrochemicals, Origin and Acquisition for Farmers' Agricultural Campaigns

Peasant families use the following agrochemicals in activities such as in the planting of various crops and cultural work: urea (solid), also called carbamide, carbonyldiamide, etc., is a chemical compound whose formula is CO (NH2)2. Chemical nitrogen (Boccolini *et al.*, 2016). The Aymara farmer uses it at the time of planting the tubers, mixing it with triple superphosphate (solid). The nitrogen found in soils comes mainly from the contribution of nitrogen fertilizers of different nature: urea, ammonia or nitric; manufactured by man (UBE, 2018).

In agricultural management, it can affect the community of ammonia oxidizing bacteria (BOA) through the prolonged use of nitrogen fertilizers such as urea, the application of which tends to increase soil acidity (Boccolini *et al.*, 2016). Some families use aldrin (powder) containing 95% w/w (wet weight/weight) of HHDN (PAHO, 1996). Furadan (powder) 350 L carbofuran nematicide insecticide, due to its use there is a risk of acute pesticide poisoning, it is related to the absence of: technical knowledge, training in the management and use of agrochemicals (Guzmán *et al*, 2016). According to the Food and Agriculture Organization of the United Nations. Over-application of fertilizers and nutrient losses due to fertilizer misuse can reduce farmers' profits and, in some cases, lead to crop failures (UN, 2019).

The farmers assert that they do not have technical knowledge about the use and application of these chemical inputs, they learned by observing and experimenting in their production and consider that the use of agrochemicals produces greater growth in the various crops. It is also evident that the agrochemicals used for pest control are: karate, sherpa (liquids) these chemical inputs are used for the purpose of pest control and the perception of farmers in their application in weeding and hilling activities, in order to reduce the population of Andean weevils, this utility generates a positive appreciation in farmers. *"We use solid agrochemicals at the time of planting tubers and we fumigate liquid on the foliage at the time of hilling to protect from pests. At the time of sowing grains, we do not use chemical inputs"* (E = 2).

Peasant farmers use a variety of agrochemicals and natural products (solids, powders and liquids) to improve the growth of their potato, quinoa, barley, cañahua and broad beans crops (Figure 1 and Table 1).

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The acquisition of agrochemical products is carried out in the different marketing areas such as in the stores that exist in the capital of the province or district of the Aymara area. The most used products are urea, karate and sherpa, because farmers assert that these inputs help improve the growth of potato plants and obtain a greater amount of production from it.

Natural Fertilizers and Bionatural Insecticides

The beneficial effect of organic fertilizers on soil fertility, especially on highly weathered soils, is of dramatic importance in relation to their contents, as it has been shown that minimal increases simultaneously benefit the physical, chemical, and biological properties of the soil (Zakarya *et al*., 2018). In the Aymara context, there is a variety of ancestral knowledge to fertilize crops (Alanoca & Apaza, 2018). For the crops of potato, oca, izaño and olluco, free-range manure is used, which is prepared several days in advance, so that the *wanu* or guano is completely fluffy and dry (Chambi, 1995). In some cases it is customary to mix it with ash, two weeks before planting. The manure is placed on the plot preparing an approximate amount of eight to ten bags (500 kilograms) for a "*mass*" of land consisting of 220 or 230 m2.

Poultry manure is used in its three stages of decomposition: *jamallach'i* or *chujña jiri* (fully decomposed manure), *q'awa* or *q'aya* (semi-decomposed manure), and *lluji wanu* (fresh manure). *Jamallach'i* serves to disinfect the seed, accelerates the emergence of shoots or buds (acts as a phytohormone) behaving as a healing agent (for fractionated seeds) and, finally, serves as food for the plant (Figure 2). This form of manure is used at the time of seed preparation, that is, with *jamallach'i*, the seeds are smeared whole or fractionated. This is done with about four or five days to go before planting.

The *q'awa or q'aya* serves for the greater retention of soil moisture, increases the microbial population (they are "plant cooks", so called because they are in charge of preparing the plant's food) and temperature, and finally serves partially as fertilizer for the first season and the rest for the next crop rotation (goose association, Olluco, Izaño and Quinoa). On the other hand, the application of *lluji wanu* is fundamentally due to the purpose of increasing soil temperature due to the effect of decomposition, greater retention of soil moisture and to increase the microbial population, among others. The fertilizing effect of *lluji wanu* is manifested only in the third year of crop rotation and even when the land comes to rest, which favors the growth of pastures. According to (Maceda, 2015).

The *jira* contains nutrients and has a higher amount of sodium and manganese, the pH is basic due to the elements calcium, magnesium and sodium. It provides bioactive compounds, two types of hormones are formed: auxins and gibberellic acid; Gibberellic acid influences the germination and dormancy of the seeds, when applying *JIRA* the dormancy is broken. Among other benefits of the *jira* we have that when applying *jira* at ground level in the potato crop, if it has a wart, it eliminates it. Jira applied at the plant level limits chewers. (p.16).

Families understand this process of transformation of natural fertilizers. "*First we have to plant the potato with a lot of natural fertilizer, that fertilizer will maintain the crops that are going to be sown in the same soil in the following agricultural campaigns, then the soil has to rest for about 3 to 4 years, in it we plant Salliwa (wild legume plant), this so that the land gains strength,* (E = 20). At the time of planting, families mix with *mataje* (island guano), which originates from the accumulation of the excrement of the guano birds that inhabit the islands and points of our coast. Among the most representative birds we have the Guanay (Phalacrocórax bouganinvilli Lesson), Booby (Sula variegata Tshudi) and Pelican (Pelecanus thagus) (AGRORURAL, 2019). To obtain this product, some families travel to the coasts and others buy from local markets. As for bionatural or biocides, for insect control, it is prepared by the farmers themselves. *"In this area we have many bitter wild plants such as: royal palm, muña, arnica, ajinco, eucalyptus, we boil that in the afternoons in a clay pot and we keep it in a large plastic container, before it was ceramic. We also have to have t'amata (fermented human urine), to fumigate we have to mix these liquids, lime is added, it is good to protect from pests and helps plants grow"* (E = 10).

Crops That Require Agrochemicals and Natural Fertilizers

According to experience, farmers consider that there are products that need more agrochemicals and others

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less. The cultivation of potatoes requires the use of more natural fertilizers (Alanoca and Apaza, 2018) and chemicals used in agriculture (Chaves *et al.*, 2013), the potato is added sheep manure, superphosphate slaughter, ammonium nitrate, urea to promote its greater growth, and so that pests are controlled, it is fumigated with sherpa and karate. and it is common for farmers in the communities to find that quinoa, cañahua and barley only require urea and fumigation products (sherpa and karate) for pest control.

The highland communities are agrocentric, therefore, in order to produce crops, crop rotation was substantial (Alanoca, 2016), in the absence of continuity of this ancestral practice, the plots of tuber crops require chemical and natural fertilizers. It is also important to highlight in this ecozone, the environmental factors of production such as frost, hail, rain and summers, we found that the agricultural campaign with enough rainfall does not require chemical fertilizer and in the campaign with little rain, that is, with little rainfall, in this campaign insects appear and attack the plants, that is why chemical fertilizers and insecticides are required (Alanoca *et al.*, 2020).

Quantity: Agrochemical Doses

We found in the research process that families have different customs in terms of the use of the amount or dose of agrochemicals and natural fertilizers, this varies from family to family and we evidenced two ways: organic farmers, only use natural fertilizers that is, sheep guano, llamas, alpacas, cattle, guinea pigs, chicken and pig. They also use cooking ash and *japucha* (burning dry pastures after fallowing) (Figure 3), farmers using mixed use agrochemicals in conjunction with organic fertilizers. The measurement is based on a handful of solid inputs such as: urea, matage, ammonium nitrate and superphosphate, liquids based on spoons or karate container lids, sherpa, furadan and mesclan with super cytogeel in a backpack (fumigation tank). *"In this community we all use agrochemicals, when the plants are raised we use insecticides, the products are tasteless"* (E=16). Some farmers are in the habit of applying agrochemicals in cultural work (first and second hilling). Others use up to three or four in the entire process of plant growth, this activity depends a lot on the farmer. *"Breeding is being attentive to our crop plots, we have to take care of livestock, insects, frost, hailstorm and floods, each crop is different, it has its time for planting, hilling and harvesting. In this breeding, we cannot exceed the use of agrochemicals to the crops, because when we consume they are sour"* (E = 8).

Among the protagonists of this research there is a feeling that the ancestral form of production was healthier for humanity and the *pachamama* (mother nature) positive and appropriate for not using agrochemicals, all natural and currently the plots are overexploited relentlessly, therefore, the use of agrochemicals is needed to guarantee production.

Agrochemicals have also caused pests to become more and more resistant and that is why stronger and stronger products have to be applied in order to combat them. As he argues (Valladolid, 2005), the main negative effect is likely to be in the form of excessive pressure on the environment that could lead to soil and environmental degradation. This notion of Valladolid is evident today and in the Aymara communities this technical change allowed the intensification of cultivation systems. It has also generated a process of soil degradation and pest resistance, which seems like a short-term gain could be a long-term loss due to the environmental consequences that this will generate.

Farmers are aware of the need to use agrochemicals, which is why some young farmers show that there is a change in production in the context. The use of these agrochemicals is shown by the lack of arable land, by not invigorating the traditional *suyus or aynoq'as* practices (crop rotation), as a result of which the land does not rest and is defertilized and the adult protagonists of the research show their concern about the agrochemicals that maintain that the first years produce the products well and then each time the soil no longer produces, The population of the Andean weevil increases and unknown pests appear. As a result of these agrochemicals, the batrachians and lizards that were indicators at various times of agricultural production and at the same time are the consumers of Andean weevils have disappeared. Not only that, the worms are affected.

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Peasant Perception of Consumption of Products Based on Agrochemicals.

Farmers perceive the use of agrochemical inputs in a positive way and on the other hand they also declare negative the use of agrochemical inputs and according to the observations made, the farmers who breed agrobiodiversity to their products use it for different purposes, depending on the way they have been cultivated, the products applied with agrochemicals are destined to be marketed, such as potatoes and derivatives (chuño, tunta) in the same way oca, isaño and papaliza, other crops such as grains: beans, quinoa, cañihua and barley. This in order to sell and buy agrochemicals for the next agricultural campaign. The products made without the use of agrochemicals are for family self-consumption. *"We have two ways of producing crops. In some plots we use chemical fertilizers and fumigate with insecticides, for good production, we send these to the market and the other production is with natural fertilizer, that is, with sheep guano. We have experience, when we cook products with chemical fertilizers it is tasteless, it makes our pharynx burn and when we keep prepared food it spoils quickly and when we make chuño in a short time it turns brown (E = 11).*

In the calendar of food consumption we find according to seasons, in the rainy season more vegetables are consumed, that is, quinoa leaves, beans and goose and processed products such as: chuño and tunta, grains; corn, beans and quinoa. The characteristic is the collective lunch, the *qoqawi* (fiambrada), in these moments of consumption of products, the inhabitants distinguish the flavor of the meals (figure 4). Depending on the production, it is generally perceived that the products prefer to use natural fertilizers since it is more pleasant.

Conclusion

The breeders of the Aymara agrobiodiversity of Puno use the following chemical fertilizers in planting: urea, superphosphate, ammonium nitrate and as natural fertilizers: mataje (guano from islands), manure from sheep, llama, alpaca, cow, guinea pig and chickens and ashes for tuber crops such as: potato, oca, izaño and papaliza. And for grains such as: quinoa, cañihua, barley and beans. As an insecticide within the chemical inputs are: sherpa, karate, furadan and super cytogeel and the bionatural or biocide the mixture of fermented urine, lime, boiled water of bitter natural plants for pest control, farmers find positive when using these inputs, which attribute to them the benefit of controlling pests and obtaining better yields in production.

Farmers' perception of agrochemicals is both positive and negative, because they are considered important inputs for potato, quinoa, barley and cañahua crops, with which a lot is produced. However, the frequent and inappropriate use of these agrochemicals has led to an increase in pests, the defertilization of arable soils, the products are tasteless at the time of consumption and the loss of biodiversity.

The use of agrochemicals and organic fertilizers in the Aymara communities of Puno has had a significant impact on the breeding of agrobiodiversity. While agrochemicals can provide an immediate increase in agricultural productivity, they have long-term negative effects on soil health, biodiversity, and the environment. In contrast, organic fertilizers offer a sustainable alternative that promotes the preservation of agrobiodiversity and reinforces traditional agricultural practices. To ensure the long-term sustainability of agriculture in these communities, it is essential that agricultural policies encourage the use of organic fertilizers and the conservation of local agrobiodiversity.

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Conflict of Interest Statement

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