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Agroecological functions of perennial forage Pinto peanut (*Arachis pintoi* Krap & Greg.) in agricultural systems

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ABSTRACT

Objective: to identify the main uses, ecological benefits and productive contributions of Pinto peanut (*Arachis pintoi*) in agricultural systems oriented toward sustainability.

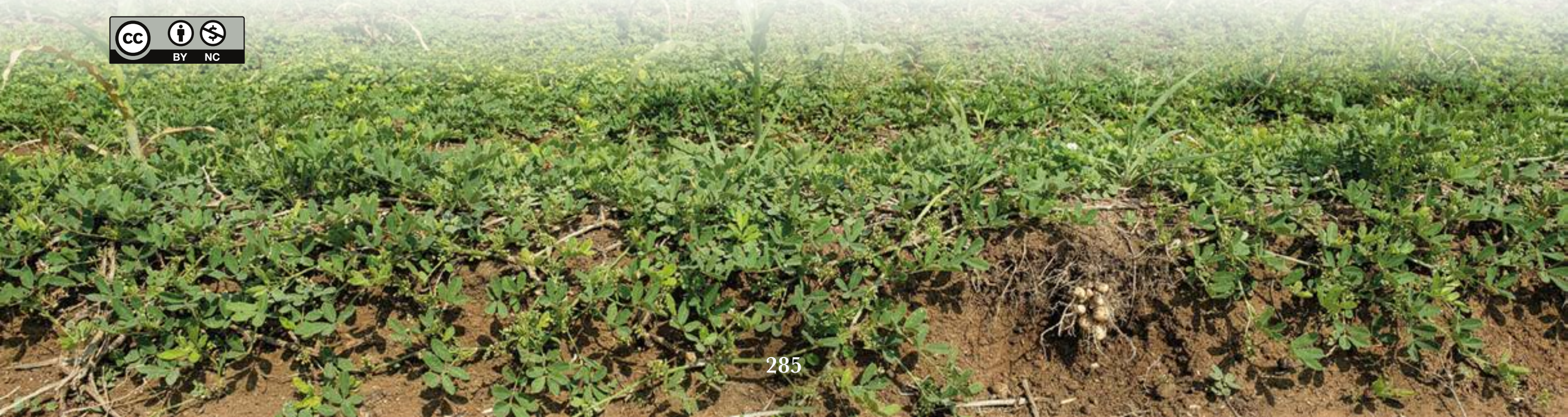
Design/Methodology/Approach: an exhaustive bibliographic review was compiled on the use of Pinto peanut (*Arachis pintoi*) in different tropical agricultural systems. Relevant information was collected about the main uses of Pinto peanut, including its function as plant cover and soil protector, a source of fodder for cattle, organic mulch, erosion control agent and raw material to produce flour for feeding guinea pigs. The bibliographic review was complemented with some other field observations, to build a comprehensive perspective about the benefits of this species within sustainable production systems.

Results: With the literature consulted as background and data from field observations in an agroecological backyard poultry rearing system, it was determined that the vegetation cover provided by Pinto peanut plants favored the presence of insects and other invertebrates that in turn served as a natural source of food for laying hens. This, significantly reduced the costs associated with the purchase of commercial meals. The consumption of crickets, moths, earthworms, beetles, worms and other soil organisms was recorded. This is evidence of the complementary ecological and economic function of this species within sustainable agricultural systems. Since it contributes both to biological balance and to economic savings in rural communities.

Limitations/Implications of the study: It was observed that most of the publications consulted present partial findings or isolated case studies, which shows the need to integrate the available information into a broader analytical framework.

Findings/Conclusions: Pinto peanut (*Arachis pintoi*) was identified as a resource of great importance in production systems. The functions observed were among others, a positive interaction between the plant and poultry rearing in backyard systems; as well as acting as a soil improver, providing feed for domestic animals, and saving costs as a natural control for weeds.

Keywords: tropical forages, legumes, protein, backyard poultry, diversified agriculture.



INTRODUCTION

The generation of safe food and the sustainable use of renewable resources are the great challenges faced by human beings, amid a scenario that brings together the effects of climate change, degraded soils and contaminated aquifers. In this context of adversity, it is necessary to promote comprehensive strategies that contribute to food sovereignty, in addition to the restoration and conservation of ecosystems. Some proposed strategies include promoting and strengthening the change in production activities from conventional agriculture to agroecological production systems (Cevallos *et al.*, 2019).

An agroecological system is defined as a production philosophy that promotes the combination of agriculture, livestock, and forestry, based on the diversification of production alternatives in harmony with the laws of nature (Zúniga & Mendoza, 2021). Agroecological production systems have the advantage that they can be managed with reduced environmental impacts, without harm to the human population, and without the use of commercial inputs (Restrepo *et al.*, 2000).

The tropical and subtropical regions in the American continent are characterized by a great diversity of ecosystems, species and genes, in such a way that it is possible to identify a range of opportunities for food production through agroecological production techniques. In addition, with the contributing research results observed in the field, reliable information is available for the adaptation and decision-making in the design of integrated production systems. The correct association of plants and animals makes food production possible, and the constant return of organic matter to the soil occurs in such a way, that it preserves the physicochemical and biological properties of the soil.

The Pinto peanut (*Arachis pintoi* Krap & Greg.) is a perennial creeping legume with high forage potential for the tropics, due to its capacity in forage production, and as a biological amendment in degraded soils and grasslands (Cab *et al.*, 2012). This legume, despite its exotic origin, can develop well in all latitudes of the Mexican tropics below 1800 m altitude and on sites with 1500 to 3500 mm of average annual rainfall (Rincón *et al.*, 1992).

Pinto peanut plants are used in various agricultural projects due to their productive impact on agroecosystems that integrate crops, trees and livestock. Andrade *et al.* (2016) mentioned that *A. pintoi* offers various benefits such as forage use, increasing fertility and soil protection, plus an easy harvesting. Therefore, we consider characterizing the diversity of uses in which this wild peanut functions in production contexts such as agriculture, and livestock associated with agroforestry. To this end, a documentary review of scientific publications and a complementary analysis of some results observed in the field were implemented. The objective of this analysis was to identify the main uses, ecological benefits and productive contributions of Pinto peanut (*Arachis pintoi*) in agricultural systems oriented toward sustainability.

MATERIALS AND METHODS

The study was conducted on the base of a systematic review of scientific papers related to the use of Pinto peanut (*Arachis pintoi* Krapov. & W.C. Greg.) in various tropical agricultural systems. For the search and selection of information, academic databases of wide international recognition were used, such as Scopus, Web of Science and Google

Scholar. Publications in Spanish, English and Portuguese were included. We prioritized studies conducted in tropical and subtropical regions, as well as those addressing indicators of productivity, soil conservation, animal nutrition and weed control.

As a complement, preliminary results out of an implemented fieldwork are included with the purpose of validating and enriching the documentary findings. This was developed between October 2022 and September 2023 in the poultry area (módulo avícola) of the Facultad Maya de Estudios Agropecuarios de la Universidad Autónoma de Chiapas, where the production capacity of 150 Brown Nick laying hens was evaluated. Each hen was fed a commercial balanced diet (120 g per day), complemented by free daytime grazing in plots established with *Arachis pintoi*, within a pasture rotation system.

Data record was oriented to observe the interaction between hens and the plant ecosystem, as well as to detect potential benefits in terms of reduction of feeding costs, foraging behavior, and the ecological contribution of Arachis pintoi as a living cover. The information obtained was added to the findings of the bibliographic review to build a comprehensive synthesis on the multifunctional potential of this plant species in sustainable agricultural systems.

RESULTS AND DISCUSSION

A wide list of uses of this species was obtained for its forage, protective and reproductive qualities, and the main uses and functions reported and observed are discussed.

Soil protection

The establishment of *Arachis pintoi* in mixed or monoculture systems has been an ecological tool to increase soil fertility and increase agricultural production of crops associated with those systems (Lok *et al.*, 2019). Due to the depth it reaches in the production of root biomass, *A. pintoi* is a species that increases the moisture retention capacity of soils; it improves infiltration, soil structure and increases the content of organic matter (Márquez *et al.*, 2017). In addition, it is easy to adapt and develop in acidic soils (pH 4.0-4.2) with a sandy crumb texture, with minimal NPK and micronutrient content (Cab *et al.*, 2012).

Soils with a clay-silty texture have a high amount of dragging in the direction of runoff, on those conditions *A. pintoi* is a good alternative as a plant cover (Ramos-Hernández *et al.*, 2016). Due to its prostrate growth, it becomes a favorable cover cropping amendment for the reduction of erosion and soil compaction due to trampling by animals (Rincón *et al.*, 1999). Sumiahadi *et al.* (2019) mentioned that in Indonesia, mulching with *A. pintoi* is used to protect the soil surface against erosion caused by rain and to prevent weeds growth. In addition, this legume reduces soil temperature in hot weather, providing organic matter and retaining nutrients of the soil.

Weed Control

In plantations of perennial fruit and timber crops, weed control can have a negative impact on production costs, as it implies payment of wages for mechanical or chemical weeding, in addition to the ecological impact generated by the excessive use of chemical products for weed elimination.

The association effect of *A. pintoi* in fruit crop plantations and agro-industrial crops has been evaluated. Rincón & Orduz (2004) recorded that in citrus plantations the coverage of *A. pintoi* reduced the presence of weeds around 79-84%. However, when soil preparation such as harrowing and fertilization are made, it is possible to achieve 100% coverage in five months after establishment (Valles & Castillo, 2006).

On the other hand, Ramos-Hernández *et al.* (2011) reported that in plantain plantations the establishment of *A. pintoi* has been shown to interfere with the germination of weed seeds that require brief light exposure to germinate. In addition, weeds are eliminated or displaced over time and the effectiveness of this biological control increases with biomass production. This effect makes it possible to gradually reduce the number of herbicide applications (Ramos-Hernández *et al.*, 2016) and this in turn reflects on the reduction of production costs.

Bareño & Clavijo (1999) observed the effectiveness of *Arachis* when used as a sustainable alternative for weed control in vine cultivation, after 240 days grass weeds, sedges and broadleaf weeds disappeared, the coverage reached 100% and the production of grapes increased by one ton (Megagram) per hectare (Mg ha^{-1}).

Benefits in the physicochemical and biological properties of the soil

In the sites where *A. pintoi* is established, changes are observed in the physical characteristics of the soil, such as the content of organic matter (24.5%) and the increase in bulk density, while in the chemical characteristics, a contribution of 1.44 kg ha^{-1} of nitrogen is reported (Márquez *et al.*, 2017).

On the other hand, Castillo *et al.* (2005) reported that three and a half years after the introduction of *A. pintoi* CIAT 17434 in native pastures on grasslands, the carbon and nitrogen content of the soil increased. The plant showcased its ability to improve fertility and its contribution toward the sustainability of tropical dual-purpose livestock systems.

A significant contribution of *A. pintoi* to the production system is the biological fixation of nitrogen made by soil bacteria (*Rhizobium*) and its association with the roots of this legume (Rincón *et al.*, 1999). Valles & Castillo (2006) identified that 16 months after the establishment of *A. pintoi* in citrus plantations there were changes in soil properties, due to the increase in the content of organic matter (0.20%), nitrogen (19.1 kg ha^{-1}), phosphorus (34 kg ha^{-1}), and potassium (30 kg ha^{-1}).

Forage production

The volume of dry matter usually increases from six months after plants establishment. However, it depends on the sowing distance and the percentage of light they receive; as the percentage of light is reduced, the volume of production decreases (Perla *et al.*, 2001). Likewise, periods of drought and rainfall have a significant influence on dry matter production. García-Ferrer *et al.* (2015) estimated a yield of 4.71 Mg ha^{-1} of dry matter (DM) at 84 days of regrowth during the dry season, in contrast to the rainy season when the yield was higher than 5.92 Mg ha^{-1} DM. In turn, Cab *et al.* (2012) reported 1.3 Mg ha^{-1}, 0.9 Mg ha^{-1}, and 4.1 Mg ha^{-1} as respective dry matter yields in winter-rainfalls, dry, and rainy seasons, when *A. pintoi* was planted associated with grass in monoculture.

The system with mixed pastures in association *B. humidicola* + *A. pintoi* cv. Centauro may demonstrate a greater capacity for adaptation in conditions of climate change, due to the contribution of nitrogen from the legume to the grass because of the fixation effect for that element. Likewise, *A. pintoi* favors the structure and composition of grasslands, which reduces the vulnerability of the system to climatic events (Rincón *et al*., 1999). In the lowland savannah of Huimanguillo (Tabasco) Mexico, Sol & Osorio (2014) evaluated the behavior of a batch of 120 hens of various breeds that were fed with Pinto peanut in a proportion equivalent to 30% of daily feed consumption and the rest was maize, plus free grazing in sites established with *A. pintoi*. Those authors reported that hens that consumed feed + *A. pintoi* gained greater weight during the evaluation period. In addition, moisture retention and the contribution of organic matter favored the presence of protein-rich microorganisms such as crickets, moths, earthworms, beetles, worms, and others.

Contributions to animal nutrition

It is reported that the association of *A. pintoi* with grasses contributes to increasing the contents of crude protein (CP) and non-fibrous carbohydrates (NFC). The crude protein content is higher (21.4%) during the peak rainfall season, but during the lower rainfall season the content drops to 16% (Sánchez *et al*., 2000). Fernández *et al*. (2006) identified that by associating *A. pintoi* with native grasses, the crude protein content increases in the forage offered to livestock, from 12.7% ± in pasture alone, to 19.5% ± in grass + *A. pintoi* association, this increase is maintained before and after grazing. On the other hand, García-Ferrer *et al*. (2015) mentioned that in the dry season the protein content (based on dry matter) decreased from 185.9 to 150.8 g kg^{-1} DM, in 21 to 84 days of regrowth, while in the rainy season it decreased from 174.64 to 134.44 g kg^{-1} DM.

In addition to the above, it should be noted that *A. pintoi* has high palatability and nutritional value. Also, because it has a large number of nodes and internodes, it resists cattle grazing, which improves livestock productivity (Fernández *et al*., 2006; Rincón *et al*., 2020). Some farms have increased milk production by 0.5 to 1 L per cow per day by using *A. pintoi* cv. Centauro as fodder, equivalent to 14%. Likewise, in a pasture of *Arachis* + grass association, milk production per day was 13 L while with only grass it was 8.5 L (Table 1).

Argel & Villarreal (1998) reported statistically significant values in weight gains of Jersey cows fed with *A. pintoi*, when consumed *Arachis* and 1.5 or 2 kg of concentrate per day. In cows grazing pastures at 3.3 (animals) of carrying capacity + 1.5 kg of concentrate per

Table 1. Milk production per dual-purpose cows in pastures with *Brachiaria humidicola* in monoculture, associated with *Arachis pintoi* cv. Centauro.

Variable	*Brachiaria humidicola* + *Arachis pintoi* cv. Centauro	*Brachiaria humidicola*	Increment (%)
Cows ha^{-1}	2.0	1.5	33
Milk production (L per cow per day)	6.5	5.7	14
Milk production (L ha^{-1} per day)	13.0	8.5	52

Source: prepared by the authors with data of Rincón *et al*. (2020).

day, there were weight gains up to 44 kg; and in cows grazing pastures at 4.2 of carrying capacity + 2 kg of concentrate per day, significant difference in weight gain was up to 94 kg when they consumed *Arachis*.

In Peru, Sotelo *et al*. (2018) used perennial forage Pinto peanut in the diet of guinea pigs (*Cavia porcellus* L.) and concluded that it has the same nutritional impact as other diets with plant nutritional inputs, showing also an efficient feed conversion.

Use in laying birds (hens)

In free foraging poultry, it was observed that *Arachis* contributes to animal welfare, due to moisture retention, organic matter contribution and foliage, it provides favorable conditions for the development of larvae, earthworms, moths, beetles, which are a source of protein that complement grazing.

A low incidence of diseases was also observed, only 5% of the birds presented infectious coryza problems. Moreover, when peaks were not removed, birds did not show any cannibalistic behavior, which is attributed to free foraging that allows the hens to develop a healthy life, which also means an increase in animal welfare. This is understood as an adequate diet, good health, without physical or thermal discomfort, without pain, stress, without inflicted fear, showing a more natural behavior (Vargas-Mendoza, 2018). In regard to egg production, 85% laying was observed, with an average weight of 60 g per egg.

Since Pinto peanut develops stolons (commonly called runners in the creeping growth habit), it allows for abundant root growth that contributes to soil retention and increased moisture. This species is another source of food for livestock in tropical areas, where it can be compared with *Canavalia ensiformis* L. (DC). *Mucuna pruriens* L. (DC), *Phaseolus lunatus* L., *Calopogonium caeruleum* Benth, *Pueraria phaseoloides* (Roxb.) Benth and *Desmodium ovalifolium* L. [*Desmodium heterocarpon* (L.) DC. ssp. *ovalifolium* (Prain). Ohashi.] which are nitrogen-fixing species, which improve the physical and chemical properties of the soil, offering high protein value and free nitrogen.

Similarly, the Pinto peanut (*Arachis pintoi*) is a species that grows very well in the tropical regions of Mexico. It is tolerant to high moisture, though without waterlogging, and it also resists droughts well. On sloping terrains, it is excellent for covering areas uncovered by runoff. For livestock purposes, it is important as a cut species, that also works well by direct consumption. Due to its high acceptance, several selected varieties have been bred and released. Likewise, because it reproduces by runners (stolons), spreading is easy. Its best use occurs in agricultural systems where it works well when growing interspersed with shrub and tree species.

CONCLUSIONS

The comprehensive analysis of the documentary evidence and field observations confirmed that the perennial legume Pinto peanut (*Arachis pintoi*) is a strategic component in the design of agricultural systems with an agroecological approach, due to its multifunctional nature and its ability to be efficiently integrated into diversified production arrangements.

This study provided evidence that *A. pintoi* not only performs as forage, but also acts as a key element in the productive and ecological intensification of agricultural systems, by promoting synergies between soils, plants and animals. Incorporating this species into silvopastoral, agricultural or livestock systems represents a viable alternative to move toward more resilient, efficient production models aligned with the principles of sustainability and food sovereignty in tropical regions.

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