Cultivos Tropicales, Vol. 44, No. 4, October-December 2023, e-ISSN: 1819-4087, p-ISSN: 0258-5936, https://ediciones.inca.edu.cu

Cu-ID: https://cu-id.com/2050/v44n4e05

Original article

Influence of live and dead covers on weeds, in an agroecosystem with rambutan (*Nephelium lappaceum* L.) in Mexico

Influencia de las coberturas vivas y muertas sobre las arvenses, en un agroecosistema con rambután (*Nephelium lappaceum* L.), en México

Humberto Osorio-Espinoza[1], Ángel Leyva-Galán[2*], Ernesto Toledo-Toledo[1], Francisco Javier Marroquín-Agreda[1]

[1]Universidad Autónoma de Chiapas (UNACH), Entronque carretera Costera y Huehuetán Pueblo; Huehuetán, Chiapas, México. CP 30660

[2]Instituto Nacional de Ciencias Agrícolas (INCA), carretera San José de las Lajas-Tapaste, km 3½, Gaveta Postal 1, San José de las Lajas, Mayabeque, Cuba. CP 32700

ABSTRACT: The influence of living and dead covers located at the base of the perennial rambutan plant (*Nephelium lappaceum* L.) in its initial stage of growth and development was studied for four years, as a substitute for the traditional method of using residual herbicides. Two variants of live covers and two of dead covers were used and a reference control was maintained with the use of herbicides. The records of the diversity of weeds present both in the rainy period and in the period of less rainfall, indicated that the variants with live covers with the use of *Arachis pintoi* was more efficient than maintaining the natural cover of weeds of the agroecosystem itself, but the Dead hedges with crop residues from short-cycle crops such as corn and beans were more efficient than using residues from the rambutan crop itself from pruned plants and it was also the best variant of all those studied, compared to the control with herbicides.

Keywords: agroecology, biodiversity, profitability, herbicides, legume.

RESUMEN: Se estudió, durante cuatro años, la influencia de coberturas vivas y muertas ubicadas hasta dos metros alrededor del tronco de las plantas de rambután (*Nephelium lappaceum* L.), en la etapa inicial de su crecimiento y desarrollo, como sustituto del método tradicional del uso de herbicidas residuales. Se utilizaron dos variantes de coberturas vivas y dos de coberturas muertas y se mantuvo un testigo de referencia con el uso de herbicidas. Los registros de la diversidad de arvenses presentes, tanto en el período lluvioso como en el período de menores precipitaciones, indicaron que las variantes con coberturas vivas, con el uso de *Arachis pintoi*, fue más eficiente que mantener la cobertura natural de arvenses del propio agroecosistema, por otra parte, las coberturas muertas con residuos de cosechas de los cultivos de ciclo corto como maíz y frijol resultaron más eficientes que usar residuos del propio cultivo de rambután de plantas podadas y, además, resultó la mejor variante de todas las estudiadas, respecto al testigo con herbicidas.

Palabras clave: agroecología, biodiversidad, rentabilidad, herbicidas, leguminosas.

INTRODUCTION

Rambutan (*N. lappaceum* L.) production in Soconusco Chiapas, Mexico, is based on traditional monoculture, which is accompanied by the use of high doses of herbicides for chemical weed control (1). This production technology has a negative influence on the profitability of production processes, with a high probability of causing negative collateral effects on the wild flora, which is responsible for maintaining the ecological balance (2).

*Author for correspondence. luleyva23@yahoo.es

Received: 14/10/2021

Accepted: 14/04/2022

Conflict of interest: The authors declare that they have no conflict of interest.

Authors' contribution: **Conceptualization-** Ángel Leyva-Galán, Humberto Osorio-Espinoza, Ernesto Toledo-Toledo. **Research-** Humberto Osorio-Espinoza. **Methodology-** Humberto Osorio-Espinoza, Ángel Leyva-Galán, Ernesto Toledo-Toledo. **Data processing and writing of the initial draft-** Humberto Osorio-Espinoza, Francisco Javier Marroquín-Agreda. **Final writing and editing-** Ángel Leyva-Galán, Ernesto Toledo-Toledo

Among the agroecological alternatives considered efficient, the use of live and dead cover crops has been one of the most efficient agronomic techniques in the management of weeds and as soil moisture conservation (3-5). However, there is no research in the literature with these purposes for the Rambutan cultivation (*N. lappaceum* L.) in Mexico (6), where the use of herbicides to combat the presence of weeds in the promotion period is fundamental, even when the benefits of cover crops are mentioned as a praiseworthy agroecological alternative (7).

The purpose of this research work was to carry out investigations that could elucidate the effects of live and dead cover crops on the diversity of weeds in the promotion stage of rambutan cultivation and to define the most efficient alternatives.

MATERIALS AND METHODOS

The research was carried out in Villa Comaltitlán municipality, Ejido "Barrio Nuevo", which belongs to the State of Chiapas, Mexico, 15 km from the capital city. The locality has a predominantly warm humid climate with abundant rainfall in summer, with minimum rainfall of 2.000 mm and maximum of 3.000 mm, with minimum rainfall in the months of December to April, a period in which crops suffer from lack of water if there is no irrigation (8).

The average rainfall of the locality amounts to 2 500 mm and the rainfall during the experimental period reached an average of 2 100 mm per year.

The experimental area, with a moderately fertile soil, has been classified as the Feozem cambic type, deep, with a sandy crumbly texture, granular structure, and slightly acid pH and low organic matter content (9). These data correspond to the analyses carried out prior to the establishment of the experiments observed in the soil characterization (Table 1).

Stages of the research

The area used was conditioned by plowing, using the harrow as a plowing and conditioning implement. Grafted rambutan plants were used, completely uniform, obtained from the nursery of Barrios Gómez family and aged 18 months. The rootstock used was the "Criolla" variety, grafted with the locally selected "Adelita" variety.

The rambutan plantation was carried out on November 8, 2009 under a real frame or square planting system, at a distance between plants of 7 x 7 m, for which a hole of 0.25 x 0.25 x 0.25 x 0.30 m was made, with application of organic fertilizer in a 1:1 ratio of soil and bocashi, based on bovine manure, cocoa fruit residues, African palm fiber, ash and banana stalks, observing the nutrient content according to chemical analysis in Table 2.

The humidity was maintained at field capacity, through the use of the drip irrigation system, only for the area occupied by each rambutan plant during the dry period (November-April), with an average of three to four irrigations per month for a period of 8 hours per irrigation at a rate of 6.5 liters per hour.

All the establishment activities and phytotechnical work carried out on the rambutan crop were conducted according to the regulations established for the crop (1), adjusted to the conditions of Villa Comaltitlán.

After planting, the entire planted area was wetted with 32 liters of water, in two applications at 30-minute intervals, with a backpack with a capacity of 16 liters. Fertilization was carried out annually with organic fertilizer of the bocashi type, at a rate of 3 kg per plant, with subsequent manual incorporation into the soil with the use of a hoe "guataca". For the control treatment (TSC) the bocashi was replaced by mineral fertilizer formula 17-17-17 (NPK) at a rate of 1 kg per plant.

Experimental design and treatments evaluated

A randomized block experimental design with six replications was used, evaluating four treatments plus a control with no cover (traditional monoculture). Treatments were as shown in Table 3.

Variables evaluated

The effect of the covers on the diversity of weeds within the agroecosystem was evaluated, through the classic indexes (10), among them were selected: the Specific Richness and the similarity of species in two times; for which the coefficient of similarity of Sorensem (Ij= c/a+b-c) was used, where: a and b represent the number of species in a and b; c, represents the common species in both (11).

The proportional abundance determinations of the weeds were carried out bimonthly after the establishment of the experiment (November 2009) and the similarity coefficient

Table 1. Chemical characterization of the soil prior to the establishment of the experiment

pH	OM	N	P	K	Mg	Ca	Na	Mn	Zn	B
(H_2O)	(%)		(mg kg^{-1})		(meq $100g^{-1}$)				(meq kg^{-1})	
6.0	2.6	0.17	26.60	0.03	0.45	0.80	0.04	10.60	4.40	0.90

Table 2. Nutritional composition of bocashi used as fertilizer in rambutan plantation

pH	OM	N	P	Ca	Mg	Na	K	Fe	Mn	Zn	Cu	B
	%	%	(mg 100 g^{-1})		(meq $100g^{-1}$)					(mg 100 g^{-1})		
7.43	22.15	0.81	87.3	92	118.75	2.78	25.0	7600	300	101	54	3.4

was determined between the initial population (2010) and at the end of the research.

Statistical analysis performed

The data were processed by the statistical package Statgraphics Centurion XVI.I, determining the Confidence Intervals and analysis of variance and Duncan's Multiple Range Test (± 0.05 %) was applied when there were significant differences.

RESULTS AND DISCUSSION

Weeds are plants that grow in crops. Some absent species, as soon as the soil is cultivated, the conditions for their development are created; therefore, weeds are inevitable as companions of agroecosystems (12) or as useful species with economic, ecological and social values, which have utilitarian values within green medicine, calling them auxiliary plants. Based on this analysis, the influence of live and dead cover on the specific richness of arborescence in the rambutan crop is presented.

Specific species richness of arboreal species in rambutan cultivation

The specific richness of weeds (Table 4) amounted to 23 species from 10 families.

Only Poaceae and Euphorbiaceae dominated with nine and four species, respectively.

The dominance of two totally different species (Poaceae-legumes) represents an interspecific relationship with a certain balance, something that does not occur in fields with

Table 3. Treatments studied in the study

Acronyms	Treatments	Description
CAp	Live cover with legumes (*ArachispintoiKrapov.* & W. C.).	12 stolons m², 15 to 20 cm long and with 5 to 6 nodes.
CAM	Natural live cover of weeds regulated with machete.	Keeping it at a height of 0.20 m (1 ft).
CRR	Dead cover of pruning residues from rambutan plants adjacent to the new plantation.	Chop them between 0.10-0.20 m and spread them to cover the 16 m² of each rambutan plant, taken to a height of 0.20 m.
CRC	Covering with crop residues of short-cycle crops and weeds.	Until reaching the total coverage of 16 m² of each plant up to a height of 0.20 m.
TSC	Uncovered control with herbicide use. *(i)* paraquat) and *(ii)* glyphosate.	Six times per year (four times in the rainy season and twice in the dry season), at a rate of 2.0 L ha^{-1} at the end of the effect, glyphosate is used at the same dose.

Table 4. Weeds present in the rambutan crop at the research beginning

N°	Family	Species	CAp	CAM	CRR	CRC
1	Poaceae	*Cenchrus echinatus* L.	8	17	48	29
2	Poaceae	*Sorghum halepense* L. Pers.	98	211	185	172
3	Poaceae	*Rottboellia cochinchinensis* L. Clayton	221	249	189	54
4	Poaceae	*Pennisetum clandestinum*Hochst.	44	16	120	63
5	Poaceae	*Chloris radiata* (L.) Swartz	0	27	68	2
6	Poaceae	*Cynodon dactylon* L. Pers.	149	958	13	482
7	Poaceae	*Cynodonn lemfuensis*Vanderyst	27	6	40	113
8	Poaceae	*Digitaria swazilandensis* L.	25	472	107	3
9	Poaceae	*Paspalum coniugatum* Bergius	0	0	0	15
10	Cyperaceae	*Cyperus esculentus* L.	950	941	300	91
11	Cyperaceae	*Cyperus rotundus* L.	35	4	0	95
12	Euphorbiaceae	*Euphorbia* sp.	114	418	103	23
13	Euphorbiaceae	*Phyllanthus niruri* L.	128	43	50	11
14	Euphorbiaceae	*Euphorbia hirta* L.	15	483	175	26
15	Euphorbiaceae	*Euphorbia hypericifolia* L.	12	209	43	16
16	Malvaceae	*Sida acuta* Burm.	84	66	581	8
17	Fabaceae	*Phaseolus lathyroides* L.	44	14	49	20
18	Araceae	*Alocasia macrorrhiza*	48	34	91	2
19	Commelinaceae	*Commelina diffusa* Burm.	8	209	94	59
20	Umbelliferae	*Eryngium* L.	5	0	8	4
21	Fabaceae	*Mimosa púdica* L.	1	232	0	0
22	Compositae	*Galinsoga parviflora* Cav.	14	186	22	9
23	Asteraceae	*Melampodium divaricatum L. C. R.*	100	22	109	70

(CAp): cover with legume (*Arachis pintoi* Krapov. & W.C. Greg.); (CAM): cover with managed weeds; (CRR): cover with rambutan crop residues; (CRC): cover with crop residues of annual crops and weeds; (CRR): cover with rambutan crop residues; (CRC): cover with rambutan crop residues; (CRC): cover with annual crop residues and weeds residual herbicide management, where only Poaceae predominate (12).

The rest fluctuated between one and two species, between permanent and sporadic. It was observed that 20 of the 23 species recorded were found in all treatments distributed in 10 families; 15 of the species were common in the five alternatives studied, of which nine belonged to the monocotyledons and six to the dicotyledons. The species with the greatest ecological plasticity were *C. dactylon* L; *C. esculentus* L. and *R. cochinchinensis* L., which were dominant, as was the case in other crops (13).

At the end of the third rambutan harvest, 16 species were found, dominated by *P. clandestinum* (L.) with the highest presence. Some subordinate species appeared during the rainy period, after the establishment of the crop, but not significantly for the agroecosystem, such as: *D. sanguinalis* Scop; *C. inflata* Link; *Panicum adspersum* Trin; *Dryopteris sprengelii* (kaulg) Kuntze; *Coccocipsilum herbaceum* Lam. and *C. diffusa* Burm and one species, which did not appear during the experimental period (*I. tiliacea*) and it was present in the areas surrounding the experiment.

The species that achieved the greatest presence during all years were: *S. halepense* L., *R. cochinchinensis* L., *C. rotundus* L. and *C. echinatus* L., something apparently normal, which occurs due to their high reproductive capacity and adaptation to the environment, since they are species that have a high ecological plasticity (12-13).

At the end of the third rambutan harvest (Table 5), 16 species were found, dominated by *P. clandestinum* (L.) with the highest presence. Species such as *D. swazilandensis* L., *S. halepense L. Pers*, *C. esculentus* L. and *Alocasia* sp. also dominated, to a lesser degree *R. cochinchinensis*.

Studies to evaluate the structural changes and dynamics of the shrubs due to the influence of cover are scarce and the existing ones do not go in depth into their variations over time.

The first results of research in this field failed to visualize a clear trend of its temporal variability under monocultural conditions (6), so it will be necessary to continue research on weeds and their role in agroecosystems until the causes of their enigmatic presence are found, which, according to recent novel results (13), seem to be linked in part to the state of the soil microbiological community.

Interesting was the presence of a native species *I. tiliacea* Willd Chois in a neighboring area, one year after the end of the experimental period (2014-2015), which took over the entire area dedicated to cultivation, including the experimental area, as shown in Figure 1. It is a weed species of high competitive capacity, but protective of the soil, due to its high biomass production, which at the same time suggests a study about its benefits and limitations within the agroecosystem, with interest as a cover for perennial crops or enriching their chemical properties.

At the conclusion of the research, the change towards the presence of the species *I. tiliacea* suggests evaluating its spatial and temporal variations, since the case of this species that appeared out of all prognosis, constitutes an attractive option, although other agronomic and physiological characters, which could be adverse, must be studied.

Promoting species for soil protection is a topic that deserves to be included in research programs aimed at obtaining long-term results in favor of soil protection with production without chemical industry residues.

Efficiency of cover crops in managing weed abundance

The bimonthly records to determine the presence of weeds in each management system by treatment and for

Table 5. Weeds registered by treatments in the fourth year after the research beginning

N°	Family	Scientific Name	CAp	CAM	CRR	CRC
1	Poaceae	*R. cochinchinensis* L. Clayton	12	33	13	6
2	Poaceae	*P. clandestinum* Hochst.	8	48	22	18
3	Poaceae	*C. dactylon*L. Pers.	6	12	1	4
4	Poaceae	*C. nlemfuensis* Vanderyst	7	1	2	0
5	Poaceae	*D. swazilandensis* L.	7	1	17	26
6	Poaceae	*S. halepense*L. Pers.	10	30	16	30
7	Cyperaceae	*C. esculentus* L.	12	26	11	2
8	Cyperaceae	*C. rotundus* L.	0	2	0	5
9	Araceae	*Alocasia* sp.	5	13	10	19
10	Malvaceae	*S. acuta* Burm.	1	1	4	1
11	Leguminosae	*Desmodium* sp.	7	11	0	1
12	Euphorbiaceae	*E. hirta* L.	0	12	3	8
13	Portulacaceae	*P. oleracia* L	0	0	1	0
14	Fabaceae	*P. haseoluslathyroides* L.	0	1	1	0
15	Euphorbiacea	*E. hypericifolia* L.	0	1	0	0
16	Convolvulaceae	*Ipomoea tiliácea* Wild Choisy.	0	0	1	0

(CAp): cover with legume (*Arachis pintoi* Krapov. & W.C. Greg.); (CAM): cover with managed weeds; (CRR): cover with rambutan crop residues; (CRC): cover with annual crop residues and weeds four years, allowed comparing the differences between treatments, knowing that rainy periods generate higher populations (Figure 2).

The cover systems used were efficient in reducing the abundance of weeds, with significant differences with the control, which maintained the natural cover managed up to a height of 0.10 to 0.15 m (CAM) and the use of *A. pintoi* (CAp), as a living cover, in its condition of established species protecting the soil, given its characteristics of covering the entire surface without vertical growth, reduced the presence of weeds without differing from the dead cover CRR and CRC; therefore, from the result it can be deduced that the alternatives used were efficient in the management of weeds.

However, weeds in CAp in the initial period (2010) is due to the *A. pintoi* species covering the surface corresponding to the treatment and preventing the proliferation of weeds, it requires at least four to five months for its total reestablishment, especially because it coincided with the dry period, with less growth of the managed plants. The CRC treatment was efficient in the management of weeds from the beginning, which makes it more efficient than the rest.

Behavior of the similarity index of weeds

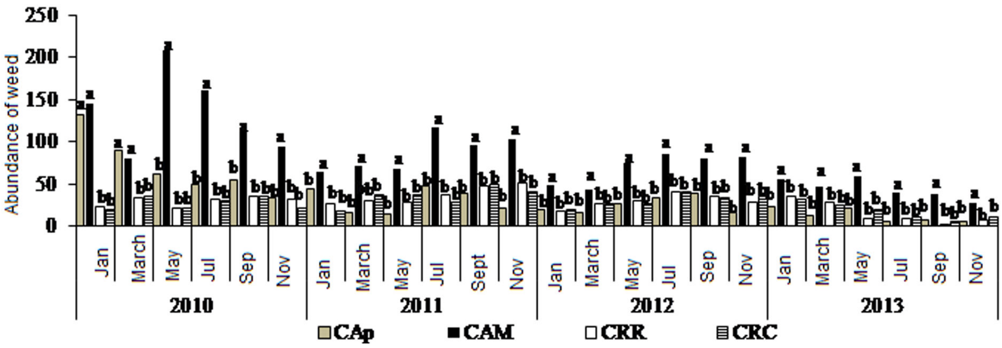
In the first year, the treatment that conserves natural diversity (CAM) was the most diverse, according to the similarity index (Table 6).

According to the results of the similarity index, the presence of species between treatments was similar to that found at the beginning of the evaluations (2010). Values were close to unity, indicating similarity with the control.

Figure 1. Presence of the native species (*Ipomoea tiliácea* Willd Choisy) at the research end

Most species were present in all treatments. Similar results were found in the last evaluation period (2013), even though the number of species decreased, all treatments presented similar behavior. However, comparing the period 2010-2013, there is a structural change of species for CAp and CRR, presenting low values in Is.

Sixteen species of weeds were observed (Table 5), where three of them were not present in previous years and, therefore, the CAp and CRR treatments were more diverse, but with lower abundance of species, compared to the control treatments CAM and CRR. The CAp and CRR treatments were modified by decreasing the diversity of arboreal species, since the similarity index indicates that



CAp): cover with legume (*Arachis pintoi* Krapov. & W.C. Greg.); (CAM): cover with managed weeds; (CRR): cover with rambutan crop residues; (CRC): cover with crop residues of annual crops and weeds

Figure 2. Abundance of weed species by treatment during four years

Table 6. Weed similarity index (Is) between treatments, at the beginning and at the end of the evaluation (2010-2013), assuming CAM as control

Similarity Index	CAM	CAp	CRR	CRC
2010	1.00	0.95	0.98	0.93
2013	1.00	0.92	0.81	0.88
2010-2013	0.60	0.44	0.44	0.59

(CAp): cover with legume (*Arachis pintoi* Krapov. & W.C. Greg.); (CAM): cover with managed weeds; (CRR): cover with rambutan crop residues; (CRC): cover with annual crop residues and weeds species are more diverse the closer they are to zero, between the surfaces compared (9).

Contrary to the results of these treatments, *A. pintoi* as a cover crop and residues of the same crop favored diversity. After some time, the abundance began to decrease in the treatment with *A. pintoi* as a reflection of effects of its presence covering the entire soil surface, as occurred from January of the last year of evaluation, where the almost total decrease in the presence of weeds is related to the lack of light caused by the perennial crop, responsible for not allowing the passage of sunlight to its agricultural space, preventing the reproduction of weeds.

Under these conditions, practically none of the treatments required management work, due to the shade provided by the rambutan plants in the 16 m^2 designated from the beginning as a protection area for this crop.

Treatments with dead cover showed their efficiency from the beginning, although the characteristics of the cover with residues of the crop itself left some gaps or spaces through which sunlight penetrates, with some species that necessarily had to be handled mechanically.

These results are unprecedented in agronomic research for this crop, (14) but are in line with the results obtained by other authors with similar evaluations of its benefits (15-16). This agroecological practice, besides making maximum use of the space in time and of benefit for the sustainability of agroecosystems, contributes to the ecological balance, by increasing their diversity.

The results of this research have made it possible to know the importance of timely management of weeds with the use of cover crops, methods specific to agroecosystems to mitigate the economic and ecological damage imposed by external inputs from the chemical industry.

CONCLUSIONS

- Live and dead mulches can substitute chemical and mechanical weed management, being more efficient the dead mulches coming from the biomass of short-cycle crops, than those coming from the rambutan crop itself.
- The abundance of weeds decreased over time, without precise structural changes in their initial composition.

RECOMMENDATIONS

The disturbances that occurred during four years in the rambutan plantation generated the presence of a native species with high reproductive capacity, which is suggested to be studied as a cover for this and other perennial crops in the locality.

BIBLIOGRAPHY

1. Pimentel Alvarado, O. y Delgadillo Aldrete, S. *Agenda Técnica Agrícola, Chiapas | ISBN 978-607-7668-15-2 - Libro* [en línea], 2.ª ed., edit. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, ciudad de Benito Juárez, en Mexico, 2015, p. 140, ISBN 978-607-7668-15-2, https://issuu.com/senasica/docs/05_chiapas_2015_sin, [Consultado: 18 de julio de 2023], Disponible en: <https://isbn.cloud/9786077668152/agenda-tecnica-agricola-chiapas/>.
2. Ruiz Corral, J.; García, G.; ACUÑA, I.; Flores, H. y Ojeda, G. *REQUERIMIENTOS AGROECOLÓGICOS DE CULTIVOS* [en línea], 2.ª ed., edit. Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Campo Experimental Centro Altos de Jalisco. Tepatitlán de Morelos. Jalisco. Méxic, 2013, ISBN 978-968-800-471-5, Disponible en: <https://www.researchgate.net/publication/343047223_REQUERIMIENTOS_AGROECOLOGICOS_DE_CULTIVOS_2da_Edicion>.
3. Cairo-Cairo, P.; Reyes-Hernández, A.; Aro-Flores, R.V. y Robledo-Ortega, L. "Efecto de las coberturas en algunas propiedades del suelo. Finca La Morrocoya, Barinas, Venezuela", *Pastos y Forrajes*, vol. 40, no. 2, junio de 2017, pp. 127-134, ISSN 0864-0394.
4. Gómez, R.G.; González Lutz, M.I.; Agüero Alvarado, R.; Mexzón Vargas, R.; Herrera Murillo, F. y Rodríguez Ruiz, A.M. "Conocimiento sobre coberturas vivas y disposición a utilizarlas por productores de varios cultivos", *Agronomía Mesoamericana*, vol. 28, no. 2, 30 de abril de 2017, pp. 489-497, ISSN 2215-3608, DOI 10.15517/ma.v28i2.23403, https://www.redalyc.org/journal/437/43750618013/43750618013.pdf.
5. Flores-Trejo, A.; Almaguer-Vargas, G.; Aguilar-Ávila, J.; Rendón-Medel, R.; Márquez-Berber, S.R.; Flores-Trejo, A.; Almaguer-Vargas, G.; Aguilar-Ávila, J.; Rendón-Medel, R. y Márquez-Berber, S.R. "Redes sociales y confianza entre productores de rambután en el Soconusco, Chiapas", *Revista mexicana de ciencias agrícolas*, vol. 7, no. 15, 2017, pp. 3009-3021, ISSN 2007-0934, DOI https://doi.org/10.29312/remexca.v0i15.423.
6. Joo-Pérez, R.; Avendaño-Arrazate, C.H.; Sandoval-Esquivez, A.; Espinoza-Zaragoza, S.; Alonso-Báez, M.; Moreno-Martínez, J.L.; Ariza-Flores, R. y Morales-Nieto, C.R. "Alternancy Study on Rambutan (Nephelium lappaceum L.) Tree in Mexico", *American Journal of Plant Sciences*, vol. 8, no. 1, 26 de diciembre de 2016, pp. 40-52, DOI 10.4236/ajps.2017.81004.
7. Arias-Cruz, M.E.; Velásquez-Ramírez, H.A.; Mateus-Cagua, D.; Chaparro-Zambrano, H.N. y Orduz-Rodríguez, J.O. "El rambután (Nephelium lappaceum), frutal asiático con potencial para Colombia: avances de la investigación en el piedemonte del Meta", *Revista Colombiana de Ciencias Hortícolas*, vol. 10, no. 2, diciembre de 2016, pp. 262-272, ISSN 2011-2173, DOI 10.17584/rcch.2016v10i2.5761.
8. Comisión Nacional del Agua (CONAGUA).*Medidas Preventivas y Mitigación de la Sequía en la Cuenca de la Costa de Chiapas* [en línea], *Gobierno de México*, 2014, [Consultado: 18 de julio de 2023], Disponible en: <http://www.gob.mx/conagua/acciones-y-programas/programas-de-medidas-preventivas-y-de-mitigacion-a-la-sequia-pmpms-por-consejo-de-cuenca>.
9. World Soil Resources FAO*World Reference Base for Soil Resources 2014. Up date 2015. International soil classification system for naming soils y creating legends*

for soil maps. [en línea], [106], FAO, Italia, roma, 2015, Disponible en: <https://www.fao.org/3/i3794en/I3794en.pdf>.

10. Leyva, A. *Agroecology Knowledge Exchange Workshop: Building a South-North Partnership | Nourishing Communities* [en línea], Balsillie School of International Affairs, Waterloo, Ontario, Canada., 25 de abril de 2016, [Consultado: 18 de julio de 2023], Disponible en: <http://nourishingontario.ca/blog/2016/04/25/agroecology-knowledge-exchange-workshop-building-a-south-north-partnership/>, [Presenters: _:n1650].
11. Moreno, C.E. *Método para medir la biodiversidad* [en línea], 1.ª ed., vol. 49, edit. Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo, 2001, (ser. M&T - Manuales y Tesis SEA), p. 86, https://studylib.net/doc/25548166/m%C3%A9todos-para-medir-la-biodiversidad---claudia-e.-moreno-2001, [Consultado: 18 de julio de 2023], Disponible en: <http://www.scielo.sa.cr/scielo.php?script=sci_abstract&pid=S0034-77442001000300090&lng=en&nrm=iso&tlng=es>, [publisher: https://creativecommons.org/licenses/by/3.0].
12. Blanco Valdes, Y. *Manejo oportuno de las arvenses en sus relaciones interespecíficas con los cultivos del maíz (Zea Mays L.) y del frijol (Phaseolus vulgaris L.) en un sistema sucesional* [en línea] [Doctorado], Instituto Nacional de Ciencias Agrícolas, 2017, https://repositorio.geotech.cu/xmlui/bitstream/handle/1234/3659/Manejo%20de%20las%20arvenses%20en%20sus%20relaciones%20con%20los%20cultivos%20del%20ma%c3%adz%20y%20del%20frijol.pdf?sequence=1&isAllowed=y, [Consultado: 18 de julio de 2023], Disponible en: <http://repositorio.geotech.cu/jspui/handle/1234/3659>, [Accepted: 2019-07-09 T18:57:58ZjournalAbbreviation: Timely management of weeds in their interspecific relationships with the crops of corn (Zea Mays L.) and beans (Phaseolus vulgaris L.) in a successional system].
13. Aguilar, F.; Vázquez, L. y González, J.M. *Avances de la agroecología en Cuba-Libro* [en línea], 1.ª ed., edit. Pastos y Forrajes Indio Hatuey, la Habana, 2016, ISBN 978-950-34-1265-7, Disponible en: <https://www.researchgate.net/publication/327105934_B6-499_Avances_de_la_agroecologia_en_Cuba-Libro>.
14. Toledo, E.T. *La cosecha en verde y conservación in situ de los residuos de la caña de azúcar (Saccharumspp.). impacto en la sostenibilidad y restauración del agroecosistema en Huixtla. México.* [en línea] [Doctorado], INCA, La Habana, 2008, Disponible en: <https://agris.fao.org/agris-search/search.do?recordID=CU2010400079>.
15. González, Y.; Leyva, A.; Pino, O.; Mercadet, A.; Antoniolli, Z.I.; Arébalo, R.A.; Barossuol, L.M.; Lores, A. y Gómez, Y. “El funcionamiento de un agroecosistema premontañoso y su orientación prospectiva hacia la sostenibilidad: rol de la agrobiodiversidad”, *Cultivos Tropicales*, vol. 39, no. 1, marzo de 2018, pp. 21-34, ISSN 0258-5936.
16. Quispe, S.S.; Mendoza Dávalos, K.; Sangay-Tucto, S. y Cosme De La Cruz, R.C. “Uso de coberturas vegetales en el manejo sostenible del suelo asociado al cultivo de maíz amiláceo (Zea mays L.)”, *Scientia Agropecuaria*, vol. 12, no. 3, julio de 2021, pp. 329-336, ISSN 2077-9917, DOI 10.17268/sci.agropecu.2021.036.