Volume 58, January-December 2024, ISSN: 2079-3480

Pasture Science and other Crops

Cuban Journal of Agricultural Science

Journal site: https://cjascience.com Cu-ID: https://cu-id.com/1996/v58e05

Morphologic indicators and harmful organisms associated to six *Moringa oleifera* origins under nursery and field conditions

Indicadores morfológicos y organismos nocivos asociados a seis procedencias de *Moringa oleifera* en condiciones de vivero y campo

Nurys Valenciaga*

Instituto de Ciencia Animal, C. Central km 47 ½, San José de las Lajas, Mayabeque, Cuba

**Email: nvalenciaga1966@gmail.com*

In order to monitor the morphologic indicators and the organisms caused of plagues associated to *Moringa oleifera* two tests were conducted: nursery and field. The treatments were represented by six moringa origin, collected in three provinces of the country. In nursery, a total of 396 polyethylene bags were used in a completely random design, with 66 repetitions. In field, a random block design with three replications was applied. In both test the arthropods and associated pathogens were monitoring. The phytosanitary damage and morphologic indicators of the crop growing were evaluated. In nursery phase, the plants did not have economic damages by harmful organisms and showed favorable grow indicators. Therefore, in field, the new transplant plantlets were affected by strong attacks of Atta insularis, which caused defoliation and plantlets loss. The survival has similar average ranges in all origins. The count of branches was better in the origins 4 and 6 with 4.40 and 4.18, respectively. The height, at 120 days after the transplant, showed sizes higher than 145 cm, in the origins 2 and 6. The higher stem thickness (31.2 mm) was showed in the origin 2. It is concluded that the evaluated origins, according to their morphologic indicators performance have potentialities for their use. It is recommended to continue with the phytosanitary alertness of the crop and to regulate the forage activity of A. insularis until achieving the moringa establishment. It should be alert in the fruiting phase of the incidence of Gitona sp. fly to minimize the damage to the seeds, to avoid the secondary presence of pathogens and to allow the harvest of healthy seeds.

Key words: *insects-plague, Moringaceae, pathogens, plantlet, transplant*

Para monitorear los indicadores morfológicos y los organismos causantes de plagas asociados a *Moringa oleifera* se condujeron dos ensayos: vivero y campo. Los tratamientos estuvieron representados por seis procedencias de moringa, colectadas en tres provincias del país. En vivero, se utilizaron 396 bolsas de polietileno en un diseño completamente aleatorizado, con 66 repeticiones. En campo, se aplicó un diseño de bloques al azar, con tres réplicas. En ambos ensayos se monitorearon los artrópodos y patógenos asociados. Se evaluó el daño fitosanitario, además de indicadores morfológicos del crecimiento del cultivo. En fase vivero, las plantas no experimentaron daños económicos por organismos nocivos y manifestaron indicadores de crecimiento favorables. Sin embargo, en campo, las plántulas recién trasplantadas, estuvieron afectadas por ataques fuertes de Atta insularis, que ocasionaron defoliación y pérdidas de plántulas. La supervivencia mantuvo rangos medios similares en todas las procedencias. El conteo de ramas fue mejor en las procedencias 4 y 6 con 4.40 y 4.18, respectivamente. La altura, a los 120 días después del trasplante, reveló tallas superiores a los 145 cm, en las procedencias 2 y 6. El máximo grosor del tallo (31.2 cm) se corroboró en la procedencia 2. Se concluye que las procedencias evaluadas, dado el comportamiento de sus indicadores morfológicos, tienen potencialidades para su empleo. Se recomienda mantener la vigilancia fitosanitaria del cultivo y regular la actividad de forrajeo de A. insularis hasta lograr el establecimiento de moringa. Se debe estar atento en la fase de fructificación a la incidencia de la mosca Gitona sp. para minimizar los daños a las semillas, evitar la entrada secundaria de patógenos y acceder a la cosecha de semillas sanas.

Palabras clave: *insectos-plaga, patógenos, Moringaceae, plántulas, trasplante*

Introduction

Moringa oleifera is a plant with ecologic plasticity, that allow it to adapt to various climates and soil conditions (Pérez *et al*. 2010). According to the goodness that show as protein plant is considered ideal as animal food, being attractive for ruminants (García-López *et al.* 2017 and Alvarado-Ramírez *et al*. 2018) as to monogastric

Received: June 05, 2023
Accepted: December 15, 2023
Conflict of interest: The author declares that there is no conflict of interest.

(Valdivié *et al*. 2017). It is also attributed several beneficial effects for human health (Hernández e Iglesias 2022 and Príncipe and Soto 2023) and as plants bio-stimulant (Pérez *et al*. 2023). However, the edaphoclimatic conditions in which it develops has a marked influence on its yields. In any regions of Cuba, the susceptibility it has showed to the attack of harmful organisms, mainly insect-pest and pathogens, involve even more it use when great biomass volume is required, as it happens when is about ruminants feeding.

To guarantee healthy plants and of good growing in the first development stages is important for the plant rooted and future performance in the adult age, aspect that are essentials to achieve satisfactory establishments. This research was develop with the objective of monitoring and control the organisms caused of plagues, associated to different *Moringa oleifera* origins under nursery and field conditions.

Materials and methods

Experimental area and climate. Two tests, one in nursery phase and the other in field phase were developed, at Instituto de Ciencia Animal (ICA) from San José de las Lajas municipality, Mayabeque province, Cuba. The Institute is located at 22º 55 NL and 82º 0 WL, at 92 m. o.s.l. The climate according to the climatic classification of Köppen is Aw type, tropical grassland climate, with a dry season (November - April) and a rainy season (May - October). The annual rainfall is of 1244 mm and mean temperature of 24.9 ºC (Anon 2016).

Treatments. The treatments were constituted by six *Moringa oleifera* origins collected in three provinces of the country (table 1). The collections start from adult plants, apparently healthy, with good growing, in fruiting phase.

Table 1. Evaluated accessions

Origin	Place	Collection identification
1	Matanzas, City-District Versalles	14
2	Sancti Spíritus, Perseverancia Farm	23-A
3	Cienfuegos, Special School	15
4	Cienfuegos, Cemetery	20
5	Sancti Spíritus, Caña river	24
6	Matanzas, Boca Camarioca	13

Nursery phase

A nursery with *Moringa oleifera* Lam. (Moringaceae) in opencast place was established.

Experimental design. A completely random design, with 66 repetitions for each of the treatments was used.

Experimental procedure. A total of 396 polyethylene bags were used. The substratum used in each bag was the mixture of three parts of the red ferrallitic soil (Hernández *et al*. 2015), and a part of organic matter (decomposed bovine manure). At the moment of sowing, October 13, 2016, two seeds apparently healthy were place at 2 cm deep, according to Cardoso *et al*. (2006), to keep only the most healthy and vigorous plant.

The nursery was place separated from the soil surface, at a 1cm height approximately. The irrigation was manually, with the help of a watering can in alternate days, until cover their filed capacity. The bags were perforated to guarantee the drainage and flooding. It is important to highlight that the selected place was at opencast, so the plantlets received directly the sun, as the rainfalls too. The manual control of the arvenses in each bag was carried out.

Once the germination of more than 70 % of the plants was guarantee, the record of agronomic and phytosanitary measures were started:

- Emergence percentage, %
- Plantlets survival, %
- Plants height, cm
- Stem diameter, mm
- Presence and quantification of arthropods and pathogens
- Determination of the caused damage, %

The emergence percentage (% E) was determined counting the emerged plantlets with more than 1 cm height, in accordance to the formula described by Ede *et al*. (2015):

$$\%\,E = \left[\frac{\text{Number of emerged seed}}{\text{Total of sowed seeds}}\right] * 100$$

The plantlets survival (% S) was determined by the counting of emerged plantlets:

$$\%\,S = \left[\frac{\text{Lp}}{(\text{Lp}+\text{Dp})}\right] * 100$$

where:
Lp: Live plants
Dp: Dead plants

The methodology described by Centeno *et al*. (1994) was considered, who establish a classification according to the obtained value: a) 80 -100 % very good; b) 60-79 % good; c) 40-59 % so- so and d) less than 40 % bad.

The plants height (cm) was determined measuring with a tape measure, from the soil to the apex of the apical branch.

The diameter or stem thickness (cm) was taken in the interception of the base of the first branch and the stem with a vernier.

The growing dynamics (GD) was determined by the following equation:

$$GD = \left[\frac{(FH-IH)}{N°\text{of days}}\right]$$

where:

GD= Growing dynamics

IH = Initial height (The measurement of the height taking after the germination and the previous to the data taking)

FH = Final height (height taking in each sampling)

Number of sampling days (at 10, 30 and 40 d after sowing)

The nursery phase lasted 45 days. The samplings were carried out in the morning, taking into account three samplings in the period. The arthropods and pathogens were evaluated through visual observations in a sampling system presence-absence. The present organisms were noted and quantified, classifying in pollinators, phytophagous and bioregulators, in accordance to the assignation of the functional groups, according to Metcalf and Flint (1965), Triplehorn and Johnson (2005), Mancina and Cruz (2017) and World Spider Catalog (2020).

The damage was evaluated according to Calderón (1982) methodology for stinging-sucking or biting insects and for both. If to be necessary, the capture of arthropods and phytophatogen microorganisms unknown for their identification in the laboratory was made. The damages by pathogen agents were evaluated according to Lenné (1982) methodology.

The plantlets were in nursery phase until reached heights higher than 25cm, moment in which their transplant was made. To counteract the risk of plant loss by plague attacks the use of control measures (chemical or biological, and both) was foresee, is to be necessary. All the agronomic and phytosanitary measurements were performed in fixed plantlets with the optimums sample size (22).

Field phase

The test was conducted in a red ferrallitic soil, in accordance with Hernández *et al*. (2015) in areas from the experimental center "Miguel Sistachs Naya" attached to Grasses and Forages department from ICA.

On December 5, 2016 a total of 378 plantlets of *M. oleifera* were transplanted to the field, with approximately height from 25 to 30 cm, previously cultivated under nursery conditions in an opencast place. The experiment lasted two years.

Experimental design. The plantation was carried out under a random block design with three replications in which the six origins were randomized in each replication.

Experimental procedure. A preparation of conventional soil was initially carried out, leaving the bed loose and free of weeds. The area included a total of 23 furrows, established at 0.70 m for a dimension of 16.10m wide and 70 m length. Each block was separated 3m among them.

At a week of transplant fertilization to the whole area was carried out, with complete formula of N-P-K (9-13-17) to cover the crop requirements, according to that reported by Pérez *et al*. (2010). The used dose was at a rate of 10 g per bunch, which leads to 200 g per plot.

The area was protected of weeds invasion. The manual cleaning was with spud and hoe, mainly around the plant.

The area was maintained in the dry season, sprayed with mobile irrigation machine (OCMIS brand, model 82 with sprinkling bar) operated with a pressure of 500 kPa and the volume of sprinkler used was of 33600 L/h. During the irrigation time (2.5 h) a water lamina of 35 mm was applied. The irrigation was applied at the beginning of the transplant, with weekly frequency which was interval from 10 to 15 d until the first rains arrives.

The area was also under phytosanitary alertness against possible attacks of leaf-cutting ants (Atta insularis) or other harmful agents. The application of chemical or biological products was prevented.

The sampling of the arthropods and pathogen incidence were monthly carried out through visual observations in the internal furrows, leaving those of the external as border effect. A total of 10 plants of each origin/replication were sampled trying to visualized, counted and identified the organisms associated in each honological stage of the crop. When it was necessary, samples were taken and transfers to the laboratory for their processing through the help of similar taxonomic keys and with the use of the stereoscopic microscopic. The classification of the organisms in accordance with the assignation of functional groups and the damages was performed as it is described in the nursery phase. In the fruiting stage, five pods from each origin/ replication were random taking to determine, under laboratory conditions, the phytosanitary state and the damages caused by the organisms associated to the crop.

The area was for seed production. There were measured as morphologic indicators the survival (%), plants height (cm), the number of branches and the stem diameter (cm), following the methodology described for nursery phase.

Statistical analysis. All the collected data in nursery and field phase were included in Microsoft Excel database. They were statistically processed and analyzed according to statistical package InfoStat version 2012 (Di Rienzo *et al*. 2012). The theoretical assumptions of the analysis of variance were verified for the analyzed variables from the Shapiro and Wilk (1965) test for the normality of errors and

Levene (1960) test for the variance homogeneity. It was taking into account that in case that the analyzed variables do not fulfill with the theoretical assumptions of ANAVA, the arcosen√% transformation will be used. If they even will not improve the fulfillment of those assumptions it was determined to carry out non-parametric analysis of variance of one-way classification (Kruskal and Wallis 1952) and to apply the Conover (1999) test for the comparison of average ranges. The height and growth dynamic, in nursery stage were analyzed according to a completely random statistically model and Duncan (1955) test was applied for the differentiation between means. The variables height and stem thickness, in field phase, were analyzed according to random block design. Tukey (1958) test was applied in necessary cases.

Results and discussion

Nursery phase

Regarding the presence of insects and pathogens, there were only visible some phytophagous (table 2) as the leaf miner Liriomyza sp. (Dipteran: Agromyzidae) in three isolated plantlets from the origin 3, 5 and 6.

It was also found a source of aphids from *Aphis* sp. (Hemiptera: Aphididae) genus with higher intensity in a plant and, lower in another one, from origin 1. It was visible in some plants leaf spots by fungus, whose causal agent could not being identified. There were five plants in the origin 2 with whitish discoloration in the leaves whose origin is unknown. However, the harmful organisms associated did not caused economic damages to the plants under nursery conditions, so the damages did not exceeded the slight degree, in accordance with the Calderón (1982) scale, in this case for insects with stinging- sucking habits.

Results from Reyes (2005) and Alfaro and Martínez (2008) reported damages in this specie in nursery phase, due to the attack of cutting ants from Atta genus. To keep the plants under nursery conditions at 1.5m separated from the soil prevent the attack of leaf-cutting ants to moringa plantlets, which constitutes an effective resource to minimize the damages that these organisms could caused.

Regarding the morphologic performance of the plantlets, in table 3 are show the average ranges of the emergency and survival (%) of the different *M. oleifera* origins at 30 days after sowing. The origin 6 (Matanzas, Boca Camarioca) showed the lower average ranges (53.50 and 57.00 for emergency and survival, respectively), although without statistical differences with relation to the rest of the evaluated origins.

When considering the mortality as the survival loss, coincide that is the origin 6 which has more plantlets loss (33 %). However, even with these values, the survival is classifying as good, according to Centeno *et al*. (1994). In nursery phase, all the origins showed acceptable values as to the evaluated morphologic indicators. Researchers from García and Mora (2018) assure that when the emergency and the initial development of M. oleífera is very good in nursery phase, this constitutes an indicator of the good vigor of the used seeds.

Figure 1 show the result of the plants diameter at 40 days after sowing. The diameter was in the range of 0.23 to 0.28, without statistical differences among the origins. Slightly high values, between 0.33 and 0.40, Toral *et al*. (2013) stated, when studying eight origins of moringa under nursery conditions, some collected in the country and other imported.

Table 2. Insects and pathogens associated to six origins of *Moringa oleifera* in nursery phase

Class	Order	Family	Scientific name	Common name	Origin
Insecta	Diptera	Agromyzidae	*Liriomyza* sp.	Leaf miner	3, 5 and 6 (one plant from each origin)
	Hemiptera	Aphididae	*Aphis* sp.	Aphid or plant louse	1 (two plants)
-	-	-	Not identified causal agent	Leaf spot by fungus	1 (some plants)
-	-	-	Not identified causal agent	Whitish spots	2 (some plants)

Table 3. Average ranges of the emergency and survival values recorded in the six origins evaluated in nursery phase

Indicator	Average ranges						Sign.
	Origins						
	1	2	3	4	5	6	
Survival	69.00 (95) SD=0.21	69.00 (95) SD=0.21	69.00 (95) SD=0.21	66.00 (91) SD=0.29	69.00 (95) SD=0.21	57.00 (77) SD=0.43	p=0.1810
Emergency	71.50 (95) SD=0.21	68.50 (91) SD=0.29	71.50 (95) SD=0.21	65.50 (86) SD=0.35	68.50 (91) SD=0.29	53.50 (68) SD=0.48	p=0.0570

( ): True data, %

SD: Standard deviation

Comparison of average ranges according to Conover (1999) test

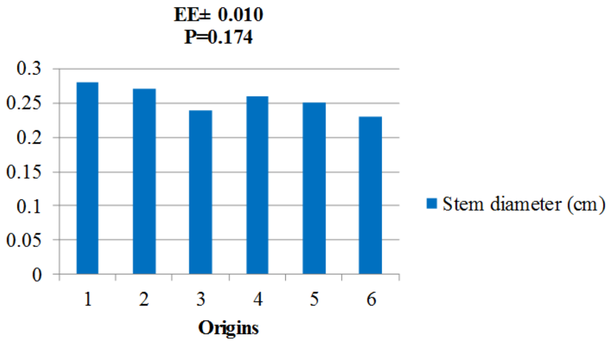
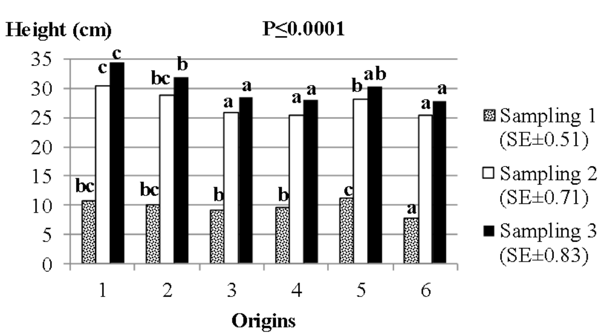


Figure 1. Stem diameter of the plantlets (cm) at 40 d after sowing

The plantlets height (figure 2) in the first sampling, 10 days after sowing, had a high performance in the origin 5 with 11.41 cm. There were not statistical differences with the origin 1 and 2, which showed values of 10.80 and 10.20 cm, respectively. In the second sampling, 30 d after sowing, the origin 1 had the highest value with 30.55 cm, without statistical differences with the origin 2 (28.91 cm), that in turn did not differ from the origin 5 with 28.23 cm. The origin 6 showed the lower height (25.32 cm) without statistical differences with the 3 and 4, whose heights were around 25 cm. At 40d, the origin 1 showed the higher size ($p < 0.0001$) (34.41 cm), followed by the origin 2 (31.95 cm) that, in turn, did not differ from the origin 5 (30.32 cm) neither this one from the rest, that ranges between 27 and 28 cm. The origin 6, similar to that occur in other agronomic indicators, showed the lowest height (27.82 cm), although in this time did not statistically differ from the origins 3, 4 and 5. These results were superior to those obtained by García and Mora (2018), whose did not reached sizes similar to those recorded in this test until after 15 weeks. Even, there were very superiors to that reported by Cadillo Rojas (2022), which used biostimulants to accelerate the germination, emergency and plants height.



[a,b,c]Means with a common letter, in each sampling, there are not significantly different ($p \leq 0.05$) (Duncan 1955)

Figure 2. Performance of the plantlets height (cm) of six moringa origins in different sampling moments (10, 30 and 40 d after sowing)

Researchers from Martínez *et al.* (2013) stated that the height is an indicator of the development of the aerial part, which determines the photosynthetic process and the plant transpiration. Miranda *et al.* (2014) studies refers heights of 7.6 cm in the first week with the use of compost and manure as substrate and low values with soil only (5.1 cm). In the tenth week heights of 104.9 cm were recorded with compost, 59.7 cm with soil and 32.7 cm with manure. In this study, the plant height is similar to the treatment with compost, maybe the result of the plants development will be conditional by the substrate used in the bags under nursery conditions, which consisted in organic (decomposed cattle manure), the quality of the used soil (red ferrallitic soil), water availability (irrigation) and other agroclimatic factors, whose performance caused variations from a study to other.

Table 4 shows the growth dynamic of the origins in each of the samplings. The origin 6 had a low growth dynamic and differing from the rest of origins at 10 d with 0.78 cm/d. At 30 d, the origin 6 was similar to 4 and 3, with values of 0.84, 0.85 and 0.86 cm/d, respectively. At 40 d, had a low growth dynamic too, without differ from the origins 3, 4 and 5 with values that ranges between 0.71 and 0.78. These results were, even, higher to those obtained by Toral *et al.* (2013). These authors reported higher increases of 0.41 a 0.43 cm/d in origins imported in the country, as Supergenius and Plain, as well as in a collection in Holguín-Mayarí. These results show the fast growth the plant species *Moringa oleifera* have. In addition, they confirm antecedents that distinguish the plant because of their great growth speed (Anon 2002). In this indicator is more reliable show that the plant has a fast growth in the first weeks, what coincides with Medina *et al.* (2007), whose state that the moringa has a fast growth from the beginning, due to it develops a root system very deep, which makes higher the use of soil nutrients and of the available water.

Field phase

Regarding the incidence of insects-plague a total of 45 species from four classes of arthropods were collected, as is show in table 5, being the Insecta class the most represented with 39 morph species, included in 8 orders and 18 families. From them, 87 %, a total of 34 morph species, corresponding to phytophagous insects, coinciding with Foidl *et al.* (1999) and Reyes (2005) researchers, when reporting some organisms which causes plagues in the establishment stage, associated to *M. oleifera*. Medina *et al.* (2007) assure that the moringa is resistant or immune to plagues and diseases. According to the results of this test, under field conditions, the criteria of the cited authors is not share, so in the course of the study it was evident the presence and incidence of harmful organisms in the different phenological stages of the crop. This caused, in some occasions, economic damages to the plants.

Table 4. Growth dynamic (cm/d) of the different *Moringa oleifera* origins

Treatments Indicator	Origins						SE± and sign.
	1	2	3	4	5	6	
Sampling 1							
Growth, cm/d	1.08[ab]	1.02[ab]	0.93[b]	0.96[b]	1.14[ab]	0.78[c]	0.05 p<0.0001
Sampling 2							
Growth, cm/d	1.02[a]	0.96[ab]	0.86[c]	0.85[c]	0.94[b]	0.84[c]	0.02 p<0.0001
Sampling 3							
Growth, cm/d	0.86[a]	0.80[b]	0.71[c]	0.71[c]	0.76[bc]	0.78[c]	0.02 p<0.0001

[a,b,c] Means with a common letter in each sampling there are not significantly different (p<0.05) (Duncan 1955)

Table 5. Atrophodsfauna associtated to the six *Moringa oleifera* origins under field conditions during the experimental period

Class	Order	Family	Scientific name	Common name
Insecta	Hemiptera	Cicadellidae	*Empoasca* sp.	Leafhopper
			Oliarus sp.	Leafhopper
			Hortensia similis (Walk.)	Leafhopper
		Flatidae	*Ormenaria rufifascia* (Walker)	Palm flatid planthopper
		Aphididae	*Myzus persicae* (Sulzer)	Aphid
	Coleoptera	Chrysomelidae	*Epitrix* sp.	Flea beetle
			Diabrotica sp.	Leaf beetle
			Cryptocephalus marginicollis (L.)	Leaf beetle
			Odionychus pictus (L.)	Leaf beetle
		Coccinellidae	*Cycloneda sanguinea* L.	Ladybird
		Curculionidae	*Pachnaeus litus* Germar	Citrus root weevil
			Not identified species	True weevils
		Lycidae	*Thonalmus suavis* Duval	Coleoptera
	Diptera	Syrphidae	Not identified species[1]	Syrphid fly
		Drosophilidae	*Gitona* sp.	Fruit fly
		-	5 morph-species not identified	Fly
		Dolichopodidae	*Condylostylus* sp.[1]	Fly
		Chamaemyiidae	*Leucopis* sp.	Fly
		Culicidae	1 morph-specie not identified	Mosquito
	Lepidoptera	Crambidae	*Omiodes indicata* Fab.	Bean-leaf webworm moth
		-	4 morph-species not identified	Moth
	Orthoptera	Tettigonidae	*Caulopsis cuspidatus* (Scud.)	Long-horned grasshoppers
		Gryllidae	*Gryllus* sp.	Crickets
	Hymenoptera	Formicidae	*Solenopsis geminata* (L.)[1]	Fire ants
			Paratrechina longicornis (F.)[1]	Crazy ants
			Wasmannia auropunctata (L.)[1]	Little fire ants
			Atta insularis (Guér.)	Leaf-cutting ants
		Apididae	*Apis mellifera* L.	Bee
		Ichneumonidae	*Coccygomimus rufoniger* Cresson[1]	Wasp
		-	Not identified species	Black wasp
	Dermaptera	Forficulidae	*Doru taeniatum* (Dohrn.)[1]	Earwig
	Odonata	-	Not identified species	Dragonfly
Arachnida	Araneae		4 morph-species not identified[1]	Spider
Gastropoda			Not identified species	Snails
Malacostraca	Isopoda	Armadillidae	*Armadillidium vulgare* (Latreille)	Common pill woodlouse

[1] Bioregulators

The *M. oleifera* plantlets, just transplanted, had a strong attack of leaf-cutting ants (*Atta insularis* Guérin) (Hymenoptera: Formicidae), which caused defoliation and loss of plantlets, equivalent to average damage according to the established by Calderón (1982) for biting insects. This led to the immediate application of management strategies to minimize the damages. The application of Blitz (i.a. Fipronil) granulated, near to the active nests found in the area control the initiated forage in the plantlets of the six moringa origins. These results coincide with Padilla *et al.* (2017) studies, which affirm that at present the *A. insularis* constitutes one of the organisms that most affects the survival of *M. oleifera* plantlets under Cuba conditions.

Researchers in other regions from the American tropic about *M. oleifera* coincide that the plagues that has most affect the plants, immediately after germination, are the cutting ants (*Atta* sp.) and also mention the small mocis moth (*Mocis latipes* Guén.) (Lepidoptera: Noctuidae). These organisms normally make an attack and did not come again to the crop, although they emphasize that even so they should be controlled to reduce the damages (Foild *et al.* 1999).

In the vegetative phase, with the emission of leaves and branches, the attack of coleoptera from Curculionidae (*Pachneus litus* and True weevils) family was proved. These last, not identified, with high population levels, caused significant reduction of the active photosynthetic area, when defoliate some plants from different origins. The degree of damage was moderate according to Calderón (1982) scale for biting insects.

Subsequently, in the fruiting phase, it was proved in all origins, damages in the pods caused by the fruit fly Gitona sp. which allow the secondary presence of fungus, which caused, even more, severe damages to the fruits and their seeds, equivalent to an intense damage, according to those described by Lenné (1982), preventing the healthy seeds harvest.

Gitona sp. is considered most important plague of the fruit in almost all the region of the world. The female infests the fruits, causing their putrefaction. Also, the opening makes possible the presence of other harmful agents that invade the inside of the fruit, as grubs and mature coleopteran, lepidopterous grubs, mites and phytopathogen microorganisms, which accelerate the damage and fruit loss (Anon 2023). The above completely coincide with the damages proved in this test in the inside of the fruits.

Every 15 d a control variant to counteract the leaf cutting ants attacks was systematically applied. Leaves of Tithonia or Marigold (Tithonia diversifolia), protein plant from Asteraceae family were spread, near to the nets according to Montoya (2020) and chemical application of Blitz (i.a. Fipronil). Any other insecticide or biopesticide was not used to counteract the attack of flying phytophagous insects, so the plants size exceeded 2cm height, and it was impossible to made any correct spraying that cover the stem and the affected branches.

The survival, measure at 90 d, it was not significant (Table 6), since the average ranges were similar in all the evaluated origins, and oscillate from 3.40 to 3.60, which means values above 90 % of survival, classified as very good, according to Centeno *et al*. (1994). The average ranges, corresponded to the count of the number of branches, showed with the best results the origin 4 (4.40), which in turn did not differed from the origin 6 (4.18). The origins 3 and 2 had low number of branches with the lowest average ranges (2.50 and 2.92, respectively). It is important to highlight that, despite the incidence of harmful organism showed in the field phase, the evaluated origins showed acceptable morphologic indexes for the *M. oleifera* species too. Maybe these optimums result of the crop growth were conditional by the cultural practices made in the field phase. In this phase, immediately after the transplant, fertilization with complete formula N-P-K was carried out. The arvenses competition was reducing, during the first years, when maintaining the manual cleaning by means of spud and hoe in the area. The irrigation in the dry season was guarantee and a constant protection against the attack of leaf cutting ants was maintained. Therefore, the applied agronomic management obviously improves the establishment, in terms of survival rates with a faster growing. Similar criteria

Table 6. Average ranges of the evaluated indicators in the six *M.oleifera* origins under field conditions

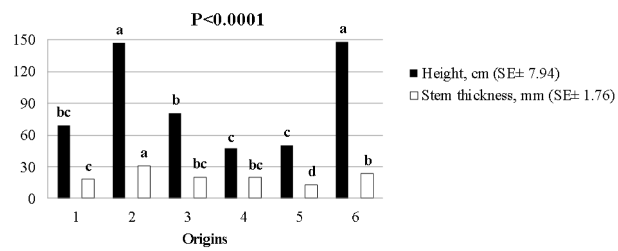
Indicator	Average ranges						Sign.
	Origins						
	1	2	3	4	5	6	
Number of branches	3.60^{bcd} (12.33) SD=4.62	2.92^{de} (10.50) SD=2.80	2.50^{e} (9.27) SD=4.12	4.40^{a} (15.80) SD=6.76	3.50^{cd} (11.80) SD=4.71	4.18^{abc} (14.00) SD=5.00	P=0.0002
Survival at 90 d	3.60 (1.00) SD=0.00	3.60 (1.00) SD=0.00	3.40 (0.93) SD=0.25	3.50 (0.97) SD=0.18	3.40 (0.93) SD=0.25	3.50 (0.97) SD=0.18	P=0.5553

( ) - True data

SD- Standard deviation

Average ranges comparison according to Conover (1999) test showed researchers by Holguín *et al*. (2018). Other authors give more important to the good species performance, favored by climatic and edaphic variables that generates the agroecological potential in which the *M. oleifera* is developed (Carrión Delgado *et al*. 2022).

The height and stem thickness (figure 3) were measured at 120 d after the transplant. The plantlets from the origin 6 and 2 were highlighted by their high size (148.1 cm and 146.3 cm, respectively). The higher stem thickness (31.2 mm) was confirmed in the plantlets from origin 2, which differ from the rest. It was proved that the morphological performance of the plants can varied depending on the biotic and abiotics factors. In this case, the palatability showed to some plants in the nursery phase, from origin 1, caused of the attack of aphids from the Aphis genus, caused that when they were transplanted to the field with the incidence of this phytophagous in the affected plants occur a growth lateness, with respect to others from the same origin that there were not affected. This could be possible because this insects, located with preference in the reverse of leaves, suck up the plants sap causing roll, chlorosis and necrosis, which prevent the normal development of the host plant. Hence the importance of having healthy seeds and plants, free of harmful organisms, in the moment of sowing or crop planting, and in both.



[a,b,c]Common letters between origins in each indicator did not differ to $p<0.05$ (Tukey 1958).

Figure 3. Performance of the height and stem thickness in six *Moringa oleifera* origins under field conditions at 120 d after the transplant

Conclusions

It is concluded that the evaluated origins, given the performance of their morphologic indicators, has potentialities for their use. It is recommended to maintain the phytosanitary alertness of the crop and to regulate the forage activity of A. insularis until achieving the moringa establishment. It should be alert in the fruiting phase to the incidence of Gitona sp. fly to minimize the damage to the seeds, to avoid the secondary presence of pathogens and to allow the harvest of healthy seeds.

Acknowledgments

Thanks to the collaboration of the engineer Daimarys González Quintero and the technician Humberto Díaz Rodríguez in the collection of the evaluated origins. It also thanked to the technician Ciro Alejandro Mora Díaz for his participation in the performing arthropods sampling, and the technician Lucía Sarduy García for her support in the statistical analysis of the results.

References

Alfaro, N. C. & Martínez, W. 2008. Uso potencial de la moringa (*Moringa oleifera* Lam.) para la producción de alimentos nutricionalmente mejorados. INCAP, Guatemala. 31 p.

Alvarado-Ramírez, E. R., Joaquín-Cancino, S., Estrada-Drouailet, B., Martínez-González, J. C. & Hernández-Meléndez, J. 2018. *Moringa oleifera* Lam.: Una alternativa forrajera en la producción pecuaria en México. *Agroproductividad*, 11(2): 106-110, ISSN: 2594-0252.

Anon. 2002. Growing Moringa for Personal or Commercial Use. Available at: http://www.moringafarms.com/New-homepage.htm. Consulted: June 13, 2016.

Anon. 2016. Clasificación climática de Köppen. Climate-Data.org. Available at: https://en.climate-data.org/nort h-america/cuba-18/. Consulted: October 12, 2016.

Anon. 2023. Cultivo de moringa: beneficios, propiedades y manejo agronómico. Agrotendencia.tv. Available at: https://agrotendencia.tv/agropedia/cultivos/cultivo-de-moringa-cuidados-y-manejo-agronomico/. Consulted: July 14, 2023.

Cadillo Rojas, G.A. 2022. Efecto de bioestimulantes en las características agronómicas del cultivo de moringa (*Moringa oleifera*) bajo condiciones de vivero en Vegueta-Huara. Tesis en opción al título de Ingeniero Agrónomo. Universidad Nacional José Faustino Sánchez Carrión. Facultad de Ingeniería Agraria, Industrias alimentarias y ambiental. Escuela Profesional de Ingeniería Agronómica. Perú. 116 p.

Calderón, M. 1982. Evaluación del daño causado por insectos. En: J. M. Toledo (Ed.). Manual para la Evaluación Agronómica. CIAT, Red Internacional de Evaluación de Pastos Tropicales. Cali, Colombia. p. 80.

Cardoso, M., Medeiros, C., Carvalho, D. & Hipólito, A. 2006. Profundidad y posición de la semilla en la emergencia y desarrollo de plántulas de Moringa. *Centro Agrícola*, 33(1): 5-8, ISSN: 2072-2001.

Carrión Delgado, J.M., Valdés Rodríguez, O. A., Gallardo López, F. & Palacios Wassenaar, O. M. 2022. Potencial agroecológico de *Moringa oleifera* Lam. para el estado de Veracruz. *Revista Mexicana de Ciencias Forestales*, 13(70): 42-63, ISSN: 2007-1132. https://doi.org/10.29298/rmcf.v13i70.1077.

Centeno, M., Herrera, Z.A. & Guatemala, M. 1994. Inventario Nacional de Plantaciones forestales en Nicaragua. Managua, (Nicaragua). p. 79.

Conover, W.J. 1999. Practical Nonparametric Statistcs. 3rd Edition John Wiley & Sons, Inc., New York, USA. p. 428-433. ISBN: 978-0-471-16068-7.

Di Rienzo, J.A., Casanoves, F., Balzarini, M.G., González, L., Tablada, M. & Robledo, C.W. 2012. InfoStat versión 2012. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina. URL: http://www.infostat.com.ar.

Duncan, D.B. 1955. Multiple Range and Multiple F Tests. *Biometrics*, 11(1): 1-42, ISSN: 0006-341X. https://doi.org/10.2307/3001478.

Ede, A.E., Ndubuaku, U.M. & Baiyeri, K.P. 2015. Media effects on emergence and growth of Moringa (*Moringa oleifera* Lam) seedlings in the nursery. *American Journal of Experimental Agriculture*, 7(3): 182-189, ISSN: 2231-0606. https://doi.org/10.9734/AJEA/2015/13602.

Foidl, N., Mayorga, L. & Vásquez, W. 1999. Utilización del marango (*Moringa oleifera*) como forraje fresco para ganado. Conferencia electrónica de la FAO sobre "Agroforestería para la producción animal en Latinoamérica" Available at: http://www.fao.org/waicent/faoinfo/agricult/aga/AGAP/FRG/Agrofor1/Agrofor1.htm. Consulted: June 13, 2016.

García, I.I. & Mora, J. 2018. Manejo y desempeño de *Moringa oleifera* (Lam) en la etapa de vivero y trasplante. En: Holguín, V. A., García, I. I. & Mora-Delgado, J. (Eds.) Árboles y arbustos para silvopasturas: uso, calidad y alometría. Editorial Universidad del Tolima, Ibagué, Tolima, Colombia. p 86-106. ISBN: 978-958-8932-56-9.

García López, R., Gutiérrez, D. & Gutiérrez, O. 2017. *Moringa oleifera* (Lam.) in ruminant feeding systems in Latin America and the Caribbean region. Chapter IX, p. 161-170. In: Mulberry, Moringa and Tithonia in animal feed, and other uses. Results in Latin America and the Caribbean. Lourdes L. Savón Valdés, Odilia Gutiérrez Borroto and G. Febles Pérez (Eds.). ISBN: 978-959-7171-72-0. https://www.feedipedia.org/node/23171.

Hernández, A., Pérez, J.M., Bosch, D. & Castro, N. 2015 Clasificación de los suelos de Cuba 2015. Mayabeque, Cuba: Ediciones INCA, 93 p., ISBN: 978-959-7023-77-7 http://ediciones.inca.edu.cu/files/libros/clasificacionsueloscuba_%202015.pdf.

Hernández, J. & Iglesias, I. 2022. Efectos benéficos de la *Moringa oleifera* en la salud de las personas. *Revista Cubana de Medicina General Integral*, 38(1): 1682, ISSN: 0864-2125.

Holguin, V.A., García, I.I. & Mora, Y. 2018. Árboles y arbustos para silvopasturas: uso, calidad y alometría. Ibagué. Universidad de Tulima. 136 p. ISBN: 978-958-6932-56-9.

Kruskal, W.H & Wallis, W.A. 1952. Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*, 47(260): 583–621, ISSN: 1537-274X. https://doi.org/10.1080/01621459.1952.10483441.

Lenné, J.M. 1982. Manual para la evaluación agronómica. J. M. Toledo (Ed.). CIAT, Red Internacional de Evaluación de Pastos Tropicales. Cali, Colombia. p. 10-15.

Levene, H. 1960. Robust tests for the equality of variance In: Olkin I., Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling, Stanford University Press, p. 278–292, ISBN: 978-0-8047-0596-7.

Mancina, C.A. & Cruz Flores, D.D. 2017. Diversidad biológica de Cuba: métodos de inventario, monitoreo y colecciones biológicas. Editorial AMA, La Habana, 480 pp. ISBN: 978-959-300-130-4. https://www.undp.org/content/dam/rblac/docs/Research%20and%20Publications/Repository/Cuba/UNDP-RBLAC-DiversidadBiol%c3%b3gicaCU.pdf.

Martínez, I.C.C., Sáenz, M.A.V., Meléndez, J.M.P. & Apaulaza, A.M. 2013. Influencia de tres sustratos orgánicos en algunos parámetros morfológicos de la planta *Moringa oleifera* (acacia blanca) obtenida en viveros de contenedores. *Revista Cubana de Ciencias Forestales*, 1(1): 27-39, ISSN: 2310-3469.

Medina, M.G., García, D.E., Clavero, T. & Iglesias, J.M. 2007. Estudio comparativo de *Moringa oleifera* y *Leucaena leucocephala* durante la germinación y la etapa inicial de crecimiento. *Zootecnia Tropical*, 25(2): 83-93, ISSN: 2542-3436.

Metcalf, C.L. & Flint, W.P. 1965. Insectos destructivos y útiles: sus costumbres y su control. Instituto Cubano del Libro. La Habana, Cuba. 1208 p.

Miranda, S., Fabricio, A., Gonzáles, G., & Lenin, S. 2014. Evaluación del efecto de tres sustratos en el desarrollo de plantas de *Moringa oleifera* en vivero. PhD Thesis, Universidad Nacional Agraria, UNA, Colombia.

Montoya, J. 2020. Abono verde y extractos de botón de oro (*Tithonia diversifolia*) para el control de hormiga arriera, Atta cephalotes (Hymenoptera: Myrmicinae). Informe Técnico Final de Investigación período 2008-2010. Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria (CIPAV). Universidad del Valle, Cali, Colombia. 41 p. Consulted: June 14, 2023. https://colciencias.metadirectorio.org/handle/11146/38013.

Padilla C., Valenciaga N., Crespo G., González, D. & Rodríguez, I. 2017. Requerimientos agronómicos de *Moringa oleifera* (Lam.) en sistemas ganaderos. *Livestok Research for Rural Development*, 29(11): 218, ISSN: 2521-9952.

Pérez, A., Sánchez, T., Armengol, N. & Reyes, F. 2010. Características y potencialidades de *Moringa oleifera* Lamark. Una alternativa para la alimentación animal. *Pastos y Forrajes*, 33(4): 349-362, ISSN: 2078-8452.

Pérez, L., Campo, C. de la C., Nápoles, L., Baldús, M., Rodríguez, R.C. & Pérez, A.T. 2023. Extracto acuoso de moringa como bioestimulante de plantas de piña 'MD-2' en fase de aclimatización. *Universidad & Ciencia*, 12 (2): 148-162, ISSN: 2227-2690. Available at: http://revistas.unica.cu/uciencia.

Principe, W.L. & Soto, Y.E. 2023. Eficacia antibacteriana de la *Moringa oleifera* sobre el Enterococcus faecalis ATCC29212 (estudio in vitro), Huánico - 2022. Tesis para optar el título profesional de Cirujano dentista. Universidad nacional Hermilio Valdizan. Facultad de Medicina. Escuela Profesional de Odontología. Huánuco, Perú. 138 p.

Reyes N. 2005. Marango: Cultivo y utilización en la alimentación animal. Guía técnica No. 5. Universidad Nacional Agraria. La Molina, Lima, Perú. Available at: http://www.underutilized-species.org/record_details_id_819.html.

Shapiro, S.S & Wilk, B. 1965. An analysis of variance test for normality (complete simples). *Biometrika*, 52: 591-611, ISSN: 1464-3510. https://doi.org/10.2307/2333 709.

Toral, O., Cerezo, Y., Reino, J. & Santana, H. 2013. Caracterización morfológica de ocho procedencias de *Moringa oleifera* (Lam.) en condiciones de vivero. *Pastos y Forrajes*, 36(4): 409-416, ISSN: 2078-8452.

Triplehorn, C.A. & Johnson, N.F. 2005. Borror and DeLong's lntroduction to the Study of lnsects. Thomson Brooks/Cole, USA, 864 p., Seventh Edition, ISBN; 003-096835-6 https://www.academia.edu/30669150/Borror_and_Delong_2005_Study_of_Insects.

Tukey, J.W. 1958. Bias and confidence in not quite large samples. *The Annals of Mathematical Statistics*, 29(2): 614, ISSN: 2168-8990. https://doi.org/10.1214/aoms/1177706617.

Valdivié, M., Bustamante, D., Caro, Y., Dihigo, L.E., Ly, J. & Savón, L. 2017. *Moringa oleifera* (moringa) in the feeding of non-ruminants. Chapter VIII, p. 141-159. In: Mulberry, Moringa and Tithonia in animal feed, and other uses. Results in Latin America and the Caribbean. Lourdes L. Savón Valdés, Odilia Gutiérrez Borroto and G. Febles Pérez (Eds.). ISBN: 978-959-7171-72-0. Available at: https://www.feedipedia.org/node/23171.

World Spider Catalog. 2020. World Spider Catalog. Version 21.5. Natural History Museum Bern, Available at: http://wsc.nmbe.ch, Consulted: September 10, 2020.