Investigation note

Typification of PRODETER bean producers to help climate change in Zacatecas

José Ángel Cid-Ríos
Manuel Reveles-Hernández
Ricardo Alonso Sánchez-Gutiérrez
Nadiezhda Ramírez-Cabral[§]

Zacateas Experimental Field-INIFAP. Zacatecas-Fresnillo highway km 24.5, Calera de VR, Zacatecas, Mexico. CP. 98500. (cid.angel@inifap.gob.mx; reveles.manuel@inifap.gob.mx; sanchez.ricardo@inifap.gob.mx).

[§]Corresponding author: ramirez.nadiezhda@inifap.gob.mx.

Abstract

The objective was to typify bean farmers belonging to PRODETER 'Sombrerete II', in Zacatecas as well as to relate the proposed technologies to actions that reduce climate change. The sample size was 38 farmers. The data were obtained in 2020 through a survey with 10 dimensions: social, economic, government supports, production unit, seed, production, tillage, fertilization, biotic control and commercialization. The data were analyzed by cluster analysis, which showed that the 38 farmers were divided into three groups with different characteristics ($p < 0.05$). The dimensions that showed discriminant power ($p < 0.05$) were: production, tillage and biotic control. Group I was made up of 11 farmers and was characterized by low values in the social, support, production unit, production and biotic control dimensions, it has the highest values in the tillage dimension. Group II is made up of 19 members, it obtained the highest values in support, seed, fertilization, biological control and commercialization, the lowest values in the economic dimension and tillage. Group III is made up of eight farmers, it had the highest values in the social, economic, production unit and production dimensions, with the lowest values in seed, fertilization and commercialization. The typification of the farmers showed that the systems are completely rainfed and they carry out conventional cultural tasks. This typification will serve as a basis for future studies and to develop a technology transfer process that allows reducing the effects of climate change with highly marginalized farmers.

Keywords: *Phaseolus vulgaris*, agricultural commercialization, traditional agriculture.

Reception date: May 2022
Acceptance date: June 2022

The typification and grouping of farmers are considered a useful tool to design better research and technology transfer programs for agricultural production (Borja *et al*., 2018a), they also facilitate diagnostic strategies to observe the conditions of farmers (Głębocki *et al*., 2019). A strategy for technology transfer is the establishment of demonstration modules on farmers' plots; however, for these modules to be successful, the direct participation of farmers is needed and for this, it is necessary to know them, know their advantages, limitations, short-, medium- and long-term perspectives; this knowledge of farmers occurs through their typification and characterization (Galindo and Zandate, 2004).

In Mexico, it is necessary to typify or characterize agricultural production systems to have an overview of the technological level and to be able to offer technologies in accordance with the needs of farmers; in addition to this, it is sought that technologies contribute to mitigating the effects of climate change (Arce *et al*., 2020). Agriculture is highly vulnerable to the climate, recently, due to climate change, there have been changes in precipitation and temperature regimes, so farmers have had to face droughts, torrential rains, hailstorms, frosts, heat waves, extreme weather events that decrease or end their harvests (IPCC, 2012).

On the other hand, during their development and growth, agricultural crops are exposed to biotic and biotic factors that cause stress. The magnitude of stress and damage depends on the intensity and duration of these effects. Climate change will intensify these stresses, negatively impacting agriculture (Ramírez-Cabral *et al*., 2016). For example, in the cultivation of beans (*Phaseolus vulgaris* L.), which is a grain of socioeconomic importance in Mexico because it plays an important role in the diet of the population, especially in rural areas where it is one of the main sources of protein (Sangerman-Jarquín *et al*., 2010).

The North-Central region of Mexico is an important area for bean production, within this region is the state of Zacatecas (Galindo and Zandate, 2004). In Zacatecas, one of the main bean-producing municipalities is Sombrerete, in 2019, 94 thousand hectares were sown under rainfed conditions with an average yield of 0.56 t ha^{-1} (SIAP, 2019a). Projections in climate change models showed a high possibility of loss in the area of bean-producing regions due to the increase in temperature, which will directly affect the farmers of this legume (Ramírez-Cabral *et al*., 2016; Medina *et al*., 2016).

In addition to the above, the guidelines of the Rural Development Program, of the Territorial Development Projects (PRODETER, for its acronym in Spanish) identified farmers in areas of high marginalization in Sombrerete. However, to date, the characteristics of PRODETER farmers are unknown. The main objective of the PRODETER program is 'to sustainably increase the productivity of the Family Production Units of the rural environment, in order to contribute to improving the income of the rural population' (DOF, 2019), in this way the typification carried out in PRODETER 'Sombrerete II' contributes to knowing the needs of the members to be able to generate technological models according to their needs.

Therefore, the objective of this work was to typify the farmers belonging to PRODETER 'Sombrerete II'' in the state of Zacatecas through social, economic, commercial and productive characteristics, as well as to present technologies that contribute to mitigating the adverse effects of the climate on bean production.

The municipality of Sombrerete is northwest of the capital of Zacatecas, at a distance of 167 km, it has an area of 3 627 km^2. The climate is temperate with an average temperature of 16 °C and height above sea level of 2 351 m. The typification was carried out based on a survey developed at the national level for all PRODETER called 'SIAP-Desarrollo Rural' version 1.3, in mobile application (SIAP, 2019b). The determination of the sample size was that suggested by Snedecor and Cochran (1967); cited by Rojas (1979), with a level of accuracy of 10% and a confidence level of 95%.

The size of the population was 150 farmers belonging to the localities of Felipe Ángeles, Buenavista and Álvaro Obregón in the municipality of Sombrerete, of which 38 were selected by means of a simple random sampling and then surveyed (Table 1). The data were obtained during February, March and April 2020 through a survey of 51 questions, which were reduced to 10 dimensions: social (S= 8), economic (E= 8), government supports (SU= 5), production unit (PU= 8), seed (SE= 5), production (P= 6), tillage (T= 3), fertilization (F= 3), biotic control (BC= 3), commercialization (C= 2). Each variable was weighted quantitatively, assigning numerical values for each answer, for example, if the houses had a roof, walls, bathroom, they were assigned a value of 2, which corresponded to the affirmative answer, otherwise a value of 1 was assigned. Finally, each of the responses was added up according to its dimension (Table 2).

Table 1. Grouping by cluster analysis of the surveyed farmers belonging to PRODETER 'Sombrerete II' in the state of Zacatecas, Mexico.

No.	Name			Group	No.	Name			Group
1	Juventino	Díaz	Martínez	3	20	Ismael	Martínez	Murillo	1
2	Leonardo	Bravo	Sánchez	2	21	Vidal	Márquez	Alanís	1
3	Ceferino	Espinoza	Díaz	3	22	Sebastián	Rivas	Herrera	1
4	Eduardo	García	Espinoza	2	23	Julián	Rejero	López	1
5	Raúl	Ramos	Méndez	2	24	José	Rivas	Hernández	1
6	Manuel	Díaz	Martínez	2	25	Juan	Moreno	Ávila	1
7	Hipólito	Quiroz	Alanís	2	26	Hipólito	Duarte	Moreno	3
8	José	Quiroz	Martínez	2	27	Alberto	Correa	Ávila	1
9	Víctor	Herrera	Bertaud	2	28	Ismael	Moreno	Manríquez	3
10	J. Abel	Rivas	Perales	2	29	Hugo	Galindo	Hinojoza	1
11	Agustín	Alanís	Rejero	2	30	Margarito	Barrios	Flores	1
12	Luis	Longoria	Mata	2	31	Manuel	R	R	2
13	Abel	Rivas	Herrera	2	32	Lizbeth	Rejero	Taranto	1
14	Gabino	Puente	Carrillo	3	33	Agustín	Solís	Martínez	3
15	José Luis	Estrada	Castañón	2	34	Saturnino	Rivas	Hernández	1
16	Jaime	puente	reyes	3	35	Adolfo	Dueñes	Bañuelos	2
17	Alberto	Hernández	Puente	2	36	José	Ávila	Amador	2
18	Emiliano	Flores	Hernández	2	37	Antonio	Aguilar	García	2
19	Juan	Ramos	Méndez	3	38	Antonio	Rosales	Domínguez	2

Table 2. Dimensions and issues considered in each dimension for the grouping by cluster analysis of the surveyed farmers belonging to PRODETER 'Sombrerete II' in the state of Zacatecas, Mexico.

Dimension	Issues that were considered
Social (S)	Sex, age, if they read and write, level of education, activities they do, native people and if they had social security or not
Economic (E)	Material of the wall, ceiling and floor of the house, number of rooms, services (bathroom, drainage, telephone, drinking water, internet and electricity), food security (concern about lack of resources to obtain foods), composition of foods for seven days (times they consumed tortillas, potatoes, vegetables, fruits, meat, egg, fish, legumes, dairy products, oils, sugar or honey and coffee or tea) and dependence to obtain foods
Supports (SU)	If they belong to an organization and receive supports from it, they have technical assistance and years they received it, origin of the resource for the productive activity
Production Unit (PU)	Locality, land tenure, property, area destined for rainfed agriculture, slope, timber extraction area, irrigated area for agriculture and livestock area
Production (P)	Grain yield per hectare, sown area, total production, presence of disasters, stubble destination and intercropping
Seed (SE)	Seed category, color, quantity per hectare, type of selection and conservation
Tillage (T)	Number of tasks to prepare the soil, sowing method, use of subsoil
Fertilization (F)	Soil analysis, fertilization source and quantity
Biological control (BC)	Type of weeds, pests and diseases, as well as method of control
Commercialization (C)	Type of market, percentage of sale of production to the intermediary

The weighted data of each dimension were standardized and subjected to a hierarchical cluster analysis based on Ward's method, using PROC CLUSTER of the SAS statistical package (SAS, 2011). The groups were chosen visually. Then a Manova and a discriminant analysis were performed.

From the results obtained, it was found that 100% of the people in charge of the production units can read and write, and 92% are male. All localities have social security that ensures the service of medical assistance, support for the elderly, maternity, among others. No farmer has timber extraction areas or irrigation areas. The agricultural lands are mechanized, they use native seed, the method of sowing is in single-row furrows, and they do not carry out soil analysis.

The analysis showed that the 38 farmers were divided into three groups (Figure 1). According to the multivariate analysis and Wik's Lambda statistic, the groups are statistically different ($p< 0.05$). The dimensions that showed discriminant power ($p< 0.05$) and contributed to the split of the groups were: production, tillage and biotic control. Group I is made up of 11 members, ten male and one female.

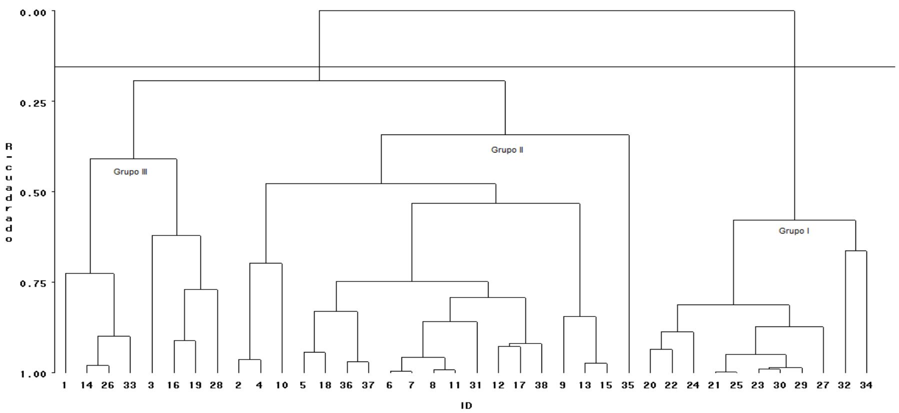

Figure 1. Dendrogram of 10 dimensions for the 38 bean farmers members of PRODETER 'Sombrerete II' in Zacatecas.

It obtained low values in the social (9.09), government support (4.54), production unit (11.65), production (7.52) and biotic control (1.77) dimensions, on the other hand, it had the highest values in the tillage dimension (3.63). There are no elderly farmers (older than 60 years), and none belong to any native people.

Fifty-four percent carry out a single activity, the rest have up to two. The materials that predominate in the construction of the house are adobe walls and cement floor. No farmer has all the services. As for the composition of the diet, it was the one that consumes the least meat products and sausages. It is the group that has the most dependence to acquire food.

They do not belong to any organization, nor do they receive government supports or technical assistance. Sixty-four percent of the farmers are from Felipe de Ángeles and the rest from Buenavista, the average of agricultural land is 5.1 ha, the ejido predominates as land tenure and they are agricultural areas that have the lowest slope.

Regarding yield, it has an average of 165 kg ha^{-1}. As for the characteristics of the seed, these are pinto and black, more than 50% preserve the seed in a loft or barn. These farmers do not report having problems with weeds, however, the attack of pests, bean beetle, worm and grasshopper is frequent. In commercialization, most have contact with intermediaries.

Group II is made up of 19 members and the predominant age is in the range of 41-60 years. This group obtained the highest values in dimensions: support (5.94), seed (36.16), fertilization (117.22), biological control (3.71) and commercialization (2.65). On the other hand, it obtained the lowest value in the economic dimension (24.4) and tillage (1.31). It has a lower level of studies, 63% only have primary education. There is the presence of six farmers of native peoples. They are diversified farmers, with more economic activities. In the house, the concrete roof and cement floor predominate.

They worry about the lack of resources for food and are less dependent for food acquisition. It has farmers who belong to an organization and receive support from it. They receive technical advice from the government and are the ones that most use their own resources for the agricultural activity. Forty-seven percent are from the town of Felipe de Ángeles, 37% from Álvaro Obregón and the rest from Buenavista.

The average sowing area is 5.6 ha, and most do it on a slope, however, they are the ones that report the highest yield (325 kg ha^{-1}). In the color of the seed, five farmers sow pinto varieties, and the rest black with a density of 30 kg ha^{-1}. It carries out few agricultural activities to prepare the soil, uses more sources of fertilizer (18-46-00, urea, even manure), with average amounts of 115 kg ha^{-1}. Broadleaf weeds predominate and, in pests, the bean beetle, for the control they apply agrochemicals mechanically.

Most of the production is sold to the intermediary. Group III is made up of 8 farmers, it had the highest values in the social (11), economic (27.73), production unit (19.4) and production (18.52) dimensions, on the contrary, it had the lowest value in the seed (31), fertilization (71) and commercialization (1.6) dimensions. In the level of studies, secondary education and high school predominate, although there is one with a bachelor’s degree. The materials in the construction of the house are adobe walls and cement floor. They have more services, between 5 and 6. They worry about the lack of resources to obtain foods, but they are the ones that have the most complete diet.

They do not belong to organizations, nor do they receive technical advice. They have ejido lands, and they are the ones that sow the most area, 12.3 ha on average. Agricultural lands with slopes predominate and it is the group that had more disasters due to drought. Sixty-two percent sow pinto seed, but their density is low (26 kg ha^{-1}). The seed is native, and they keep it in a loft. They use a single source of fertilizer, 18-46-00 and apply 70 kg ha^{-1}. Sixty-three percent do not mention problems with weeds, but they do mention pests such as bean beetle and worm.

They are farmers who sell less production because they use the grain for self-consumption, in addition to preserving grain to be used as seed for the next sowing cycle. In addition to this, the destination of the grain is the local market, not the intermediary. The results show that the three groups of PRODETER ‘Sombrerete II’, being located in an area of high marginalization, having a totally rainfed agriculture, having monoculture and not having adequate technology, are highly exposed to the effects of climate change.

Small rainfed farmers have felt the most affected by these changes in climate patterns, they know it is happening, but they do not know how to adapt to these changes to protect their harvest, their family and ensure their food security (Schmidt *et al*., 2012). The technology to mitigate some of the effects of climate change exists and the typification conducted in this research serves as the basis for proposing specific measures so that PRODETER ‘Sombrerete II’ can reduce the impacts of climate change. The proposed technological measures are listed in the following paragraph.

To reduce climate impacts, achieve better competitiveness, greater profits in production and improve the food and quality of life of these farmers, it is necessary to implement strategies to transfer technological components derived from the variables that showed discriminant power.

For group II and III, promote tillage with multi-plow, which reduces production costs, furrow diker or level curves, they prevent soil deterioration and increase water productivity, sowing in beds with high densities of plants and it is of great importance in the face of the phenomena of intermittent rains and drought that have been occurring (Borja *et al*., 2018b).

For group I and III, recommend the use of seeds adapted to the region with characteristics of higher yields and resistant to biotic and abiotic factors that surpass native seeds, such as varieties resistant to high temperatures (Ramírez-Cabral *et al*., 2015). For group I, train personnel to identify pests, diseases and weeds, as well as to carry out an integrated management that is friendly to the environment as far as possible (Amador *et al*., 2004; Mena and Velázquez, 2010). Also implement methodologies for the selection and storage of the seed (Cid *et al*., 2014) and as an alternative for grain not suitable for commercialization, carry out transformation processes to give added value (Figueroa *et al*., 2011).

Conclusions

The typification made it possible to identify that 100% of the respondents are in charge of the production units and depend entirely on rainfed agriculture. Of the 38 farmers, they were divided into three groups with different characteristics. Group I was characterized by having the smallest areas and carrying out the largest number of tasks for the preparation of the land. Group II was characterized by the best practices in the management of the crop. Group III has almost all the services in the houses, they sow the largest area, but they had losses due to disasters. With the typification carried out in 'Sombrerete II' and considering those variables that divided the groups, specific actions were proposed, which will be able to mitigate the effects of climate change and thereby establish sustainable production systems.

Cited literature

Amador, R. M. D.; Acosta, D. E.; Escobedo, R. J. S. y Gutiérrez, L. R. 2004. Control de malezas con escardas y herbicidas preemergentes en frijol en Zacatecas. Folleto científico núm. 6. Campo Experimental Zacatecas. 20 p.

Arce, R. A.; Monterroso, R. A. I.; Gómez, D. J. D.; Palacios, M. M. A.; Navarro, S. E. N.; López, B. J. and Conde, A. A. C. 2020. Crop yield simulations in Mexican agriculture for climate change adaptation. Atmósfera. 33(3):215-231.

Borja, B. M.; Osuna, C. E. S.; Arellano, A. S.; García, H. R. V. y Martínez, G. M. A. 2018a. Competitividad y eficiencia en la producción de frijol en condiciones de temporal con tecnología tradicional y recomendada. Rev. Fitotec. Mex. 41(4):443-450.

Borja, B. M.; Vélez, I. A. y Ramos, G. J. L. 2018b. Tipología y diferenciación de productores de guayaba (*Psidium guajava* L.) en Calvillo, Aguascalientes, México. Región y Sociedad. 30(71):1-22.

Cid, R. J. A.; Reveles, H. M. y Velásquez, V. R. 2014. Selección y almacenamiento de semilla de frijol. Folleto técnico Núm. 64. Campo Experimental Zacatecas. CIRNOC-INIFAP. 17 p.

DOF. 2019. Diario Oficial de la Federación. Lineamientos de Operación del Programa de Desarrollo Rural de la Secretaría de Agricultura y Desarrollo Rural para el ejercicio fiscal 2019. Cámara de Diputados. Séptima Sección vespertina.

Figueroa, G. J. J.; Juárez, I. C. A.; Herrera, H. M. G.; Guzmán, M. S. H. y Sánchez, T. B. I. 2011. Manual elaboración de productos agroindustriales de frijol. Publicación especial núm. 21. Campo Experimental Zacatecas. CIRNOC-INIFAP. 35 p.

IPCC. 2012. Summary for policymakers. *In*: Field, C. B.; Barros, V.; Stocker, T. F.; Qin, D.; Dokken, D. J. and Ebi, K. L. (Ed.). Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, UK, and New York, USA. 19 p.

Galindo, G. G. y Zandate, H. R. 2004. Caracterización de productores del noreste de Zacatecas y el uso de variedades de frijol. Folleto técnico Núm. 13. Campo Experimental Zacatecas. CIRNOC-INIFAP. 120 p.

Głębocki, B.; Kacprzak, E. and Kossowski, T. 2019. Multicriterion typology of agriculture: a spatial dependence approach. Quaestiones Geographicae. 38(2):29-49.

Medina, G. G.; Ruiz, C. J. A.; Rodríguez, M. V.M.; Soria, R. J.; Díaz, P. G. y Zarazúa, V. P. 2016. Efecto del cambio climático en el potencial productivo de frijol en México. Rev. Mex. Cienc. Agríc. 7(13):2465-2474.

Mena, C. J. y Velásquez, V. R. 2010. Manejo integrado de plagas y enfermedades de frijol en Zacatecas. Folleto técnico núm. 24. Campo Experimental Zacatecas. CIRNOC-INIFAP. 83 p.

Ramírez-Cabral, N. Y. Z.; Kumar, L. and Taylor, S. 2016. Crop niche modeling projects major shifts in common bean growing areas. Agric. Forest Meteorol. 102-113 pp.

Ramírez-Cabral, N. Y. Z.; Sánchez, G. R. A.; Cabral, E. M.; Cruz, B. R. y Rosales, S. R. 2015. Selección de materiales promesa de frijol para el estado de Zacatecas. Folleto técnico núm. 65. Campo Experimental Zacatecas. CIRNOC-INIFAP. 41 p.

Rojas, S. R. 1979. Guía para realizar investigaciones sociales. Facultad de Ciencias Políticas y Sociales. Universidad Autónoma del Estado de México (UAEM). DF. 271 p.

Sangerman, J. D. M.; Acosta, G. J. A.; Shwenstesius, R. R.; Damián, H. M. A. y Larqué, S. B. S. 2010. Consideraciones e importancia social en torno al cultivo de frijol en el centro de México. Rev. Mex. Cienc. Agric. 1(3):363-380.

SAS. 2011. Base SAS® 9.3. Cary, NC: SAS Institute Inc.

SIAP. 2019a. Servicio de Información Agroalimentaria y Pesquera. Anuario estadístico de producción agrícola.

SIAP. 2019b. Servicio de Información Agroalimentaria y Pesquera. Manual para el llenado del cuestionario para el diagnóstico de los Proyectos de Desarrollo Territorial (PRODETER). Guía para el uso y manejo de la aplicación mobil ‘SIAP-Desarrollo Rural’. 113 p.

Schmidt, A.; Eitzinger, A.; Sonder, K. and Sain, G. 2012. Tortillas on the roaster. TOR. Central American maize-bean systems and the changing climate. Project led by catholic relief services, involving CIAT and CIMMYT as principal partners, and funded by the Howard G. Buffett Foundation. 108-112 pp.