Essay

Grain production using the southern grain model and its contribution to food sovereignty

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Abstract

The Grains of the South corn production model, implemented by INIFAP in the state of Chiapas, Mexico, during the Autumn-Winter 2015-2016 cycle, consists of four elements for its operation: technological supply, supplies and timely technical assistance, a multimedia transfer strategy for the development of capacities and the management of agro seed companies. Eighteen irrigated plots were established with different sources of supply, a characterization of producers and production units was carried out and two commercial hybrids generated by INIFAP were tested, with the aim of contributing to food security through the production of corn in irrigation units; the results indicate that in spite of the conditions of depletion of the aquifer mantles of the artesian wells, and the prevailing environmental conditions of high temperatures and precipitation decreased by 65%, the hybrids are statistically superior to the commercial hybrids of transnational companies, so that if at least three of the four elements of the model are met, it is possible to have an impact on approximately 6 million units of production and thereby contribute to the reduction of imports of corn grains and have food security and thus sovereignty necessary for the almost 120 million Mexicans.

Keywords: corn, food security, southeast of Mexico, transfer.

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Introduction

Corn is one of the most important cereals for human and animal consumption, such as grain and fodder. The world production is around 638 million tons of grain in approximately 143 million hectares (González and Macias, 2007). In Mexico, 8.5 million hectares of corn are grown annually, with a national production of 22.5 million tons and an average of 2.8 t ha^{-1}; nevertheless, seven million tons of whole grain of yellow corn and three million broken grain are imported each year, so it is necessary to increase the production of this type of corn (Turrent 1998; Turrent, 2004; Ortiz-Cereceres *et al*., 2007). It is contradictory to know that during 2011-2012 Mexico was the second largest importer, with 11% of world imports (Márquez *et al*., 2014).

Mexico has 31 million hectares of farmland, of which 6.3 million are managed under irrigation and almost 25 million are rainfed. The annual freshwater resource is 1 530 km^3 of which 147 km^3 are retained in the dams, 410 km^3 drain to the sea. The 67% of the runoff occurs in the southeast, with minimal use in irrigation, with an amount almost twice higher than what is currently retained for irrigation in the irrigation districts of the country. The use of working land (irrigation and temporary) is mainly extractive and the country already accumulates a large deferred investment for the rational use of the resource (CONAGUA, 2007). Irregular availability of water is a global problem even in areas of high precipitation (Wanjura and Upchuch, 2000, cited by Unland *et al*., 2006).

FAO (2002) mentions that agriculture is the activity that uses the largest volume of water; more than two thirds of that provided by the rivers, lakes and aquifers of the planet. Approximately 70% of all water used for human use is destined, fearing that this may affect the future of food production. Under irrigation conditions a commercial production is good from 8 to 9 t ha^{-1}, with a grain humidity of 10 to 13%. The efficiency of water use for grain production then varies between 0.8 and 1.6 kg m^3 (FAO, 2002). The water used for irrigation includes, in addition to the one actually transpired by the growing crop, all the water applied to it. On the other hand, there are losses due to leaks and evaporation in the conduction of the water and percolation in the plots, without it being used by the crop (FAO, 2002).

FAO estimates that in the next 30 years world food production should increase by about 60% to feed this growing population. It mentions that, in many cases, agriculture cannot compete economically for the scarce water resources available, given that cities and industries are in a position to pay higher amounts for water.

The agricultural sector has to demonstrate that the water supplies it receives are adequately used to guarantee food security, in this aspect, Ayala and Schwentesius (2014), mention that food security is defined as the timely, sufficient and inclusive supply of food to the population, while food sovereignty is defined by the country's self-determination in terms of production, supply and access to food for the entire population.

Gordillo and de Anda (2013), based on texts from NGOs and various intellectuals and academics indicate that food sovereignty rests on six pillars: “... 1) it focuses on food for the people; 2) value food suppliers; 3) locate the food systems; 4) place the control locally; 5) promotes knowledge and skills; and 6) it is compatible with nature ...”. On the other hand, and in the same tenor, Altieri, (2009) indicates that to achieve food sovereignty and be able to stagger thousands of successful local agroecological experiences, changes should be promoted in agrarian policies that give farmers access to land, seeds, credit, extension services, etc, as well as access to local markets and fair prices.

For this, in the south-southeast of Mexico, mainly in the states of Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatán, natural resources are abundantly available; fresh water and farmland that remain idle in the autumn-winter cycle (A-W). In this region flows 63% (260.8 km^3) of the annual runoff (415.9 km^3) of the country’s rivers (SARH, 1988). While in the Spring-Summer cycle (S-S) 2.5 million hectares of maize are sown in the eight states, in the Autumn-winter cycle (A-W) only 384 000 ha of maize were planted as the second crop, the rest is idle due to the lack of rain in the season and the lack of irrigation infrastructure (Turrent *et al*., 2004).

Taking into account the importance of the areas susceptible to irrigation in the eight states mentioned above, as potential producers of grain that can contribute to reduce the import thereof, the National Institute of Forestry, Agriculture and Livestock Research (INIFAP), based in Experimental work and validation of the Grains of the South project developed during the autumn-winter cycles 1996-1997, 1997-1998 and 1998-1999, showed that in the state of Chiapas it is possible to have an impact on the productivity of corn, improving its production systems and promoting the use of the potential of the four irrigation districts and irrigation units that are currently underutilized, in addition to the existence of a cultivable area with technology of 34 956 and 38 553 hectares, respectively, with the safe supply of water, of which only half is irrigated (López *et al*., 2008).

The objective of this work was to demonstrate and validate that through the model of production of irrigated maize “Grains of the South” in the areas that have irrigation from The Frailesca, Chiapas, it can impact the corn production and contribute to the production deficit what the population requires. In INIFAP, the objective is to develop and promote strategic and frontier research to contribute in a timely manner to the solution of the major problems of productivity, competitiveness, sustainability and equity, as well as to promote and support the transfer of knowledge and technologies in the forestry sector, agricultural and livestock of the country according to the needs and priority demands of producers and society, contribute to the formation of human resources and the generation of technology transfer models for the increase of agricultural and forestry production, such is the case of the “Grains of the South” corn production model (Cadena *et al*., 2009; Cadena *et al*., 2015).

The production model “Southern Grains”

It consists of the production of corn under irrigation, based on experimental results developed since 1998. This includes the application of four main agronomic components, sowing dates, population density, nitrogen fertilization, phosphoric and potassium, and high yield hybrids. In addition, part of the model includes the timely provision of inputs, technology transfer through training to technicians and producers and field schools, as well as demonstration events, meetings of producers and institutional linkage forum, to present the results of the evaluation of the impact of the model. The last point of this model is that producers are organized and self-managers of seed companies to reduce costs for the purchase of seeds, which has not been achieved given the lack of entrepreneurs (Cadena *et al*., 2009). The model contemplates a multimedia strategy to achieve the expected results, based on the methodology of field schools, widely developed by: Gallagher (2003); Morales and Galomo (2006); Morales (2007); Morales (2008); Cadena *et al.* (2013); Cadena (2016); Morales *et al.* (2016).

Study area

The model was established in 11 localities in three municipalities of The Frailesca, Chiapas, Villaflores, Villacorzo and The Concordia, located in the central part of the State; it worked with producers who have irrigation plots, a socio-economic characterization was carried out and the production unit was interviewed, 28 producers were interviewed, of which only 25 were left, soil samples were taken to determine the nutritional requirements of each plot, and hybrids H-561, (Coutiño *et al*., 2013) and H-380A, white first and yellow second. The sources of water supply were wells, rivers and dams and was carried out by various irrigation systems, rolled, belt, spray and cannon. The commercial hybrids generated by the INIFAP, H-561 and H-380A were tested, and topological arrangements were made different from those used by the producers. The indispensable elements for the implementation of the model are described in Figure 1.

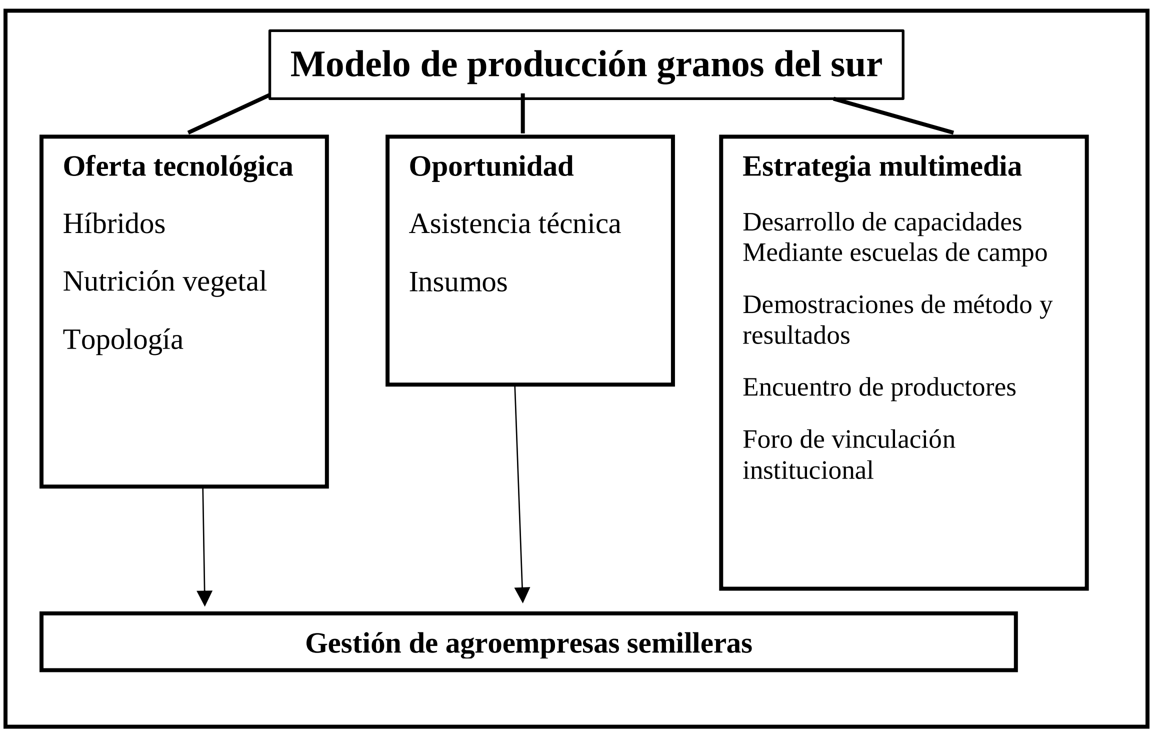

Figure 1. Essential elements for the operation of the "Southern Grains" corn production model (INIFAP, 2016).

From the social characterization that was made with 25 producers, it was found that the type of producer of The Frailesca does not differ much from the national average, on average the producers are 53 years old and with a cultivated area of 4.71 ha, of which 2.63 ha, are dedicated to the cultivation of corn in irrigation. They apply inputs recommended by the local oral tradition, without systematically providing constant technical assistance. The area dedicated to the production of maize in irrigation is for corn production, which is marketed in the regional markets of Tuxtla Gutiérrez, Chiapas. Although they use commercial hybrids, where they are most affected are the production costs for the production of corn for grain or corn, given that the cost exceeds 300% the cost of materials suggested by INIFAP and commercially available.

The results of grain yield obtained in the plots with the hybrids H-561 and H-380A, are presented in the following tables (Table 1, 2 y 3).

Table 1. Combined variance analysis of the white grain yield of hybrid H-561 and commercial controls, under irrigation in 11 locations in the Autumn-Winter 2015-2016 cycle. (INIFAP, 2016).

Variation source	Freedom degrees	Sum of squares	Average square	F calculated	Pr>F
Location	10	268 743 433.9	26 874 343.4	84.67	<0.0001
Hybrids	1	1 2376 147.3	12 376 147.3	38.99	<0.0001
Repetitions	9	5 831 888.8	647 987.6	2.0423	0.0423
Repetition x locality	90	35 800 804.5	397 786.7	1.25	0.1362
Locality x hybrids	10	39 537 133.8	3 953 713.4	12.46	<0.0001
Error	99	31 421 761.9	317 391.5		
Total	219				

Table 2. Average yield (kg ha^{-1}) of H-561 and commercial controls in 11 locations under irrigation conditions. Autumn-Winter cycle INIFAP, 2016.

Num.	Loc/producer	H-561	Control	Average
1	Common Galeana, Villaflores. Antonio	8 658 a	7 600 bc	8 129 a
2	Common Independencia, The Concordia. Limbano	8 765 a	7 681 bc	8 223 a
3	Common 16 sep. Villaflores. Raquel	7 181 c	7 704 b	7 442 b
4	Common The jardín, Villaflores. Osvaldo	8 079 b	6 706 cd	7 392 b
5	Common San Luis, Villaflores. Octavio	7 860 b	6 749 cd	7 304 b
6	Common Galeana, Villaflores. Mariano	7 780 b	6 619 d	7 199 b
7	Common S. P. Buenavista, Villa Corzo. Gabriel	6 484 d	7 831 b	7 157 c
8	Common The campana, Villa Corzo. Tavín	5 933 e	5 400 f	5 666 d
9	Common The Tigrilla, La Concordia. Francisco	5 940 e	4 821 g	5 380 d
10	Common Villa Hidalgo, Villaflores. Sergio	5 183 f	5 269 f	5 226 d
11	Common 16 septiembre, Villaflores. Alfonso	5 046 f	5 348 f	5 197 d
Average/hybrid		7 081 a	6 521 b	6 756
$DMS_{0.05}$ for hybrids = 150.7				
$DMS_{0.05}$ for locations = 353.5				
$DMS_{0.05}$ for location x hybrid = 499.9				
CV= 8.3				

Table 3. Average yield (kg ha^{-1}) of H-380A and control hybrids in 4 locations under irrigation conditions, Autumn-Winter cycle (INIFAP, 2016).

Num.	Loc/producer	H-380A	Control	Average
1	Common S. P. Buenavista, Villa Corzo. Gabriel	9 413	6 350	7 881
2	Common San Luis, Villaflores. Octavio	8 849	6 237	7 543
3	Common Totonilco, Villaflores. Gregorio	8 789	6 488	7 638
4	Common Villa Hidalgo, Villaflores. Hermilo	8 475	6 291	7 383
Average		8 881 a	6 341 b	
$DMS_{0.05}$ for hybrids = 447.44				
CV= 9.1				

The average yields of H-561 (7 t ha^{-1}), H-380A (8.8 t ha^{-1}) and their respective commercial controls (6.5 and 6.3 t ha^{-1}) in the Autumn-Winter 2016 cycle were affected due to limitations in the availability of irrigation water and high temperatures. In the first case during the mentioned agricultural cycle there was a decrease in the water table and with it the reduction of the water supply sources of the artesian wells and jagüeyes, being unbearable to provide the risks in time and form in different plots. Faced with this problem, some producers in order to solve this situation opted to deepen their wells, although not all had the economic resources for that purpose, even reaching the limit of suspending crop management. The above is attributed to the fact that during the Spring Summer 2014 and 2015 cycles the rainfall in the region was approximately 65% below normal (Figure 2).

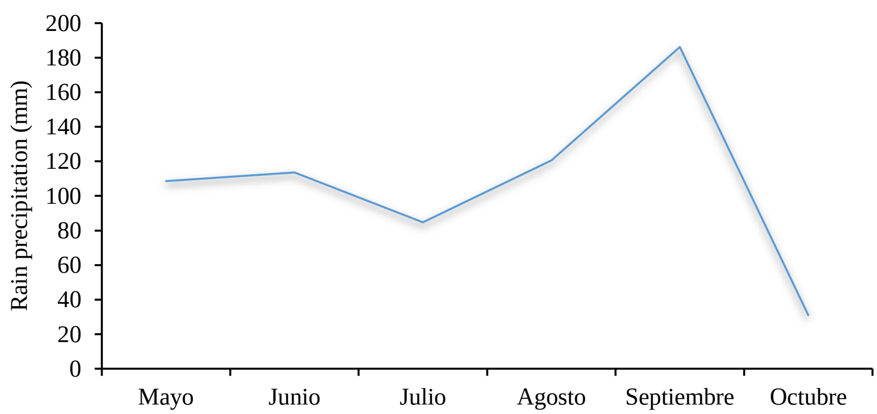

Figure 2. Monthly rainfall between May and October 2015 at the "Tehuacán" property. Common Francisco Villa, Villaflores, Chiapas.

As far as the temperature is concerned, in the study cycle, the average maximum temperature during the hottest months, from March to May, was up to 36 °C, presenting days with a maximum of 38.8 °C (Figure 3). The above is even more drastic to take into account that for the months of March to May in most plots the crop was in the stages of male flowering (R0), female (R1), at physiological maturity (R6), being able to cause problems in pollination in the first two cases and in the rest until R6 low efficiency in the translocation of photosynthates to the grain (Lawlor, 2005).

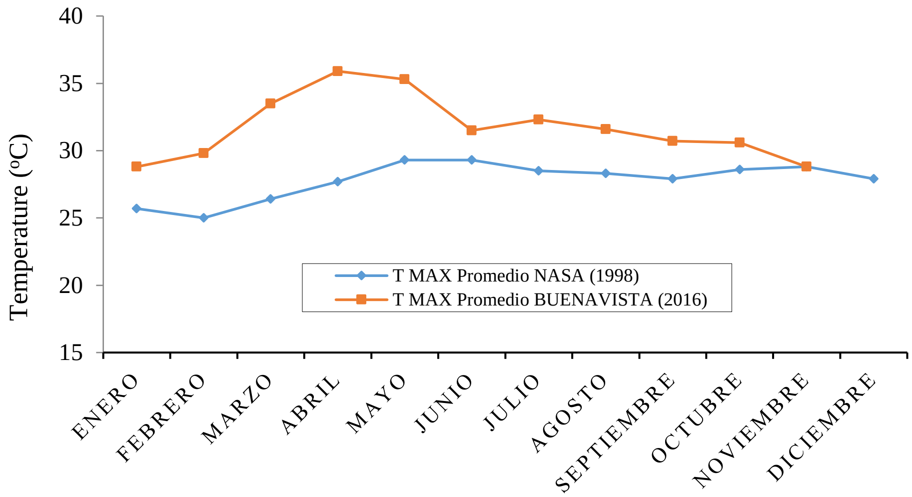

Figure 3. Monthly and historical temperature January-December, 1998 (NASA) and 2016 in the town of San Pedro Buenavista, municipality of Villacorzo, Chiapas.

The yield results indicate that H-561 and H380A, were statistically superior ($p < 0.05$) to the commercial controls of the producers (Tables 2 and 3) and although for irrigation it is a low yield, taking into account that said yields can be achieved in temporary, these yields have to do with the agroclimatic conditions of previous years, where the temperatures presented in The Frailesca are shown, to which Cheikh and Jones (1994) mention that for corn a temperature greater than 35 °C accompanied by a low relative humidity causes drying of the stigmas and that temperatures above 38 °C reduce the viability of the pollen.

Based on the above, it has been suggested that for each degree Celsius (°C) that the temperature increases above the optimum (25 °C), grain yield is reduced by 3 to 4%, since it affects the photosynthesis of the plants and in this case, according to the temperature graph (Figure 3) of the last two years, it can be observed that during the dry season, these rise substantially, therefore the risks that the producers perform are insufficient for the plants make efficient use of the water received, and rather has an effect of decreasing the temperature of the soil. Ellis *et al*. (1990) and Lawlor, (2005), affirm that the increase of the environmental temperature can affect their growth rate, limit their photosynthetic activity and increase their respiration in the development of the plant that is why they become more demanding of water and it becomes increasingly inefficient.

Although it is true that both the data referred to in the results in the land of the producers under the same management conditions and changing only the control materials, it can be seen that the yields for the irrigation condition are low, these are due to the environmental conditions not controllable by man and that the technology proposed by the “Southern Grains model”, applied under the circumstances of the producers, are highly profitable, even with the conditions presented, it is possible to contribute to the reduction of grain imports of corn.

For this, it is necessary that the institutions involved in the organization of producers, insurance, loans, technical advice, granting support to the production, marketing and sale of inputs become more involved, a situation previously suggested by Altieri in (2009), given that producers are sometimes not aware of the support they can receive and thereby support and ensure the success of the program that is clearly good. In the case of producers, being involved and organized would be much easier to access support in machinery, supplies, technical advice, and even in support of the federal government program "energy for the field" and "extension" for 2016-2017 they are valid, and with this the producers would have permanent advice.

Ayala (2014) indicates that models of technology transfer for production are contextual and adoption is not always the result of a process, but often is a phenomenon that depends on observation, intelligence, decision and risk of the producers themselves. In this regard and in a study conducted in the south-southeast region of Mexico, in marginalized areas of The Tuxtlas, Veracruz, it was found that the management of innovations for the economic and social development of the rural productive sector of these areas is a high-quality process social, institutional and organizational complexity, which requires institutional linkages with decision makers and providers of support and services (Zambada *et al*., 2013).

In the study region, there is a differential in terms of the type of water supply source that include artesian wells, rivers, jagüeyes and irrigation channels of dams, which continue with the same prevailing environmental conditions of 2015- 2016, there will be the same risk that the water tables drastically decrease that it will be impossible to supply water to the crop until the production of grain. Therefore, it should be promoted that the institutions in charge of water administration can ensure the participation of a greater number of producers that can access water when there are dams, dams or rivers with sufficient flow, on the other hand, the institutions in charge of the equipment they should provide equipment and infrastructure for the efficient use of the water resource.

When analyzing the agricultural extension system in the country, Amaro and de Gortari (2016) conclude that this system has evolved at different times; it has gone from being a state service to one with quasi-private overtones. However, they strongly indicate that ... "there has not been a process of integration of efforts between the different institutions involved and what is observed is a disarticulated system whose success and failure often depends on the regions and the organization of the producers, in addition to aspects such as the performance of technicians and the problems they face around them, such as continuity or evaluation of results and impact ..." (SIC), something similar to what has been found in this study.

From the institutional forum held in Villaflores in 2016, with 12 federal, state and municipal agricultural offices of Frailesca, it was concluded that: the technical use of water is a necessity, for this, the National Water Commission (CONAGUA) offered advice to those who require it for the application of water expenses, consumptive uses and irrigation sheets, according to the sources, so it is necessary to organize the producers for a better training on the subject. With the edaphic and management characteristics of the producers who participated in this program and model, with the potential support expressed by the institutions and technologies proposed by INIFAP, all that remains is for the producers to take the final step to create their own production companies. of seeds, of commercialization and of storing of harvests to attain better final prices by his products, and to give them an added value, since until now they only sell in bulk and for corn.

In summary, under the normal environmental conditions of good rain in the storm so that the water table recover and can supply sources of supply for irrigation in the Autumn-winter cycle, on the surface that can be irrigated in the south-east of the country, sufficient quantities of corn grain can be produced to contribute to the reduction of imports and be self-sufficient in the production necessary for the consumption of Mexicans. This model can be scaled to the southeastern states that currently have runoff of water that are not used.

Conclusions

The Southern Grains corn production model, even with the environmental limitations that occurred in the two previous years that caused decreases in the water table, was efficient, given that the yields obtained with the technologies offered by the INIFAP were statistically superior to the witnesses commercial.

The contribution to agrifood security and its respective sovereignty has to do not with the model itself, but with the staggering of a south-south-east program of the republic and that requires the implementation of a public policy that allows the institutions of the agricultural sector and private initiative join this effort of research-transfer of technology, to increase production levels and thereby reduce imports to the growing population in Mexico.

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