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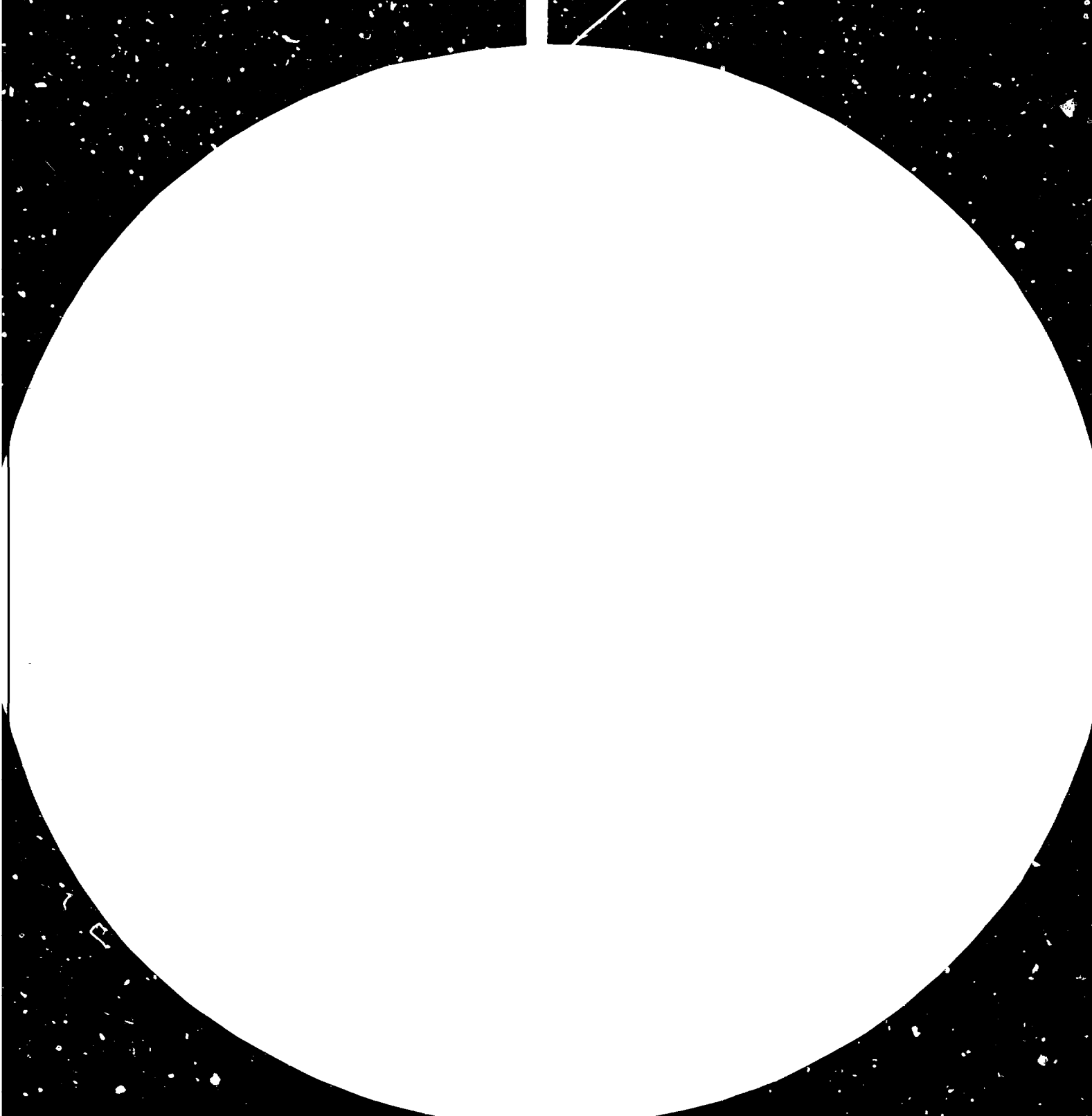
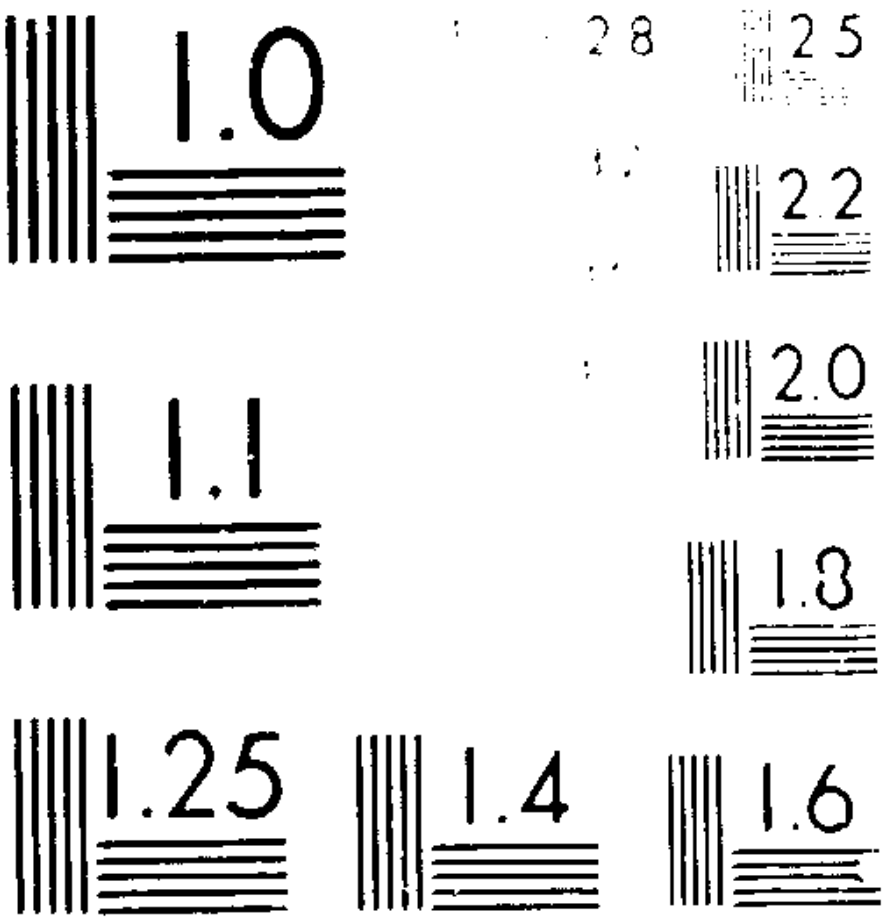
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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PROJECTIONS ON THE USE OF PLASTICS IN THE AGRICULTURAL REGIONS OF THE ARID ZONES OF MEXICO*

by

S. Fernández**

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the UNIDO Secretariat. This document has been translated from an unedited original.

** Research Centre for Applied Chemistry (CIQA), Saltillo, Coahuilla, Mexico.

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Summary

In the near future Mexico's secondary petrochemical industry will have the capacity to produce in surplus synthetic resins which it will be possible to use, in the form of plastics for agricultural applications, as a means of increasing the productivity of the country's rural economy. On traditional farms located in arid and semi-arid zones the use of plastic films will be introduced for the lining of irrigation channels, the trapping and retention of water, and the ensilage, storage and transport of grain. The technically more advanced agriculture of the irrigated districts will be able to profit from such techniques as mulching (mainly for vegetables and possibly for certain cereal crops like maize and beans as well), the use of greenhouse-protected seed-beds, and the greenhouse-growing of a number of vegetables, such as tomatoes and cucumbers for the export market.

CONTENTS

Any effort to describe the economic potential represented by the use of plastics in agriculture must be based on an understanding of the current situation within the Mexican agricultural sector. For this reason, the present paper will begin with some observations on the development of agro-industry in Mexico, following which there will be a discussion of the possible role of plastics in the two types of agriculture found in Mexico.

I. MEXICAN AGRICULTURE: ITS POLARIZATION

During the administration of President Lázaro Cárdenas (1935-1940) social experimentation in Mexican agriculture lead to the rapid development of this sector. Thus it was that by 1940, although a large number of farmers and operators of small holdings carved out of formerly large estates ("ejidatarios") were barely eking out a subsistence living, a small percentage of growers were competitively producing half of the value of Mexican agricultural products (1). In any case, the year 1940 marked the beginning of the accelerating development of the country's industry as well as of a more modern agriculture based on a wider use of inputs, machinery and technology and inspired by the concept of an agro-business increasingly oriented towards economies of scale. The result of these developments was a steadily deepening polarization within our agriculture, to the degree that in present-day Mexico, as in the majority of underdeveloped countries, two forms of agriculture coexist side by side.

The first of these forms, which is more or less capital-intensive, is concerned mainly with the growing of fruits, vegetables, and certain grain crops, and is characterized by a high level of technology and the intensive use of such inputs as fertilizers, insecticides, farm machinery, etc. This form of agriculture is found in areas where there is sufficient water, either as the result of irrigation or because the regions in question are located in low-risk storm zones which enjoy abundant rainfall.

The second form of agriculture, which is based on a peasant economy and is more traditional in nature, concentrates on the production of staple food crops, very largely for consumption by the farmer's own family or for sale on the local market. Farming of this kind is conducted with very few technical aids and very little capital. Whereas the primary motive in the first form of agriculture is the maximizing of profit, the second is concerned mainly with producing what the grower himself requires for his own subsistence.

So extreme is the dichotomy between these two forms that by 1960 less than one per cent of all farms controlled 30 per cent of the country's arable land and 39 per cent of its entire irrigated area, whereas 50 per cent of the farms worked 11 per cent of the arable land, and none of the latter was located in the irrigated districts (2).

II. DEVELOPMENT OF AGRICULTURE (1940-1975): THE CURRENT CRISIS

Mexican agriculture's rapid growth began at the end of the 1930s, its pace quickening during the post-war era as a result of the greater use of machinery and the introduction of fertilizers and pesticides. Although major research and development projects in the irrigated districts led to an increase of 74 per cent in the national agricultural product during the ten-year period 1940-1950, during the next decade (1950-1960) the increase was only 25 per cent, with even slower growth recorded during the years following. For example, whereas the annual rate of growth was 4.5 per cent during the decade 1950-1960 and 4.8 per cent during the five-year period 1960-1964, the rate dropped to 2.7 per cent in 1965-1970 and to only 1.8 per cent in 1970-1974 (3).

However, this pattern of behaviour did not apply to the entire sector. For example, capital-intensive agriculture has enjoyed sustained growth since the 1960s in terms of both production volume and added value (table 1), more as a result of rising per-hectare yields than as the consequence of any expansion of the actual area under cultivation. Because of the greater

Table 1. Comparison of the total area under cultivation and in production with the area devoted to the growing of fruits and vegetables *

Years	Area, in thousands of hectares			Production, in millions of tonnes		
	Total agricultural area	Fruits and vegetables	%	Total agricultural area	Fruits and vegetables	%
	A	B	B/A	C	D	C/D
1960	12 152	1 932	15.9	21 102	4 657	22.1
1962	12 473	2 320	18.6	24 004	5 678	23.6
1964	14 435	2 767	19.2	29 031	6 667	23.0
1966	15 757	2 959	18.8	32 177	8 312	25.8
1968	15 089	2 575	17.1	34 034	8 350	24.5
1970	14 975	2 600	17.4	33 362	8 899	26.7
1972	15 076	2 699	17.9	34 965	10 296	29.4
1974	14 636	2 575	17.6	37 266	10 690	28.7
1976	15 781	2 075	13.1	37 046	10 347	27.9

* Taken from: El Complejo de las Frutas y las Legumbres en México, R. Rama and R. Vigorito, p. 89, Editorial Nueva Imagen, Mexico City, 1979.

profitability of this form of agriculture, the most fertile lands (usually located in the irrigated districts) have been allotted to such high-value-added crops as tomatoes, peas, egg plant, red pepper, and others, which are exported fresh to the United States of America and, to a lesser extent, Canada (table 2).

On the other hand, the growth rate in the production of staples - corn and beans - has not been satisfactory. Since these products yield a smaller financial return, the total area dedicated to these crops has not been increased and, what is more, the growing of corn and beans has been discontinued in the irrigation districts (commercial farming regions where the average national yield is 2,400 kg/hectare) and transferred to storm areas in which the only source of water is rainfall and where agricultural conditions are precarious and the average national yields very low (1,100-1,200 kg/hectare). Specifically, from 1950 to 1960 the number of hectares under maize and maize production itself steadily increased until in 1967 there was a maximum total cultivated area of 8,237,000 hectares producing 9,282,000 tonnes (1,127 tonnes/hectare). From 1967 on, since the officially supported prices remained uncompetitive with those of other products, the growth rates for this grain were negative (-12 per cent from 1966 to 1973 and -8.7 per cent from 1973 to 1976), with total production down in 1976 to 6,017,000 tonnes grown on 5,783,000 hectares (1,176 tonnes/hectare). If this trend continues, it is estimated that there will be a deficit of 2,441,000 tonnes by the year 1982 (4). This deficit will be covered by imports, which began in 1971.

The situation with respect to beans is similar, although not so serious. For this crop the first shortages and imports date back to 1973, and it is calculated that in 1982 the shortfall in beans will amount to 317,000 tonnes (5).

Table 3 below indicates the volumes of these products that have been imported since 1971, together with the projected import figures for 1982 (6, 7).

Table 2. Destination of agricultural production
(percentage in 1970 pesos) *

Years	Internal consumption	Exports	
		Fresh	Processed
1960	91.8	7.0	2.2
1962	91.4	6.1	2.5
1964	91.4	6.5	2.1
1966	91.1	6.0	2.9
1968	92.0	6.1	1.9
1970	88.0	9.2	2.8
1972	88.5	8.5	3.0
1974	87.5	8.0	4.5
1976	88.8	8.7	2.5

* Taken from: El Complejo de las Frutas y las Legumbres en México, R. Rama and R. Vigorito, p. 56, Editorial Nueva Imagen, Mexico City, 1979.

Table 3. Imports of maize and beans
(thousands of tonnes)

	1971	1972	1973	1974	1975	1979	1982 (7)
Maize	135	1 646	1 112	2 717	2 600	ND*	2 441
Beans	-	-	48	92	ND*	177	317

* No reliable data available.

Summing up, it is correct to say that although there has been an increase in the national agricultural product in terms of both volume and value, this has been the result of productivity increases achieved mainly in the irrigated districts in the case of certain export crops. On the other hand, there has been a substantial decrease in the production of basic food crops, the growing of which has, for the most part, been shifted to small farms located in storm areas and operated - without the advantages of technology or the possibility of achieving higher productivity - by subsistence farmers for their own needs.

III. THE AGRICULTURAL DEVELOPMENT PLANS

In the last 50 years our population has quadrupled its growth rate until today it has reached the figure of 70 million. As a consequence of this rapid demographic growth and the decline in agricultural production capacity, it is estimated that 50 per cent of all Mexicans are currently surviving on diets that fall below accepted minimum standards (2,750 calories per person per day). In other words, 35 million Mexicans, living mainly in rural areas or making up the unemployed or underemployed in the nation's large industrial centres, have need of better nutrition. Our traditional diet is based on beans, maize and maize products, and on a number of fruits and vegetables, including tomatoes, onions, and chillies.

For the reasons discussed above, increasing quantities of basic grains and other food products have been imported in recent years. It is clear that in order to avoid dependence on external food sources and to ensure a minimum standard of living for the population, the following are necessary: efforts to increase the production of basic foods (mainly by that sector of the population which is most in need of it), the more effective use of resources, and the attainment by small communities of self-sufficiency.

These objectives have inspired the formulation of what are known as the National Agro-Industry Development Plan (PNDA) and the Mexican Food System (SAM). The aim of the latter is to achieve self-sufficiency in maize and bean production within only two years (1980-1981), calling for an increase of 2,441,000 tonnes of maize and 317,000 tonnes of beans. As its 1985 target, the SAM plan envisages the production of sufficient quantities of sorghum, wheat, and other grains (table 4).

To meet these goals, four million hectares of storm land and 200,000 hectares in the irrigated districts have been made available for cultivation this year. These lands, as well as those which are already in agricultural production, will be supplied with solid fertilizers and ammonia, for which purpose a gas pipeline is being built to carry ammonia to three major agricultural areas: the semi-arid region of the North, the Bajío region, and the South-east (figure 1).

The intention is that by 1982 two-thirds of the land under maize and beans should be sufficiently fertilized to make possible an increase in the yields of these crops.

For its part, PNDA seeks to strengthen three agro-industry areas for the purpose of increasing the production of the following items:

- Basic foods, thereby supplementing the objectives of the Mexican Food System;
- Essential agricultural inputs, such as fertilizers, pesticides, improved seeds, and farm machinery;
- Basic non-food products - in general, all those agricultural products whose production requires simple processes which can competitively employ the largest possible number of workers.

Table 4. Mexican Food System (SAM) production targets (thousands of tonnes)

Crop	Years	
	1982	1985
Maize	13,050	14.950
Beans	1 492	1 640
Rice	-	1 133
Wheat	-	4 606
Sesame	-	159
Safflower	-	666
Soya	-	1 000
Sorghum	-	5 186

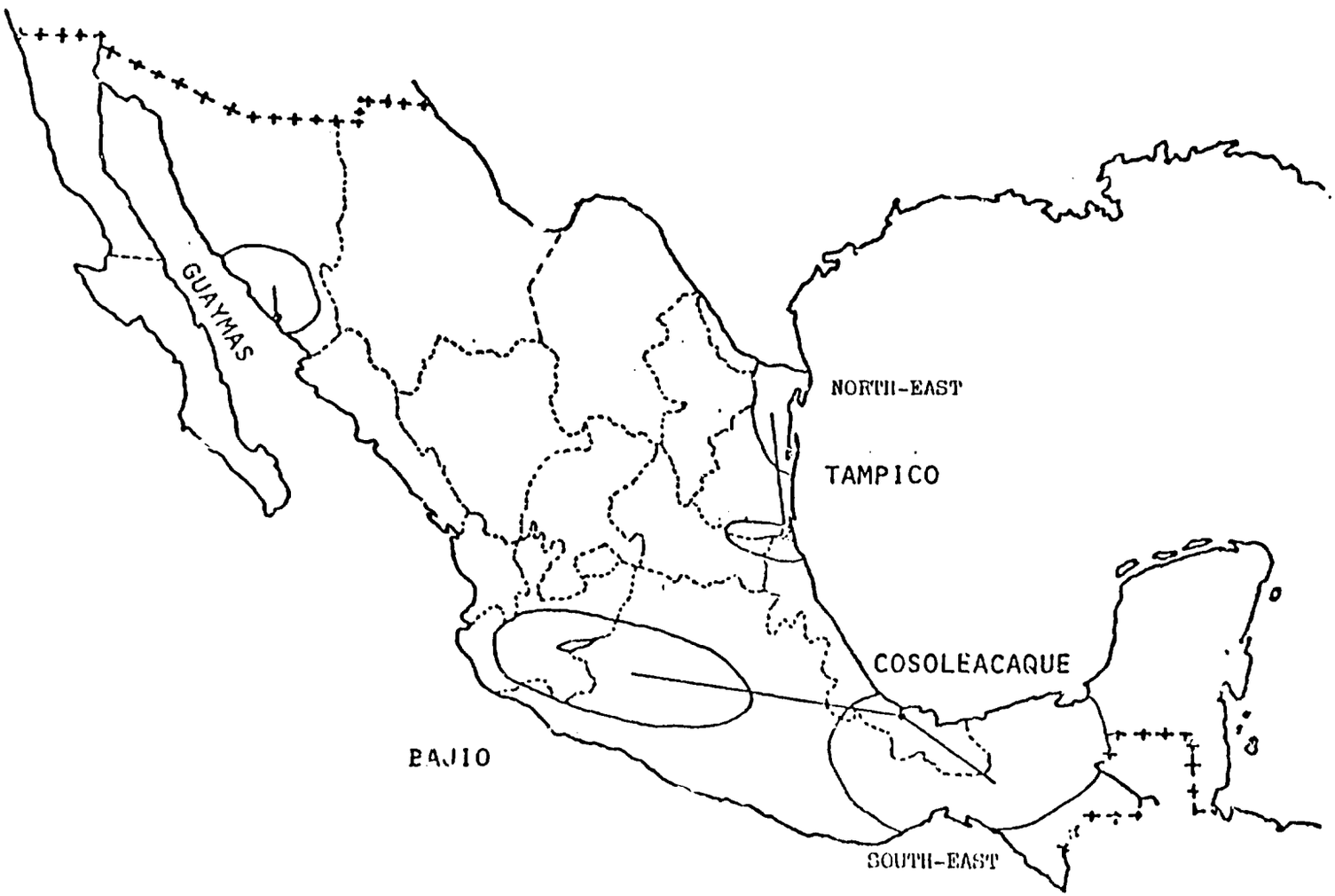

Figure 1. Gas pipeline under construction to carry ammonia to the agricultural regions of the North-East, Bajío and the South-East

Both SAM and PNDA place emphasis on the need to convert stock-raising, which is now usually an extensive activity consuming approximately ten hectares of pasture land per head of livestock, to an intensive activity in order to release as much arable land as possible for use in the growing of food crops.

Without losing sight of the need for intensive agriculture for the vegetable export market, both plans have been designed with social considerations in mind and thus seek to promote the intensive use of the rural work force, for whose benefit they are in fact intended.

IV. SECONDARY PETROCHEMISTRY: PRODUCTION PROJECTIONS

As important as the Government's food production policy is the national policy on the harnessing and use of the country's energy resources. On the basis of its current probable oil reserves, Mexico ranks fifth within the group of petroleum-producing countries. This means that an enormous potential exists for the production of basic and secondary petrochemical products.

For the time being, we lack sufficient capacity to produce these products, but the expansion plans currently being put into effect by Petróleos Mexicanos (PEMEX) will make it possible to make up the existing capacity deficit by 1982 and to begin producing at levels exceeding the projected consumption of certain of these products. For example, it is planned by 1982 to boost the production capacity for low-density polyethylene to 220,000 tonnes a year and for polyvinyl chloride to 320,000 tonnes a year, representing a substantial increase over present capacities in the order of 95,000 and 70,000 tonnes a year, respectively. In addition, plans call for an installed capacity capable of producing 100,000 tonnes of high-density polyethylene a year and a similar amount of polystyrene (8).

It is altogether reasonable to say that two of the general policies of greatest importance to the Mexican Government - the development of agriculture and the development of petrochemistry - may converge in the use of plastics as a means of increasing agricultural production, and that, as a result,

partial solutions may be found to two distinct problems: the absorption of the surplus of petrochemicals that will become available in the near future, and the production of an agricultural surplus capable of contributing, through increased exports, to easing our balance of payments deficit.

V. AGRICULTURE IN THE ARID AND SEMI-ARID REGIONS

The arid and semi-arid regions, which account for half of the country's total area (103 million hectares), are located mainly in the north, in the states bordering on the United States: Baja California Norte, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas, and partially in the states of Durango, Zacatecas, and San Luis Potosí. The first three of the country's five agricultural regions are located in these states (figure 2):

- The Pacific North, specifically the areas comprising the Sonora Desert;
- The North Centre, the highland areas which are located between the Sierra Madre Oriental and the Sierra Madre Occidental and which form the region known as the Chihuahua Desert (the states of Chihuahua, Coahuila, parts of Nuevo León, Durango, Zacatecas, and San Luis Potosí);
- The North-East, consisting of the state of Tamaulipas;
- The Centre, where climatic conditions are temperate and dry-tropical;
- The South, where the climate is tropical and wet.

In all three agricultural regions characterized by arid and semi-arid agro-climatological conditions there are approximately 5.5 million hectares under cultivation, of which 1.5 million enjoy some form of irrigation and the rest are classified as high-risk storm areas (table 5).

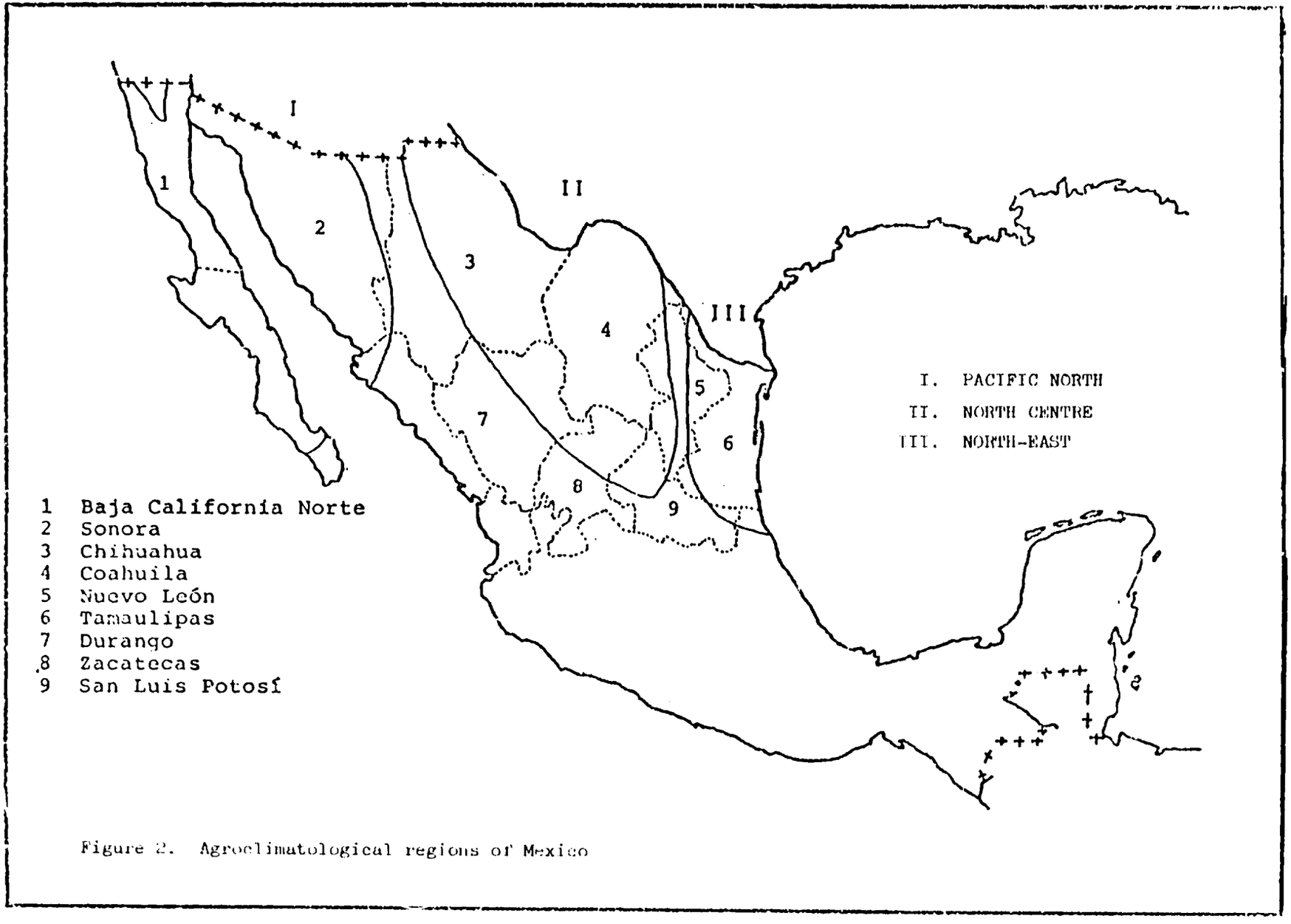

Figure 2. Agroclimatological regions of Mexico

Table 5. Soil use in Mexico, by region, during 1970
(thousands of hectares)

	Arid and semi-arid	Temperate	Tropical, dry	Tropical, wet	Total
Irrigation	1 464	911	920	141	3 437
Storm (rainfall)	3 537	4 404	3 191	3 151	14 283

In terms of the number of hectares sown, the principal crops grown in the arid and semi-arid regions are: maize, wheat, sorghum, cotton, beans, soya, and safflower. Among the less widely produced but economically important crops, special mention should be made of tomatoes, chillies, melons, water-melons, onions, garlic, and egg-plant. Of all the crops listed, only maize and beans are grown mainly in the storm areas, whereas the others are produced for the most part under irrigation (tables 6, 7 and 8).

VI. THE POSSIBLE USE OF PLASTICS

Before discussing the areas in which plastics might be used to advantage in our agriculture, it would be useful to note that at the present time domestic production of polyethylene (90,000 tonnes/year, supplemented by imports of approximately 50,000 tonnes/year) and of other plastic resins is insufficient to satisfy the demands of the processing sector. The resins are used in the manufacture of films for use as bags, packaging, and industrial sacking produced from low-density polyethylene, whereas the polyvinyl chloride and high-density polyethylene are basically employed to manufacture the piping used in water conveyance systems. Except for some special cases, the use of plastics has been limited by the constraints discussed above and by the fact that there are at present no standards to guarantee the quality of the materials and to ensure the user that their average service life is such that they represent an economically sound investment for the various applications which are common in other countries.

Table 6. Total crop production in the irrigated districts of the agricultural regions in Mexico's arid and semi-arid zones in 1978

Crop	Pacific North		North Centre		North-East	
	Area	Yield	Area	Yield	Area	Yield
Maize	31 462 ha	2.775 tonnes	17 088 ha	2.647 tonnes	217 749 ha	2.388 tonnes
Wheat	425 601	4.073	24 715	3.275	883	2.923
Sorghum	31 579	4.452	31 116	4.053	186 228	2.783
Cotton	184 278	3.139	82 673	3.038	635	1.501
Beans	40 449	1.104	19 283	1.201	27 400	0.962
Soya	89 067	1.989	6 454	2.329	11 034	1.173
Safflower	294 759	1.662	2 165	1.271	523	1.120
Tomatoes	22 845	33.578	-	-	6	4.333
Chillies	8 493	14.208	1 559	28.000	-	-
Melons	4 338	16.205	1 851	21.272	57	8.789
Total	1 132 871	8.3185	186 904	7.454	445 115	2.885

Table 7. Hectares under cultivation by agricultural region in the arid and semi-arid zones

Crop		1960		1970		1976	
		Irrigation	Storm	Irrigation	Storm	Irrigation	Storm
Maize	Pacific North	35 253	14 120	7 135	21 920	15 731	2 575
	North Centre	27 388	519 595	21 920	1 002 349	214 232	770 012
	North-East	158 803	101 619	153 179	249 410	173 429	242 881
Beans	Pacific North	18 677	759	1 558	2 066	5 386	6 031
	North Centre	4 637	296 098	4 978	433 134	96 017	518 900
	North-East	1 540	50 668	961	12 183	9 383	27 428
Wheat	Pacific North	273 841	39 666	253 949	219 234	458 605	-
	North Centre	23 625	93 201	42 783	126 970	116 154	530
	North-East	10 944	9 958	6 977	36 246	13 728	5 114
Cotton	Pacific North	236 578	69 916	208 912	39 420	88 821	-
	North Centre	344 637	167 484	98 325	24 757	76 969	-
	North-East	8 806	9 350	6 700	13	2 340	1 550
Sorghum	Pacific North	14 711	-	8 501	2 609	36 745	30
	North Centre	52 820	616	35 274	22 117	65 390	2 746
	North-East	4 109	-	98 121	-	291 737	137 627

Table 8. Tonnes produced in the agricultural regions of the arid and semi-arid zones

Crop		1960		1970		1976	
		Irrigation	Storm	Irrigation	Storm	Irrigation	Storm
Maize	Pacific North	61 567	13 354	36 416	96 524	47 776	4 825
	North Centre	35 237	322 398	67 432	622 847	261 635	419 498
	North-East	216 765	85 904	470 456	172 417	386 709	259 616
Beans	Pacific North	25 964	547	2 911	2 164	6 134	5 625
	North Centre	2 872	125 903	5 342	189 717	101 915	187 903
	North-East	875	25 224	446	7 070	10 038	13 587
Wheat	Pacific North	710 990	18 000	980 541	806 589	1 173 954	-
	North Centre	44 546	126 134	133 373	148 856	351 519	34 176
	North-East	10 027	11 867	8 064	66 499	31 377	4 142
Cotton	Pacific North	174 904	-	176 005	-	97 417	-
	North Centre	91 524	-	89 512	-	86 226	-
	North-East	42 168	-	74	-	2 032	322
Sorghum	Pacific North	28 519	363	134 360	-	130 989	50
	North Centre	2 434	1 987	29 814	73 530	226 792	3 406
	North-East	135 754	-	552 649	241 663	851 102	305 291

1. Storm areas; mulching of maize and beans

As already mentioned, the principal crops grown in the storm areas are the basic cereal crops which require minimum technical aids and little capital, maize and beans being the most important. The average yield for maize varies according to the "technology" or the extent of the technical aids used in growing it. For example, where crops are sown in high-risk areas (in which only three out of every ten harvests are successful) using few inputs and technical aids, yields are in the neighbourhood of 540 kg/hectare, a figure which can be increased to 1,740 kg/hectare through the use of agricultural machinery together with the extensive use of inputs and technical services.

Considering that polyethylene film is priced in Mexico at 36 pesos ($US 1.57) per kilogram, and assuming a consumption rate of 250 kg/hectare (using 25-micron film), the required investment per hectare amounts to 9,000 pesos ($US 390). Since the guaranteed price for the maize is 4,800 pesos, production would have to be doubled (1,875 kg more) merely to recover the cost of the plastic, and for the technique to become truly economically attractive even higher yields would be required, possibly in the order of 5 to 5.5 tonnes/hectare in the low-risk storm areas.

The situation in the case of beans is similar. The national average in the storm areas is 600 kg/hectare (against a desirable goal of 760 kg/hectare). This year's guaranteed price for this product is 11,000 pesos ($US 480), which means the need to achieve a minimum production increase of about 820 kg to cover the investment in the 250 kg of plastic required to mulch this crop. This implies a more than twofold increase over the customary yield (from 600 kg to 1,420 kg/hectare).

Although these production goals are regarded as attainable, it must be remembered that the growers with whom both the Mexican Food System and the National Agro-Industry Development Plan are concerned are peasants who farm on a subsistence basis, are unaccustomed to working with complicated techniques, and are unlikely to be willing to make use of alternative

methods of this kind, to say nothing of the fact that they lack the money to pay for them. It is possible that growers with access to greater technical resources might employ this method, provided of course that yields exceeding the 3.7 and 1.4 tonnes/hectare for maize and beans, respectively, prove to be attainable.

2. Storm areas; other alternatives

An analysis similar to the one given in the preceding section but applied to the other traditional crops reveals the same results. For all these crops, production must be more than doubled if the use of plastics as a mulching material is to become economically attractive.

On this evidence, all the relevant factors appear to indicate that plastics might be used in agriculture almost exclusively as a grain-protecting material designed to reduce losses resulting from faulty storage techniques. Plastics might also find application in the blending, packaging and transport of the grain to the distribution centres. Solutions must be found to the problem of the storage, in the field itself and at high temperatures, of grains with a significant moisture content in ways designed to protect them from spoilage.

Since one of the principal factors limiting agricultural operations in arid and semi-arid regions is the scarcity of water, the adaptation and further development of techniques for optimum water management is certain to take on major importance. Considering that by 1982 it is planned to have 3,574,000 hectares under cultivation in the irrigated districts, the savings that might be realized through the simple expedient of lining the irrigation channels with polyethylene and polyvinyl chloride film are substantial indeed. This application will require the development by Mexican manufacturers of black-stained film material of sufficient quality to be able to withstand the elements for periods longer than the five months which is the duration of the normal agricultural cycle. Apart from films measuring 100 and more microns in thickness, we have not, in our testing, found any materials that meet this requirement.

Another possible application, which has already been introduced, is in the trapping and retention of rain-water for drinking troughs. At the present time, there is a subprogramme, under the National Programme for the Use of Fodder (PRONAFOR), which is concerned with the construction of more than one hundred watering troughs of different sizes (the standard dimensions are 25 x 25 x 3 metres). The purpose of these devices is to trap ordinary rain-water on hill and mountain sides, from where it can be run off into the appropriate tanks. PRONAFOR has experimented with a variety of materials for this purpose and has found that there are two major problems: the widest films produced in Mexico measure 6 metres, and ideally what are required are discardable films of 10 or more metres in width; since once they have been installed these films are not covered by any kind of external layer, mechanical problems soon begin to occur, with tears developing, usually at points where the film is joined together or secured to the supporting structure. The need here is for the manufacture of larger-sized films and, in particular, film specially formulated to ensure long serviceability, even after several years of exposure to the weather.

More than half the area of the arid and semi-arid zones is covered with pasturage, and, although the pasture-to-livestock ratio is very low, by working these areas on an extensive basis they are able to support one-third of the country's cattle. It is the aim of the Mexican Food System to convert these lands into areas of intensive stock-raising, an effort which will require that the production and preservation of fodder be increased and improved. At the moment, only rudimentary preservation techniques are in use, involving the use of underground trench-type silos in which the farming waste and secondary products are placed directly on the ground. For more effective preservation of the fodder and the avoidance of oxidation losses, a greater effort should be made to encourage the wider use of plastics. Here again, the most difficult problem will be to produce film which is wide enough to permit ease of handling and which has the kind of physical and mechanical properties that will ensure satisfactory durability. Since the normal method of ensilage in Mexico

involves the use of underground deposits, film deterioration due to photodegradation is not a serious problem, so that transparent materials - and perhaps even materials without special ultra-violet absorbents - might be used.

In summary, it would appear that the use of plastic films in the country's agricultural storm zones cannot be introduced on a finacially sound basis unless farming methods are developed which will make it possible to double the yields achieved under the best conditions as regards technology and inputs. In this context, the use of such materials will remain outside the reach of the farmers operating on a subsistence level. On the other hand, even these growers could benefit from the use of plastics for the protection of their crops and the retention of rain-water. Another possible and very useful application which should be encouraged is in the area of ensilage.

3. Irrigated zones; maize, beans, and other grains

As a general statement it is fair to say that the possibilities for the profitable use of plastics are greater in the irrigated zones than in the storm regions. In view of the fact that by 1982 the total area of these irrigated zones will increase to 3.5 million hectares, and even assuming that they will account for the use of relatively minor quantities of plastics, the installed resin production capacity would be insufficient to meet the potential demand that may result.

Given the assured supply of water for irrigation and the advantages of the more extensive use of technology and machinery, there are greater opportunities in these zones for achieving increased yields for grains in general. On the other hand, the grain crops grown in these districts will face competition from other, potentially more profitable crops, such as vegetables. The grains have the advantage of guaranteed price supports which protect them from the fluctuations so common in the fresh fruit and vegetable markets. It is likely, therefore, that if yields can be increased sufficiently (in the proportions cited above), the consumption of film may reach considerable volumes. Because it requires less labour, it may be necessary to introduce the use of photodegradable film, following the practice in Europe and Israel.

4. Irrigated zones; vegetables

Vegetable growing in Mexico is limited to the irrigated zones, and of these in particular to the agricultural region in the centre of the country (where temperate climatic conditions prevail) and, to a lesser extent, to the Pacific North (in the fertile valleys of the state of Sinaloa). From 1960 until the present, the total area devoted to vegetable production has varied from 16 to 19 per cent of the nation's total agricultural area, with its value fluctuating between 22 and 30 per cent of the country's gross agricultural product. Of the total production, approximately 74 per cent is consumed fresh within the country, 14 per cent is processed, and 12 per cent is exported, fresh and processed (9 and 3 per cent respectively), to the United States and Canada. Of the export crops, tomatoes are the most important and represent 40 to 60 per cent of total United States demand during the winter and spring months (350,000 tonnes). During the same period, cucumber exports may on occasion amount to as much as 30 per cent of total United States demand, being followed in importance by chillies, egg-plant, and garlic.

Plastics can be used for all these crops in applications ranging from the simplest, such as mulching, to the erection of greenhouses to shelter the plants both as seedlings and at more advanced stages of growth. Apart from the nursery production of tomatoes, a method employed to a minor extent in the Pacific North, no specific growing technique is used on a large scale in our country.

Considering the potential area of 1.5 million hectares of irrigated land within the national arid zones, including an estimated total of 350,000 hectares devoted to vegetable-growing, one arrives at a possible figure of 90,000 tonnes of plastic per year for use exclusively in mulching. Even higher figures are conceivable, depending on the success of the effort to introduce other techniques, such as the use of greenhouses and large and small cultivation tunnels, the trapping and retention of water, and the lining of irrigation channels.

In summary, the irrigated zones offer a great potential area for the use of plastics. Such methods as the mulching of vegetable crops may generate a demand for thousands of tonnes of plastic film, in addition to contributing to more abundant harvests and making possible the optimal management of available water. Other techniques, such as the development of films for use as covering materials with greenhouse-grown vegetables may take on importance, as also, if to a lesser extent, the greenhouse production of other crops. Additional very large amounts of plastics might be consumed in the mulching of cereal crops, but only if farming methods can be perfected which will ensure substantially heavier yields for these crops.

It is further possible that, through experimentation and publicity, the use of plastics in agriculture may gain acceptance in our arid zones as well, contributing in this way to the realization of the full potential of these lands.

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