PROSPECTS FOR THE DEVELOPMENT OF A GROUND SPRAYER FOR COLOMBIAN AGRICULTURE

by

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INTRODUCTION

Tropical regions present specific advantages and limitations for the production and protection of the different crops needed or useful to mankind. Most of the research advances in crop protection during the present century, although made in countries of temperate regions, have found application in tropical areas after local research and experimentation.

In the last twenty-five years Colombian agriculture has been in a process of change, directed mainly to the establishment of mechanized or semi-mechanized annual crops in the Colombian low lands and fertile valleys.

Today, traditional Colombian agriculture and modern systems of agriculture, coexist in an agrarian whole, the former accounting for the majority of the rural population, and the latter representing the most dynamic, and promising sector of the agrarian economy.

Mechanization in the new sector of Colombian agriculture has played an important role in the increased utilization of other improved agricultural practices resulting in a higher productivity per farmer and unit of land as well as in a better quality of the products.

Now that Colombia is making efforts not only to satisfy its internal demand for agricultural products but to increase and diversify its export products, it has been realized that one of the main constraints for this expansion is that the

level of costs for the production of annual mechanized crops is very high when compared with other countries of the world. There is also a lack of accurate records about the composition of the costs of production for mechanized or semi-mechanized crops, making it difficult to give a precise analysis of each of the hand, mechanized, or mixed operations. As a general rule, the costs of crop protection account for a significant part of the total costs, and in extreme cases like in cotton they account for nearly 30% of the total direct costs of production.

The general pattern in the application of chemicals for crop protection followed by most of the commercial farmers in the low lands with holdings of 20 hectares or more is as follows:

a. Weed control in the first stages of row crops is done with tractor operated cultivators. After a certain level of development of the crop when these machines can damage the crop, wage laborers using hand tools weed the field up to advanced stages of the crop development.

b. Only a small percentage of the commercial farmers are using preemergence application of herbicides.

c. The application of chemicals for pest control has relied almost completely on the use of man operated or horse mounted sprayers for the small growers, and aircraft applications for large holdings.

Tractor mounted sprayers are only used by a few farmers in the central part of the country, and by the experimental

research farms of the government.

It has been assumed in this work that the shortcomings of the conventional tractor operated sprayers are specially relevant for Colombian conditions. The great amount of water needed for an application (60 to 200 G.P.Ha.), the size of sprayers required for spraying big fields, and the waste of time in the number of refilling operations have been determining factors for tractor operated sprayers not being adopted by the Colombian commercial farmers. The above reasons are also partially responsible for the development of the general pattern of crop protection and application of chemicals followed by Colombian farmers in recent years.

Concentrated applications of chemicals, called Low Volume (L.V.), and Ultra Low Volume (U.L.V.) (almost undiluted applications), and equipment suited for their application, either by aircraft or ground sprayers, have had a great development in the USA since 1950.

In this report, the claim is made that a ground tractor operated sprayer, adapted to concentrated applications (2-6 G.P.A.) has a potential use in the production of several Colombian mechanized crops. This sprayer can expand the use of cheaper and more effective methods of weed control and eventually will reduce the overall costs of crop protection for several important annual crops.

REVIEW OF LITERATURE

Pest control under tropical conditions has been extensively analyzed by Froalich and Rodewald (1970). A general survey was made about the effects of humidity, light intensity, temperature, and daylight variation upon the development of pests, and diseases of fruit, oil, food, fibre, medicinal and luxury crops and their control. It is a very valuable general reference book on the subject.

Webster and Wilson (1966), based on a classification of tropical climates stated the main consequences for the different agronomic practices, such as soil and water conservation, tillage, weed control and crop protection.

Development of agriculture in underdeveloped countries has been a subject of extensive research in the last two decades. In the case of Colombia, important contributions have been made by the United Nations through the Economic Commission for Latin America (CEPAL) and through the Interamerican Committee of Agricultural development (CIDA) in research programs for economic and social development of rural areas in Colombia.

The Food and Agriculture Organization of the United Nations (FAO), offers complete annual records of production, and world trade of the main agricultural products, and materials used in agriculture. Agricultural Commodity Projections based on advanced statistical methods are presented periodically in separate publications.

The U.S. Department of Agriculture has also made important contributions sponsoring and conducting many individual

projects of research in the different areas of agriculture in underdeveloped countries.

Currie, L. (1950), an American economist, dedicated a great deal of time to conducting research programs of economic development in Colombia. In 1949, he headed a mission to Colombia sponsored by both the International Bank of Reconstruction and Development, and by the Colombian government. His research findings were published in a book entitled "Colombian Operation" which constituted the basis for the development programs in the Colombian rural sector during the 1950's.

Smith, T. L. (1969), offers a quite complete and up to data account of the Colombian agriculture, including all the geographical, sociological, economical, technical, and political factors that constitute the present structure of the Colombian rural sector.

The field of concentrated agricultural sprays, equipment, and application methods has been a subject of extensive research since the 1930's.

Potts, S. F. presents a review of the subject up to 1957, with the most significant advances made since 1928 in the field of highly concentrated sprays for crop protection. His book is an excellent guide to all the persons interested in the chemical possibilities of crop protection as far as equipment is concerned.

A comparative analysis of the different systems for the application of chemicals from the standpoint of efficiency, economy, versatility, and secondary effects of the applications

has been made by Rose, G. J. (1963).

In recent research developments, Wilkes, L. H. (1961), determined the relationship existing between the droplet sizes, and droplet size distribution while applying equal volumes of spray material upon the effectiveness of control and the yield in cotton.

Drift problems associated with low volume applications have been studied by Yates, W. E. and Kaupke, C. R. (1967). The effect of several spray adjuvants in the reduction of drift from concentrated applications, has been studied by Butler, B. J. Akesson and Yates, W. E. (1969).

During the final stages of this report, the International Plant Protection Center, in cooperation with the Department of Agronomic Crop Science, Oregon State University, published a manual of Pesticides Application Equipment. This manual includes most of the equipment, and components offered by the industry in the United States and abroad with a brief description and technical specifications. As many as 30 groups of equipment classified by their category and 231 firms, each producing one or more items of the equipment, are included in this manual.

CROP PROTECTION UNDER TROPICAL CONDITIONS

Whereas in temperate climates, temperature is the predominant ruling factor, which together with geographical conditions, governs the length of the period when the vegetation is dormant, in the tropics, humidity is the ruling factor. It is not the quantity, but the distribution of the rainfall in the course of the year, which determines the type of vegetation and thus the limits of agricultural production.

On the basis of this distribution, the tropical region has been subdivided into the following regions: (See Table 1).

Table 1. Tropical Regions According to Rainfall Distribution

REGION	HUMID MONTHS	VEGETATION
Prehumid	10 - 12	Humid evergreen forest (tropical rain forest
Humid	8 - 10	Humid raingreen forest with partial defoliation
Damp Subhumid	7 - 9	Wet savannah, savannah type forestand grassland
Dry Subhumid	6 - 8	Dry savannah raingreen dry forest with total defoliation every year grassland
Semi-arid	4 - 6	Savannah occasionally with scattered fertile areas grown with shrubs or trees

Table 1 (Cont'd)

REGION	HUMID MONTHS	VEGETATION
Arid Region	less than 4	

Source: Adapted from Frohlich, G., and Rodewald W. (1970)

The crops cultivated in these regions of different humidity vary widely and naturally involve the occurrence of specific pathogens and pests.

Another factor associated with the adaptability of different crops to the different regions, and the occurrence of specific pests and pathogens is light intensity. In Colombia, coffee, and cocoa, two important tropical crops, are grown in the humid and damp humid regions, mostly in mountainous areas. These permanent crops need shading, either natural shading by planting the crops in a damp high forest, or by planting trees or banana species which provide semipermanent shading. These conditions create a special ecological system, characterized by high relative humidity and the absence of strong winds at the crop level which determines pests incidence and control.

The annual crops, several of them in a process of adaptation to tropical conditions, are grown mostly in the arid and semiarid regions and some of them in the dry subhumid region. The altitudes of the land where these crops are grown ranges from sea level up to ten thousand feet above sea level.

The main factors affecting the distribution of the different annual crops, their yield, pest incidence and control under tropical conditions are:

a. Altitude

b. Mean annual temperature (For each 328 feet of change in altitude, there is a change in mean annual temperature of 1.1 F^0).

c. Rainfall distribution. Although most of the annual crops are grown in regions with less than six humid months with two rainy seasons, rainfall distribution is not equally uniform in the different areas, and microclimatic factors play an important role.

The combination of these three factors result in a great variety of ecological conditions for the development of annual crops in tropical areas presenting specific problems for their production and protection.

At the Equator, the length of the daylight is twelve hours, and the maximum variation for the tropical regions is just under three hours. Consequently, the possible daily amount of sunlight is never less than nine hours. Several annual crops actually produced in the tropics are photo-periodic thus they need daylight for a period of time either long enough (long day plants), or short enough (short day plants), or alternate periods of long and short days for the induction of some physiological process such as flowering and tuber formation.

To illustrate this point Wrigley, G. (1971), presented the influence of sowing date on a photosensitive rice variety in the Bogor-Java region which although not very close to the

equator has less than 3 hours of daylight variation during the year.

Table 2. Influence of Sowing Date on a Photosensitivity Rice Variety at Bogor-Java.

Sowing Date	Crop Duration in Days	Yield in Pds/A.
10th Nov.	147	3,570
24th Nov.	140	4,000
8th Dec.	132	4,500
22nd Dec.	125	3,760
5th Jan.	118	3,330

It has been concluded by several authors that the relationship between sowing date, yield and crop duration is valid wherever photosensitive varieties are grown.

Another example of this situation is the Colombian experience with the adaptation of wheat to tropical conditions. This crop was introduced to our country during colonization and today after many years of research and experimentation with new varieties not only the yields, but the quality and uniformity of the latest varieties are still far less than those obtained in temperate regions.

The general ability of photosensitive annual crops to compete with weeds is reduced in tropical areas and this in no small measure increases weed control problems and costs. Regardless of the wide variety of ecological conditions present in the tropics, chemicals have long been used for crop protection.

Pyrethrum for insect control, sulphur dioxide for the control of several fungus diseases, and the older non-selective weed killers, such as arsenate and sodium chlorate, are examples of widely used chemicals under tropical conditions which have been used for many years.

For some perennial crops where the value of individual plants is greater than annuals, and especially in crops of high economic value for shipment to the US, such as coffee, cocoa, and bananas, important improvements have been made, not only in crop protection, but in all the aspects of crop production. It does not seem reasonable to draw a distinction though between tropical crop protection, and crop protection for annual crops in regions of temperate climate, because there is no basic difference between the task of crop protection in different geographical regions. It happens that many of the economically important pests of these crops in tropical regions are the same that affect them in temperate areas. We do, however, have to consider the wide variety of ecological conditions present in tropical areas. They play a determinant role not only in the success of the control, but also in its applicability to the local situation. To illustrate this point, it is pertinent to point to the case of cotton in tropical conditions, which is spectacularly damaged by even small traces of 2 - 4 d. Tobacco is severely damaged by the majority of weed killers and other crops while showing susceptibility to certain chemicals can tolerate application at certain stages in the growth

of the crop, and at an appropriate concentration.

The low lands of Colombia in the arid and semiarid regions represent an important potential for the production of some annual crops. Unfortunately rapid ontogenetic development is favored by the given temperature conditions, the sequence, and number of generations of pathogens brought about during the rainy season is larger than in temperate zones, and this in no small measure will increase the population density of fungus, spores and other pests. Temperature and humidity conditions influence not only the habits, and the development of pests and pathogens, but also control means and their application. This particularly applies to chemical control agents.

Many research programs have been carried out in the last twenty years about the use of chemicals under tropical conditions, and more still are needed. But, in general, it can be said that the most important advances made in temperate regions in the field of crop protection have had their impact in the modernization of tropical agriculture. After research and field experiments they have been adapted to tropical conditions.

Research carried out in temperate countries concerning the influence of environmental factors such as temperature, relative humidity, and illumination in the response of the applied products in terms of its persistance, phytotoxicity, degradation and general effectiveness for crop protection have contributed in no lesser degree to the crop protection advances in tropical areas.

Commercial farmers in Colombia use modern systems of pest control, and have been increasing the use of chemical herbicides. Due to the increase in labor costs and the shortcomings of mechanical control, the efficiency of modern herbicides has helped to cut production costs. It is often difficult to weed annual crops at their most vulnerable stage, which is soon after planting. Heavy rains often make it difficult to control weeds early by cultivation.

PRESENT STATUS OF AGRICULTURE IN COLOMBIA

General Considerations

In 1970, the population of Colombia was estimated at 21 million, with 53 percent in the urban areas and 47 percent in the rural areas.

Its surface is of 113,833,800 hectares of which approximately 15,000,000 are occupied by grasslands, and 3.7 million under agricultural production.

Present day Colombian agriculture with its varied patterns, and practices is to an important extent the product of several processes, starting at the beginning of the 1950's. Prior to this period, agricultural activities were concentrated almost exclusively in the high lands, and in the mountainous areas of the central part of the country. Some of the reasons for this pattern of settlement were:

1. The immigrants coming from Spain during the colonization period preferred to live in cool hills in tropical countries.

2. The Indian tribes already settled before the coming of the Spaniards lived in these regions.

3. Prior to this time, tropical diseases such as malaria and yellow fever made life very difficult in the low valleys, and big plains of the northern part of the country.

4. The lack of communication between the tropical valleys, and low lands, and the mountain regions produced a type of agriculture which was very diversified, and oriented

toward the local markets, with the exception of coffee, cocoa, and banana plantations.

Currie, L. (1950), heading a mission of the World Bank, since 1949, writes: ". . . land use follows an unusual pattern. As a rule the fertile level valleys are used mostly for grazing, while the steep mountain-side slopes are cultivated. . . The cattle graze on the plains while the people often have to struggle for a bare existence in the hills."

After World War II, Colombia participated in the world campaign against malaria, yellow fever and other tropical diseases, and successfully removed one of the main obstacles for the settlement of farmers in low lands.

The number of farm tractors in Colombia in 1947 was 3,821. Two important developments of the 1950's accelerated agricultural modernization. Technical innovations were applied to additional agricultural enterprises. Transportation improvements including highway networks were constructed and the Atlantic railroad was finished in 1961.

Later Currie, L. (1967), quotes a break with history as agriculture shifts from the hills to the flat lands in both new and old regions of Colombia. Improved transportation created for the first time a single national market for industrial and agricultural products. He points out that "prior to this period Colombia included regional or sectional markets which had more or less autonomy. National development is now an option which was unrealistic so long as Colombia structure involved separate regions or sectors."

During the last two decades, the average annual increases of agricultural production has been around 3.3 percent. One interesting aspect is that increase has occurred in spite of heavy rural-urban migration. Production increased more than the 3.2 percent annual rate of population growth during the years of 1941-1964. During the period of 1968-1971, an annual increment of agricultural production of 5.2 percent was achieved. Referring to this period, Smith, L. T. (1967), states: "During the third quarter of the twentieth century, Colombia's system of agriculture was undergoing modifications that are more drastic than those experienced at any time in its history."

Agricultural performance in Colombia, however, is still far from a satisfactory level. Agriculture has 47 percent of the national labor force, but contributes slightly more than 30 percent of the gross domestic product.

One of the main obstacles Colombia has had for its economic and social development has been the land tenure system, characterized by the coexistence of the Latifundio-Minifundio system. The origin of this situation has historical reasons including the nature of the property rights to the land which was ruled by Spain during more than 3 centuries, and other geographical and political reasons which are out of the scope of this work.

The only source of information of Colombian land tenure is the 1960 agricultural and stock-raising census. Table 3 shows the distribution of holdings from this census.

Table 3. Structure of Holdings

Farm Size Hectares	Farm Units Number	Percent	Hectares Accumulated Number	Percent
Less than 1.0	298,071	24.7	132,000	0.5
1.0 to 2.9	308,352	25.5	546,000	2.0
3.0 to 9.9	319,327	26.4	1,726,000	6.3
10.0 to 499.9	277,020	22.9	13,881,000	50.8
500.0 and larger	6,902	0.5	11,053,000	40.4
TOTAL	1,209,672	100.0	27,338,000	100.0

Source: DANE. Directorio Nacional de Explotaciones. (Censo Agropecuario). Bogota, 1964.

Although many small units are urban plots, this data shows both property concentration and fragmentation, with 76.6 of the farm units having less than 10 hectares (24.7 acres), and 0.5 percent of the farms having 40.4 percent of the agricultural area.

The most serious attempt to change the structure of the land tenure system has been the 1961 Land Reform Law, which has been in operation since that year. This has resulted in the settlement of more than 40,000 rural families on their own land with services of credit and technical assistance. Important improvements have been made by the National Institute of Agrarian Reform in the construction of countryside roads, schools, cooperatives, and irrigation districts with the potential to irrigate more than 150,000 hectares.

Mechanization

Of the 15 million hectares used for cattle raising it has been estimated that mechanized operations have been applied in some degree on only 300,000. There are 3.7 million hectares used for agriculture, of which 845,000 make use of tractors. It is pertinent to point out that a crop like coffee which covers an area of 815,000 hectares is cultivated with animal power and hand tools. Machinery is only used in some of the post-harvest operations.

As it was pointed out in the last section, the beginning of the 50's can be considered a landmark in the history of agricultural modernization in Colombia. Currie, L. (1950) stated: "The gradual substitution of animal drawn and tractor powered machines for hand tools should be encouraged as a means of improving productivity on farms. It should be recognized however, that a large number of farms are not now adapted to the use of tractor drawn or mounted equipment, and many farms are so rough that animal drawn machinery is impracticable. Nevertheless, mechanization will be an important means of raising productivity in many cases."

In 1968, the Economic Survey of Latin America published by the United Nations (1970), referring to the major sections of production in the Colombian economy, states that during the year of 1968, the agricultural sector grew at a rate of 5.5 percent, and that during this year large increments of increase in cotton, rice, sugar cane, and bananas accounted for the major increase in agricultural production. It is interesting to

point out that these same crops are the most highly mechanized in Colombian agriculture today.

Johnson, W. and Benson, J. L. (1966), summarizing the effects of the new mechanized age, point out the effect of mechanization upon total agricultural production in the following way: "The effect of mechanization upon total production is not readily obtained because of the many scientific advances associated with mechanization. Improved seed, the utilization of fertilizers, improved weed control, complete water control, and more skilled farmers are all contributing factors to increased production potential."

In Colombia, research advances in all fields of crop production are far ahead of their application for most of the farmers. However, it has been demonstrated during the transition from traditional agricultural to a new form of commercialized agriculture using mechanization for the main operations, that mechanization does not come alone, but is closely associated with the use of other technical advances such as the use of better seeds, fertilizers, and modern systems of crop protection. It is a recognized fact that the profitability of many advances in other fields of agricultural sciences is incompatible with the traditional systems of crop production.

According to Rico, E. (1968) the existence of farm tractors and their use in 1967 were as shown in Table 4.

Table 4. Number of Farm Tractors in Colombian Agriculture in 1967.

Years of Use	No. Tractors	%	% in Actual Operation
with less than 10	17,400	70	95
with between 10 and 15	5,600	23	60
with between 15 and 20	1,800	7	30
Totals	24,800	100	82.4

Source: Rico, E. (1968)

Their use in different sectors was as follows:

	Area (Thousand of hectares)	Number of tractors	Hectares per tractor
Agriculture	845,000	21,000	40
Grasslands	300,000	2,000	150
Road Construction	-----	1,800	---
Forest, Industry			
Total	1,145,000	24,800	

There is an inverse relationship between the population density in rural areas and the degree of mechanization in the Colombian states. See Table 5.

Table 5. Groups of States According to Their Density in Rural Population, and Number of Tractors in Use.

Group of States	Rural Population Density*	Number of Tractors (1967)
1. Caldas, Risaralda, and Quindio	41 - 80	630
2. Cundinamarca, Valle, and Tolima	21 - 40	11,090

Table 5 (Cont'd)

Group of States	Rural Population Density*	Number of Tractors (1967)
3. Antioquia, Cordoba, Atlantico, Bolivar, Santander, Norte de Santander, Cauca, Narino, Huila	11 - 20	5,960
4. Magdalena, Boyaca, Meta	1 - 10	4,835
5. Guajira, Putumayo, Choco, Arauca, Vichada, Guainia, Vaupes, Caqueta, Amazonas	less than 1	2,285
Total		24,800

* Habitants per square kilometer, 1967
Source: Adapted from DANE (1967), and Rico, E. E. M. (1968).

From this data we can infer several relevant facts about the mechanization process in Colombia:

1. The first group with the highest population density corresponds to a predominantly mountainous area where an important part of the coffee crop is grown. Topographical conditions are a limiting factor for the establishment of mechanized annual crops.

2. The second group includes the states of the central part of the country with access to the main urban markets. A variety of topographical and ecological conditions exist including areas suited for perennial crops as well as the big valleys of the Magdalena and Cauca rivers which are suited for the production of annual crops and the highland savannahs also suited for the same purpose. Due to their access to the urban markets of the most populated part of the country, this group of states

has played a leading role in the process of agricultural development in Colombia.

3. The third and fourth groups include many vast agricultural areas that prior to 1950 were isolated from the local markets due to the lack of roads and other means of transportation. In the last two decades, these areas have had major agricultural development in the production of annual crops (especially cotton, rice, soybeans, sorghum, and corn). The construction of transportation facilities in areas where the rural population concentration is relatively low has permitted the establishment of mechanized commercial agriculture. This area constitutes the best reserve for the development of mechanized annual crops in the future.

4. The last group includes all the Eastern Plateaux, the Amazonas Jungle, and desert areas which present serious limitations for agricultural purposes.

Use of Fertilizers

Twenty years ago, the use of fertilizers in Colombian agriculture, with the exception of organic compounds from a few slaughterhouses, was lacking in almost all agricultural production. Currie, L. (1950) pointed out that "The principal problem with respect to fertilizers is the lack in Colombia of the raw materials essential for their manufacture . . . . The nitrogen, potassium, and phosphorus compounds necessary

to make fertilizer mixtures all have to be imported. High transportation costs make the use of mixed fertilizers very expensive." At the same time, referring to the use of pesticides, he states: "There is widespread complaint among farmers, and growers that supplies of these products are generally inadequate or wholly unavailable."

On the other hand, during this period, experimental research with regard to fertilizer formulas, techniques of use, soil deficiencies, and responses of the most important crops together with research experiments about the use of chemicals for crop protection, were reasonably advanced. Since that time the situation has changed both in the production and use of fertilizers, as well as pesticides, and herbicides. The trend in production and consumption of the major fertilizers from 1948 to 1969 can be seen in Table 6.

Although there are not complete records for all the years during the 1948 - 1969 period, from Table 6 it is possible to see the increase in use and production of fertilizers in the country. The jump in the figures starting with 1964 can be explained by the fact that the "Abocol" (Colombian factory of fertilizers) entered in full production that year.

Table 6. Use of Fertilizers in Colombian Agriculture

Year	Production*			Consumption*		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1948 - 1949 1952 - 1953	-	4	-	26	51	47
1952 - 1953 1956 - 1957	-	20	-	48	153	85
1964 - 1965	481	88	-	531	558	524
1965 - 1966	390	100	-	450	558	300
1966 - 1967	350	47	-	447	578	343
1967 - 1968	400	65	-	470	550	400
1968 - 1969	470	75	-	530	600	450

*Each figure x 100 metric tons.
Source: Adapted from Production Yearbook. Food and Agriculture Organization of the United Nations. Rome. Vol. 23. 1969. Tables 139, 141, 142, 144.

Use of Pesticides

As shown before, the process of agricultural modernization in Colombia, in many aspects, is still in its first stages; today we find in the country a mixture of traditional and modern systems of agriculture, the former involving the majority of the rural population and the latter which is responsible for most of the increase in crop production during the last twenty years. As an indirect measure of this situation we can use some of the results obtained in the National Agrarian census of 1969 about the use of chemicals for crop protection in Colombian farms. See Table 7.

Table 7. Chemicals in Colombian Agriculture

Total Farm Units	Number and Percent of Farms Using Chemical							
	Herbicides		Insecticides		Fertilizers		Fungicides	
	No.	%	No.	%	No.	%	No.	%
1,508,800	63,578	4.2	160,755	10.7	121,420	8	144,495	9.6

Source: Adapted from Encuesta Agricola Nacional, DANE 1969.

Although the percentage of farm units actually using chemicals for crop protection is very low, they represent the most dynamic sector of the Colombian agriculture. They are constituted mostly of commercial farmers who in recent years have developed the modern sector of Colombian agriculture.

In 1970 the imports of raw materials for the production of pesticides accounted for 14,402,804.89 dollars as shown in Table 8.

Table 8. Imports of Raw Materials for Pesticides 1970

	Quantity*	Value in US Dollars
Insecticides	6,620,921	6,618,664.63
Fungicides	3,826,452	867,539.50
Herbicides	3,705,996	6,582,596.37
Pesticides (Various)	1,328,358	334,004.39
Total	15,481,727	14,402,804.89

*Quantity in Kilograms or liters.
Source: ICA 1971.

PROSPECTIVE USE OF A TRACTOR MOUNTED SPRAYER ADAPTED FOR CONCENTRATED APPLICATIONS

Economic Considerations

In the past Colombia has almost exclusively depended on its coffee exports for its foreign trade. In the period 1945 - 1957 they accounted for approximately 80% of the total export value as shown in Table 9.

Table 9. Colombia: Volume and Value of Coffee Exports, 1945 - 1957

Year	Volume (a)	Value in Millions of Dollars	Percentage of Total Export Value (b)
1945	5,149	104.5	74.4
1946	5,611	156.7	77.9
1947	5,339	196.5	77.1
1948	5,588	225.2	78.1
1949	5,410	242.3	79.5
1950	4,472	307.4	78.1
1951	4,794	356.2	66.0
1952	5,032	379.9	80.3
1953	6,632	492.2	82.6
1954	5,754	550.2	83.7
1955	5,867	487.3	83.5
1956	5,670	412.8	76.9
1957	4,824	421.0	76.9

Sources: Boletin de Estadistica de la Federacion Nacional de Cafeteros No. 34: (Cited by FAO).

a: In Thousands of 60-kilogram bags.

Although coffee is still the mainstay of the Colombian economy, its prices in the world market, a few years excepted, have a trend downward and the necessity to diversify export products has long been recognized. This situation has been created mostly by the tremendous expansion of the coffee growing areas in the tropical region, especially the African countries, in the last forty years. Table 10 illustrates the world coffee supply and demand situation from 1950 to 1961.

Table 10. World Coffee Supply and Demand (Millions of 132 pound Bags).

Year	Demand	Supply
1950 - 1951	31	35
1951 - 1952	32	34
1952 - 1953	33	35
1953 - 1954	34	36
1954 - 1955	31	39
1955 - 1956	38	48
1956 - 1957	38	46
1957 - 1958	37.5	54
1958 - 1959	37	67
1959 - 1960	42	88
1960 - 1961	43	110

Sources: Pan-American Coffee Bureau (1962).

National programs for the development of other crops to satisfy the internal demand and to increase exports have been steadily changing traditional foreign trade and the agricultural system in the last decade. This is shown in Table 11.

Table 11. Composition of Colombian Exports During the 1963 - 1968 Period (100,000 Dollars)

Year	1963		1965		1967		1968	
	Value	%	Value	%	Value	%	Value	%
Total Exports	4,467	100	5,391	100	5,099	100	5,271	100
Agricultural Products	3,438	77	4,012	74.5	3,894	78	4,325	82
Coffee	3,031	67.8	3,440	63.9	3,224	63.2	3,493	66.2
Textile Fibers	96	2.1	83	1.5	155	3.0	261	4.9

Source: Adapted from FAO. Trade Yearbook Vol. 23. 1969.

From Tables 9 and 11, we can see that the participation of coffee in the Colombian exports changed from nearly 80% in the 1950's to 66.2% at the end of the 1960's. On the other hand, cotton exports which started at the beginning of the 1960's, reached a value of 26,100,000 Dollars in 1968, accounting for 4.9% of the Colombian exports that year.

One important aspect of recent Colombian agriculture has been that the efforts of the country to satisfy its internal demand for agricultural products and increase the value of exports has been directed toward the development of mechanized annual crops in the lowlands with the application of modern technology. This trend is actually in a very dynamic stage, and according to several authors it will continue in the future.

Some records of several selected annual crops in the last decades illustrate the process. See Table 12.

Since the beginning of the development of these crops in the early 1950's, the application of chemicals for crop protection relied almost completely on the use of hand and horse

Table 12. Colombian Production of Several Selected Crops in the Period 1948 - 1970

	Year	1948-52	1961-65	1966	1967	1968	1969	1970
Cotton	Area	39	152	165	175	204	236	220
	Production	8	73	88	101	122	125	134
	Yield	2.0	4.8	5.3	5.8	6.0	5.3	6.1
Sorghum	Area	-	13	30	40	45	52	60
	Production	-	30	60	90	100	120	150
	Yield	-	23.9	20.0	22.5	22.2	23.2	25.0
Soybeans	Area	4	21	35	48	51	56	50
	Production	5	32	52	80	101	101	88
	Yield	12.5	15.7	14.9	16.7	20.0	18.1	17.6
Rice	Area	129	290	350	291	277	250	236
	Production	248	576	680	662	787	695	700
	Yield	19.3	19.9	19.4	22.8	28.4	27.7	29.7

Area = 1000 Hectares Production = 1000 Metric Tons Yield = 100 Kg/Hectare
Source: Production Yearbook. Food and Agricultural Organization of the United Nations. Rome. Vol. 24. 1970. Tables 20, 21, 78, 96.

mounted sprayers for the small growers and the use of aircraft operated sprayers for the larger growers. The first two types of sprayers are produced in the country and are suited for the application of chemicals in most of the traditional agricultural areas of relatively small holdings in the mountainous area. Complete records of the production and use of these two types of sprayers are difficult to find since many of the census and statistic articles include them under the title "Other Machinery For Crop Production." However, Rico, E. (1970) found that during the period from 1962 - 1964, 10,194 of these units were produced in the country.

Tractor operated sprayers are not produced in the country and their use has been restricted to a few commercial farmers in the central part of the country and to government experiment stations.

Since the beginning of the 1950's, commercial farmers in the lowlands with large holdings have adopted the services of aircraft spraying companies for all of the spraying operations. They offer the advantages of speed and reliability in fields where hand operated or horse mounted sprayers are impractical.

In its foreign agricultural economic report No. 59, the USDA (1970), in the chapter about Colombia, points out as one of the main aspects of the recent Colombian modernization process, the relative success in achieving the goals of production for the domestic market as well as several products for exportation; but, at the same time, it presents the high costs of

production of the commercial farmers as one of the most relevant aspects of this recent development. This has made difficult the competition of Colombian products coming from annual crops in the world market to the extent that an export subsidy has been offered by the government for minor exports (different from coffee) since 1968. In its conclusion about Colombian agriculture the report points out: "When other countries, even fully developed ones, make progress in improving production and reducing costs, Colombia loses ground in a very real sense if it does not make comparable advances. For example, if a product is being sold abroad in competition with other countries, the loss will be direct and prompt, because international prices will decline reflecting costs."

The use of chemicals for crop protection has increased as new farm enterprises for the growing of annual crops have expanded in the lowlands. This process can be reflected by the increase in the area treated with one or more chemicals for crop protection for several selected crops during the period 1965 - 1970. (See Table 13)

From this table we can infer that the increases in the total area treated during this period has been 37.2% for cotton, 31.6% for rice, and 13% for sorghum. These figures show the dynamic increase of chemicals for crop protection for this short period in the modern sector of Colombian agriculture. At this point it should be pointed out that, in the cattle raising areas which occupy 15 million hectares and which have been used traditionally in extensive farms of natural grass, the use of chemicals

Table 13. The Use of Pesticides in Selected Colombian Crops

	1965		1966		1967		1968		1969		1970	
	Ha.	% Treated	Ha.	% Treated	Ha.	% Treated	Ha.	% Treated	Ha.	% Treated	Ha.	% Treated
Cotton	148	33.8	164	55.0	174	57.0	198	63.0	236	63.4	240	71.0
Rice	375	13.4	350	25.6	290	38.0	277	40.0	280	42.0	290	45.0
Sugar Cane	326	10.7	327	13.7	324	13.9	341	14.6	415	12.1	420	14.3
Soybeans	30	-	35	.4	48	.8	51	1.0	55	4.5	60	5.0
Barley	46	21.8	55	37.3	61	32.8	47	64.2	48	63.0	45	62.0
Sorghum	30	-	40	12.5	30	16.6	25	28.0	30	23.3	35	23.0
Grasslands*	-	.2	-	.4	-	.5	-	.5	-	.8	-	1.0

*The area in Grasslands has been estimated in 15,000,000 hectares for this period.
Source: ICA. 1970.

for pest and weed control rose in the period 1965 to 1970 from 30,000 to 150,000 hectares.

According to a survey made by the Agricultural Economic Department of the Colombian Agrarian Institute, (ICA) with 10 commercial farmers selected as representatives of the cotton area for the harvest of 1969, the average of the direct costs per hectare accounted for 227.30 dollars per hectare (92 dollars per acre) as shown in Table 14.

Table 14. Average Direct Costs of Production in Cotton 1969

Seedbed Preparation	$14.00
Fertilization	12.50
Planting	7.00
Thinning	11.40
Hilling	3.40
Hand and Tractor Weeding	36.00
Pest Control:	
Material for 10 applications	34.00
Value 10 aircraft applications, 2 dollars each	20.00
Harvest (hand made)	62.00
Post Harvest Operations	29.00
Various Expenses	10.00
Total	$227.30/ha.

Source: I.C.A. 1970

From this data we can infer that crop protection including hand and tractor weeding and pest control, accounted for nearly 30% of the total cost of production which is an amount higher than all the other pre-harvest operations combined. It is

important to point out that for weed control, these farmers did not use herbicides. The procedures used by most of them is to cultivate the crop during the first stages when a tractor mounted cultivator can be used without damaging the crop and later wage laborers weed the crop with hand tools. Another interesting aspect is that all of these growers relied exclusively on aircraft applications for pest control.

It can not be said that this example can be considered truly representative of the composition of direct costs of all of the Colombian commercial farmers in the lowlands, mainly due to the fact that other crops in equivalent stages of modernization such as sorghum and soybeans do not have as serious problems of pest control as cotton. However, it is useful to illustrate several situations of semi-mechanized commercial crops in these areas as follows:

1. Programs for integrated control of pests have been in practice for more than 10 years and as a general rule, all make use of chemicals for crop protection.

2. The use of chemicals relies almost exclusively on aircraft applications.

3. Crop protection costs represent a very high percent of the total cost of production.

4. The practice of weed control, with a few exceptions relying on mechanical systems, has been mostly manual, using hand tools.

5. No serious attempt has been made for the introduction of ground tractor mounted equipment for the application of chemicals among the commercial farmers.

Another important economic consideration for the development of a ground sprayer adapted to concentrated applications is its low cost as compared with equivalent conventional sprayers. Potts, S. F. (1958), analyzing this aspect, concluded that the price of a low volume sprayer is approximately one half that of a conventional one.

Technical Considerations

Concentrated applications have been defined as having three necessary characteristics:

1. The application of a low volume ($\frac{1}{4}$ - 15 gallons) total spray per acre.

2. Pesticide concentrations many times that of any dilute mixture of the same pesticides.

3. Fine automization compared to that for dilute sprays with most of the spray volume in drops less than 300 microns in diameter.

The fact that they offer a drastic reduction in the solvent used by conventional ground sprayers overcomes the limitation present in farms where water is limited or must be hauled a considerable distance to the field. This situation can be more easily realized if we compare the amount of spray material, and number of refilling operations for the application of aldrex at a rate of 0.5 G.P.A. over 500 acres, using conventional and low

volume sprayers of the same tank capacity as shown in Table 15.

Table 15. Application of Aldrex (0.5 G.P.A.) over 500 Acres

Type of Application	Concentration	G.P.A. Applied	Number of Refillings	Total Spray Applied (Gal.)
Traditional	2%	25	63	12,500
Low Volume	15%	3.3	8	1,650

Tank capacity 200 gallons

Operated under low pressure and usually having a smaller tank, low volume ground sprayers can be built considerably lighter throughout. This offers the advantage of less compaction of the soil, when compared to a conventional sprayer carrying larger loads of water. With lower operating pressure they require less power for pumping and less power to pull the lighter machine.

High volume sprayers have been classically examined using features as tank capacity, pump outputs and pressures, nozzles outputs, rate of liquid recirculation, distance of spray projections, etc. Conventional spraying implies bringing the foliage to a state known as run-off. An excess of spray liquid is applied to the foliage and much of it drips off onto the ground, leaving a residue to be retained by the leaf surface.

Crafts, A. S. (1962), reported savings up to 30% in the active product necessary for weed control using ground sprayers adapted to concentrated applications. Droplet size distribution has long been considered an important parameter in measuring the efficiency of a spray application. Wilkes, L. H. (1961), in his report about the effect of nozzle type, and spray application methods on cotton insect control using a boomless spray nozzle

designed to cover six rows of cotton, found variations in droplet size from 50 to 1,000 microns in diameter, and a direct relation between the size and distribution of the droplets and the quality of control and yield. See Fig. 1.

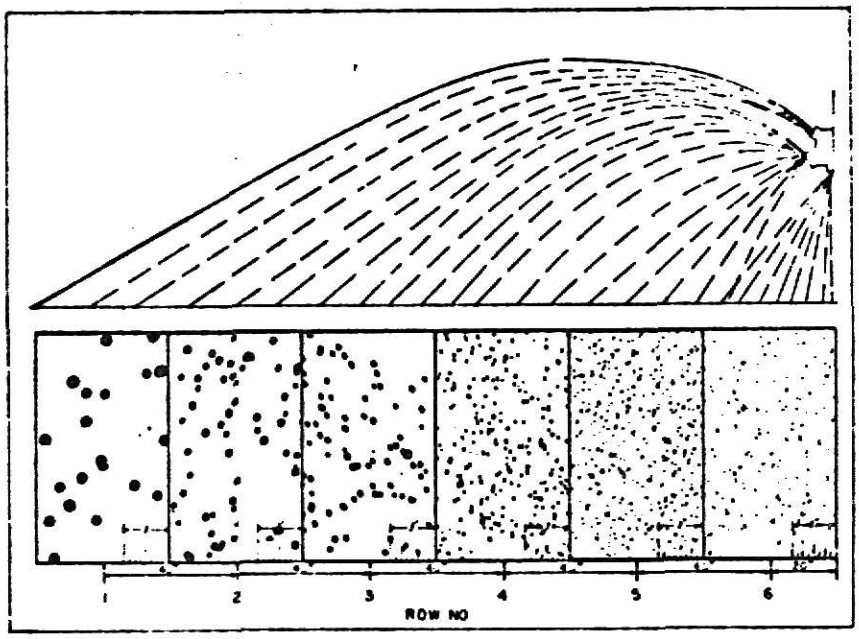

Fig. 1. Reproduction of 3 x 5 index cards showing relative size of droplets as collected on the card placed along the rows of the swath covered by the boomjet nozzle.
Source: Wilkes, L. H. (1961)

Information pertaining to Fig. 1 is as follows:

1. Application rate = 6 G.P.A.

2. Following the manufacturer recommendations, uniform volume was obtained in the 6 rows.

3. The diameter of the droplets varied from 50 to 100 microns in the row adjacent to the nozzle, increasing progressively to the sixth row with diameters of 1,000 microns and larger.

4. Average yields in the outside rows were 32% less as compared to the rows adjacent to the nozzle. The level of infestation in the rows kept a similar proportion.

Hedden, O. K. (1961), studying droplet size and distribution in pesticide sprays, found that with a pressure of 100 Psi using several size ranges of flat spray patterns, droplets of sizes greater than 300 microns accounted only for 0.55% of the total number of droplets, but at the same time, droplets above this range contained more than 55% of the spray material. This information is shown in Table 16.

Table 16. Percent of Spray Drops and Spray Volume in Various Ranges of a Flat Spray Pattern.*

Size Range Diameters (microns)	% of Total Drops	% of Total Volume
0 - 100	99.45	6.2
100 - 300	.48	36.0
300 - 600	.06	53.5
Over 600	.00	2.3

*65 degrees nozzles operated at 100 Psi.
Source: Hedden, O. K. 1961.

Wilkes, H. L. (1961), working in pest control in cotton at the Texas Agricultural Experiment Station, reported after extensive field tests, that effective control of boll weevils and worms, can be maintained with low rates of spray material in concentrated applications using simple nozzle arrangements on ground sprayers. There have been many positive experimental results about the use of concentrated applications for crop protection in annual crops in the United States. Today its effectiveness is

generally accepted.

Spray droplet size distributions between 75 and 300 microns have been found optimum for control purposes by several authors. Agricultural sprays that produce excessive droplets below 75 microns tend to increase the drift problem. Yates, W. E. (1966), found that U.L.V. applications under the most favorable weather conditions produced higher residues in surrounding fields, than a standard dilute application during the most unfavorable conditions. Butler, B. J. (1969), using three commercial spray adjuvants to reduce drift, obtained an important reduction in the number of droplets below 100 microns, but at the same time increased the percentage of droplets of about 300 microns, which is considered undesirable from the uniformity of coverage standpoint.

Several research programs are being developed to solve the drift problem from agricultural sprayers, especially in the modification of the spray mixture itself.

Simultaneous field operations, such as the application of herbicides or insecticides at the same time with the planting or cultivating operations, are possible when using low gallonage tractor mounted sprayers. This potential use further expands the possibilities of costs reduction in crop protection.

Design and Operational Requirements

The prime requirements for any sprayer for applying pest control materials are:

1. That it dispense the material uniformly over the area being treated.

2. That it distributes the material uniformly over the area being treated.

3. That it be easily calibrated to apply a predetermined dosage.

In choosing or designing a tractor mounted sprayer for Colombian agriculture adapted to concentrated application of chemicals, it is necessary to consider each of the various essential elements which include the following:

Pump:

According to Potts, S. F. (1958), the best pump for a particular sprayer is one that delivers the desired spray volume at the required pressure for an economical span of service.

Fairbanks, G. E. (1951), referring to the selection of pumps for a low volume tractor P.T.O. operated sprayer for the application of herbicides points out: "Pump capacity does not need to be very high. For example, a sprayer with a 19 nozzle boom operating at 30 pounds per sq. in. pressure with nozzles rated at 5 gallons per hour will apply less than 2 gallons per minute. It is desirable however to have a pump which will supply more than is actually needed since the excess liquid passes through the pressure control valve and back to the supply tank thus helping to keep the material in the supply tank agitated."

Gear, roller, vane, centrifugal and diaphragm pumps are the most commonly used in low gallonage power operated sprayers. Most of these pumps do a satisfactory job of handling solutions and emulsions which are the most common forms of herbicides and insecticides now in use. However, if the use of suspensions or wettable powders is expected from the sprayer, special care should be taken in the selection of the pump. The use of concentrate sprays accentuates the wear problem and makes the correct selection of the pump more critical.

Wesley, W. G. (1954), made a durability test of 17 different pumps, 13 of them used in low volume sprayers to compare their relative resistance to abrasion. The spray liquid used in testing the pumps was a mixture of 24 pounds of hydrated lime and 48 pounds of wettable sulfur per 100 gallons of water. The pumps were run continuously, but the spray material was replaced after approximately 100 recirculations to eliminate the effect of reducing the rate of abrasion caused by the recirculation of the spray suspension. The pumps were installed in the test stand, and arrangements were made to fit the manufacturer's recommendations about operating specifications.

The best results from the endurance test were obtained with the diaphragm pumps. The double diaphragm pump with an original capacity of 6.99 G.P.M. did not drop in capacity after 701 hours of operation. The single diaphragm pump had an original capacity of 4.38 G.P.M.. After 500 hours of operation it dropped to a 4.21 G.P.M. of capacity.

Very good results were also obtained from a cast iron semi-open impeller centrifugal type of pump, with an original capacity of 10.7 G.P.M. After 500 hours of operation its capacity was still the same. However, the speed of rotation was considered a limiting factor. Internal gears, roller, vane and plunger types of pumps did not perform satisfactorily in this test.

Results are summarized in Table 17.

Table 17. Results from the Endurance Test of Different Types of Pumps

Type of Pump	Pressure Psi	RPM	Capacity G.P.M. Original	Capacity G.P.M. End	Hours of Operation
Double Diaphragm	80	340	6.99	6.99	701
Single Diaphragm	80	485	4.38	4.21	500
Centrifugal	63	2,640	10.70	10.70	500
Internal Gears	80	895	7.70	2.00	115
Roller	80	510	6.00	2.68	68
Vane	80	3,520	7.50	2.00	60
Plunger	80	480	3.15	1.96	56

Source: Adapted from Wesley, W. G. (1954)

Nozzles:

The two general types of nozzles most commonly used for low volume applications are the fan and the cone type.

Fan type nozzles are generally used for the application of herbicides. This type of nozzle produces a flat or fan shaped spray pattern with uniform distribution across the center portion of the spray becoming somewhat lighter at the outer edges. This nozzle is normally operated at a pressure from 30 to 50 Psi.

Hollow cone spray nozzles are most frequently used in the application of insecticide sprays. This type of nozzle produces a hollow cone shaped spray pattern usually having a spray angle of from 70 to 80 degrees, and is usually operated at pressures of 60 to 80 Psi. for concentrated applications. According to Johnson, A. K. 1957: "For most cone spray nozzles, the spray droplet size is relatively smaller than for flat fan spray types. These smaller droplets are desirable since they are still of sufficient size to have residual value and also small enough and numerous enough to thoroughly cover the plants or insects."

When the nozzles are assembled and fixed on the spray boom, 20 inches of nozzle separation is generally used. At specified pressures and discharges, adjustments in the boom height may provide even distribution of the spray.

Various manufacturers make nozzles of all types for the farm sprayer industry. The nozzles usually consist of a nozzle body, a cap, a strainer and a nozzle tip which contains the orifice. This tip may give either a flat spray or a cone spray pattern.

For low volume applications the nozzles have a fine 100-200 mesh cylindrical screen within the nozzle itself, which protects the very small orifice through which the spray is discharged from being clogged.

Each manufacturer has a marking system particular to their own nozzles. However, all manufacturers publish easy to read catalogues which give detailed information as to the flow rate in G.P.M. and applications rate in G.P.A. for various nozzle spacings, pressures and ground speeds.

Pressure Control Valve:

The function of the pressure control valve is to provide a steady pressure at the nozzles. It can be adjusted so that any quantity of liquid in excess of that required to maintain a desired pressure at the nozzles is allowed to pass through the valve itself and back to the supply tank.

Pressure Gauge:

The pressure gauge is located on the nozzle side of the pressure control valve and should be visible to the operator. Fairbanks, G. E. (1951), suggests that the capacity of the pressure gauge should not exceed the intended spraying pressures to any great extent, because if it does the gauge will not give readings with the same degree of accuracy.

Line Strainers:

Two line strainers are recommended, one in the suction line and the other in the pressure line of the pump. The mesh of the screen of these strainers should be the same as that used in the nozzles. An adequate selection of the strainers helps to prevent the clogging of the nozzle screens and tips which is one of the main sources of trouble in the operation of this type of sprayer.

Agitation Device:

The use of wettable powder and suspensions makes the selection of an adequate agitation device more critical. Wooten, O. B. and Holstum, J. T. (1961), in their progress report on hydraulic agitation of wettable powders, tested pressurized and non-

pressurized commercial devices for agitation purposes and concluded that a Jet Agitator with three straight orificies (drill size, 5/64 inch), delivering 3.33 G.P.M. at 30 Psi. pressure did give adequate agitation. This device was suspended on a rigid pipe in the center of a 55 gallon steel drum with the orificies approximately 1 inch from the bottom of the tank.

A smaller Jet agitator of the same type but with orificies (drill size 1/16 inch), delivering 1.4 G.P.M. did not give adequate agitation.

A pressure agitator operates from the same line that supplies the nozzles tips and provisions should be taken in the selection of the pump to provide enough discharge at its rated pressures for both the agitation device and nozzles.

Cut-Off Valve:

The sprayers should have a fast acting shut-off valve that will start or stop the flow of spray material to the boom. Additional cut-off valves are necessary if it is desired to use only a part of the boom at one time.

Supply Tank:

The tank need not withstand pressure. A clean 55 gallon oil drum may be used for a low gallonage sprayer; however, special provisions must be made where corrossive materials are used.

Pipe for Boom:

Galvanized steel pipes are widely used for the sprayer boom and are satisfactory. A good boom mount should be strong, easily attached to the tractor and should provide a simple adjustment

for regulating the height of the boom.

Hoses and Fittings:

Hoses and fittings should be strong enough to withstand the pressure used, and should be of material that is not deteriorated by spray solutions. Brass pipe fittings are corrosion resistant and satisfactory for this type of sprayer.

Supply Tank Mount:

The framework for the supply tank should be strong enough to support the load when the tractor is working on irregular surfaces. The entire sprayer may be mounted by the tractor three point hitch.

SUMMARY AND CONCLUSIONS

Most of the research advances in crop protection made during the present century have found application in tropical regions. However, their adoption in many of these regions has been restricted to a limited percentage of the farm units.

In the last two decades there has been a trend in Colombian agriculture toward the establishment of mechanized or semi-mechanized annual crops in its low lands. This trend has been the result of the Colombian efforts to satisfy its increasing internal demand for agricultural products as well as to diversify and expand its exports. It has been found, however, that the costs of production of these crops run very high as compared with other countries.

The costs of crop protection account for an important part of the overall costs of production, and in extreme cases, as in cotton, they are greater than all the preharvest costs together.

The application of chemicals for crop protection has relied upon the use of knapsack or horse mounted sprayers for the small growers, and aircraft applications in large holdings. The most common methods of weed control are done by laborers using hand tools. Some mechanized farmers make use of cultivators. Only a small percentage of the growers use modern herbicides.

The developments made by the pesticide industry, together with important improvements in the equipment for their application of chemicals in agriculture, have greatly increased the possibilities for cheaper and more effective methods of crop protection.

A good example of these improvements is the advances made on ground equipment designed for concentrated applications. These sprayers applying low rates of total spray material (2-6 G.P.A.), being lighter in weight, simpler in construction and cheaper, overcome serious shortcomings of the conventional type of ground sprayers.

The introduction of a tractor mounted sprayer adapted to concentrated applications is presented in this report as a promisory solution in the reduction of the costs of protection and production of several important mechanized crops in Colombia. The design and operational requirements for the construction of this sprayer are also included.

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PROSPECTS FOR THE DEVELOPMENT OF A GROUND SPRAYER FOR COLOMBIAN AGRICULTURE

by

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Costs of crop protection in Colombian mechanized or semi-mechanized annual crops are very high as compared with other countries.

At the present, farm tractors for the production of annual crops are used on more than 845,000 hectares. However, tractor operated sprayers have not been adopted by most of the Colombian commercial farmers. The application of chemicals for crop protection is done mainly with the use of knapsack or horse mounted sprayers for the small growers and by aircraft applications on larger farm units.

After a survey of the present systems of agriculture in Colombia, and based on economical and technological considerations, the production and adoption of a tractor mounted ground sprayer adapted for concentrated applications is presented here as a promisory solution in the reduction of costs of protection for mechanized and semi-mechanized Colombian farmers. Simultaneous application of herbicides or insecticides along with the planting or cultivation operations would seem to offer a distinct advantage for the tractor operated sprayer to help reduce crop protection costs.

Design and operational requirements of the necessary components for a tractor operated sprayer are also presented in this report.