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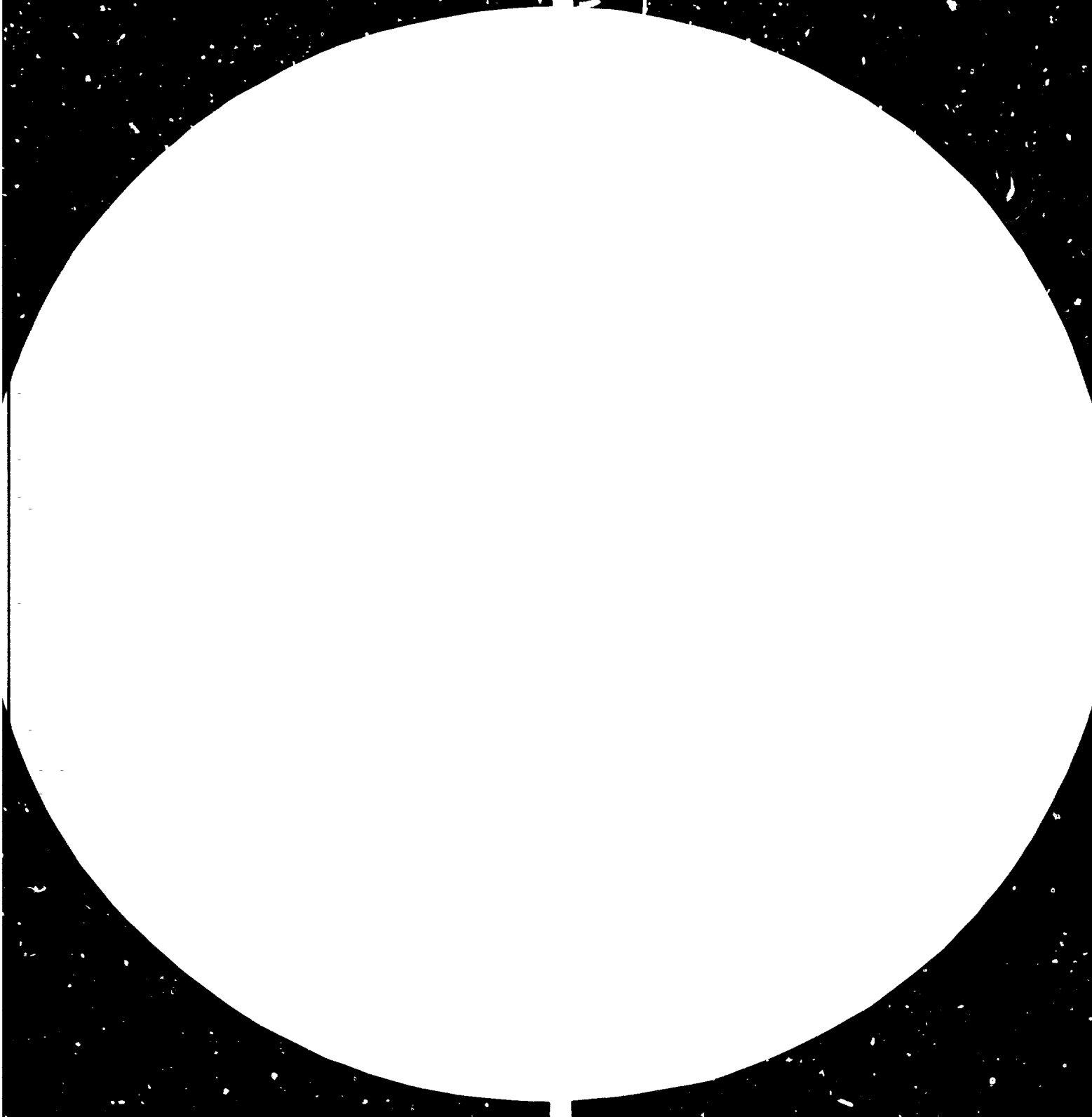

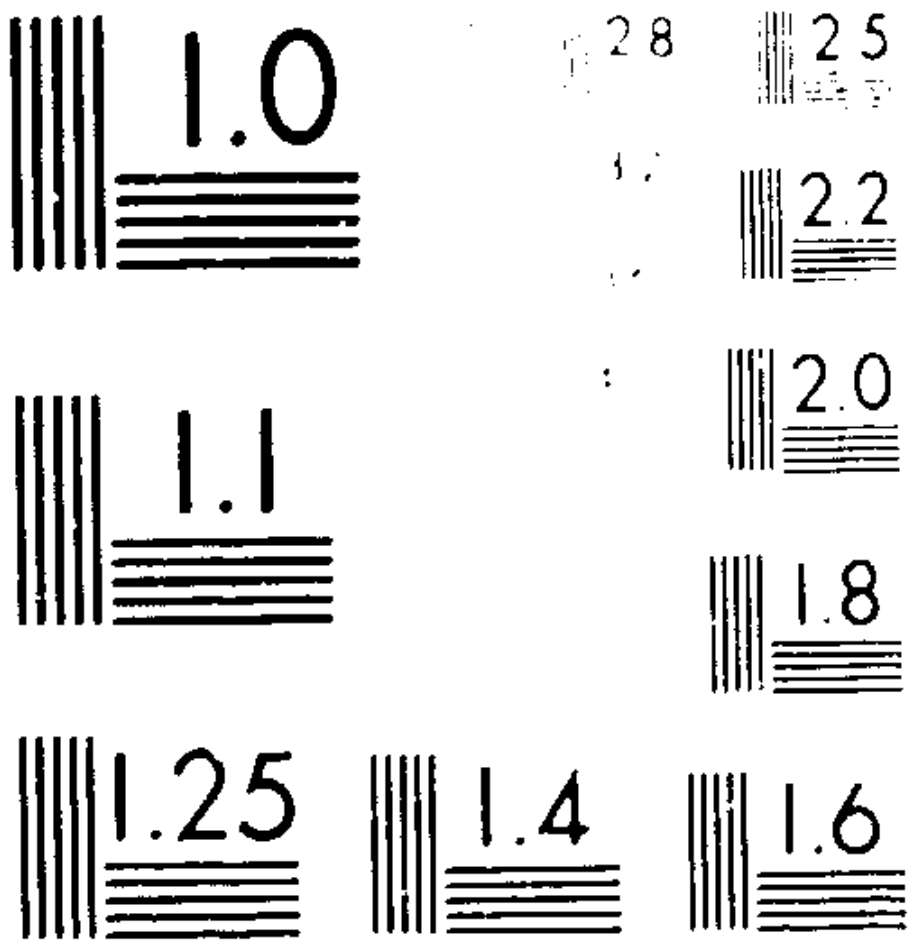
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LIMITED

ID/WG.330/3
22 September 1980

ENGLISH

United Nations Industrial Development Organization

Meeting on Exchange of Experiences and
Co-operation among Developing Countries in the
Development of Agricultural Machinery Industry

Beijing, China, 20 - 27 October 1980

AGRICULTURE, MECHANIZATION AND ENERGY PROBLEMS:

THE ITALIAN EXPERIENCE*

by

Giuseppe Pellizzi**

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** Director and Professor of Agricultural Machinery and Renewable Energies, Institute of Agricultural Engineering, State University of Milano, Italy.

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1. Agriculture and its Development

Italy's geographical position (between the 36th and 47th Northern parallel) and specific plano-altimetric and orographic situation and, therefore, widely different pedoclimatic conditions, made it possible to implement and intensive agriculture having widely diversified vegetable and animal productions. Italy's agriculture developed (Tab.1), on the 16.5 million ha farmed at present, by means of proper usage of ceaselessly updated technologies. Among these, mechanization has played a primary role for produce quality improvement and loss reduction, while progressively increasing labour productivity and cultural intensiveness (because of the greater timeliness and wider potential development of double crops), as well as raising the standard of living of the rural population.

The development of these last 30 years could be synthetically represented as follows :

- Size of holdings : Reduction from 4.8 million farms (88% less than 5 ha) with an average size of approximately 3.2 ha, to 2.6 million farms with an average size of approximately 6.5 ha (65% less than 5 ha). In the meantime, a progressive diffusion of cooperative systems for the common use of land or, more frequently, of the technical means of production and commercialization has been set up. Cooperatives at present account for approximately 30% of small and medium farms;

The author if a full professor of Agricultural Machinery at the State University of Milan; scientific director of the National Coordinated Research Programme on Agricultural Mechanization of the Italian National Research Council (C.N.R.); Vice President of the Italian Association of Agricultural Engineering (A.I.G.R.); UNIDO and FAO consultant on agricultural mechanization and renewable energies for agriculture.

C.N.R. - Coordinated Research Programme on Agricultural Mechanization - Report n. 163.

Tab. 1 - Main Parameters of the Development of Italian Agriculture (1950-1979)

Parameters		Years		
		1950	1960	1979
			Structures	
Farming Surface	(000 ha)	20,687	20,130	16,500
Number of farms	(000 n.)	4,830	3,600	2,600
Mean farm size	(ha)	4.3	5.8	6.5
Farms below 5 ha	(%)	88	79	65
Active population	(millions)	8.5	4.8	2.7
			Main crops	
Cereals	(000 ha)	6,660	6,600	5,200
	(000 t)	11,380	11,770	17,860
Forage	(000 ha)	9,145	10,476	9,402
	(000 t hay)	28,360	44,200	44,200
Industrial crops	(000 ha)	232	300	315
	(000 t)	4,550	7,900	11,000
Seed oil crops	(000 ha)	1,022	1,070	280
	(000 t)	730	740	430
Horticultural crops	(000 ha)	180	328	550
	(000 t)	5,040	6,560	11,500
Potatoes	(000 ha)	392	378	180
	(000 t)	2,430	3,818	2,840
Textile crops	(000 ha)	74	22	6
	(000 t)	75	33	20
Grapes	(000 ha)	978	1,143	1,170
	(000 t)	6,750	8,640	11,000
Olives	(000 ha)	862	916	1,080
	(000 t)	1,012	2,100	2,600
Citrus fruit	(000 ha)	60	85	98
	(000 t)	900	1,200	2,600
Fresh fruit	(000 ha)	195	416	590
	(000 t)	1,900	3,900	2,200
			Animals	
Cattle	(000 units)	5,885	9,845	8,724
Sheep and goats	(000 units)	8,256	9,612	9,800
Swine	(000 units)	3,044	4,335	8,920
Poultry	(000 t)	58	221	950
Milk	(000 t)	3,290	7,980	9,580
Eggs	(000 t)	286	351	760

- Active population : Decrease from approximately 8.5 million workers (50% of the Italian active population - 1.9 ha/workers) to less than 2.7 million workers (15% of the total active population - 6.2 ha/ workers);
- Gross salable product : At constant currency value, the increase was some 2.2 times. This is chiefly due to genetic improvement and better agronomic practices; to the diffusion of irrigation (irrigated land grew by approximately 30% over 1950 and now accounts for some 25% of cultivated land) to the more general use of propagation materials, fertilisers (5 times higher), pesticides and herbicides (4 times higher) and to the development of mechanization. The last has helped by 35-40% the above mentioned increase of gross salable product by improving work quality, cutting losses and allowing the required operations to be performed at the right time.

At the same time, the scope of agriculture changed radically, to a prevailingly market economy. Hence a consequent increase of storage and processing of animal or vegetable produce. In fact, 30 years ago, preserved or processed agricultural products accounted for about 40% of agricultural production, while they now represent more than 80%. This has had quite an impact on the management methods of agriculture as a supplier of raw materials to the home and export markets and on the growing use of mechanical equipment.

Because of the low cost of oil energy and because of synthetic products competing against the natural ones (from fertilisers to fibres), this system has shown a growing trend towards industrialisation : thus, certain crops were dropped in favour of others, and the natural cycles were tampered with; the consequence being growing wastage and growing direct and indirect energy demand, to the point that the overall ratio of energy input to edible energy available at man's mouth became very close to one.

Obviously, all this also had an impact on the development of mechanization as concerns equipment, its rating and capacity, etc. During this development process, inevitable mistakes were made which often led to the use of oversize equipment in certain regions and chiefly in the

fertile Po valley, with its high concentration of cattle farming.

2. Farm Mechanization and its Growth

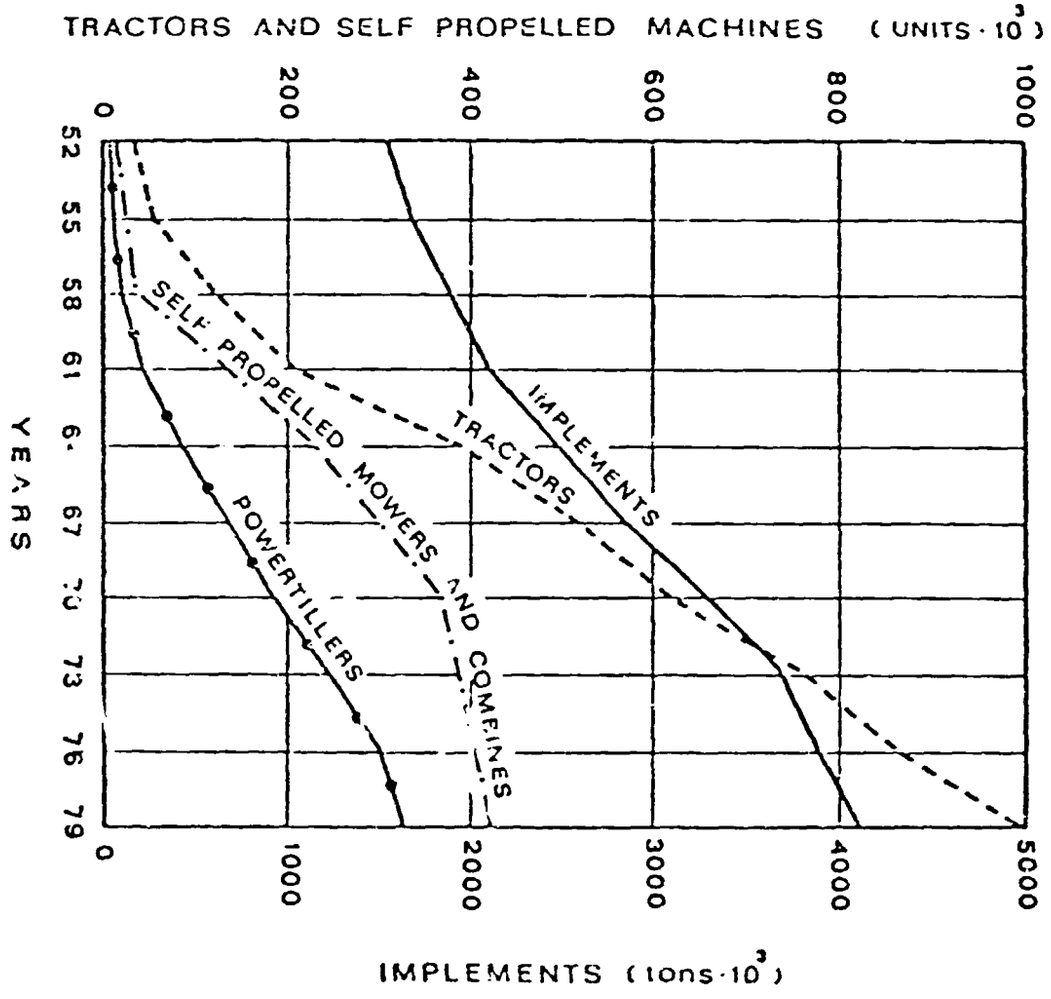
The remarkable development of farm mechanization was made possible, as mentioned above, by a growing diffusion of tractors, agricultural machines and implements. These have been developed over the years in terms of :

- meeting the growing requirements for higher labour productivity and timely interventions in the fields;
- improving work quality and cutting losses;
- technological improvements in machine design, materials used, operator's comfort and safety.

This was brought about by close cooperation between scientific research, carried out mainly in the 16 Agricultural Engineering Institutes (13 belonging to Universities; 2 to the National Research Council; 1 to the Ministry of Agriculture) throughout Italy, and the agricultural and industrial community.

Some significant figures on the quantitative growth of mechanization are given in Tab.2. It can be seen that the tractor fleet has reached the one million units (one tractor every 16.5 ha) for a 15-fold increase since 1950, while total rated power increased by 23 times. This means an average power load of the order of 2.4 kW/ha, as compared with 0.08 kW/ha in 1950, and an average size of 42 kW/unit (1950 : 23 kW/unit).

A concurrent development, mainly until the end of the 60s, was experienced by power tillers and other self-propelled farm implements, and specifically by mowers and harvesting combines. The latter were practically unknown in 1950 and by 1960 had grown to a fleet of some 6,000 units. Today they number 32,000, all of them self-propelling, for approx. one machine every 160 cereal-cultivated hectares. As concerns agricultural machinery and implements, growth was rather limited in quantity (from 90 to 260 kg of hardware per hectare), while an important qualitative development first occurred when animal-drawn equipment gave way to mechanical traction; then, when drawn implements were replaced by tractor



Tab. 2 - Development of Agricultural Mechanization in Italy

mounted ones and finally when combined-purpose machines replaced the single purpose ones. This was one of the reasons for the higher power rating of the tractors and made possible the above mentioned increase in labour productivity. Such productivity improvement became necessary as the available agricultural manpower progressively decreased while concurrently production intensity increased, chiefly in the 2-yearly crop areas (some 20% of the national agricultural land), thus requiring more timely interventions. Consequently, labour productivity rose an average of 6-10 times over these thirty years (see Tab.3).

At the same time, much work was done to improve quality (and raise the yield) and cut losses. This specifically occurred in seed bed preparation, sowing and fertilizer distribution, plant protection and harvesting, with particular reference to herbaceous crops. Great strides were also made in the mechanization of animal husbandry : from fodder distribution (more and more based, at present, on the principle of uniform feeding over the entire year, and automated ration distribution according to the needs of the individual animals) to milking. Milking is now mostly done in milking parlours with a low milk line.

From a technological viewpoint, it should be pointed out that high quality materials, sophisticated machining and heat treatment processes are becoming more and more common, while the trend is toward lighter machines; the growing diffusion of electronics, hydrostatics and hydrodynamics; a continuous trend towards better comfort and safety for the operator calling for soundproofing and vibration-dampening devices as well as for safety cabs and frames.

At present, therefore, the mechanization of the various operations related to cereal, forage and sugarbeet crops (which altogether account for more than 70% of Italian agricultural land) can be considered as complete and widespread. The same applied to soil tillage, fertiliser and pesticide application in orchard, industrial and fruit-tree crops. The relevant equipment is made available by individual or cooperative purchase or by renting from specialised firms. Renting especially applies to heavy harvesting equipment. The same can be said for the impact of mechanization in animal (cattle and swine) husbandry and poul-

Tab. 3 - Labour Productivity Increases due to Mechanization in Certain Crops

Crops	Years	Labour Productivity (ha/100 man hours)			Productivity Ratio (Average)
		Pre-harvesting operations	Harvesting Transport, Storage	Total	
Cereals	1950	1.2-1.6	0.6-0.8	0.4-0.6	1
	1960	2.0-2.5	1.7-2.5	0.9-1.25	2.2
	1979	4.0-6.0	8.0-10.0	2.7-3.8	6.5
Hay	1950	1.3-2.5	1.0-1.4	0.8-1.0	1
	1960	2.0-3.0	2.5-3.0	1.4-1.6	1.7
	1979	8.0-10.0	8.0-10.0	4.0-5.0	5.0
Sugar beets	1950	0.5-0.6	0.5-0.8	0.25-0.3	1
	1960	1.5-2.0	2.5-3.0	0.9-1.2	2.7
	1979	3.0-4.0	8.0-10.0	2.2-2.8	10.1
Potatoes	1950	1.0-1.2	0.3-0.4	0.27-0.30	1
	1960	2.0-2.2	0.7-0.8	0.40-0.50	1.6
	1979	5.0-6.0	5.0-7.0	2.5-3.2	10.0
Tomatoes	1950	0.4-0.5	0.1-0.15	0.07-0.09	1
	1960	0.6-0.8	0.2-0.3	0.15-0.20	2.2
	1979	4.0-5.5	2.0-2.2	1.3-1.6	16.0
Onions	1950	0.4-0.5	0.2-0.25	0.14-0.16	1
	1960	0.9-1.0	0.4-0.5	0.25-0.35	2
	1979	2.0-2.2	3.0-4.0	1.25-1.65	9.7
Peas	1950	0.4-0.5	0.2-0.3	0.14-0.16	1
	1960	0.9-1.0	0.8-1.0	0.45-0.50	3.2
	1979	2.0-2.2	5.0-6.0	1.4-1.6	10
Cauliflower	1950	0.4-0.5	0.4-0.5	0.20-0.25	1
	1960	0.9-1.0	0.9-1.0	0.40-0.45	1.9
	1979	2.0-2.2	2.0-2.5	1.00-1.25	5.0
Olives	1950	1.0-1.2	0.25-0.30	0.20-0.22	1
	1960	2.0-2.2	0.45-0.55	0.35-0.45	1.9
	1979	3.0-6.0	4.0-6.0	2.2-3.0	12.4
Grapes	1959	1.0-1.2	0.5-0.6	0.2-0.3	1
	1960	2.0-2.1	1.5-2.0	0.7-1.0	2.8
	1979	4.0-5.0	5.0-7.0	2.2-3.0	10.4

try farms : only the smallest breeders (10% of the national livestock) are excluded.

Among the most original and significant solutions, typical of the "Italian way to agricultural mechanization", mention should be made of :

- the introduction and worldwide success of the four-wheel drive tractors, the performances and advantages of which, as compared to the standard wheel or crawler ones, need no demonstration here;
- the development and success of the small power (< 30 kW) articulated tractor, as derived from the power-tillers experience;
- the development and worldwide success of self-propelled mowers and reaper-binders, rotary ditchers and spading machines for primary tillage, as well as smaller farm implements mechanization, fruit-tree crops harvesting, and self-levelling combines fitted for cereals harvesting in hilly areas.

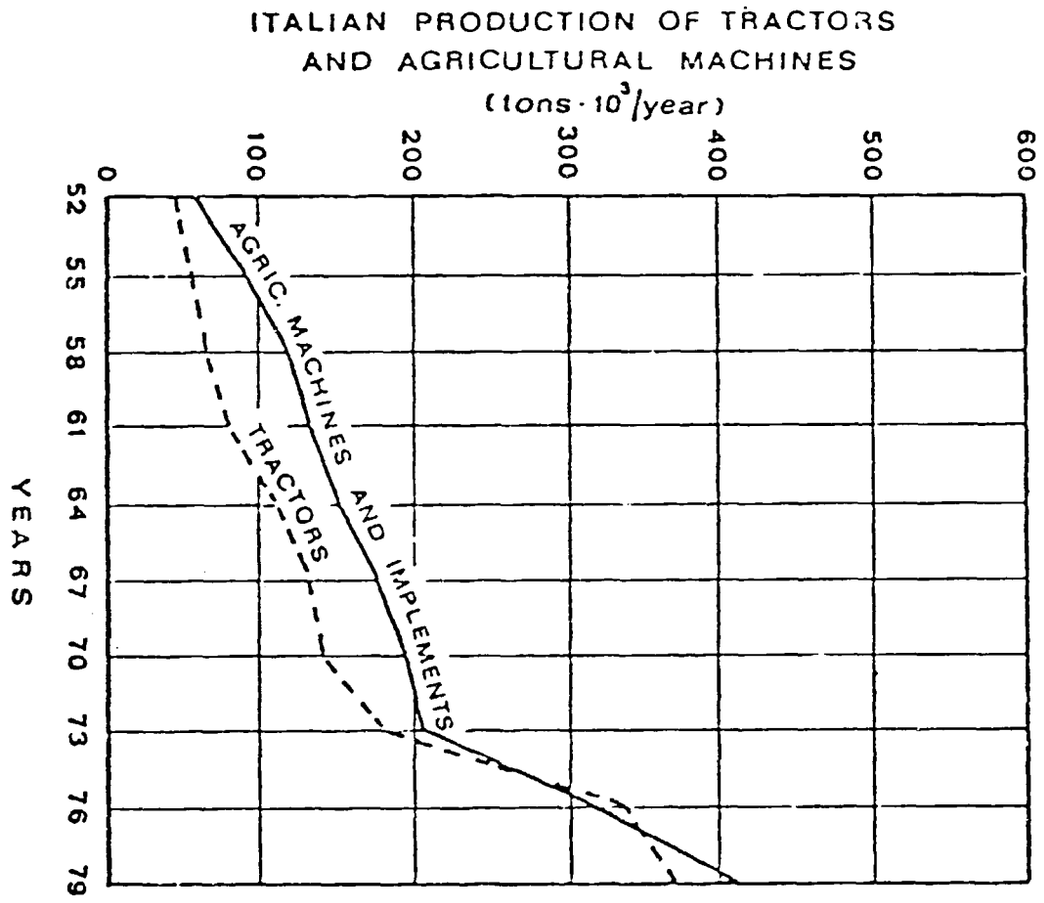
All tractors are type-tested and approved according to Italian and OECD specification codes; a number of agricultural machines and implements are also rated by official institutions, according to field tests run to common standard methods.

3. The Growth of the Italian Agricultural Machinery Industry

The development of agricultural mechanization, as outlined above, was made possible by a concurrent development of the manufacturing industry, part of which was already existant before the last war.

This branch of industry, whose output in 1950 was slightly more than 100,000 t per year of agricultural machines and implements (Tab.4), 30% of which tractors, grew to turn out more than 770,000 t yearly, 50% being tractors. At today's prices, this corresponds to an overall turnover of more than US$ 3,000 million. 30% of this production is exported, while imports of agricultural machinery account for barely more than 10% of internal demand.

The evolution of quantitative demand for agricultural machinery was accompanied, as seen before, by progress in machine typology and technology. The simple, drawn-type implement, suitable for 20-30 kW tractors, gave way to combined-purpose machines, chiefly in seed-bed preparation and herbaceous crop harvesting, designed for tractors rated at 40 to



Tab. 4 - Development of Italian production of tractors and Agricultural machines

60 kW.

Important developments also took place in tractors : here the machines have become progressively lighther, following the diffusion of three-point links with hydraulic lift and p.t.o. for implement driving, and the four-wheel drive has gradually taken over. In 1950, the average Italian-built tractor was rated at 25 kW; this grew to 40 kW in 1970 and eventually to 48 kW in 1979. In these same three years, the production of tractors rated above 45 kW represented 2%, 12% and 45% respectively; four-wheel drive tractors production accounted for 1%, 13.7% and 45% respectively. On the other hand, the production of crawler tractors, partly replaced by four-wheel drive units, dropped from 25% (1950) to about 12% (1979).

Along with these developments, however, the Italian industry continued and expended the production of smaller machinery, especially 3-12 kW power tillers and small two-or four-wheel drive tractors, rated at 12 to 24 kW, engineered specifically for small farms, on plains or hills, specialising in fruit-tree or horticultural crops, as well as for greenhouses the area of which - 16,000 ha at present - has grown tenfold in the last 30 years.

Thus, Italian production ranges from 12 to 150 kW tractors, built to the tune of more than 115,000 units per year (total weight : 282,000 tons/year) by about 80 firms. 80% of this production, however, is turned out by 10% of the manufacturers who continuously update their technology and facilities and are competitive all over the world. This is made possible by large-scale economies based on advanced standardization of the components, so as to ensure easier, simpler after sales service and spare parts supply. To this production we have to add that of detached components and of spare parts for a total of 75,000 tons, 80% of which for export.

Agricultural machine and implement production covers all sectors (from soil preparation to sowing, irrigation, harvesting, milking, produce storage and first processing) and comes from more than 1800 firms having an overall turnover of some 50% of the total. The 1979 production reachers about 415,000 tons. These firms also specialise by sector,

in order to meet the manifold requirements of as diversified an agriculture (by produce, by pedoclimatic and orographic conditions and by farm size) as Italy's.

Production is therefore less heavily concentrated in this sector. Indeed, the 100 major manufacturers, representing about 7% of the total, account for only 15% of the total production. This branch occupies directly some 80,000 people altogether, while a large induced occupation is due to the manufacture of special components and to after sales service. The latter is performed by more than 5,000 maintenance and repair shops, spread all over the agricultural regions; some of these shops also manufacture small series of implements for the local markets.

4. Research Underway

As mentioned, all the operations concerning cereal, forage and sugar beet crops, soil preparation and fertilizers or pesticide distribution for horticultural, industrial and fruit-tree crops and animal husbandry have been fully mechanized in Italy with the latest equipment.

This progress was also made possible by the help of the research carried out in 16 specialised public institution mentioned above.These institutes perform theoretical, basic and experimental, applied research in close cooperation with farmers and manufacturers. Applied research chiefly concerns field or lab testing of tractors and farming machinery aiming at their technical, functional and economical optimisation.

Around ten years ago we started also with research on scientific farm management and work organization as well as on the definition of optimum mechanization levels with reference to the actual social, economic and structural background of Italian agriculture.

Such research led to highly interesting results, most of which were acknowledged by the industrial and agricultural world who gradually and mutually adjusted the machines to the farms and the famrs to the machines in order to minimize production costs.

However in 1974 social and economic factors were leading to the implementation of suitable harvesting mechanization for the horticultural and industrial crops and pruning and harvesting mechanization of vines,

citrus, fruits and olive trees. This along with the need for mechanization development and improvements of : harvesting and storage chains for forage and agricultural byproducts for animal feed; sheep and goat milking operations, as intensive raising in stables is becoming more and more common; recovery and re-utilization of spontaneous crops of Alpine and Apennine grasslands.

The development of these sectors also entails an expected increase of direct energy consumption of the order of some 35% over the present values. Such values are now approx. 3.2 M toe/year (about 0.2 toe/ha year) and are expected to attain 4.5 toe/year by 1990 (0.29 toe/ha per year); mechanical or electrical energy production accounts for approx. 60%, the balance (40%) being for thermal energy.

Moreover, if the direct energy requirements for the standard of leaving of the rural population (assessed at 4.5 M toe/year, more than 60% of which for heat) are taken into account, agricultural direct energy consumption will appear to make up at present some 5.3% of the overall nationwide demand. This is no negligible figure, in view of the worsening of the worldwide energy crisis and the need for reliable supply, specific of the agricultural system.

Because of these two needs - mechanization growth and energy crisis - a national, coordinated research programme on farm mechanization was started in 1976. This programme is being carried within the framework of the Italian National Research Council (C.N.R.), by about fifty research teams (coordinating mechanical and agricultural engineers, agronomists, zootechnicians, economists, etc.), located in various Italian regions and belonging to the C.N.R., to the Universities and Research Institutes of the Ministry of Agriculture and Ministry of Industry.

The programme - which in part takes up, coordinates and widens previously started work - was developed to study, define and apply those machines and mechanization chains to cut costs and improve the yield of vegetal and animal production to make them competitive and remunerative. This mainly concerns :

production where the Italian food balance shows a severe deficit (such as cattle, sheep and goat raising);

crops (fruit-tree, horticultural and industrial) having large commercial significance, but which economical competitiveness becomes lower and lower.

The programme also takes into consideration the production proper and the recovery of waste and byproducts for possible zootechnical and/or energy utilizations. This last point, with the evolution of research and because of the worsening of the energy crisis, has acquired growing importance.

Several sectors are covered by this programme; the major results of which may be outlined as follows : The first sector covers forage crop mechanization problems with specific reference to : quality improvment and harvesting cost reduction for hay forage; the recovery and exploitation, by suitable mechanical chains, of cereal byproducts (chiefly maize and wheat for animal feed or energy conversion); the productive recovery of marginal or grazing land in the Alps or Apennines. This with a view to the development of milk and beef cattle raising and to the reactivation of sheep and goat raising so as to set forth optimal,less costly solutions and thereby increase - other factors being equal - Italian production in this sector.

Final results, already applied to practical agriculture, were obtained for the optimisation of forage harvesting, handling and storage. Moreover, research to reduce field haymaking losses has now been concluded; optimum harvesting humidity ratios have been established and "two-stage drying" techniques implemented, on low cost, economically operable facilities. These solutions are based on the mowing and conditioning of forage left on the field until its residual moisture content is approx. 50%; it is then barn-dried by preheated air having Δt = 10-18°C. It was thus possible to reduce by 40-50% the nutritional value losses as compared with traditionally-handled forage. Consequently, in view of a possible widespread use of artificial drying of forage, renewable energies, especially solar energy and energy from byproduct conversion for such techniques,were investigated.

In addition, technically and economically optimised chains for maize stalk harvesting, storing and utilization were defined; also under

investigation are technologies for the utilization of straw, blended with various integrative products to improve the metabolic transformation of lignin, as a component of ordinary cattle fodder. This question is being examined both from a mechanical and zootechnical approach, while investigating, from an agronomic viewpoint, possible soil degradation due to the removal of such byproducts.

More recently, this research was extended to verify as an alternative, the energetic conversion of such byproducts by anaerobic digestion and/or thermochemical processes. This was done by developing simple, modular systems, easy and economical to run on an ordinary farm. In this context, however, it was soon realized that the hitherto adopted mechanization chains for the separate collection of grains and byproducts, which entail heavy losses of the latter and high energy costs, should be modified. This problem is now being tackled and practical results should be available within the next 4 or 5 years.

As concerns the recovery of mountain grazing land, machines were designed and developed for weed removal and for undergrowth removal of the "Mediterranean shrubs". Further experiments on the breakage of surface stones and rocks on southern Italian marginal land are underway. The above aims at making possible the use of simple, low cost harvesting equipment for the plentiful spring forage of these areas, to be stored as cattle or sheep fodder during the dry summer and winter seasons. From this viewpoint, a specially significant research is now underway to define "farm models" in intensive or marginal agricultural areas. These models should be used to rationalize energy consumption and to set forth the best crop combination under actual, given conditions.

In this context, the development and experimental implementation of integrated facilities for the use of renewable energies (solar and from biochemical or thermo-chemichal byproduct conversion), aiming at energy self-sufficiency on the farm, is especially important.

Lastly, entirely new, mobile or stationary equipment was developed for sheep and goat milking; the results are very satisfactory, as productivity can be as high as 120 head milked per hr. and man. Prototypes are now being manufactured by two Italian industries.

The second research sector covers mechanised harvesting for some of the main industrial and orchard crops and specifically :

for sugar beets, tomatoes, string beans and peas : the development of mechanization chains to improve the quality of product delivery to the food processing industries and a longer, planned harvesting period under the various pedoclimatic conditions, so as not to require oversize chains and delivery equipment. For sugar beet in particular, it was established that the transformation cycle could be modified by the intermediate preparation of semi-finished products. Mechanical or photo-optic tomato grading equipment, for field or factory use, is now being developed to reduce production costs.

for tobacco : harvesting and curing mechanization (using renewable energy for curing) for Bright, Burley and Kentucky tobaccos, to reduce the production costs of the crop, very important for the European Community.

for cauliflower, artichokes and peppers and other minor orchard vegetables : the necessity of rendering economical such produce, by developing suitable mechanization, possibly of the selective type, to take into account the different ripening periods.

Once the definition of an optimal mechanization for pea picking is completed, research on sugar beets, tomatoes, string beans and peppers and on semi-mechanized picking of cauliflower and artichokes will be concluded within 1980.

Regarding the sugar beet, it was easy to introduce the improvements developed for leaf stripping and to reduce the "earth load" and losses, as several industries in our country manufacture harvesting machines. Existing, widely used machinery for tomatoes, string beans and peas was also improved. However, the impact of this research on the industry was rather poor, with the exception of the manufacture of a tomato harvesting machine.

Research for the mechanical, selective picking of artichokes and cauliflowers still lags behind; for these crops, some interesting prototype machines, the first in Europe, are under development.

Last, but not least, tobacco, for which integrated harvesting-curing

mechanization was investigated.

Machines for leaf or whole plant harvesting (according to the cultivar considered), and suited to the Italian conditions, are under development. For the curing, bulk system in mechanical harvesting-compatible boxes is being investigated, as well as room optimisation. As curing heat requires about 1.2-1.5 kg fuel oil per kg of tobacco, research and experiments are being carried out on the possible integrative use of solar energy. The results achieved over the last two years led to conventional energy savings ranging from 35 to 60% and are to be considered decidedly favourable, taking into account the actual weather conditions of the region.

Moreover, long-term, innovative research is under way for this crop; this will concern the harvesting of chopped tobacco plants, extracting noble proteins from them and reconstituting "leaves" of smoking tobacco. This solution would slash harvesting and production costs while increasing the present gross salable product per hectare by some 50%.

The third and last sector covers mechanization problems in the pruning and harvesting of grapes, olives, perishable fruit, citrus fruit and strawberries. The basic target is to set forth mechanical and/or mechanized chains for these crops to reduce production costs and to even out the required work load over the year, cutting the peaks typical of these two operations, while adjusting the culture layout for a better yield and efficiency of the harvesting equipment. Further, because of the impact of mechanical harvesting on the processing in terms of transport organization and delivery, as well as its consequences on produce quality, the research was extended to include these problems too, in order to set forth detailed work plans for the agricultural world.

In particular, as concerns grapes, the actual possibility of harvesting and winter pruning mechanization was established. The grapes harvesters, of which the prototypes were engineered by the research team, are now in the industrial stage, and are suitable for hedgerow and double courtain vineyeards on a plain or slight slope (less than 20%).

An outstanding result of this work was the introduction in the last two years - after a number of experiments - of grape harvesters, more

than 40 of which are now in use in Italy, as well as of pruning machines.

For olive harvesting, the shaker, having a gathering yield of 70% and slashing by some 50% the cost of manual picking, is now well defined and accepted; further research aims at the setting up of shaking and catching chains (three catching-frame prototypes were developed in collaboration with Italian industries and one is already commercially available); to the definition of full lines, based on small, high picking efficiency machines, suitable for the smaller farms; to the study of live tree pruning methods to obtain a better response to the action of the shakers, while improving harvest efficiency; to technological studies to determine the optimum harvesting times for the major cultivars so as to have an exact schedule of operations.

As concerns fruit for processing, the problem of mechanical harvesting is considered as solved for cling peaches, plums, apricots and sweet and sour cherries, for which adequate shakers and catching-frames were developed. These implements have met with wide interest in the agricultural and industrial work and allow some 30% cost reduction as compared with annual harvesting. Thorough research is still needed on the problem of the mechanical harvesting and catching of fresh fruit, for which high quality is required.

The prototypes developed for strawberry picking lead us to believe that the problem is being solved for strawberries to be processed. However, cultivars, having closer ripening times should still be developed for a better economical exploitation of the machinery.

Finally, for citrus fruit, mechanized harvesting chains, with machines helping the hand work and mechanical pruning machines are now in the final development stage.

Through economic studies on all the above, important, decisive contributions were made (as in the case of grapes, cling peaches and olives) and the advantages of the developed chains were clearly underscored.

As mentioned previously, moreover, research on the agricultural use of renewable energies has become greatly significant over the last three years, for the definition of simple, reliable, low cost technologies, to suit the specific energy requirements of the rural world. This specifi-

cally refers to solar energy and to the energy conversion processes of vegetal or animal byproducts. It was calculated that some 7 million toe/year could be economically obtained; 70% of this amount coming from biomass conversion.

In particular :

A number of air or water type, flat plate collectors to be installed on existing building roofs were developed. Their cost is about one-fifth of the commercially available collectors and their efficiency is practically the same; they are to be used for low temperature heat requirements.

An experimental programme was started on solar energy storage systems, among which, at least for the southern regions, the solar pond appears to be most interesting.

In the field of biomasses, and specifically for animal or vegetal by-products, experiments on anaerobic digestion have been going on for some 2 years and simple, modular facilities, for 15 and 30 cattle equivalents, of the batch, plug-flow and anaerobic filter types have been realized. The very first results show that the production costs of these processes could be kept to some 60% of today's commercially available systems, mainly used for swine manure, while attaining fully satisfactory efficiency.

The thermochemical processing (direct combustion, carbonisation, gasification) of wood and cellulosic byproducts is also being investigated, chiefly for cereal straw (5 million ha) and for the pruning waste of some 2.5 million ha of fruit-tree crops.

It was found out here that byproducts could only be economically used as energy sources within their areas of production, or within the boundaries of what was conventionally defined as "farm-bound circuit".

At the same time, it was found that :

- on the one hand, when evaluating the conversion processes, the agronomic and/or zootechnical value of the effluents to be returned to the field should be taken into account; thus, non-destructive processes are preferable;
- on the other hand, the only economical way to meet the variable energy

demand of a farm lies in engineering and implementing integrated energy systems, making use of different technologies for the different users. Experimental studies are now under way at a few pilot farms.

Studies for a more rational mechanization, from an energy point of view, have been going on for a few years, in terms of proper selection and exploitation, as well as of a reliable, frequent repair and maintenance service for the machinery. Experience gathered in these last few years seems to point out that - other factors being equal - some 12-15% fuel saving could be obtained.

As mentioned before, this entire research was carried out in close cooperation with the agricultural and industrial communities.

The latter also collaborated in the development of suitable tractors for the needs of the agriculture of developing countries. Three types (12, 18 and 26 kW, two- and four-wheel drive) have been developed so far; they are based on the industrial technologies currently used in the mass production of tractors (and thereby are backed by the firms' manufacturing experience), but they are stripped of certain electrical or hydraulic components, which are difficult to mantain and less needed in those countries where there is a large share of the active population in agriculture.

These tractors are available in three different versions, according to specific requirements (from the simpiest and least costly to the most sophisticated and expensive), although based on the same standard components, thereby making the spare parts and service problems simpler. Local production - through local joint ventures - and with gradually growing added value - has also been considered : from the mere assembling (3.5% added value approx.), to local manufacture of about 40% of tractor value. These machines are now being tested in certain developing countries with very positive results.