

WP: 29A-2

Working Paper



**INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD**

USE AND MARKETING OF
PLANT PROTECTION APPLIANCES

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W P No. 254

September 1979

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of the IIMA is to help faculty members
to test out their research findings
at the pre-publication stage

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Introduction of plant protection appliances in Indian agriculture dates back to the thirties. Their use was then systematically promoted by extension agencies. Later, in the community development programme they formed an important item of extension work. Keeping in view the scarce uses to which plant protection appliances were then put and the difficulty of farmers in bearing the cost of ownership, state governments arranged for their purchase and made them available to farmers either free of cost or on a small rental. As a government supply system could hardly reach every village and every farmer, states' effort in time was changed toward subsidizing ownership of these appliances by farmers, co-operatives, and panchayats. This had a significant impact on increase in the number of appliances. In 1966, when data began to be collected, there were 2.1 lakh appliances with farmers in the country. In 1972, their number increased to 4.5 lakh.

Development in organic chemistry and discovery of chlorinated hydrocarbons as insecticides and the latter's availability at reasonable cost and later on introduction of susceptible high yielding varieties resulted in a large expansion in the use of plant protection chemicals and appliances. Wide spread use of pesticides is easily perceived, but the gradual and not so prominent changes in plant protection appliances over the years have yet to be suitably acknowledged. The acceptability of plant protection ~~has~~ chemicals has reached such a stage that their shortages are frequent. While some market studies of pesticides have appeared, very little attention--if any--has been paid to study the use and marketing of appliances. It is however being recognized that, next to availability of suitable pesticides, plant protection equipment are a must for efficient pest and disease control. Some of the enterprising manufacturers have adapted imported technology for design and manufacture of these appliances and have at the same time attempted to innovate designs suited to Indian farming conditions.

Along with the expansion of pesticides that is taking place in the country, there is need to know the many details which go in the ownership and use of appliances by farmers. Their experiences, difficulties, and opinions for these appliances can provide an insight on the suitability or otherwise of appliances, preferences of

farmers, availability of maintenance, repair facilities and, a host of other related issues.

HYPOTHESIS

Acceptance of new agricultural technology is not uniform in time and space. Plant protection and the appliances needed for it are common in cash crop regions. These appliances would be owned by large farmers who can afford to invest or borrow the required amount. That even such large farmers experience difficulties with appliances is not commonly known. Organizational and financial mechanisms to facilitate their use and ownership by small farmers do not exist, and areas of intervention for larger use have not been identified.

OBJECTIVE

The main objective of the study was to ascertain constraints for larger ownership/usage of plant protection appliances. More specifically, it is intended to ascertain patterns of ownership of appliances and their relation to crops in an area, farmers, and their land. An attempt is also to be made to determine the value of investment for appliances and its relationship to i) size of holding, ii) crops needing protection and their area and iii) any other relevant aspects. Dependence on borrowed or rented appliances or institutional availability is also to be investigated.

The investigation was in two main directions. One direction was to ascertain at a macro level whether the number of appliances in an area is dependent on some factors such as crop pattern, extent of area irrigated, availability of labour and educational levels, etc.

At the macro level, certain information has become available for Gujarat. The available secondary data was analysed so as to gain an insight into the factors which may be influencing the number of appliances in the area. As some fairly clear picture seems to emerge for Gujarat State, it was considered advisable to publish it as a working paper so as to provide a background for the research under way.

The second direction relates to a field study of farmers' opinions and the situation prevailing at the village level in regard to use, cost, repair, and maintenance, preference, and a host of other factors influencing use and marketing of appliances. Gujarat was selected for the field study and the results, when compiled, will be incorporated in a report, to be published later.

Review of Literature

A wide variety of agricultural implements are being used for varied farm needs. The sources of power for agricultural implements are human, bullock and oil engines, and electric motors. The stage of agricultural development is indicated by the relative quantum of these sources of power. The percentage of human, cattle, and

mechanical/electrical power input on Indian farms is reported to be 25,64, and 11 per cent respectively (Sharan, Mathur, and Vishwanath, 1974). Thus bullocks continue to be the main power source. An increase in mechanization is associated with a decrease in the use of bullocks. The same authors have also observed that tractorization is not always associated with higher cropping intensity and that custom hiring of tractors was an intermediate step leading to greater mechanization. The more common substitution of bullocks power has been for water lifts, where mechanical and electrical sources are rapidly substituting bullock power. Use of tractors is mainly for pre-sowing operations transportation, and marginally for post harvest operation. Their use in standing crops, as is required for plant protection, is significantly limited due to ~~the~~ constraints of agronomic practices and agro-climate.

A number of studies on mechanization in agriculture, mainly on water lifts and tractorization are available. Studies on marketing and use of plant protection appliances are however rare. A review of the type of plant protection equipments has been published recently (Patal, 1976). Unlike tractors which at present are mainly, confined to pre-sowing operations, plant protection equipments, either manual or power operated, have to be adapted for standing crops the needs of which vary greatly. The height of crops, row space, time of use, and labour availability can be some of the crucial factors influencing use and choice of plant protection equipments. A wide range of plant protection equipments have therefore developed. They are operated from stationary position with long discharge tubes, or carried on back of human beings or trolleys or tractors. The manually operated ones have also a

wide range. There are some which can be operated by two hands, one hand and one leg, or by two legs; some are carried on human back and operated with air/hydraulic pressure created by an ordinary pump. Some power operated ones are designed to be carried on human back, while other power equipped plant protection appliances also are carried on chassis or trolleys or tractors. For each of these, low or high volume nozzles are provided. A more recent addition is a battery operated revolving disc, light weight low volume sprayer. It is reported that manual knapsack sprayers (continuous type) are in largest number (35% of the total), 25 per cent are compression sprayers, and 15 per cent stirrup pumps, 10 per cent rocking piston and foot sprayers, and 5 per cent small nursery sprayers. Dusters are said to constitute 10 per cent of the total. Hydraulic, gaseous (including thermal), centrifugal, kinetic, and thermal energy sources are used for plant protection equipments.

Pest control methods related to plant protection equipments are high volume spray, low volume spray, ultra low volume, aerial spraying, foam spraying, dusting wet dusting, granules, and integrated pest control (Patel 1974). The progressive development in plant protection equipment is leading to a wider use of aerial application method.

Thus a very wide range of appliances has been made available to agriculturalists by enterprising manufacturers. It is however significant to note that even though bullocks are the main sources of power in Indian farms, plant protection has been an exception in so

far as such use of bullocks for traction of plant protection appliances or as a source of power for plant protection appliances has not yet succeeded on a large scale.

Amongst the rare references throwing some light on the status of plant protection appliances are the series of pesticide market studies (Pesticides association of India, (1972)). These studies were primarily designed for study of pesticides and incidentally record the number of appliances in the areas studied. The period of these studies was just before the seventies, when several years had passed since the introduction of high yielding varieties. According to these studies sprayers were commonly used than hand dusters, but a large number of farmers, then, used to dust even without plant protection appliances.

In the third plan and earlier, governments were subsidizing purchases by farmers of approved manually operated plant protection appliances to an extent of 50 per cent of the value. Most states had some pattern of assistance in this regard. During the fourth and fifth plans, such assistance was reduced to 25 per cent and many states altogether discontinued such assistance, except for scheduled tribes and castes. The current levels of assistance to farmers for owning plant protection appliances are given in appendix I

Such assistance was reintroduced for small and marginal farmers during the fourth and fifth plan periods. The financial assistance provided by governments to farmers gave a large push to ownership of appliances by farmers and consequently helped to increase their production.

Plant Protection in Gujarat

The earliest attempts for hemical plant protection on a substantial scale in Gujarat were for seed treatment of sorghum against smut, mango against jassids and mildew, and citrus canker. In the district of Valsad in Gujarat, mango crop is being treated with some pesticide for the past forty years. In this state plant protection for field crops enlarged extensively after the introduction of chlorinated hydrocarbons, but an explosion in demand for plant protection occurred after the introduction of pest and disease susceptible high yielding varieties, particularly hybrid cotton and paddy. Seed treatment of cereals became particularly widespread after the change-over from the decentralized, local self sufficiency of seed to centralized production and commercialization of seed distribution in the wake of introduction of hybrids. The need for plant protection is primarily related to crop and varietal susceptibilities. A study of plant protection appliances can therefore be best made in situations where plant protection is already practised to a substantial extent. Such situations will be naturally in areas where need for protection exists.

Data Base —

Manually operated sprayers and dusters (together), power, and tractor units are being separately recorded as a part of quinquennial household livestock census. Further details as to the number of different types are not available in this census. The number of

appliances in a locality is considered a good indicator of the adoption of field plant protection measures.

For this paper, 1972 live-stock census data incorporating the number of appliances were available for Gujarat. In table 1, number of appliances in each district along with net sown area (NSA) per appliances is shown. As certain crops are known to be protected against pests, the area under such special crops was ascertained. Area of these special crops per appliance is also shown in the table. Table 2 shows the population of agricultural workers and their availability per hectare NSA in each district. The districts were arranged in a descending order of the total number of appliances and the ranks of each district in regard to i) rank as per number of agricultural workers per hectare NSA ii) NSA per appliance and iii) area of special crops per appliance, are shown. The lesser the area per appliance, the higher the rank. Along with the ranks as per percentage area irrigated, per cent area double cropped, and rank as per NSA per power appliance are also given.

For each of the possible factors influencing number of manual appliances power appliances and total appliances, the correlation was worked out and R-values are shown in Table 4.

Analysis of Data

In Gujarat there were 6,100 appliances in 1966, which increased to 41121 in 1972. an increase of over six times in six years.

The highest number of appliances were in the districts of Vadodara (6749) followed by Sabarkantha (5472). These districts account for 16.4 and 13.3 per cent of the total appliances in Gujarat (Table 1). It is pertinent to note that these districts which are most advanced in regard to the number of appliances have 17.8 and 14.3 per cent gross sown area irrigated and rank as far low as fifth and eighth in regard to per cent gross sown area irrigated (Table 3). This may indicate that plant protection and number of appliances are not a function of intensity of cropping, but other considerations such as susceptibility of crop/varieties may be more relevant. The districts of Vadodara, ^{bar}Sabarkantha and six others in the descending order of number of appliances (Table 1) accounted for 82.5 per cent of the total appliances in Gujarat indicating a wide disparity in the extent of adoption and/or the need for plant protection.

Vadodara followed by ^{bar}Sabarkantha had the highest number of power operated appliances, as for manual ones. Their number varies greatly in various districts (Table 1). In regard to the total number of power operated appliances, Vadodara and Kheda had the largest numbers. These two districts however differ greatly in regard to land use. Percentage area irrigated (Vadodra 16.2 per cent

Kheda 24 per cent) and double cropped area (Vadodra 3.3 per cent, Kheda 10.7 per cent).

The ratio of manually operated to power operated appliances also varies greatly. In Bhavnagar district, which otherwise has less number of appliances, has 2.2 manually operated appliances for every power operated one, principally because of larger number of tractor operated appliances. Such favourable ratios also prevail in the districts of Gandhinagar (2.8 :1) and Banaskantha (3.4 :1). Kheda district, which has relatively high percentage of irrigated and double cropped area, has also a fairly favourable ratio (3.2 :1). However, a relatively agriculturally less developed district of Kutch has also a ratio of 3.5 : 1. In the state as a whole there are 6.9 manually operated appliances for every power operated one.

The largest number of tractor operated appliances are in Rajkot district (175) followed by Bhavnagar (126). Here again, the cropping intensity is relatively less than that in several other districts which have lesser number of these appliances.

Net sown area for each appliance in the districts of Gujarat is also shown in Table 1. Vadodra district which has the highest number of appliances has also the largest net sown area covered by the appliances. In this district for each appliance there is 77 ha. of net sown area followed by Sabarkantha (81 ha.). Figures for other leading districts are Surat 93 ha., Bharuch 103, Valsad 113, Junagadh 137, Kheda 154, and Rajkot 206.

In the remaining districts for each appliances, there are 414 to 3812 ha. of net sown area indicating a rather low level of advancement of plant protection.

The progress of mechanization in agriculture is related to several factors. Physical factors such as soil, methods of cultivation, time constraints for farm operations, and availability of labour and its cost at the time of operations are some of the basic considerations. Shortage of labour and its high cost, and/or physical constraints insurmountable by human and animal power obstructing farm operations are factors which necessitate introduction of farm mechanization. Related to the use and mechanization of appliances are factors of cultivation methods like row spacing, height of crop, varieties grown, and frequency of use. Nearness to source of water is an additional factor influencing choice and use of these appliances.

In order to have an idea as to whether the number of appliances has some relationship with the availability of labour the number of agricultural workers available per ha. of net sown area was worked out. The districts, arranged in the descending order of per ha. availability of labour are shown in Table 2. The ranks of the districts as per total appliances (column 1) net ^{area} sown per appliance (Column ²) number of agricultural workers per units of net sown area, and net sown area per power appliance are shown in Table 3. Due to the factors which may be influencing the number of appliances, not very close relationship in ranking can

be expected. However, rankings for all these can be considered proximate for Vadodara, Valad, Surat, Bharuch, and Kheda. Dissimilarity between ranks for percentage area irrigated and double cropped and the rest seem prominent (Column 7 and 8, Table 3).

It is common knowledge that in Gujarat plant protection is practiced more on commercial crops. Amongst cereals, the one which is considered for plant protection and that too occasionally is paddy. In recent years, epidemics of jassids, blast, and blight on paddy have been frequent necessitating pesticide application on this crop. The other field crops which require and receive plant protection are groundnut, cotton, and, to a very limited extent, tobacco. Amongst tree crops, mango (table varieties) is regularly protected, while coconut is occasionally so treated. Sugarcane is another crop which gets often infested and for which protective measures are resorted to. All these and a host of other crops, such as vegetables, spices, condiments, etc. though occupying small area, were grouped as special crops needing plant protection.

The area of this group of special crops per appliance can also be an important criterion for the study of distribution of appliances. The area of special crops per appliance is also shown in Table 1. Rankings of districts in regard to number of appliances (Column 1, Table 3) net sown area per appliance (Col. 3) and area of special crops per appliance (Col. 6) appear somewhat close in so far as the top eight districts are concerned.

The wide variants or exceptions appears to be Kutch, which ranks fourth in the area of special crops per appliance, and conversely Rajkot ranked tenth.

In order to obtain a more exact picture of the relationship of the number of appliances with other factors, a correlation matrix was obtained for the number of appliances in a district and individual and aggregate special crops, percent of gross sown area irrigated, per cent area double cropped, net sown area. As the number of agricultural workers and rural literacy are often associated with ^{the adoption of} sophisticated agricultural technology, correlations of these with the number of appliances were also worked out. These are given in Table 4. The table excludes the r values of some individual special crop like, groundnut, sugarcane, mango, coconut, and area under two other varieties of cotton as these values were very small.

From the r values (Table 4) it is quite obvious that, as per expectation, the area under Hybrid 4 cotton is the major determinant of the need and existence of appliances in a district. The r values for other factors are low at the level of district aggregate analysis. The results will have to be compared for taluka level and farmers level, as the study proceeds.

The negative r values of the number of appliances with per cent of area double cropped and net sown area call for an examination. Cotton in Gujarat is a long duration Kharif crop extending over the winter season, which generally prevents taking

of a second crop in winter. Further, cotton is one crop, for which irrigation is mostly used, but irrigation facilities are not generally such as to permit a second irrigated crop in summer after harvesting cotton.

The number of appliances having some positive correlation with cotton crop can therefore be expected to have negative correlation with per cent of area double cropped.

The negative correlation of the number of appliances and net sown area can be incidental to larger districts (with larger net sown area) not having equally large areas under cotton.

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TABLE 1 : No. of FPA in Districts of Gujarat (1972)

District	Manual sprayers and Dusters	Power Sprayers + Dust- ers	Tractor Sprayers + Dusters	Total Applia- nces and percentage to total	Net Sown Area ^c Applian- ces (HA)	Special crops applian- ces (HA)
Vadodara	5604	1109	36	6749 (16.4)	77	56
Sabarkantha	4766	695	11	5472 (13.3)	81	40
Bharuch	3447	668	12	4127 (10.00)	103	71
Surat	3668	517	25	4210 (10.2)	93	61
Kheda	2415	696	59	3170 (7.7)	154	73
Kutch	1108	290	104	1421 (3.4)	442	62
Valsad	2241	102	21	2364 (5.8)	113	98
Bhavnagar	474	86	126	686 (1.7)	879	391
Rajkot	3304	73	175	3552 (8.6)	206	142
Junagadh	4236	92	4	4332 (10.5)	137	100
Panchmahals	599	25	41	623 (1.5)	776	303
Jamnagar	1396	23	45	1469 (3.6)	414	224
Ahmedabad	837	32	27	896 (2.2)	679	311
Mehsana	1021	50	10	1081 (2.6)	600	336
Banaskantha	175	39	10	224 (0.6)	3812	193
Amreli	437	23	1	461 (1.1)	1038	618
Gandhinagar	50	17	1	68 (0.2)	699	NA
Surendranagar	173	18	1	192 (0.5)	3516	1839
Danga	21	1	-	22 (0.1)	2031	NA
	35932	4480	709	41121		

Table 2 : Density of Agricultural Workers As Related to Net Sown Area in Gujarat

Rank	District	Agri- workers - Agricultural Labour & Cultivators	Net Sown Area	Number of Agriculture Workers per Ha.
1	Valsad	354,943	262,620	1.35
2	Panchmahal	594,083	485,145	1.22
3	Kheda	516,177	488,652	1.06
4	Surat	410,028	390,371	1.03
5	Vadodara	415,059	521,059	0.80
6	Danga	34,511	44,681	0.77
7	Gandhinagar	36,542	47,542	0.77
8	Bharuch	308,756	423,692	0.73
9	Mehsana	411,684	669,690	0.61
10	Sabankantha	267,625	441,507	0.61
11	Junagadh	333,413	593,338	0.56
12	Bhavnagar	258,060	599,543	0.43
13	Ahmedabad	254,631	603,466	0.42
14	Amreli	184,161	478,819	0.38
15	Banaskantha	313,523	819,668	0.38
16	Rajkot	277,947	731,611	0.38
17	Jamkantar	232,226	607,433	0.32
18	Kutch	178,526	627,741	0.28
19	Surendranagar	173,562	675,091	0.26
Gujarat		5,507,667	9,519,669	0.58

Table 3 : Ranking of Districts

Rank Total applian- ces Li. No.	District	Rank NSA PPA	Rank Agri Wrok- ers/ Ha. NSA	Rank Power NSA PPA	Rank Ha Crop PPA	Rank % Area Irri- gated	Rank % Area double crop- ped
1	2	3	4	5	6	7	8
1	Vadodara	1	5	1	2	5	17
2	Sabarkantha	2	10	2	1	8	7
3	Junagadh	6	11	10	8	4	4
4	Surat	3	4	5	3	7	11
5	Bhauruch	4	8	3	5	12	18
6	Rajkot	8	16	9	10	6	9
7	Kheda	7	7	4	6	1	5
8	Valsad	5	1	7	7	11	6
9	Jamnagar	9	17	12	12	14	8
10	Kutch	10	18	6	4	15	15
11	Mehsana	11	9	14	9	2	14
12	Ahmedabad	13	13	13	14	9	13
13	Panchmahal	14	12	11	13	18	1
14	Bhavnagar	15	12	8	15	13	12
15	Amreli	16	14	16	16	16	10
16	Banaskantha	19	15	15	11	10	3
17	Surendre Nagar	18	19	17	17	17	16
18	Gandhinagar	12	7	-	NA	3	2
19	Dangs	17	6	-	NA	19	19

PPA = Plant Protection Appliances.

NSA = Net Sown Area.

Table 4 : Correlationship of Number of PPA in the Districts of Gujarat with Possible Important Factors

Manual Plant Protection Appliances r Values		Total Power + Tractor Appliances r Values		Total Appliances r Values	
Hybrid 4	0.531	Hybrid 4	0.765	Hybrid 4	0.587
Hb4+ Mango	0.515	Hb4+Mango	0.552	Hb4 + Mango	0.534
Literacy	0.402	Tobacco	0.515	Literacy	0.424
% Gross Sown Area Irrigated	0.368	Literacy	0.416	% Gross Sown Area Irrigated	0.381
Special crops	0.365	Cotton Area	0.386	Special crops	0.336
Area Cotton	0.255	% Gross Sown Area Irrigated	0.375	Area Cotton	0.285
Agricultural Workers	0.231	Paddy	0.313	Agricultural Workers	0.252
Paddy	0.198	Agricultural Workers	0.312	Tobacco	0.241
		Special crops	0.120		
Tobacco	0.179	-	-	-	-
% area double cropped	-0.061	% area double cropped	-0.238	% area double cropped	-0.093
Net Sown Area	-0.333	Net Sown Area	-0.0344	Net Sown Area	-0.345

APPENDIX I

SUBSIDY ON PLANT PROTECTION APPLIANCES

A : Subsidy given by the Central Government

- i) Subsidy given by Crops Division :- Under the Pulses Development Programme, the Crops Division is providing 50 per cent subsidy on the cost of Plant Protection Equipment under the Centrally Sponsored Scheme for Endemic Areas. In addition, a subsidy on operational charges at the rate of Rs. 12.50 per hectare is being given.
- ii) 50 per cent subsidy on Plant Protection Equipment under the ICDP for Hissar and Sirsa districts of Haryana is also provided by the Government of India.

B : Subsidy given by the State Governments :

Name of State/ Union Territory	Subsidy to small and marginal farmers	General subsidy to farmers
1. M.P.	Subsidy at 25% or Rs.62/- per Plant Protection Equipment, whichever is less, on hand operated and 25% or Rs.390/-, whichever is less, on power operated sprayers to small cultivators, cooperative societies, Panchaya, Market multi-committees and agro-centres.	
2. Karnataka		Subsidy in the supply of Plant Protection equipment at 25% in the case of hand operated and 25% or Rs.200/- whichever is less in the case of power operated sprayers.
3. Tamil Nadu		
4. Kerala		25% subsidy on Plant Protection equipment.
5. Punjab		Rs.30,000/- given as 50% subsidy for purchase of Plant Protection equipment in border districts.
6. Assam		50% subsidy on Plant Protection equipments.

Name of the State/ Union Territory	Subsidy to small and marginal farmers	General subsidy to farmers								
7. Badra and Nagar Haveli		25% subsidy for Plant Protection equipment to adivas, cultivators.								
8. Arunahal Pradesh		50% subsidy on Plant Protection equipment.								
9. Orissa		25% subsidy on sprayers.								
10. Andaman and Nicobar Islands		20% subsidy on Plant Protection equipment. In addition, 100% transport subsidy on all Plant protection equipments.								
11. Tripura		<p>i) 50% subsidy on sale of Plant Protection equipment, during 4th Plan Period ending 73-74.</p> <p>ii) During 5th Plan Period Working Group on Agriculture recommended the following rate of subsidy on sale of Plant Protection equipments.</p> <table> <tbody> <tr> <td>1974-75</td> <td>33%</td> </tr> <tr> <td>1975-76</td> <td>10%</td> </tr> <tr> <td>1977-78</td> <td>10%</td> </tr> <tr> <td>1978-79</td> <td>nil</td> </tr> </tbody> </table>	1974-75	33%	1975-76	10%	1977-78	10%	1978-79	nil
1974-75	33%									
1975-76	10%									
1977-78	10%									
1978-79	nil									

Source : Plant Protection Advisor Ministry of Agriculture, Faridabad
(Haryana)