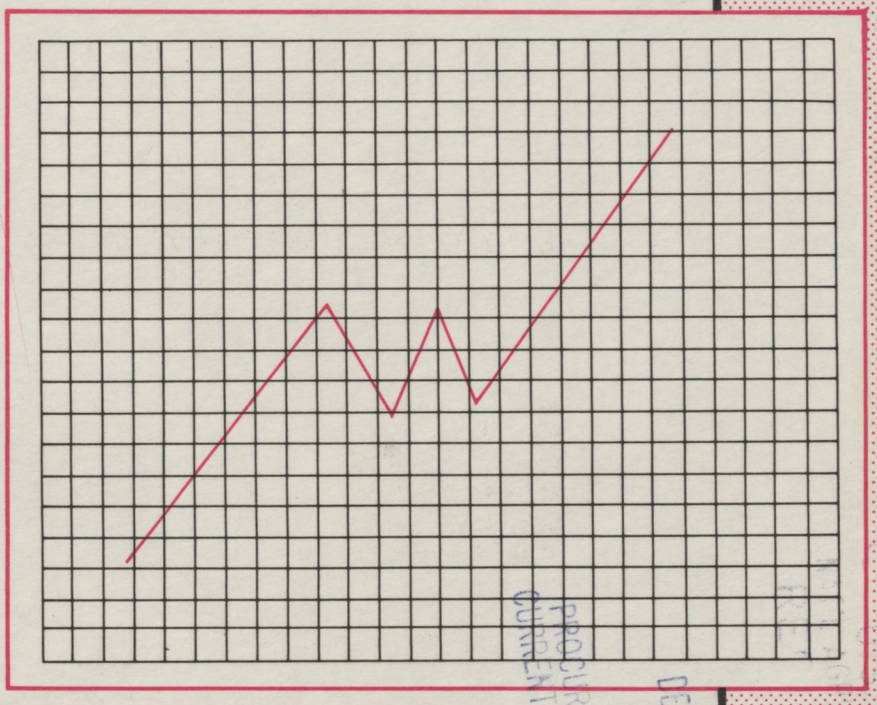

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A MODEL FOR AGRICULTURAL COMMODITY R&D*

by P.A DONOVAN ** and W.L. NIEUWOUDT***

ABSTRACT

With constraints on State funds, consideration should be given to the private sector and agricultural commodity organisations undertaking their own R&D. Private organisations tend to adopt a goal-orientated research approach. Examples are the SASA Experiment Station and international private sector poultry research. A model is constructed based on data available from the SASA Experiment Station depicting a detailed functional breakdown of activities and costs of such a research programme.

INTRODUCTION

The purpose of agricultural research and development (R&D), as a single integrated function, is to increase producers' profitability. The research component usually consists of applied research but does not exclude some basic research, if necessary, while development embraces all the activities required for new knowledge, products or processes to be used in practical production.

With constraints on State funds and in terms of the privatization policy, consideration should be given to the private sector and agricultural commodity organisations undertaking their own R&D. The purpose of this paper is to develop a management model for commodity organisations wishing to conduct their own research and development.

INVESTMENT IN R&D

Expenditure on agricultural R&D in South Africa (Science Planning Directorate 1984) and on agriculture generally (Annual Report of the Department of Agriculture 1985) is well documented and the data have been reclassified into six functional categories as listed in Table 1.

Estimates were also made of the expenditure on commodity R&D by non-governmental organisations so that the total investment in commodity R&D could be estimated as in Table 2.

Brand (1983) has suggested that the State's policy of moving closer to a free market economy could include at least some agricultral R&D. In terms of benefits and objectives there would seem to be no reason why almost all commodity R&D as defined above should not be left to the private sector, most suitably to producer associations. There are sufficient examples of successful private enterprise commodity R&D to provide the managerial experience and cost criteria that would be required in privatising the existing State commodity orientated research institutes. There are also examples in the literature of methods for calculating the private and social benefits of private research at institute level (SASA Experiment Station, 1983; Simmonds, 1974) and in terms of particular commodities (Sunnquist *et al.*, 1981; Dalrymple, 1981).

If all commodity R&D became the responsibility of the various producer organisations, the State's control of agricultural R&D would be reduced from 71 to 25 (measured in terms of percentage of expenditure) and there would be a reduction of some R70 million in the State's expenditure on agriculture (Donovan & Lynas).

Two kinds of agricultural R&D that need to remain the State's responsibility are resource R&D and control R&D (Donovan, 1986 : p.63). The former is required to improve and accelerate the protection and development of the nation's natural resources, including human resources, which are exploited commercially but which are not themselves marketable, and on which a permanent and healthy agriculture depends. A high level of social return may be expected from such expenditure but the level of private return is too low to attract investments other than perhaps by consulting services. The State must therefore remain responsible for resource R&D and if the nearly R68 million (see Table 1) spent in 1983/84 on commodity R&D could be devoted to resource R&D the present rate of resource degradation might be reduced significantly. Among the many advantages such an arrangement would have is the removal of competition between commodities and resources for funds. Not only is such competition undesirable, but the problem is compounded by the fact that objective arbitration between the commodities is almost impossible and is subject to political and economic pressures.

Control R&D is required in the formulation, improvement and application of government regulations to which agriculture is subject. Nieuwoudt (1986) has said that there are many (control) measures in agriculture that act as a brake on productivity; there are others introduced at the behest of interest groups which restrict production itself. If all unnecessarily restrictive controls were to be removed, those justifiably retained could cost less than the R19,55 million spent in 1983/84 on control R&D. This saving could also be used to increase expenditure on resource R&D.

*The paper is based on the senior author's Master of Agricultural Management thesis entitled 'Management of Agricultural Research and Development with particular reference to the Sugar Association Experiment Station'

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TABLE 1 - Expenditure by the Department of Agriculture in 1983/84 classified by functional objectives

Functional objectives	Expenditure R mill	% of total Departmental expenditure	% of total value of agricultural production (R8 200 mill)
Commodity R&D	67,68	8,07	0,83
Resource R&D	34,62	4,13	0,42
Regulatory & control	19,55	2,33	0,24
Financing, subsidies & assistance	670,60	79,99	8,18
Supporting services	29,74	3,55	0,36
Administration	16,21	1,93	0,20
Total	**838,4**	**100**	**10,23**

Source: Donovan, 1986: p. 54

TABLE 2 - Estimated total investment in commodity R&D by all sectors in 1983/84 (after Donovan, 1986)

Sectors	R mill	% of total
Government	**67,7**	**62**
Co-operative	19,7	18
Municipal	11,3	10
Business	8,0	7
Non-profit	1,5	1,5
Marketing boards	1,5	1,5
Total non-government	**42,0**	**38**
Total	**109,7**	**100**

Source: Donovan, 1986: p. 55

ADVANTAGES OF COMMODITY R&D

Public investment in agricultural research and development is rationalised on the grounds that (a) research findings are not patentable, (b) research is a public good, (c) consumers are the main beneficiaries if the price elasticity of demand is less than unity and (d) the marginal cost of extension may be small.

Concerning (a) and (b) no individual farmer has sufficient incentive to undertake R&D on his own, but a commodity organisation has such an incentive, since the sum of the benefits for all its members is compared with the cost of R&D. A public good (b) implies that the commodity (research benefits) is collectively consumed. Regarding (c), South Africa is a price taker on the export market and farmers producing export commodities will be almost the sole beneficiaries of R&D. For commodities that are not exported, local prices may fall from R&D but it is less likely that profits will fall, since farmers may be able to switch to other crops. Concerning (d), extension may be provided effectively by a commodity organisation that serves a large, reasonably specialised farming area.

In future the private sector will be expected to play a more prominent role in research because State funds are limited, and more attention should be focused on research privately funded by commodity organisations.

There are five principal advantages to be derived from commodity associations assuming responsibility for their own R&D. First, decisions on what research should be done and what services are needed, as well as their priorities, would be taken solely by those who pay for and obtain private benefit from them. Secondly, South Africa is a price taker on the agricultural export market and the relevant price elasticity could be high. This is expected to apply to all products, depending on the internal production substitution of products. Thirdly, the difficulties of recruiting and retaining staff are more easily overcome by private enterprise than by a State department. Fourthly, and adequate, specialised and integrated extension service is an essential part of R&D and only in a commodity controlled organisation is it possible to achieve this. Finally, and perhaps most important in the present political and economic environment in South Africa, is the strategic advantage of being independent of State funds. The competition for public monies is getting stronger; security, education and the development of agricultural and human resources are all political imperatives that will, rightly, have higher priority than State-funded agricultural commodity R&D which generates a high proportion of private profit.

FINANCING COMMODITY R&D

Commodity associations funding their own R&D programmes, wholly or partly, usually do so by raising a levy on the value of their own production. This normally requires enabling legislation (owing to the free rider problem) but voluntary contributions by members based on their own production is an alternative method which, in the case of the SA Citrus Exchange, has proved successful (Stanton, 1985). There is a recent tendency for commodity associations to charge members for certain routine technical services such as soil analysis; this is desirable because it reduces the levy and avoids criticism that those who use a particular service are subsidised by those who do not. As marginal costs of services are met by direct charges, levies can be used for overhead costs and to fund the important non-tradable services such as extension. Attempts to charge directly for extension services in Tasmania have failed (Fountain, 1985) and this important function could be regarded as a fair charge on levies. An additional advantage of direct charges for services is that they can be compared and may operate in competition with similar services available commercially. This reassures association members and motivates R&D staff to reduce costs.

POLICY AND CONTROL OF COMMODITY R&D

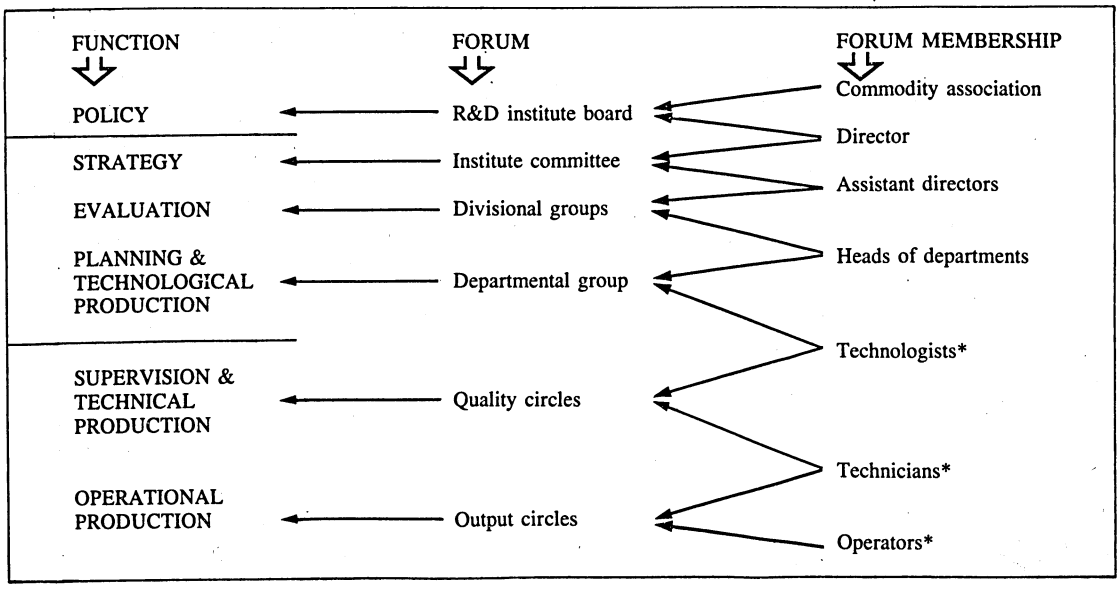
A commodity organisation's primary goal is to improve the profitability of its product. One of the

most important means of achieving this goal is to have appropriate production technology readily available for use. The most satisfactory way - sometimes the only way - to ensure its appropriateness and availability is for the commodity association to generate its own R&D. A commodity R&D organisation should therefore be regarded as a wholly-owned subsidiary enterprise of the commodity association, whose policy is determined by a board or committee appointed by the commodity association, but whose management is entrusted to the (managing) director and staff of the R&D organisation.

CONSTRUCTING A MODEL FOR COMMODITY R&D

The model is based on data available from the SASA Experiment Station and is therefore most appropriate for a single commodity R&D institute of similar size. However, with suitable modifications it can probably be used for institutes of different sizes and also for R&D institutes serving more than one commodity provided there are no conflicting interests. Since the Experiment Station, as a system, cannot be described realistically in strictly mathematical terms, heuristic procedures have been used (Reese, 1985). Qualitatively these can be used as guidelines on organisational structure and quantitatively they can be used to assess the amount of R&D that can be supported by a particular commodity at different levy levels. In developing the model two assumptions were made: first, that policy is determined by producers of the commodity and, second, that employees of the commodity R&D organisation serve only the interests of the association. The conflicts of goals, loyalties and functions in R&D institutes that serve more than one interest group so complicate orga ıisational structure and management that heuristic models would be of little value. It is largely for this reason, too, that services (though not necessarily research) provided by such institutes are regarded as unsatisfactory by the customers (farmers).

The first part of the model, the policy-management structure, shown in Figure 1, illustrates the relationship between the policy makers, who constitute the 'Board' (which represents producers), and management, which at three levels deals successively with strategy, evaluation and planning. To involve and motivate staff at the technical and operational levels, quality and output circles are suggested as the means by which objectives of both management and employee can be promoted. An essential feature of such a structure is that the designated office-bearers both above and below a particular forum should be full members of both those forums. This not only provides for effective downward communication of authoritative information but also commits successive levels of management to the policies of the association and of the institute. In this way the 'they have decided' attitude on the part of employees, which is common in bureaucracies, can be changed to 'we have decided', which is necessary for productivity. Figure 2, the management-production submodel, illustrates the important difference between a commodity R&D institute and a research institute. In commodity R&D the primary goal is to improve the profitability and productivity of the commodity's producers, therefore the primary structure must be concerned with the primary functions required to achieve that goal. The secondary structure is then concerned with carrying out the secondary functions, and so on. In a research institute, with a primary structure based on scientific disciplines, primary goals relate to the



*In this paper the title *technologist* is used for staff with at least a two-year post-matriculation qualification *or* good record of experience in posts that normally require such a qualification. At the Experiment Station technologists' qualifications range from doctorates to none at all and there appears to be little correlation between performance and qualifications. *Technicians* usually have a matriculation certificate and most are trained on the job. *Operators* range from labourers usually without school qualifications to persons sufficiently literate and numerate to follow written instructions and to record data

FIG. 1 – Policy-management structure sub-model of a commodity R&D institute

TABLE 3 - Unit costs of a commodity R&D institute (R1 000 p.a.), 1985/86

	Cost per employee unit			All other costs	Number of units	Cost per team
	Technologists	Technicians	Operators			
*Line-function departments						
Agronomy	26,1	8,78	3,19	41,71	5	88,56
Chemistry & soils	34,8	8,25	3,46	31,66	4	112,24
Engineering	29,6	8,73	-	42,73	15	82,81
Breeding	32,5	8,02	3,32	111,71	9	154,89
Pathology	28,7	8,44	3,75	35,56	7	72,97
Entomology	35,9	8,24	3,09	62,43	6	125,1
Extension	29,4	5,95+		56,24	17	88,44
Education & training	37,3	11,82	-	163,81	4	252,15
Publications & PR	24,3	9,33	-	31,53	3	71,41
*Service (staff-function) departments. These costs have been allocated and to and included in the line-function departments						
Biometry data processing	37,3	8,67	-	47,08	3	98,86
Farm services	32,93	10,47	3,39	15,93	5	250,01
Transport & bldg	26,19	7,94	2,8	27,63	7	129,32
Administration	27,3	12,3	5,16	8,21	4	63,9

+Part-time employees

promotion of the sciences; this may be appropriate in a basic research organisation but is counter-productive in a commodity R&D institute.

Table 3 sets out the costs per staff and team unit. These were derived from the recording of work done by all technologists and an analysis of costs at the SASA Experiment Station for the 1985/86 year (Donovan, 1986: p. 164). The cost of a team is made up of the cost of one technologist and all his or her associated subordinate staff as well as 'non-staff' costs. Team costs obtained for different disciplines can then be used in the application of the model to other commodities.

The contribution of communications, both internal and external, to the success of an R&D organisation is generally underestimated. The authority channel of formal communication has already been mentioned and it remains only to emphasise the importance of formality and regularity of meetings if these are to provide an effective channel for the communication of policy downwards and of information upwards. The second, or technological, channel of communication is as important to the success of a R&D organisation. This channel consists of various forums at which there is discussion and an exchange of information and ideas on the planning and conduct of R&D projects as well as on the results and recommendations that emanate from projects. The various forums must have been established formally and their proceedings should also be formal, with recorded minutes or notes taken in order to facilitate decision-making by the Directorate or for the information of other groups.

In addition to the authority and technological channels, management should encourage and provide both time and facilities for informal discussion among staff on R&D projects. For example, informal discussions are likely to be more productive if no notes or minutes are recorded and if no members of the Directorate attend. Although the decisions and conclusions reached by these peer groups are not part of the institute's formal decision-making procedure, they are likely to influence them.

APPLICATION OF MODEL

Although the model has been constructed with the experience and data obtained from the SASA Experiment Station's work on sugar-cane, the procedures and costs should apply reasonably well to a number of traded crop and horticultural commodities.

Crop and horticultural commodity values given in Table 4 have been extracted from the *Abstract of Agricultural Statistics* (Department of Agricultural Economics and Marketing, 1986). The table lists the commodities in descending order of mean gross value based on the five years 1980 to 1984. Commodities that have been grouped together are those which do not

TABLE 4 - Field crop and horticultural commodities listed in descending order of mean gross value for the five years 1980-1984, excluding those with gross value less than R60 mill (after Donovan, 1986)

Commodities	Gross value R mill
Maize	1 262
Hay	689
Wheat (546), barley (28), oats (13), rye (1,4)	588
Sugar-cane	469
Vegetables (291), dried beans (55), dry peas (3,4)	349
Deciduous fruit (294), dried fruit (42)	336
Citrus (152), subtropical fruits (91), nuts (2,2)	245
Viticulture	181
Potatoes	181
Oilseeds: Sunflower (85), groundnuts (68), soya (11)	157
Tobacco	123
Sorghum	70
Flowers and bulbs	63
Cotton	62

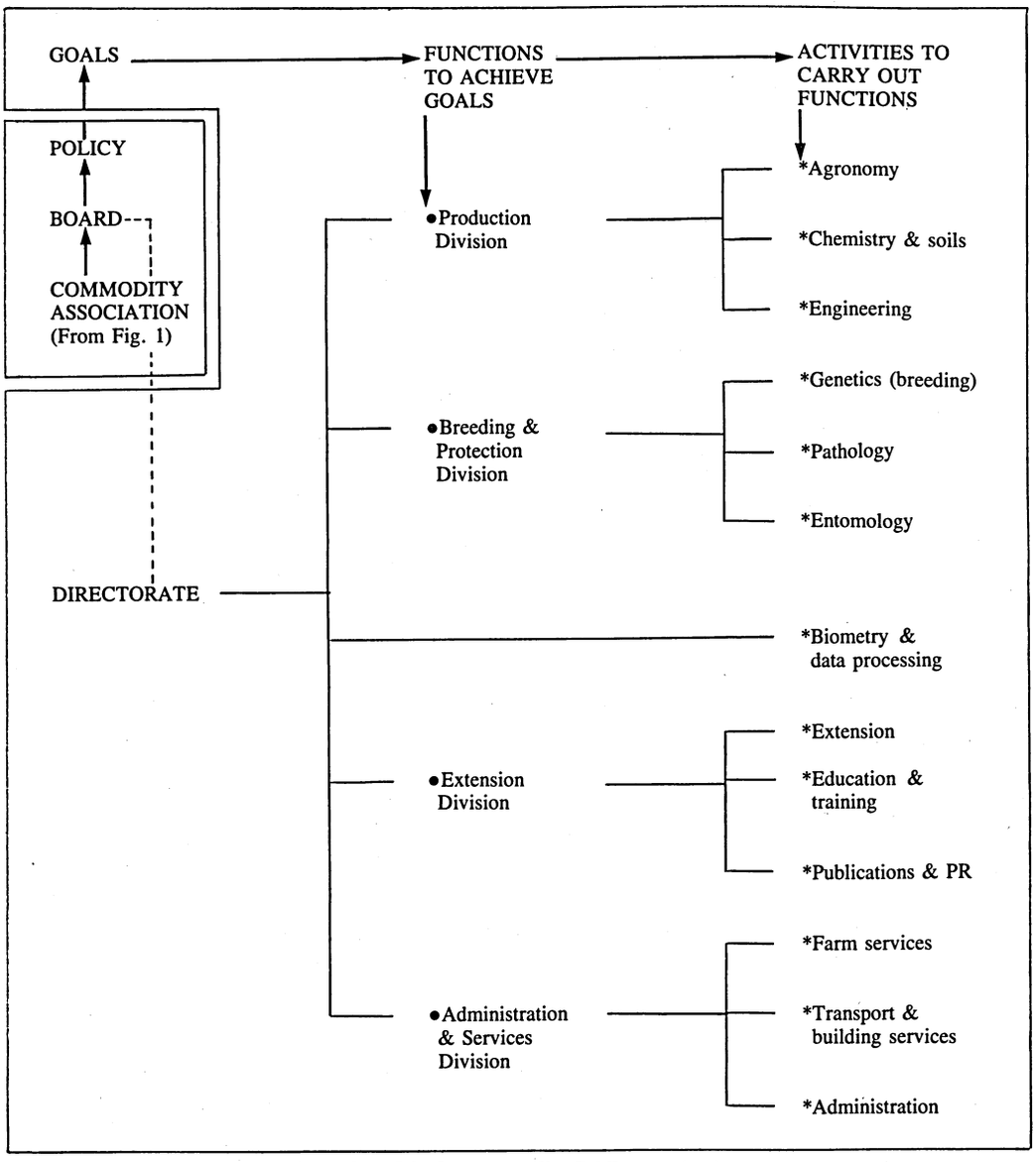


FIG. 2 – Management-production submodel of a commodity R&D organisation

compete with each other in the market place and could therefore be served by the same R&D institute without prejudice to any of them and without giving management the responsibility of making choices between them. An example of an acceptable grouping of commodities for R&D purposes would be wheat, barley, oats and rye because they are not competitive in the market place and would therefore not compete for R&D funds. An unacceptable grouping would be one of maize and sorghum; in spite of their similarities with regard to ecology, production intensity and methods, and their similar R&D requirements, they compete as products on the market and would therefore be in competition for the available R&D resources.

One of the major advantages of commodity R&D is that management is not expected to exercise the 'political' responsibility of deciding on priorities between, or the allocation of scarce R&D resources to, commodities that compete in the market. This difficulty is compounded in a non-commodity institute by the fact that R&D resources are State funds. The first use of the model might be to facilitate the decision on whether or not a commodity association has the financial resources to undertake its own R&D.

For this the data available on the costs of R&D (Donovan, 1986) and the experience of organisations that are already responsible, wholly or partly, for their own R&D should be considered. The SA Sugar Association Experiment Station was established in 1925 on a levy of 0,14% of the value of sugar-cane produced. The levy did not exceed 1% of sugar-cane's gross value until 35 years later. Its levy now varies more or less inversely with crop yield; it was at its highest (1,89%) in 1964/5, when the industry experienced its second lowest rainfall and in the last ten years the levy has averaged 1,41%, with the highest at 1,79% and the lowest at 0,92%. The Zimbabwe Sugar Association meets its own R&D requirements, except for an extension service (which is not required under their circumstances), on an average levy of 0,74% varying from 0,94% to 0,47% over the last nine years (Cackett, 1986). It is not possible to determine the total expenditure on

citrus R&D in South Africa because State and university spending on citrus research and extension is not published as such but the SA Citrus Exchange spends 0,74% of the crop's gross value on R&D (Stanton, 1985), and if State and universities together spend as much as R0,5 million, total expenditure on citrus R&D would amount to no more than 1% of the value of the crop. In deciding on the level of a levy required, it is also interesting to note that State R&D expenditure in South Africa on food crops, horticultural crops and livestock products was 0,47%, 1,13% and 0,9% of their respective commodity values in 1984 (RSA 1985). If non-government expenditure is included, an average of 1,3% of the total gross value of these commodities is spent on R&D (Donovan, 1986: p. 56).

Data on R&D expenditure in other countries are given in Table 5.

Consensus on what level of levy for R&D resources might be acceptable to producers belonging to a commodity association will depend on a number of factors but these data show that it will probably be between 0,75% and perhaps 2,5% of the gross value of production of the commodity.

The next factor to be considered in deciding whether a commodity can or should undertake its own R&D is the minimum 'critical mass' of an independent R&D institute. Opinions on what constitutes minimum critical mass will vary, but Sugar Experiment Station experience suggests that it will probably be between R1,3 million and R2 million. From Figure 3 it is apparent that three of the commodities listed in Table 4, namely sorghum, flowers and bulbs and cotton would require a levy greater than 1,5% in order to establish a viable R&D institute.

There are eight other commodities or groups of commodities with much lower gross values, from tea at R31,4 million to lucerne seed at R2,6 million. For these commodities separate viable R&D institutes may not be feasible but at a levy level of 2,5% most

TABLE 5 - R&D expenditure as a percentage of the gross value of some major commodities

Country/commodity	Year	%	Reference
Australia:	1974/5		Lindner, 1981
Field crops		1,0	
Sugar-cane		1,2	
Horticultural crops		2,4	
Livestock products		1,6	
Fishery products		5,4	
Forestry products		4,4	
Hawaii:			
Sugar-cane	1983/4	1,34	Sugar Y Azucar, 1984
United Kingdom:			
Sugar beet	1983/4	0,69	Brisbourne, 1984
Zimbabwe:			
Tobacco (flue-cured)	1966/7	1,64	McDonald, 1986
	1980/1	1,55	
	1984/5	1,23	

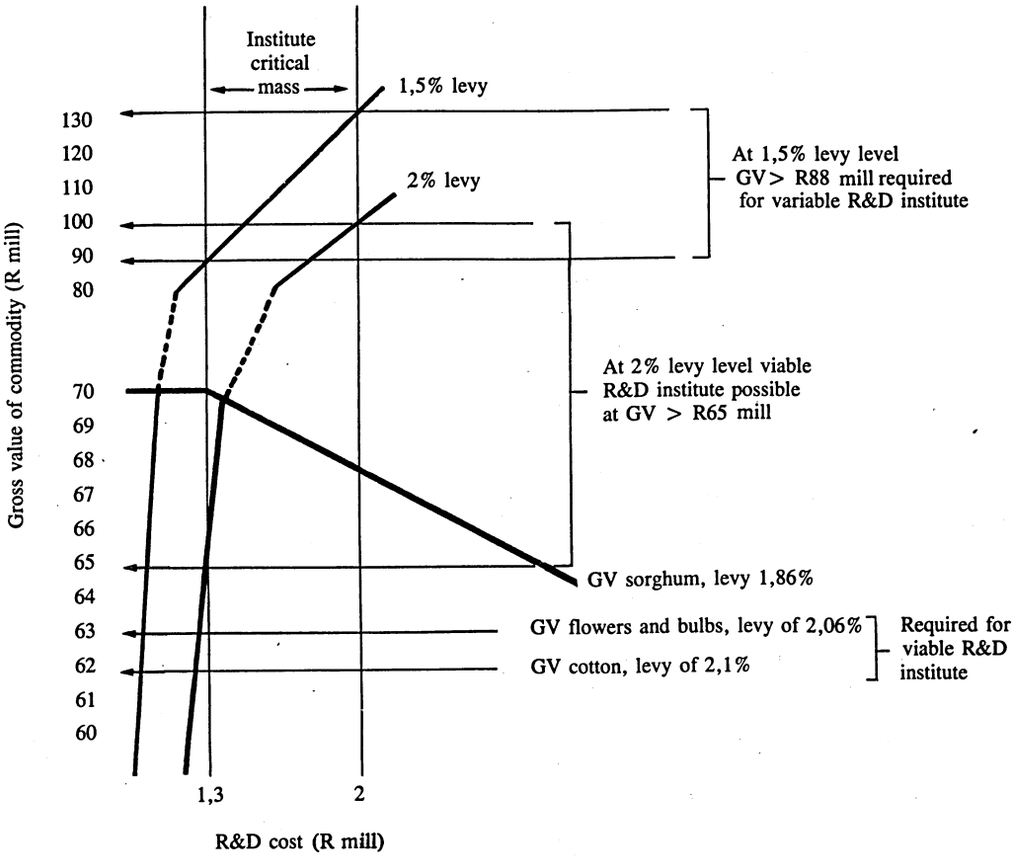


FIG. 3 – Relationship between commodity gross value (GV), level of levy and viability of a commodity R&D institute; at GVs between R60 mill and R130 mill

TABLE 6 - Procedure for determining the funds and levy required to implement commodity financed R&D on the sorghum crop

Priority	Step 1 R & D programmes	Step 2 Number and type of team	Step 3 Accumulated cost of teams	Step 4 Levy (% of gross value)	Step 5 No. of lists
1	Start cultivar/area trials Set up breeding activity Employ an extension agent	1 Agronomy 1 Breeding 1 Extension	331 900	0,14	3
2	Priority 1, plus: Increased breeding work Increased extension	1 Agronomy 2 Breeding 2 Extension	575 200	0,82	5
3	Priority 2, plus: Start disease investigations Start pest investigations	1 Agronomy 2 Breeding 2 Extension 1 Pathology 1 Entomology	773 300	1,1	7
4	Priority 3, plus: Start nutrition and herbicide trials Increase extension Start fertilizer advisory service (add 1 technologist for general services)	2 Agronomy 2 Breeding 3 Extension 1 Pathology 1 Entomology 1 Chemistry & soils 1 General services	1 062 400	1,52	11
5	Priority 4, plus: Increase cultivar/area trials Start mechanization advisory service Start publication of reports and information leaflets (add 1 technologist for farm services and 1 for administration)	3 Agronomy 2 Breeding 3 Extension 1 Pathology 1 Entomology 1 Chemistry & soils 1 General services 1 External com'cat'n 1 Administration 1 Farm services 1 Engineering	1 305 200	1,86	16
6	Priority 5, plus: Increase in breeding work Increase in disease Investigations Increase in fertilizer advisory service	3 Agronomy 3 Breeding 3 Extension 2 Pathology 1 Entomology 2 Chemistry & soils 1 General services 1 Engineering 1 External com'cat'n 1 Administration 1 Farm services	1 424 700	2,04	19
7	Priority 6, plus: Increase in extension Increase in pest investigations (add 1 technologist for general services)	3 Agronomy 3 Breeding 4 Extension 2 Pathology 2 Entomology 2 Chemistry & soils 2 General services 1 Engineering 1 External com'cat'n 1 Administration 1 Farm services	1 638 200	2,34	22
8	Priority 7, plus: Start education and training courses Start biometry and data processing services (add 1 technologist for scientific services)	3 Agronomy 3 Breeding 4 Extension 2 Pathology 2 Entomology 2 Chemistry & soils 1 Engineering 1 External com'cat'n 1 Administration 1 Farm services 1 Scientific service	1 890 300	2,7	23

of them would generate sufficient financial resources to contract out their major R&D requirements to other institutes.

The third category of information required when considering establishment of a commodity R&D institute, is the cost of different kinds of R&D and how to estimate costs of different sizes of R&D programmes. A method suggested for obtaining this information was proposed by Donovan (1986: p. 170), using the sorghum crop as an example. The procedure suggested, to be carried out by the producers' association with the assistance of R&D consultants, is illustrated in Table 6 below and consists of five steps, as follows:

Step 1: List in order of priority the R&D programmes considered to be required to improve the commodity's profitability.

Step 2: For each priority, list the number and types of R&D teams required to conduct these programmes. (The unit costs of teams obtained in the analysis of SA Sugar Experiment Station costs in Table 3 have been used for this example.)

Step 3: Accumulate the unit costs of successive priorities.

Step 4: Express the accumulated cost of priorities as a percentage of the commodity's gross value.

Step 5: Enter the accumulated number of technologists (one per team) adding one each for Administration and Farm Services at 14 and a second for Transport and Building Services at 20 and one for Biometry & Data Processing at 23, and so on.

The commodity association can now decide more confidently whether it can afford to undertake its own R&D or whether to retain its present arrangements. If the association can determine the number of technologists working on their commodity at present, the decision is made easier. For example, cost of a team of 16 full-time technologists is estimated, from Table 6, to be R1,3 million. This would require a levy of R1,86% which, as indicated in Figure 3, is probably the lower limit of viability for an R&D institute. Priorities 6, 7 and 8 in Table 6 are given to indicate the increases in R&D programmes that could be obtained by raising the levy to 2,04%, 2,34% and 2,7% respectively.

It can be assumed that 16 technologists working together as an interdisciplinary group with a common goal and no other or conflicting objectives, would be more productive and more responsive to the practical R&D requirements of sorghum producers than the same number distributed among a number of bureaucratic organisations with different, often conflicting, goals.

CONCLUSION

If the 14 commodities, or groups of commodities, listed in Table 4 imposed on themselves a levy averaging 1,5% of their gross value, R117,8 million would be raised to finance their own R&D. In 1983/84 the total expenditure on commodity R&D in South Africa has been estimated (Donovan, 1986: p. 54) at R109,7 million, of which the State share was R67,7 million. Privatization of commodity R&D could therefore result in an increase in R&D expenditure on commodities by some 7,4% and an annual saving of nearly R68 million by the State. Notwithstanding these advantages, the greatest gain would undoubtedly be the increase in commodity productivity and profitability, with the spin-off of higher social benefits for the community.

BIBLIOGRAPHY

BRAND, S.S. (1983). Structuring of the South African agriculture in a free-market orientated economy. *Agrekon* 22(2): 1-5

BRISBOURNE, D. (1984). Sugar beet research and education. *British Sugar Beet Review* 52, 56

CACKETT, K.E. (1986). Director, Zimbabwe Sugar Association Experiment Station. Personal communication

DALRYMPLE, D.G. (1981). Yield information needed for the analysis of crop improvement research. *Evaluation of Agricultural Research* Agricultural Experiment Station Miscellaneous Publication No 8, University of Minnesota

DEPARTMENT OF AGRICULTURAL ECONOMICS AND MARKETING (1986). *Abstracts of Agricultural Statistics*

DONOVAN, P.A. (1986). *Management of agricultural research and development with particular reference to the Sugar Experiment Station* M. Agric. Mgt. thesis, University of Natal

DONOVAN, P.A. and LYNAS, M.G. (1987). The political, structural and managerial advantages of commodity-controlled agricultural R&D. Paper accepted for publication in *Agricultural Administration and Extension*

FOUNTAIN, P.J. (1985). Director, Tasmania Department of Agriculture. Personal communication

LINDNER, R. (1981). Accountability in research funding through industry funding. *Evaluation of Agricultural Research* Miscellaneous Publication No 8, Minnesota Agricultural Experiment Station, University of Minnesota

McDONALD, I. (1986). Director, Tobacco Research Board, Zimbabwe. Personal communication

NIEUWOUDT, W.L. (1986). The role of the agricultural economist in agricultural policy. *Agrekon* 25 (2): 2-6

REESE, K. (1985). *Corporate planning* Trident Publishing, Durban

SCIENCE PLANNING DIRECTORATE (1984). *Resources for R&D, 1981/82* Department of Constitutional Development and Planning, Pretoria

ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE 1 APRIL 1983 TO 31 MARCH 1984 (1985). Government Printer, Pretoria

SASA EXPERIMENT STATION (1983). Assessment of Cost Effectiveness of the Experiment Station. Mimeographed

SIMMONDS, N.W. (1974). Costs and benefits of an agricultural research institute, *R&D Management* 5, 23-28

STANTON, D. (1985). Assistant General Manager (Technical). SA Co-operative Citrus Exchange, Pretoria. Personal communication

SUGAR Y AZUCAR (1984). Vol 79: 5,9

SUNNQUIST, W.B., CHENG-GE CHENG and NORTON, G.W. (1981). Measuring returns to research expenditure for corn, wheat and soya beans. *Evaluation of Agricultural Research* Agricultural Experiment Station Miscellaneous Publication No 8, University of Minnesota